House of Commons

Science and Technology Committee

Scientific advice and evidence in emergencies

Third Report of Session 2010–11

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The Science and Technology Committee

The Science and Technology Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Government Office for Science and associated public bodies.

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The Reports of the Committee, the formal minutes relating to that report, oral evidence taken and some or all written evidence are available in printed volume(s).

Additional written evidence may be published on the internet only.

Committee staff

The current staff of the Committee are: Glenn McKee (Clerk); Ed Beale (Second Clerk); Farrah Bhatti (Committee Specialist); Xameerah Malik (Committee Specialist); Andy Boyd (Senior Committee Assistant); Julie Storey (Committee Assistant); Pam Morris (Committee Assistant), Jim Hudson (Committee Support Assistant); and Becky Jones (Media Officer).

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Summary

Scientific advice and evidence play a key role in the prediction and assessment of risks as well as the resolution of an emergency once it occurs. We chose to examine science in emergencies using four case studies: (i) the 2009-10 H1N1 influenza pandemic (swine flu); (ii) the April 2010 volcanic ash disruption; (iii) space weather; and (iv) cyber attacks. These case studies provided focal points and real-life examples to draw upon.

The UK is regularly hit by national crises, or emergencies. Natural hazards that cause emergencies range from extreme weather to animal disease outbreaks and, more recently, pandemic influenza and volcanic eruptions abroad. In addition, man-made threats such as physical or cyber attacks have become increasingly likely over the past decade.

We have been left with the impression that while science is used effectively to aid the response to emergencies, the Government's attitude to scientific advice is that it is something to reach for once an emergency happens, not a key factor for consideration from the start of the planning process. This is not trivial: had the risks of volcanic ash disruption been assessed prior to the emergency, the Government would undoubtedly have been better able to cope with the situation that occurred in April 2011, when ash from the Eyjafjallajökull volcano in Iceland resulted in the closure of airspace over Europe at a cost of hundreds of millions of pounds to the UK economy. Our chief concern was the uncertain role that the Government Chief Scientific Adviser (GCSA) played in the National Risk Assessment (NRA)—the assessment of risks to the UK carried out by the Cabinet Office. We consider that science should be at the heart of the NRA process and have recommended that the GSCA has greater involvement. We urge the Government to do better at embedding scientific advice and an evidence-based approach in risk assessment and policy processes before emergencies occur.

We also looked at the mechanisms of science advice to Government during emergencies. For the swine flu pandemic and volcanic ash disruption Scientific Advisory Groups in Emergencies (SAGEs) were set up, with membership specific to the requirements of the particular emergency. We found that the SAGE, particularly for volcanic ash, tended towards an unnecessarily secretive way of working thus closing doors to the wider scientific community, and did not appear to adhere to any published guidance or code of conduct. A SAGE—which is, after all, a scientific advisory committee to Government—should not be given a *carte blanche* to operate however it pleases simply because an emergency is occurring and we have recommended that the Government clarify what codes, principles or guidance govern its operation.

The Government must communicate risk effectively to the public in an emergency; this is vital to prevent mistrust and anxiety. We examined this issue using the swine flu case study and had misgivings about the Government's communication of what it termed "reasonable worst case scenarios", that is, the worst situation that might reasonably happen. While such scenarios are useful for organisations preparing for, and responding to, emergencies, use of such scenarios led to sensationalised media reporting about the projected deaths from swine flu. We concluded that the Government must establish the concept of "most probable scenarios" with the public, in all future emergencies.

1 Background

The inquiry

1. As the new Science and Technology Committee, formed in July 2010, we were keen to build upon the work of our predecessor committees which scrutinised science and engineering in policy-making. In this inquiry we examined how scientific advice and evidence is used in national emergencies, when the Government and scientific advisory system are put under great pressure to deal with atypical situations.

2. We decided to focus our inquiry towards four very different case studies in order to build up a richer picture of how science is used in emergencies. The case studies were: (i) the 2009-10 H1N1 influenza pandemic (swine flu); (ii) the April 2010 volcanic ash disruption; (iii) space weather; and (iv) cyber attacks. In July 2010 we issued a call for evidence, seeking views on the following questions in relation to the case studies:

- What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?
- How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?
- What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? For case studies (i) and (ii) was there sufficient and timely scientific evidence to inform policy decisions?
- How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?
- How important is international coordination and how could it be strengthened?

3. We received over 40 written submissions. On 13 October, the Committee was briefed in private by senior officials from the Cabinet Office Civil Contingencies Secretariat (CCS) and Government Office for Science (GO Science), on "how things work", that is, the civil contingencies framework and the central Government response to emergencies. We found this meeting to be useful in providing background information and context and we would like to thank the Cabinet Office CCS and GO Science for taking the time to organise and host this briefing.

4. We held five oral evidence sessions between October and December 2010; one for each case study (split across two panels) and a final session with the Government Chief Scientific Adviser and Ministers (current and former). We took oral evidence from 32 witnesses in total.

i. The first evidence focused on swine flu and we took evidence from, on the first panel: Professor Sheila Bird, former Vice President, the Royal Statistical Society; Professor Neil Ferguson OBE, Director, MRC Centre for Outbreak Analysis and Modelling; Justin McCracken, Chief Executive of the Health Protection Agency;

and Dr Peter Holden representing the British Medical Association. In the second panel, we took evidence from: Professor David Harper CBE, Chief Scientist, Department of Health; Professor Sir Gordon Duff, Chair, Scientific Pandemic Influenza Advisory Committee; and Sir Liam Donaldson, former Chief Medical Officer, Department of Health.

ii. The second evidence session covered the volcanic ash emergency and again we took oral evidence from two panels. The first panel included: Dr Ray Elgy, Head of Licensing and Training Standards, Safety Regulation Group, Civil Aviation Authority; Dr Guy Gratton, Royal Aeronautical Society; Dr Sue Loughlin, Head of Volcanology, British Geological Survey; and Captain Tim Steeds, Director of Safety and Security, British Airways. In the second panel we heard from: Professor Brian Collins, Chief Scientific Adviser, Department for Transport; Dr Miles Parker, Deputy Chief Scientific Adviser, Department for Environment, Food and Rural Affairs; and Professor Julia Slingo, Chief Scientific Adviser, Met Office.

iii. Covering space weather, our third evidence session saw us taking oral evidence from: Professor Mike Hapgood, Royal Astronomical Society; Professor Paul Cannon, Royal Academy of Engineering; and Chris Train, Network Operations Director, National Grid. The second panel of witnesses consisted of: Professor Brian Collins, Chief Scientific Adviser, Department for Business, Innovation and Skills; Phil Evans, Director Of Government Business, Met Office; Paul Hollinshead, Director of Science and Innovation Group, Department of Energy and Climate Change; and Phil Lawton, Downstream Gas and electricity Resilience Manager, Department of Energy and Climate Change.

iv. During our fourth evidence session, on cyber attacks, we took evidence from: Professor Ross Anderson, Professor of Security Engineering, University of Cambridge; Robert Hayes, Senior Fellow, Microsoft Institute for Advanced Technology in Governments; Malcolm Hutty, Head of Public Affairs, London Internet Exchange; and Professor Peter Sommer, Visiting Professor, London School of Economics. The second panel of witnesses consisted of: Professor Bernard Silverman, Chief Scientific Adviser, Home Office; Professor Mark Welland, Chief Scientific Adviser, Ministry of Defence; and Dr Steve Marsh, Deputy Director, Office of Cyber Security and Information Assurance.

v. We concluded the oral evidence with a final session of three panels. First, we heard from Professor Sir John Beddington, Government Chief Scientific Adviser. Second, we took evidence from Rt Hon Lord Adonis, former Secretary of State for Transport and Rt Hon Andy Burnham MP, former Secretary of State for Health. The third panel was Rt Hon Baroness Neville-Jones, Minister for Security and Counter-Terrorism, and Rt Hon David Willetts MP, Minister for Universities and Science.

5. We would like to put on record our thanks to everyone who provided written or oral evidence to this inquiry.

6. Finally, we appointed three specialist advisers to this inquiry: Mike Granatt CB, Director at Luther Pendragon, for the whole inquiry; Dr Sandra Mounier-Jack, Lecturer in Health

Policy, London School of Hygiene and Tropical Medicine, University of London, for the swine flu case study; and Dr Richard Clayton, Security Group, University of Cambridge, for the cyber attacks case study. Their expert advice was invaluable and we are grateful for their contributions.[1]

The work of predecessor committees

7. Three reports produced by our predecessor committees have provided a starting point for our inquiry. The 2006 report on *Scientific Advice, Risk and Evidence Based Policy-making* examined risk and public communication in Government.[2] The 2009 report on *Putting Science and Engineering at the Heart of Government Policy* included suggestions for Government scientific advisory structures and improvements to science in the civil service.[3] Finally, we note the 2003 report on *The Scientific Response to Terrorism,* which looked at how science and technology can be harnessed to develop countermeasures to chemical, biological, radiological and nuclear (CBRN) devices employed by terrorists.[4]

8. There has been no recent parliamentary scrutiny of the way science is used in planning for, and responding to, emergencies, although the individual case studies have attracted attention. The last two years have brought two significant emergencies to the UK: the swine flu pandemic and volcanic ash disruption to aviation, both of which required scientific advice and evidence to inform policy. In addition there are growing concerns over the risks of cyber attacks and space weather. To provide focus for our investigations, we chose to focus on these four case studies, and use them to draw out cross-cutting issues and broad lessons about scientific advice and evidence in emergencies. We begin our report by providing some background information on the case studies and relevant Government structures before scrutinising emergency preparation and response.

1 Relevant interests of the specialist advisers were made available to the Committee before the decision to appoint them on 13 October 2010. The Committee formally noted that Mr Granatt declared an interest relevant to the Committee's work as a consultant to the Chief Executive of Community Resilience, an Advisory Board Member of the Science Media Centre, an Adviser to Media Consulta, the provider of on-site support and advice to the European Centre for Disease Prevention and Control and that he had led Luther Pendragon's support for the Independent Climate Change E-mails Review. Dr Clayton declared an interest relevant to the Committee's work that he was jointly employed by the University of Cambridge and the National Physical Laboratory as a 'post-doc' researching Internet Security Mechanisms and as Treasurer of the Foundation of Information Policy Research. The Committee formally noted that Dr Mounier-Jack declared no interests relevant to the Committee's work.

2 Science and Technology Committee, Seventh Report of Session 2005-06, *Scientific Advice, Risk and Evidence Based Policy-making*, HC 900–I

3 Innovation, Universities, Science and Skills Committee, Eighth Report of Session 2008-09, *Putting Science and Engineering at the Heart of Government Policy*, HC 168–I

4 Science and Technology Committee, Eighth Report of Session 2002-03, *The Scientific Response to Terrorism*, HC 415–I

2 The case studies

Swine flu

9. Influenza, or flu, is caused by a virus that affects the respiratory tract. "Ordinary" influenza circulates constantly in humans and tends to peak in the winter months. Pandemic influenza, on the other hand, results from a new strain of virus that spreads globally due to lack of human immunity to the new virus. Influenza pandemics have occurred several times over the last century, although they are difficult to predict and the virulence and mortality rate can vary greatly.

10. The most severe infections are caused by influenza A viruses, such as H5N1 or A/H1N1 (the "H" and "N" numbers refer to the protein structure of the virus). The "swine flu" virus (A/H1N1, frequently referred to as H1N1) was a new strain of H1N1 flu virus. The A/H1N1 virus is far less virulent than the less-transmissible, but more deadly, H5N1 virus.

11. Fears around the impact of a new influenza pandemic have focused on the threat of an H5N1 pandemic. H5N1 is an avian (bird) influenza virus that emerged in 1997 in Hong Kong and re-emerged in 2003 in a number of countries of South East Asia to become endemic[5] in a number of them. As of 13 January 2011, there have been 306 confirmed deaths due to H5N1, approximately half of them in Indonesia.[6] It is impossible to predict when the virus might reach a sufficient level to allow for widespread human-to-human transmission. The World Health Organisation (WHO) estimates that in the case of a pandemic caused by H5N1, millions of people could die of the disease. Since 2005, there have been significant investments by national governments and the international community to prepare for an H5N1 pandemic. In the UK, preparedness has involved comprehensive emergency planning in the NHS, antiviral and H5N1 vaccine stockpiling, and the provision of sleeping contracts for pandemic strain vaccines (meaning that manufacturers reserve a certain number of doses of vaccines they develop).

12. The swine flu story began on 23 April 2009 when cases of H1N1 virus were confirmed in Mexico and the USA. A few days later, cases in the UK were confirmed. A timeline of key events is summarised in Box 1.[7]

5 Endemic means that the infection is sustained in the population without external inputs.

6 "Cumulative Number of Confirmed Human Cases of Avian Influenza A/(H5N1) Reported to WHO", *World Health Organisation,* 13 January 2011, www.who.int

7 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, pp 2–5

Box 1: Swine flu pandemic timeline

2009	
23 April	Cases of H1N1 virus are confirmed in Mexico and the USA
27 April	The first two UK cases of H1N1 are confirmed in a couple from Scotland
29 April	Government announces that the stockpile of antivirals will be increased from 33.5 million to 50 million
1 May	First case of human-to-human transmission in the UK is confirmed
15 May	Agreements made to secure up to 90 million doses of pre-pandemic vaccine
11 June	World Health Organisation raises its pandemic alert level to 6, the highest level
16 July	Chief Medical Officer announces that up to 65,000 people could die from swine flu in a worst case scenario[8]
13 August	Secretary of State for Health announces the identification of priority groups: pregnant women, front-line health and social care workers, and everyone in at-risk groups aged over six months
10 September	The four UK health departments release critical care strategies to cope with the expected increases in demand during the second wave of the pandemic
21 October	Vaccination programme begins: front-line healthcare workers and their patients who fall into at-risk categories
19 November	Phase two of vaccination programme begins: children over six months and under five years
2010	
18 March	Total UK deaths: 457; 342 in England, 69 in Scotland, 28 in Wales and 18 in Northern Ireland
1 April	Antiviral medicines no longer available from national stockpiles Antiviral collection points in England are closed The Swine Flu Information Line is terminated Treatment of people with flu-like symptoms returns to business as usual

8 "Swine flu could kill 65,000 in UK, warns chief medical officer", *The Guardian*, 16 July 2009, www.guardian.co.uk

13. The virus remained in circulation even though the pandemic was no longer treated as an emergency. October normally marks the start of flu season, and in October 2010 the consultation rate for influenza-like illnesses in England and Wales—a proxy for the level of influenza—began to rise, peaking at 124.2 consultations per 100,000 population in early December 2010. By 12 January 2011, 112 fatal cases from across the UK had been reported to the Health Protection Agency and confirmed to be associated with influenza infection, out of which 95 were caused by H1N1.[9] The swine flu (H1N1) virus was being treated as one of the group of seasonal flu viruses circulating around the world rather than as a pandemic (that is, an emergency situation).[10] (We were interested in the differences in vaccination strategy and, in January 2011, wrote to the Government to ask why the seasonal vaccination programme differed from the pandemic. The Government's response can be found in the written evidence accompanying this Report[11] and we examine this matter briefly at paragraph 129.)

14. The swine flu pandemic was the first emergency where a Scientific Advisory Group for Emergencies (SAGE) was convened to advise Government. SAGE was a key focus of our inquiry and is explained in detail in chapter 6. During the swine flu emergency, a SAGE committee met 22 times between 5 May 2009 and 11 January 2010.

Volcanic ash

15. Iceland is situated on the Mid-Atlantic Ridge, the boundary between two tectonic plates. The island itself was formed by volcanic activity and has several active volcanoes. In April 2010, the Eyjafallajökull volcano erupted, ejecting significant quantities of ash into the atmosphere. The ash eruption coincided with meteorological conditions that meant the ash covered much of Europe. Historically, Icelandic volcanic eruptions producing ash which is deposited in the UK is nothing unusual.[12] However, there has not been an eruption affecting the UK for decades, coinciding with the time period over which aviation became part of everyday life. The most significant impact of the eruption in April 2010 was that airspace was closed for a week, causing huge disruption to aviation, stranding passengers around the world and costing the UK economy hundreds of millions of pounds. The key scientific issue was determining the tolerances of aircraft and their engines to the particular ash particulates present in European airspace.

16. A timeline of key events is summarised in Box 2.

9 Health Protection Agency, *HPA Weekly National Influenza Report,* 12 January 2011

10 "October - flu season and HPA flu surveillance begins", Health Protection Agency press release 2010, 6 October 2010

11 Ev 164

12 "Iceland and the British Isles: the volcanic connections", *British Geological Survey*, www.bgs.ac.uk

Box 2: Volcanic ash emergency timeline

2009	
December	Seismic activity detected at Eyjafjallajökull volcano in Iceland
2010	
20 March	Eyjafjallajökull volcano in Iceland first erupts through a side fissure Impacts are largely confined to Iceland
14 April	A more intense and sustained eruption occurs in the central crater, resulting in ejection of solid matter up to11 km into the atmosphere
15 April	Many European aviation authorities (including UK) close airspace. Government Chief Scientific Adviser meets with Cabinet Office[13] British Geological Survey start advising civil contingencies secretariat[14] Met Office uses NERC[15] plane for four-hour test flight
18 April	Government Chief Scientific Adviser meets Prime Minister British Airways conducts three-hour test flight in Cardiff
19 April	British Airways CEO declares blanket restrictions on airspace are unnecessary after engines were found to be unaffected
20 April	Scottish airspace reopens
21 April	All UK airports reopen First SAGE meeting takes place[16]
3 May	Ash cloud returns; some airports in Scotland and Northern Ireland close
6 May	All UK airports (re)open
16 May	Several airports in northwest England close as ash cloud returns
17 May	Heathrow and Gatwick close Several airports in northwest reopen
23 May	Volcanic Ash Advisory Centre at Met Office declares eruption over

13 Ev 100 [Government Office for Science and Cabinet Office]

14 Ev 124 [Research Councils UK], para 33

15 Natural Environment Research Council

16 Ev 100 [Government Office for Science and Cabinet Office]

17. This was the second time a SAGE was convened. The SAGE formed to provide scientific advice in this emergency met four times between 21 April and 24 June 2010.

Space weather

18. "Space weather" refers to changes in the space environment near Earth, caused by varying conditions in the Sun's atmosphere. Table 1 summarises the different types of space weather and indicates examples of impact.

Table 1: Categories of space weather

Space weather	Cause	Examples of potential impacts
Coronal Mass Ejections (CMEs)	Plasma ejected violently from outer atmosphere of Sun	Fluctuations in Earth's magnetic field (geomagnetic storms), driving additional current into power grids, disrupting satellites, GPS and radars
Solar Energetic Particle (SEP) events	High energy particles expelled from Sun during solar events like CMEs	Damage to electronics, computer chips and power systems in spacecraft (possibly at ground level too), raised ground radiation levels
Solar radio bursts	Intense bursts of radio noise produced by solar events like CMEs	Interference with low power wireless radio technologies such as mobile phones, wireless internet and GPS receivers
Solar flares	Outburst of radiation and energetic particles	Modest effects at Earth

19. Space weather is an everyday occurrence and resilience is routinely built into some components of infrastructure such as satellites. However, more severe events do occur. The Carrington event in 1859, named after the British astronomer who first witnessed the solar activity, was (and remains) the most severe space weather event recorded. The Carrington event was a CME that caused global disruption to telegraph systems around the world. Even when telegraphers disconnected the batteries powering the lines, induced electric currents in the wires still allowed messages to be transmitted.[17] So wide-ranging was the impact that aurorae (visual effects caused by geomagnetic disturbances in the atmosphere, normally seen towards polar regions) were seen in near equatorial regions such as Hawaii.

20. It is widely believed that an event of the same magnitude today would have a much greater impact due to our increased reliance on electricity-based technology.[18] There have been less severe events since 1859. For example, in 1989, a geomagnetic storm caused by a CME caused Quebec's power grid to collapse within 90 seconds, affecting several million people for nine hours.[19] In 2003, space weather caused an hour-long power outage in

17 "A Super Solar Flare", *NASA Science News*, 6 May 2008, nasa.science.gov

18 Ev 120 [Royal Aeronautical Society], para 37

19 Ev 119 [Royal Aeronautical Society], para 36

Sweden. The effects of severe space weather are not limited to particular latitudes; the 2003 event also affected South Africa.

21. Solar activity changes according to a cycle lasting approximately 11 years. In this period, solar activity increases during a solar maximum, making space weather events more likely. However, space weather events do not necessarily obey the solar cycle; the Carrington event occurred in the middle of an unexceptional solar cycle.[20] The next solar maximum (a period of likely increased activity) is predicted to occur around 2012-13. Given the impending solar maximum, we were interested in how the Government was assessing the risks posed by space weather and preparing for a potential emergency.

Cyber attacks

22. The Government publication *Cyber Security Strategy of the United Kingdom*, published in June 2009, defines cyber space as encompassing "all forms of networked, digital activities; this includes the content of and actions conducted through digital networks".[21] Cyber security is usually taken to mean the resilience of these complex interconnected networks.

23. There are different types of cyber attack, many of which occur on a daily basis in the UK. Table 2 provides a summary.

Table 2: Types of cyber attack

Attack	Description
Denial of Service (DoS/DDoS)	DoS attacks overload systems with so much traffic that they cannot cope. Distributed denial of service (DDoS) attacks come from many sources simultaneously. The machines creating the attack traffic are usually running "malware" (malicious software) which has been delivered by email or picked up by visiting a website. Users are generally completely unaware that their machines have been compromised.
Phishing	Forging e-mails to entice users to visit a fake version of a bank website, so that their login details can be stolen
Spear phishing	E-mails addressed to a single person within an organisation, perhaps forged to appear to come from colleagues. The malware within these e-mails will infect that person's computer with the aim of perpetrating a major financial crime, or stealing commercial secrets.

20 Ev w37 [UCL Institute for Risk]

21 Cabinet Office, *Cyber Security Strategy of the United Kingdom: Safety, security and resilience in cyber space,* June 2009, p 7

Subversion of supply chain	Altering technology supplied to an individual or organisation (for example implanting malicious programs) in order to make network attacks easier or to deliberately leak financial data
Complex attacks on infrastructure	Much of the "critical national infrastructure" relies upon computers and communications networks. Cyber attackers might interfere with these, perhaps over the Internet from a remote location, and thereby cause widespread disruption.

24. The cyber attacks case study, in contrast to the other three, described a man-made threat rather than a natural risk. As well as the different types of attack, the motivations of attackers—criminal, political or state-sponsored—must also be considered. As we began our inquiry, the "Stuxnet" worm had just been identified to be circulating. It is understood to be the first-known worm designed to target physical infrastructure such as power stations, water plants and industrial units, and, in this case, for the sole purpose of disrupting Iran's uranium enrichment programme.[22] Subsequent analysis has shown it to be a highly sophisticated program that can not only spread over the Internet but can also be carried from machine to machine on portable flash drives, giving it the ability to infect isolated systems. We were told that it would have taken six people to create the worm over five months, with funding to the order of £1 million.[23]

25. The Stuxnet worm provided an actual example of how organised and structured cyber attacks on critical infrastructure systems could succeed[24] and how they could be used in the future to cause emergency situations. We wanted to find out more about how the Government is assessing the risks of cyber attacks and preparing for a potential national emergency.

22 "Israeli Test on Worm Called Crucial in Iran Nuclear Delay", *The New York Times*, 15 January 2011, www.nytimes.com

23 Qq 257–58

24 Q 258

3 Government structures

The Civil Contingencies Act 2004

26. The key legislation governing how the UK deals with emergencies is the Civil Contingencies Act 2004. The Act was designed to create a modern civil defence framework and respond to criticisms that Britain's emergency services lacked the capabilities and resources to cope with a major terrorist attack.[25] The Act, together with its supporting statutory and non-statutory guidance, provides the framework for civil protection activity by local emergency planners and responders across the country.

27. The Civil Contingencies Act defines an emergency as:

- an event or situation which threatens serious damage to human welfare in a place in the United Kingdom;
- an event or situation which threatens serious damage to the environment of a place in the United Kingdom; or
- war, or terrorism, which threatens serious damage to the security of the United Kingdom.[26]

28. The Act divides emergency responders into two categories and imposes different sets of duties upon them. Category 1 responders are those organisations at the core of the response to most emergencies (for example, the emergency services, local authorities and NHS bodies). They are subject to the full set of civil protection duties and are required to:

- assess the risk of emergencies occurring and use this to inform contingency planning;
- put in place emergency plans and business continuity management arrangements;
- put in place arrangements to make information available to the public about civil protection matters and maintain arrangements to warn, inform and advise the public in the event of an emergency;
- share information and cooperate with other local responders to enhance coordination and efficiency; and
- provide advice and assistance to businesses and voluntary organisations about business continuity management (local authorities only).[27]

29. Category 2 responders (for example, the Health and Safety Executive, transport and utility companies) are "co-operating bodies". They are less likely to be involved in the heart of planning work but will be heavily involved in incidents that affect their sector. Category

25 "Civil Contingencies Act 2004", *The Guardian*, 19 January 2009, www.guardian.co.uk

26 Civil Contingencies Act 2004, section 1

27 "Civil Contingencies Act", *Cabinet Office: UK Resilience*, updated 17 January 2011, www.cabinetoffice.gov.uk/resilience

2 responders have a lesser set of duties and are mainly required to cooperate and share relevant information with other Category 1 and 2 responders.[28]

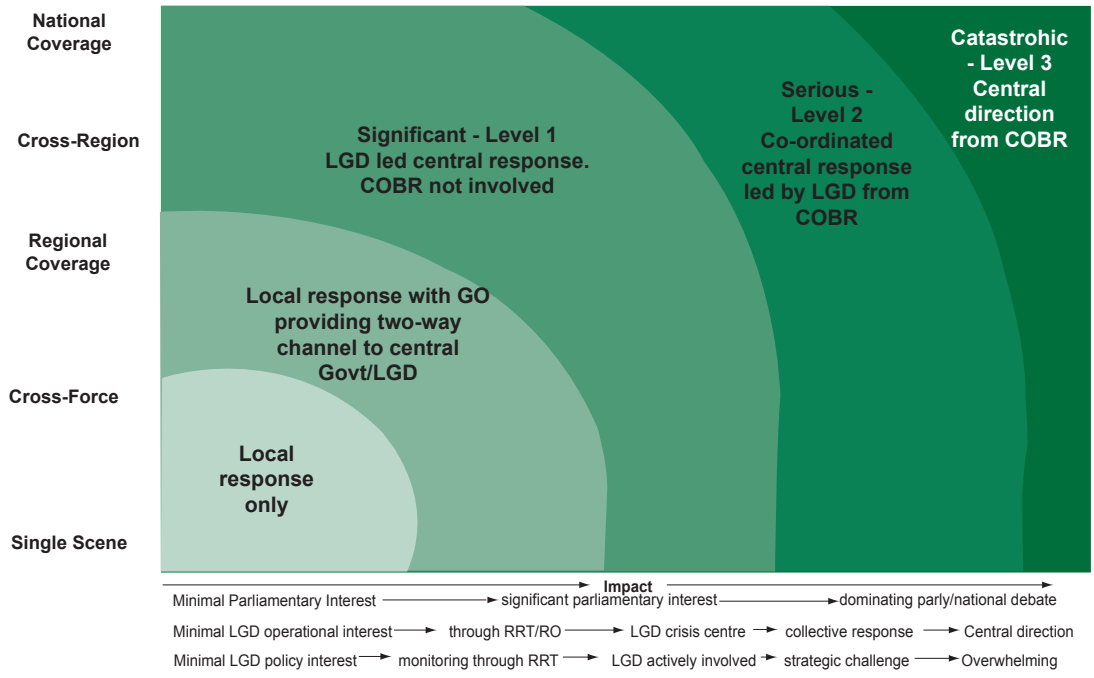
30. The management of the risks of civil emergencies in the UK is coordinated by the Cabinet Office, working in partnership with other Government Departments and the Devolved Administrations.

Responding to Emergencies

31. The *Responding to Emergencies: The UK Central Government Response: Concept of Operations* (Conops) guidance sets out the guiding principles and a framework for emergency management.[29] The Conops guidance categorises emergencies into three types:

- Significant (level 1), for example severe weather;
- Serious (level 2), for example pandemic influenza and terrorist attacks; and
- Catastrophic (level 3), for example a major natural disaster (the UK has no recent experience of a level 3 emergency).

Figure 1: Likely form of Central Government engagement based on the impact and geographic spread of an emergency in England[30]



32. The swine flu pandemic and volcanic ash disruption were classed as level 2 emergencies, requiring a central Government response.

28 "Civil Contingencies Act", *Cabinet Office: UK Resilience*, updated 17 January 2011, www.cabinetoffice.gov.uk/resilience

29 Cabinet Office, *Responding to Emergencies: The UK Central Government Response: Concept of Operations,* March 2010

30 Cabinet Office, *Responding to Emergencies: The UK Central Government Response: Concept of Operations,* March 2010, p 68; GO is an acronym for Government Office in the region.

COBR

33. In the event of a level 2 or 3 emergency, the central response framework would be initiated and would involve the activation of Central Government's crisis management facilities—the Cabinet Office Briefing Rooms (COBR). COBR should facilitate rapid coordination of the Central Government response and effective decision-making.[31] Named after a physical meeting place, COBR is a forum of Ministers and senior officials from relevant Departments and agencies, brought together to make decisions on an emergency response. External representatives and experts are invited to attend COBR meetings as appropriate; discussions are confidential.

34. During an emergency, one of two senior decision-making bodies within COBR—the Strategy Group or Civil Contingencies Committee—will usually be activated. The Strategy Group discusses the response to terrorist-related emergencies. For civil (non-terrorist) emergencies, the Civil Contingencies Committee (CCC) will meet. On rare occasions, both the Strategy Group and CCC could meet to consider different aspects of the same emergency. When it is considering civil emergencies, COBR is supported by the Civil Contingencies Secretariat (CCS) of the Cabinet Office.

Lead Government Departments

35. The Government comprises 19 central Departments and numerous agencies with varying levels of independence from direct ministerial control. In an emergency where a central response is required, a Lead Government Department (LGDs) is appointed. The Cabinet Office maintains a list of LGDs that sets out where the lead should lie in both the response and recovery phases for a wide range of emergencies. Where the UK Government lead is unclear, it is the responsibility of the Cabinet Office to make a judgement and advise the Prime Minister's Office on the most appropriate LGD.[32] The LGD is responsible for ensuring that appropriate plans exist to manage the emergency, for ensuring that adequate resources are available and for leading on public and parliamentary handling. LGDs are also responsible for ensuring they have effective arrangements to access scientific and technical advice in a timely fashion in an emergency.[33] This may involve establishing a Science Advisory Group for Emergencies (SAGE). The SAGEs set up during the swine flu pandemic and volcanic ash emergency were a key focus of our inquiry and are explored in more detail in chapter 6 (Scientific advice and emergency response).

36. When we asked Rt Hon Baroness Neville-Jones, the Minister for Security, how the Cabinet Office chooses a LGD, she explained:

> Normally, it is not difficult to see to which Government Department the lead should fall. Most topics present themselves with an obvious answer. If it doesn't, [...] then the Cabinet Office will act and it will draw in the Government Departments that are

31 Cabinet Office, *Responding to Emergencies: The UK Central Government Response: Concept of Operations,* March 2010, para 2.2

32 Cabinet Office, *Responding to Emergencies: The UK Central Government Response: Concept of Operations,* March 2010, para 2.10

33 HM Government, *Guidance on emergency response and recovery*, April 2010, para 13.4.3

> needed to be there in order to handle whatever crisis it is. What we don't intend to do is to end up with the Cabinet Office becoming departmentally responsible.[34]

37. Baroness Neville-Jones explained that the appointment of a LGD "will depend, to some extent, on the analysis of the factors that go into your assessment of likelihood, impact and, therefore, risk, and the nature of those risks".[35] While this is reasonable in itself, it is unclear how a LGD is identified if an emergency occurs when there has been no prior risk assessment or allocation of responsibility to a LGD—this was the case for the volcanic ash disruption.

38. **We consider that, more important than having a list of pre-identified LGDs, it is essential to have a flexible and fast mechanism to ensure that the most appropriate LGD is appointed. One of the Cabinet Office's first tasks in an emergency should be to review whether the pre-identified choice is most appropriate. During a long-running crisis where the emergency evolves and the focus of the response may change (for example, from the initial response to recovery phase), COBR should review the lead periodically.**

39. **We recommend that, in responding to this report, the Cabinet Office clarify how it makes the decision to appoint the first LGD if one has not been pre-identified.**

40. One of our case studies, space weather, covers a risk that is currently being assessed by Government for the National Risk Assessment and National Risk Register. A LGD is yet to be appointed. A severe space weather event could have impacts cutting across Departments' responsibilities, and therefore coordination is important in preparation for a potential emergency. We note with concern that the Royal Academy of Engineering has stated "there is little indication of any coordination across Government"[36] and the Royal Astronomical Society told us that:

> The major obstacle to provision of reliable, timely scientific advice and evidence has been the fragmentary nature of governmental activity in this area. Indeed, the past experience of the expert community has been that of "pass the parcel", i.e. when a particular body is asked, the responsibility always lies elsewhere.[37]

41. Others suggested that the new UK Space Agency could have a significant role in providing leadership. For example, Research Councils UK pointed out that "the establishment of the UK Space Agency could have significant bearing over the direction of the UK's strategic investment in space weather preparedness and related areas".[38]

42. **We recommend that a LGD/LGDs for a space weather emergency be identified alongside the publication of the 2011 National Risk Register.**

34 Q 392

35 *As above*

36 Ev 148, para 4

37 Ev 113, para 32

38 Ev 128, para 71

The scientific advisory system

43. In order to draw upon scientific expertise in general, the Government takes advice from a range of sources. The scientific advisory system includes:

- Scientific Advisory Committees or Councils (SACs) that are committees of experts independent of Government who are tasked with advising Departments, Ministers, Chief Scientific Advisers, or, in the case of the Council for Science and Technology, the Prime Minister;
- Chief Scientific Advisers (CSAs) who are usually eminent scientists or engineers employed by Government on fixed terms, whose job is to ensure that science and engineering underpin policy decisions in their Department; and
- the Government Chief Scientific Adviser (GCSA) who is a senior scientist heading the Government Office for Science (GO Science) and advises the Prime Minister and the Cabinet. The GCSA is responsible for the network of CSAs and for SACs.

44. There are now over 60 SACs. The current GCSA, Professor Sir John Beddington, and his predecessor, Professor Sir David King, have ensured that there is a Chief Scientific Adviser in almost every Government Department. The only exception is the Treasury, which we consider to be anomalous.

SAGE

45. A Scientific Advisory Group for Emergencies (SAGE) is the main mechanism for channelling scientific advice to Government in an emergency. A SAGE's composition depends on the nature of the emergency, drawing in experts from Government, agencies, academia and industry as necessary. In all level 1 and most level 2 emergencies, decisions on activating a SAGE would be taken by the LGD, which would also appoint the chair. In the most complex level 2 and in all level 3 emergencies, decisions on activating a SAGE would be taken by the Cabinet Office in consultation with the Government Office for Science and the LGD.[39] The GCSA chairs or co-chairs SAGE, and should play a key role in ensuring that the composition of the group is appropriate. We examine SAGE in more detail in chapter 6.

39 Cabinet Office, *Responding to Emergencies: The UK Central Government Response: Concept of Operations,* March 2010, para 3.44

4 National Risk Assessment

46. What is risk? The Royal Society of Chemistry distinguished between hazards and risks and provided a simple definition, which we adopted for this inquiry. It stated that:

> Hazard is an intrinsic property of a substance or situation. Risk differs from hazard, as it involves a consideration of the probability or likelihood of a consequence occurring as well as what the consequence might be.[40]

47. While the Cabinet Office looks after risk assessment in the context of emergencies, it is the Treasury that aims to improve government's capability to handle risk and uncertainty more widely.[41] The Treasury provides the following definition of risk which makes it clear that risk is not seen as inherently good or bad. Rather, it is about uncertainty:

> Risk is most commonly held to mean "hazard" and something to be avoided. But it has another face—that of opportunity. Improving public services requires innovation—seizing new opportunities and managing the risks involved. In this context risk is defined as uncertainty of outcome, whether positive opportunity or negative threat, of actions and events. It is the combination of likelihood and impact, including perceived importance.[42]

48. The key process by which risks to the UK are evaluated is the classified National Risk Assessment (NRA), led by the Cabinet Office. This is a comprehensive, classified assessment of the most significant emergencies (malicious and non-malicious) that the UK could face over the next five years. Most types of risk are reviewed every year, but some are reviewed at longer intervals. There are three stages to the assessment: the identification of hazards; assessment of the risks and their impacts; and comparison of the risks.[43] We examine these stages later in this chapter.

49. Since 2008, an unclassified version of the National Risk Assessment, the National Risk Register (NRR) has been produced to assist individuals and communities interested in improving their own preparedness for emergencies. Unlike the NRA, the NRR is publicly available and provides an indication of the types of risks the UK faces and an indication of what the Government is doing to prepare for them. [44]

The role of the GCSA

50. We would expect the NRA to be strongly informed by scientific evidence in all three stages of assessment. It is easy to see why this should be so: scientists and engineers are involved in the prediction of terrestrial and solar weather, the design of cyber systems, modelling disease outbreak patterns and understanding volcanic activity. Indeed there are

40 Ev w15, para 1

41 "Governance and risk management", *The Treasury*, www.hm-treasury.gov.uk

42 "Risk management: definitions", *The Treasury*, www.hm-treasury.gov.uk

43 Ev 94 [Government Office for Science and Cabinet Office]

44 Cabinet Office, *National Risk Register of Civil Emergencies*, 2010 edition

few emergency risks that do not have a scientific dimension. The Government appeared to confirm this view in its written submission:

> The National Risk Assessment and Register, and the crisis management response, are all underpinned by scientific advice coordinated by the Government Office for Science (GO-Science), under the Government Chief Scientific Adviser. [This includes advice on social sciences, engineering and technology.][45]

The Government Office for Science website states:

> Contingency planning includes monitoring and assessing threats/hazards (e.g. terrorism, pandemic disease), planning to mitigate the risk, carrying out research and evaluation to ensure that the plans are suitably robust, and exercising and training to ensure implementation of the plans. The work of the GCSA and GO-Science is to ensure that all these stages are underpinned across Government by strong science—whether research or advice.[46]

51. We wanted more detail on how GO Science and the GCSA underpinned the NRA and NRR. However, when Sir John Beddington, the GCSA, appeared before us, the following exchange occurred:

> **Stephen Metcalfe:** [...] are you saying that you hadn't, until the volcanic ash incident, been involved in setting up the national risk assessments?
>
> ***Sir John Beddington****:* No, not directly.
>
> **Stephen Metcalfe:** You weren't having an input into that at all?
>
> ***Sir John Beddington****:* I had not had it initially, no.
>
> **Stephen Metcalfe:** Who would now make the final decision? You now having become involved and made recommendations, who is going to make the final decision about what makes it on to the national risk assessment?
>
> ***Sir John Beddington****:* I really don't know, I'm afraid, Mr Metcalfe. The discussions are at the Secretariat level. If there was any debate about that issue, quite how that would be resolved I couldn't say at the moment [...] It may be that the National Security Council would make the final decision, and I input into that through the Senior Officials Group.[47]

52. When asked whether he was surprised that he did not know who made the final decisions about the NRA, Sir John said "yes" and continued:

> I suppose what I am thinking [...] is that by and large you would expect a consensus to go forward, so it would be a decision by them with a consensus coming in from the scientific advice. In the event of some disagreement about what might constitute

45 Ev 94

46 "Civil Contingencies", *Government Office for Science*, www.bis.gov.uk/go-science

47 Qq 329–31

> a risk, I would obviously have to get involved, although I have not encountered such an event.[48]
>
> The thing is that the Cabinet Office own the National Risk Register and the National Risk Assessment. It is their responsibility, so I should imagine that Sir Gus O'Donnell would be the person who ultimately might have the final say, but obviously Ministers would need to endorse that.[49]

53. We pushed this issue with Rt Hon Baroness Neville-Jones, Minister for Security, who told us:

> The Cabinet Office takes charge of the regular updating of the National Risk Assessment and that is done by a team in the Civil Contingencies Secretariat, who have a structured relationship with the scientific advice available to Government through the Government Office for Science and particularly Sir John Beddington. Scientific advice and, indeed, help in the definition of what constitutes the risk, particularly both likelihood and impact, is fed in from the very start. I wouldn't say that there is any stage at which scientific advice is not available or, indeed, not actively involved in the process of consideration.[50]

When pressed further on who provides scientific advice to the NRA, the Minister told us that "there are a whole series of committees [that] exist in relation to different sorts of advice that the Government need".[51]

54. **We are surprised and concerned that the Government Chief Scientific Adviser (GCSA) had no direct involvement with the National Risk Assessment (NRA) process until recently. In addition, we are concerned that the GCSA's oral evidence appears to be at odds with the Government on an issue that is a matter of fact—either GO Science and the GCSA are involved with the NRA process or they are not. We consider that science should be at the heart of the NRA process and ask the Government and the GCSA to clarify this matter.**

55. Another situation illustrated the GCSA's detachment from the NRA. During the course of our inquiry, severe winter weather in the form of heavy snow and ice was causing disruption across the UK, particularly to road, rail and air transport. In this respect, we noted similarities to the disruption to aviation caused by volcanic ash during April 2010. On 19 December 2010, the Transport Secretary, Rt Hon Philip Hammond MP, announced that the Government had asked the Government Chief Scientific Adviser "to give us a report on future weather planning assumptions", that is, whether the Government should be planning for more severe winters in future.[52] **Severe weather is already included as a risk on the National Risk Register. We are disappointed that it appears, from the Secretary of State for Transport's comments, that the GCSA had little or no input to the risk assessments that must have taken place on severe weather.**

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48 Q 332

49 Q 333

50 Q 383

51 Q 384

52 "Government seeks severe winter advice", *BBC News Online*, 19 December 2010, news.bbc.co.uk

56. The National Risk Assessment should be based on the best available evidence from a range of relevant sources. The Cabinet Office may receive advice from committees, presumably including scientific advisory committees, but this is not enough. **The Government Office for Science, working with the Cabinet Office, should be involved at all stages in the NRA. We recommend that the GCSA should be formally involved in the NRA process at a high level. The NRA should not be signed off until the GCSA is satisfied that all risks requiring scientific input and judgements have been properly considered.**

GO Science and the Cabinet Office

57. The need for a close relationship between GO Science, headed by the GCSA, and the Cabinet Office is fundamentally important in ensuring risk assessment and planning is underpinned by the best available scientific evidence. Our predecessor Science and Technology Committees evaluated the benefits of co-locating GO Science within the Cabinet Office and recommended co-location on several occasions. For example, the 2006 report *Scientific Advice, Risk and Evidence-Based Policy-Making* considered that "the Cabinet Office [...] would in many respects be a natural location for the GCSA, reflecting his role as CSA to the Cabinet and Prime Minister, his cross-departmental remit and his independence". Having considered the "strong arguments for and against" relocation the Committee stated "on balance, we recommend the relocation of the GCSA's office to the Cabinet Office".[53] More recently, the 2009 report *Engineering: turning ideas into reality* recommended that the GCSA should be renamed the Government Chief Scientific and Engineering Adviser (GCSEA) and should head up the Government Office for Science and Engineering, which should be placed in the Cabinet Office.[54] The Government's responses to both recommendations stated that "the location and responsibilities of Ministerial and GCSA posts are a matter for the Prime Minister and will be kept under review".[55]

58. Considering the relationship between the Cabinet Office and GO Science afresh while looking at emergencies led us to consider the location of GO Science too. When we asked the GCSA for his views on the matter, he responded:

> there are advantages and disadvantages. In particular, the major advantage is the close proximity of the Government Office for Science with both the Science Minister and also Adrian Smith's [the Director General for Knowledge and Innovation at the Department for Business, Innovation and Skills] team [...] We are co-located. My office is about 50 metres from Adrian Smith's, and I think that is a very substantial advantage of getting joined-up Government. In terms of access to the Cabinet Office, my reporting line is to Sir Gus O'Donnell and we do link in on a very regular basis with his office, the Civil Contingencies Secretariat and so on. On balance, I would say

53 Science and Technology Committee, Seventh Report of Session 2005–06, *Scientific Advice, Risk and Evidence Based Policy-making,* HC 900-1, paras 24–25

54 Innovation, Universities, Science and Skills Committee, Fourth Report of Session 2008–09, *Engineering: turning ideas into reality*, HC 50-I, para 313

55 Innovation, Universities, Science and Skills Committee, Fifth Special Report of Session 2008–09, *Engineering: turning ideas into reality: Government Response to the Committee's Fourth Report*, HC 759, p 22; Science and Technology Committee, First Special Report of Session 2006-07, *Scientific Advice, Risk and Evidence Based Policy Making: Government Response to the Committee's Seventh Report of Session 2005–06*, HC 307, p 3

> the location, in proximity with Adrian and his team and David Willetts, probably outweighs the advantages of contiguity with the Cabinet Office.[56]

59. The view of Rt Hon David Willetts MP, Minister for Universities and Science, was that:

> [GO Science] has been located in various places over the years. I don't think there is any ideal location. All I can say is that we are very comfortable with the current arrangement. The Prime Minister took a very clear view when the coalition Government came into office that he wasn't going to divert his energies into reorganising Whitehall.[57]

60. The argument for co-location goes both ways: closer proximity to the Cabinet Office and Prime Minister, the key recipients of the GCSA's advice, could provide substantial advantages too. The Cabinet Office has "an overarching purpose of making government work better", supporting the Prime Minister and the Cabinet and "helping to ensure effective development, coordination and implementation of policy and operations across all government departments".[58] This complements the role of the GCSA and GO Science, which is to ensure that all levels of government, including the Prime Minister and Cabinet, receive the best scientific advice possible, and to enable Departments across government to create policies that are supported by strong evidence.[59] Both the Cabinet Office and GO Science have cross-departmental remits and a shared aim of helping departments improve their policy processes. There are compelling arguments for bringing the two together.

61. We are fully aware that changes to the machinery of Government must be given a great deal of consideration, particularly in the current economic climate. However, there is rarely an ideal time to reorganise Government Departments. **We recommend that the Government Office for Science, while remaining a semi-autonomous body, be located within the Cabinet Office.**

Identifying risks

62. The first stage of the NRA process is to identify risks. According to the Government's written submission:

> Risks are identified by consulting, through Government departments, a wide range of experts who are able to take an informed view of the seriousness of the risks according to the criteria in the Civil Contingencies Act. After initial scrutiny, most proposals are taken forward into a detailed assessment phase; some may be kept under review.[60]

63. Of our four case studies, two are on the current NRA: pandemic flu and cyber attacks. The risk of disruption caused by volcanic ash was not. We were informed by the Government that:

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56 Q 326

57 Q 411

58 "About the Cabinet Office", *Cabinet Office*, www.cabinetoffice.gov.uk

59 "About us", *Government Office for Science*, www.bis.gov.uk/go-science

60 Ev 95

> For national emergency planning purposes, the risk of disruption to aviation caused by a natural disaster occurring overseas was kept under review annually for the National Risk Assessment (NRA), from 2005 to 2008. No review was undertaken in 2009.[61]

64. No explanation was provided for why the risk of disruption to aviation caused by a natural disaster was dropped from the NRA process. Clearly not all identified risks can be taken forward for further assessment and inclusion on the NRA. However, we consider that there should be a well-reasoned justification for excluding an identified risk, backed up by evidence. Therefore we were concerned by the comments made by Dr Sue Loughlin, Head of Volcanology at the British Geological Survey, who told us that "it wasn't particularly a surprise to the volcanology community that something like this would happen, but somehow that message hadn't got through to Government."[62] The Royal Geological Society also stated that:

> some Earth scientists report that they have been warning Government and others of the potential for major disruption due to Icelandic eruptions for a number of years, but feel that little notice has been taken of these warnings.[63]

65. **We recommend that the Government clarify why no review of the risk of disruption to aviation caused by a natural disaster, including volcanic eruptions, was undertaken in 2009; and provide the evidence behind the decision.**

66. **It appears that there may have been a breakdown of communication between the earth sciences community and Government. We recommend that the GCSA assess whether this was the case and improve the mechanisms by which scientists can engage with the Cabinet Office.**

67. The other case study not on the NRA was space weather. When we announced our inquiry and the terms of reference in July 2010, we noticed that space weather was gaining prominence in political discourse. In the light of the 1989 CME event that affected Quebec's grid, the National Grid was of concern to us. The Minister for Security told us that although "every country [...] is specific in this" and "there are no generalisations", she believed that "there must be some risk" to the National Grid.[64] In September 2010 the Cabinet Office held a workshop on severe space weather with representatives from across government, the scientific community and the energy, communications and transport sectors. The purpose of this workshop "was to hold an initial exchange of views on the likelihood of severe space weather and possible impacts" which would "contribute to the process Government uses to understand risks in this area".[65] The Government is currently conducting a space weather risk assessment for the next NRA and NRR.[66] This represents

61 Ev 100

62 Q 60

63 Ev w54, para 3

64 Q 397

65 Ev 109 [Government Office for Science and Cabinet Office]

66 Ev 102 [Government Office for Science and Cabinet Office]

progression on the Government's position as stated by the Minister of State for Energy and Climate Change (then Rt Hon Joan Ruddock MP) on 9 June 2009:

> although solar storms are not included specifically in the National Risk Register, the resilience measures place to deal with the risk I have mentioned [complete outage of electricity supplies] would be equally applicable to the effects of solar storms.[67]

68. We were curious why space weather was being assessed for the 2011 NRA, given that space weather has been known about since the Carrington event which occurred around 150 years ago. We were told by Professor Mike Hapgood, on behalf of the Royal Astronomical Society, that:

> We have been talking about this for a long time. I have been involved in these activities for 15 years or so. We had a lot of discussion around the previous solar maximum, as we call it, 11 years ago. But then interest decays away. [...] Because the cycle is so long, unless you are an expert and very deeply involved in it, most organisations tend to forget it during the quiet years of the solar minimum. [...] Now solar activity is rising again. We can see it coming over the horizon. It is helping to focus things. It is also the way the science and our understanding of the engineering impacts has grown hugely in the last decade. I think it is just a critical mass. We've reached that critical mass now.[68]

69. **We are pleased that the Government is assessing the risks posed by space weather ahead of the next solar maximum. This is vital given that the Government believes the National Grid could be at risk. The Government should take all possible action to put in place and coordinate resilience measures across different sectors.**

Horizon scanning

70. As well as getting input from external experts, Government Departments and agencies can identify potential risks and threats through horizon scanning. There are various horizon scanning mechanisms in Government Departments and agencies. The Foresight team within GO Science produces in-depth studies looking at major issues 20–80 years into the future. The Horizon Scanning Centre (HSC) within Foresight carries out shorter projects looking 10–15 years ahead.[69] In addition, Scientific Advisory Committees might conduct horizon scanning.

71. Of key interest to our inquiry was the Cabinet Office's Domestic Horizon Scanning Committee. This committee aims to give Government Departments a "heads up on approaching potential disruptive challenges up to 12 months ahead".[70] It appears to be the primary horizon scanning body informing the Cabinet Office's risk assessment. We were therefore interested in how the Domestic Horizon Scanning Committee's work is assessed scientifically and asked Sir John Beddington whether he assessed its quality. He told us, rather disappointingly, "we are getting involved in that; in terms of assessing the quality of

67 HC Deb, 9 June 2009, col 211WH (Rt Hon Joan Ruddock MP, Minister of State for Energy and Climate Change)

68 Q 166

69 "Horizon Scanning Centre", *Government Office for Science*, www.bis.gov.uk/foresight

70 "UK Government", *Cabinet Office,* cabinetoffice.gov.uk/ukresilience

it, no."[71] **We are disappointed that the GCSA has little involvement with the Domestic Horizon Scanning Committee in the Cabinet Office. We recommend that GO Science and the GCSA consider ways of assessing the quality of the Domestic Horizon Scanning Committee's work.**

72. Before the SAGE mechanism, there existed a Scientific Advisory Panel on Emergency Response (SAPER), which was an informal expert committee designed to provide independent scientific advice to the GCSA (then Sir David King) on resilience and counter-terrorism issues. SAPER was also tasked to conduct independent, classified studies when required.[72] Rather than being an ad-hoc advisory group put together in an emergency, it was a standing committee. Membership and activities of SAPER were classified.[73] According to Professor Peter Sommer, Visiting Professor at the London School of Economics:

> SAPER was set up by Professor David King when he was GCSA to support his role in COBR. […] The essential idea was that the GCSA needed to have a wide variety of sources to inform his advice. A number of scientists from the ministries, agencies and wider academia would be briefed about government plans for addressing emergencies both in terms of structure for decision-making and underlying analyses.[74]

73. It is unclear to us when and why SAPER was abolished. A SAGE is put together to provide scientific advice to Government once an emergency has occurred, that is, from the response phase onwards. SAPER, on the other hand, appears to have been a committee involved in resilience and preparation for emergencies. **We recommend that, in replying to this report, the GCSA clarify why SAPER was abolished and to what extent its functions, particularly in planning for emergencies, have been retained and by whom.**

74. **We consider that the NRA would benefit from more scientific scrutiny. We recommend that a new independent scientific advisory committee be set up to advise the Cabinet Office on risk assessment. This committee should review the NRA, setting up temporary sub-committees as appropriate. Having an independent scientific advisory committee for risk assessment to review the NRA would improve public and parliamentary confidence in a necessarily unpublished document. The committee should inform the judgement of the GCSA in ensuring that all risks requiring scientific input and judgements have been properly considered in the NRA and support his greater involvement with the Domestic Horizon Scanning Committee.**

71 Q 325

72 "Civil Contingencies" webpage dated 7 January 2008, *The National Archive: web archiving*, webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/science/science-in-govt/st_policy_issues/civil_con/page24457.html

73 Science and Technology Committee, Eighth Report of Session 2002–03, *The Scientific Response to Terrorism,* HC 415–1, para 21

74 Ev 128, para 4

Reasonable worst case scenario

75. The second stage of the NRA process is assessing risks and their impacts. Risks are assessed using available historical, statistical and scientific data. Where possible, the assessment should take account of probable developments over the next five years.[75] Impacts are assessed against five main criteria:

- the numbers of fatalities that are likely to be directly attributable to the emergency;
- the extent of human illnesses or injury over a period following the onset of an emergency;
- social disruption;
- economic damage; and
- the potential for significant outrage and anxiety to be caused to communities.[76]

76. The assessment leads to the development of a "reasonable worst case scenario" for every risk. The reasonable worst case scenario is "designed to exclude theoretically possible scenarios which have so little probability of occurring that planning for them would be likely to lead to disproportionate use of resources."[77] The Government stated that:

> They are not predictions of what will happen but of the worst that might realistically happen, and therefore we would expect most pandemics to be less severe and less widespread than the reasonable worst case. By planning for the reasonable worst case planners are assured that they have a high probability of meeting the demands posed by the hazard should it occur.[78]

77. We discuss the communication of the reasonable worst case scenario to the public and emergency responders in chapter 5.

78. Reasonable worst case scenarios existed for two of our case studies: the swine flu pandemic and cyber attacks. Because the specific vulnerabilities of critical cyber infrastructure tend to be kept out of the public domain, we have focused on the reasonable worst case scenario for swine flu.

Swine flu

79. The UK has been preparing for an influenza pandemic for years, having experienced three pandemics in the 20th century. In January 2002, the Chief Medical Officer for England published *Getting ahead of the Curve: A strategy for combating infectious diseases*, which identified a new pandemic as a particular disease threat.[79] Human pandemic influenza has been on the NRA since the first version was produced in 2005 and during

75 Ev 95 [Government Office for Science and Cabinet Office]

76 *As above*

77 *As above*

78 *As above*

79 Department of Health, *Getting ahead of the curve: a strategy for combating infectious diseases*, January 2001

annual reviews of the NRA it has been consistently identified as among the highest risks, when both likelihood and impact are taken into account.[80] The emergence of the highly infectious H5N1 strain of avian influenza in 2003 caused a great deal of concern, with fears that the H5N1 strain may undergo genetic changes enabling human to human transmission. Fortunately, this possibility did not materialise (the UK has been officially free from avian influenza since November 2008).[81] Following the emergence of the avian influenza virus, the World Health Organisation (WHO) raised concerns about the likelihood of another pandemic, which led to active preparations for a pandemic across many countries.[82]

80. The Department of Health (DH) is the LGD, responsible for identifying and assessing the risks, and for determining policy in preparing for a pandemic. Following the publication of the UK influenza pandemic contingency plan in 2005, a Scientific Advisory Group on Pandemic Influenza (SAG) was set up to advise UK health departments on the scientific evidence base for health-related pandemic influenza policies. In 2007, the role of the SAG was reviewed and membership of the group was expanded to include a wider range of scientific disciplines, including traditional infectious diseases-related sciences such as virology and immunology, and also sciences such as risk management, behavioural sciences and diagnostics. The group became known as the Scientific Pandemic Influenza Advisory Committee (SPI).[83] In 2007 the Department of Health and the Cabinet Office jointly published *Pandemic Flu: A national framework for responding to a pandemic*.[84] This refined earlier planning and formed the basis for the 2009 pandemic response.[85]

81. The result of much risk assessment and planning for pandemic influenza is a reasonable worst case scenario that suggests:

- up to 50% of the population would become ill (with infection attack rates up to 80–85%), of which 10% to 25% are expected to have complications, half of these bacteriological;
- there would be peak illness rates (measured in new clinical cases per week as a proportion of the population) of around 10–12% in each of the weeks in the peak fortnight;
- absence rates for illness would reach 15–20% in the peak weeks;
- case hospitalisation demand rates would be up to 4% with an average six day length of stay; and

80 Ev 96 [Government Office for Science and Cabinet Office]

81 "Avian flu", *NHS Choices*, 14 October 2009, www.nhs.uk

82 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 1.6

83 Ev 97 [Government Office for Science and Cabinet Office]

84 Department of Health, *Pandemic flu: a national framework for responding to an influenza pandemic*, November 2007

85 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 1.13

- there would be case fatality ratios (the ratio of deaths within the population infected with influenza, over a given period of time) of up to 2.5%.[86]

82. We questioned the concept of a reasonable worst case scenario, with the expectation that it would be, as the Government told us, "the worst that might realistically happen".[87] Therefore we were concerned when Professor Neil Ferguson, Director of the Medical Research Council (MRC) Centre for Outbreak Analysis and Modelling, told us:

> That reasonable worst case scenario was based on the mortality we saw during the 1918 Spanish flu pandemic—namely a 2% case fatality rate [...] Now, the term "a reasonable worst case" is, by definition, not an objectively definable term; it is a subjective term. One could take the other extreme, and I remember David King and Sir John Beddington challenging what we were doing by saying, "Well, if you look at bird flu, that has a 60% case fatality rate", so the reasonable worst case is, of course, that bird flu becomes transmissible and we get a 60% case fatality rate. That was felt certainly to be a worst case but almost unpreparable for. So from the point of view of something reasonable for the NHS to plan for and reasonable in terms of cost, that is why the Spanish flu example was used.[88]

83. An independent review of the UK response to the 2009 influenza pandemic, chaired by Dame Deirdre Hine, noted that "there was some unease about how reasonable the 'reasonable worst case' scenarios were".[89] The review also stated that "there was general agreement that the term was unhelpful" because it implied that the scenario was likely to occur.[90] A key recommendation was that "the GCSA should convene a working group to review the calculation and presentation of worst-case scenarios".[91]

84. We asked the GCSA whether reasonable worst case scenarios were evidence-based and Sir John responded:

> To the extent it is partially evidence based, it is quite difficult to come in any particular scenario to what is a reasonable worst case because in fact the very word "reasonable" implies there is something that is going beyond what would be pure analytic judgment. Following the swine flu outbreak and the inquiry by Dame Deirdre Hine, I have been charged with developing ideas on how we could calculate the reasonable worst case scenarios in a variety of situations. The Blackett group [...] is working on that at the moment and I have a couple of people who have made comments on what was the reasonable worst case scenario in the case of swine flu, but that is very much work in progress.[92]

86 Ev 104 [Government Office for Science and Cabinet Office], Appendix A

87 *As above*

88 Q 5

89 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, p 8

90 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 4.51

91 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 4.74

92 Q 339

85. The GCSA told us that the Blackett Group "is a set of groups that I bring together to look at particular aspects of scientific advice, bringing in and tapping in the academic and industry communities on a variety of areas".[93] The aim of Blackett Reviews is to go "beyond what might be termed more conventional thinking [...] bringing in completely different people [...] who have hitherto not been involved in these particular areas".[94] He clarified that, although members of the Blackett Group would be briefed in the public domain, "the application of [findings] and the individual ways that they might work through Government would be subject to some degree of confidentiality".[95]

86. We asked Rt Hon Andy Burnham MP, the former Secretary of State for Health during the swine flu pandemic, whether he perceived there to be an alternative to the reasonable worst case scenario and he responded "I don't actually, no".[96]

87. **We are concerned that the word "reasonable" appears to be influenced by the need to find a reasonable level of public expenditure for contingency planning rather than outlining the worst scenario that might realistically happen, based on the best available evidence.**

88. **We welcome the fact that the GCSA is reviewing the concept of a reasonable worst case scenario. We request that, if possible, the results of this review are sent to us and published before any policy change is adopted.**

89. We consider the communication of the reasonable worst case scenario in chapter 5.

The National Risk Register

Risk matrix

90. The final stage in the NRA process is the comparison of risks. On the National Risk Register—the unclassified version of the NRA designed to assist communities and the public—the risks are summarised on a matrix of relative likelihood versus relative impact.

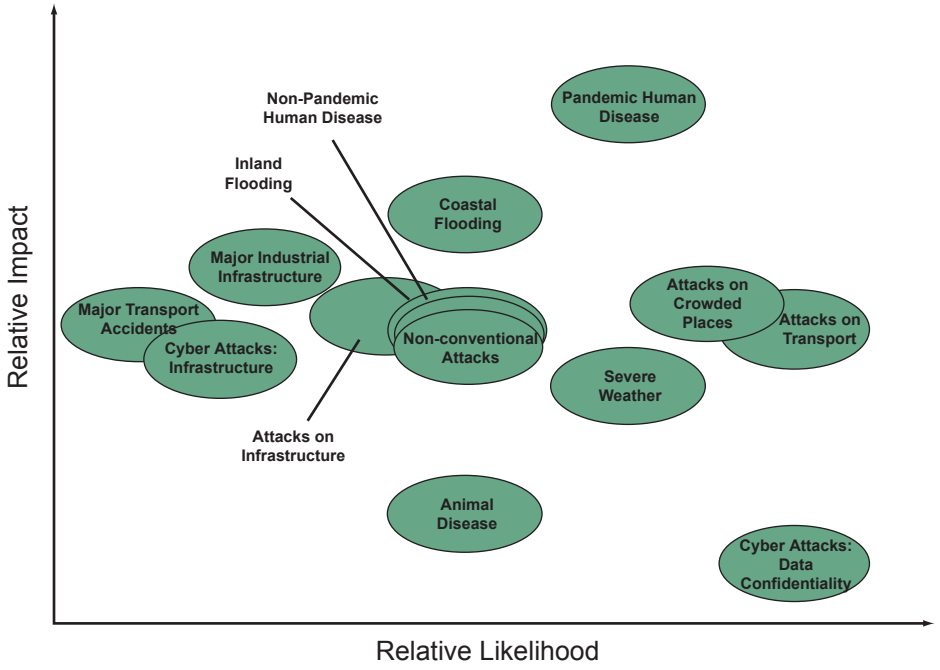
93 Q 325

94 Q 355

95 *As above*

96 Q 361

Figure 2: An illustration of the high consequence risks facing the United Kingdom[97]



91. The NRR matrix is an attempt "to illustrate the breadth of the high-consequence risks we face"[98] although it excludes some risks that are classified for reasons of national security. We wanted to know whether the matrix, which simplifies a great deal of information on risk, was useful to communities and the public. On the one hand, it could be a valuable way to summarise complex risks in an accessible manner. On the other, it may be little more than an attractive diagram. The matrix is also currently being reviewed as part of the Blackett Group set up by the GCSA.[99] We asked the GCSA for his views on the usefulness of the matrix and he responded:

> I think it is a useful tool, but there are some issues with it. [...] you have a point on that matrix. These are logarithmic scales so they are fairly robust to having a point, but, if you think about a number of events, the ones with less impact are likely to be more frequent. If you think about it, the reality is probably that you have something shaped a bit like a banana for any individual event—a banana sloping downwards.[100]

92. The reasonable worst case scenario provides an indication of relative risk. As we have outlined before, risk is a combination of potential impact—the hazard—and the likelihood of the impact occurring. Rather confusingly, the Government stated that the reasonable worst case scenario for swine flu was assessed to have a "medium high likelihood of

97 Cabinet Office, *National Risk Register of Civil Emergencies*, 2010 edition, p 5

98 Cabinet Office, *National Risk Register of Civil Emergencies*, 2010 edition , para 1.6

99 Q 337

100 *As above*

occurring over the next five years".[101] When we asked witnesses for their views on what this meant, Professor Neil Ferguson commented that it was "questionable".[102]

93. Problematic risk comparisons within government have been identified before. In 2006, the former Science and Technology Committee's report on *Scientific Advice, Risk and Evidence-Based Policy-Making* found that:

> There is no process in place to ensure that if one department describes the risk of an event happening as "very small", the probability involved is broadly similar to that of a different risk described as "very small" by another department. Nor is there any explanation or guidance available for the public on what a "very small" risk actually means—one in a thousand or one in a million?—or what sort of other known risks might be similarly described.[103]

94. The Committee recommended that "the Government build on existing work to develop, subject to academic peer review, a scale of risks for use by all departments, as appropriate, when communicating levels of risks to the public".[104] In its response to the report, the Government stated:

> Just as the Government has not developed a standardised table of risks, as risks mean different things to different people, it does not agree that a common terminology or scale of risks would be helpful to [...] the public. [...]
>
> The Government does however adopt a common methodology and scale in specific areas where the advantages outweigh the disadvantages, for example in assessing disruptive challenges to the UK. There is a duty on Category 1 responders (those organisations at the core of the response to most emergencies, e.g. emergency services, local authorities, NHS bodies), under the Civil Contingencies Act 2004, to assess risk in their area and communicate those risks by publishing a community risk register. The Civil Contingencies Secretariat in the Cabinet Office provides these responders with guidance on which risks to consider, a common methodology and a common scale for assessing the likelihood of those risks to ensure that there is some consistency between the assessments made.[105]

95. The high consequence risks summarised on the NRR risk matrix are broad in scope, encompassing accidents, deliberate attacks and natural phenomena with impacts ranging across health, infrastructure and the environment. However, terms such as "medium-high", used to describe the likelihood of the reasonable worst case scenario for pandemic influenza occurring,[106] are vague and unquantified. **We conclude that it should be clear what criteria are used in developing risk comparisons, particularly when they cut across**

101 Ev 96

102 Q 12

103 Science and Technology Committee, Seventh Report of Session 2005-06, *Scientific Advice, Risk and Evidence Based Policy-making,* HC 900–1, para 187

104 Science and Technology Committee, Seventh Report of Session 2005-06, *Scientific Advice, Risk and Evidence Based Policy-making,* HC 900–1, para 194

105 Science and Technology Committee, First Special Report of Session 2006-07, *Scientific Advice, Risk and Evidence Based Policy Making: Government Response to the Committee's Seventh Report of Session 2005–06,* HC 307, p 29

106 Ev 96 [Government Office for Science and Cabinet Office]

Government Departmental responsibilities. We recommend that the Government clarify the common methodology and scale for assessing the likelihood of risks that are used in developing the NRA and NRR.

Local risk assessment

96. Local authorities are key recipients of information in the NRR and the risks identified in the NRR should inform the development of Regional Risk Registers (RRRs). The process is two-way: the risks identified in RRRs and Community Risk Registers (CRRs) should be fed back into the classified NRA.[107] This two-way communication between central government and local authorities is essential to planning—the vast majority of emergencies are local, and every national emergency affects local communities. In addition, there is significant expertise among local authorities, police forces and fire authorities where COMAH[108] sites exist. We requested written information from the Local Government Association (LGA), which has over 400 member authorities in England and Wales, on the relationship between local authorities and central government on the NRR and wider sharing of information. It stated:

> In theory the development of the NRR is a two way process. [...] In practice the process is very top-down and provides very little opportunity for local authorities to input. [...] the NRR is rarely informed by issues identified at the sub-regional and regional level.[109]

97. **We are concerned that the development of the NRA and NRR appears to be a "top-down" process hindering the involvement and influence of local authorities. This situation is unsatisfactory. We recommend that the Cabinet Office review its procedures to ensure that the input of local authorities is given full consideration and appropriate weight.**

98. The LGA also expressed concerns about access to the classified NRA:

> There is [...] concern and frustration amongst local authorities that officers with security clearance do not have access to the classified information in the National Risk Assessment, which makes it difficult to assess how the threats identified in the National Risk Register will impact on local areas and how local authorities should manage these through their emergency planning arrangements.[110]

We took this to the Minister for Security, who told us that "the classified document is available to those who have the right clearance to see it".[111] There are two issues here. First, that the NRR may provide insufficient information if access to the classified NRA is necessary for local authorities to plan for emergencies, and, second, that security-cleared officers have difficulties accessing the NRA. **If it is the case that access to the NRR alone is insufficient to allow local authorities to assess the potential impacts of risks to local**

107 Ev w70 [Local Government Association], para 3.1

108 Control of Major Accident Hazards

109 Ev w70, paras 3.1-3.2

110 Ev w70, para 3.3

111 Q 387

areas, and access to the classified NRA is necessary, then we question the operational value of the NRR. We recommend that the Government conduct a consultation with Category 1 emergency responders, including local authorities, to evaluate how useful the information on the NRR is for risk assessment and emergency planning.

99. **We recommend that the Government review whether those with appropriate security clearance outside of Central Government have difficulties accessing the NRA, and put in measures to resolve the problem.**

Behavioural sciences

100. Emergencies do not happen in a vacuum and the Government must consider the influence of human behaviour on the outcomes of an emergency. Human behaviours are particularly critical to a public health emergency that will rely on promoting compliance to recommended public health measures, including the uptake of vaccines. In the case of swine flu, the SAGE used the Behaviour and Communication subgroup of the Scientific Pandemic Influenza Advisory Committee (SPI) to address behavioural components of the Government's response.

101. For some risks, an understanding of behaviour should contribute to risk assessment. We considered this to be particularly true of cyber attacks for two reasons: (i) because attacks are launched by people; and (ii) the public have a role to play in maintaining cyber security. The first is beyond the reach of our inquiry, but we did consider the role of the public.

102. Denial of Service (DoS) attacks are carried out using the computers of unwitting members of the public. For a computer to be compromised it must run a malicious program, hence cyber security advice is to ensure that computers are capable of recognising malicious programs by using up-to-date anti-virus programs and ensuring there are no unpatched security holes (that is, the machine's software is being updated on a regular basis).

103. We came across some disagreement over what expectations could be placed on the public in maintaining cyber defences. For example, Professor Ross Anderson, Professor of Security Engineering at Cambridge University, told us that "people aren't going to do stuff. People have busy lives. People buy computers and they expect them to work".[112] Malcolm Hutty, Head of Public Affairs at the London Internet Exchange (LINX), disagreed:

> I wouldn't be dismissive about the importance of encouraging the public to raise their own level of protection. I accept that this does not fix the problem, but this kind of problem is not fixed: it is managed. [...] The public is better protected when the public helps to protect themselves. Therefore, they should be encouraged to do so.[113]

104. There is little that automated defences can do when the user unwisely overrides the system's protection mechanisms. For example, criminals can spread their malware over instant messaging (chat) systems by arranging for all of the chat "buddies" to receive a

112 Q 280

113 *As above*

message such as "is this your photo?" followed by a link. When the link, which leads to the malware, is clicked upon, the computer operating system will put up a warning about the risks. However, a great many users ignore this warning because they trust their buddy, and so will become infected and then, in turn, they send out misleading messages to spread the malware to all of their buddies. These novel types of attack and the general problem of how diligent people are in protecting their machines raised the question of whether the Government incorporates social and behavioural sciences in its risk assessments around cyber attacks. Professor Peter Sommer, Visiting Professor at the London School of Economics (LSE), stated:

> The temptation is to think that with cyber security what we want is better encryption and better intrusion detection systems. All of those things are important. The social science aspect of it, criminology, human motivation and the economics [...] all of these are important research areas in understanding the nature of the problem and how you are going to manage it.[114]

105. We took this issue to Dr Steve Marsh, Deputy Director of the Office of Cyber Security and Information Assurance (OCSIA), who admitted:

> To be honest, we have not done enough on behavioural science so far. Over the years people have concentrated on the technical response. We have been trying over the last three or four years through the Technology Strategy Board and elsewhere to bring in this broader range of issues. [...] we need to do more on behavioural science, we need to do more on the economics, we need to do more on forming relationships and so on. We absolutely need to bring in this broader scientific base, not just the technical response around the machines or networks themselves.[115]

106. A behavioural insight team was recently set up in the Cabinet Office "to help the UK Government develop and apply lessons from behavioural economics and behavioural science to public policy making".[116] The team is composed of "a small group of civil servants, drawing on academic and empirical evidence from the world's leading behavioural economists and behavioural scientists".[117] To date, it has produced one discussion paper; *Applying behavioural insight to health*, published in December 2010, which aims to promote debate.[118]

107. The GCSA recently admitted to us that an area where GO Science could do better was in "making certain that we link in better with the social science analysis community", adding that "social science needs to be built up more and I think on that I could have done better".[119] The former Chief Scientific Adviser to the Home Office, Professor Paul Wiles, had an important additional role as the Government Chief Social Scientist (GCSS). Upon

114 Q 281

115 Q 323

116 "Applying behavioural insight to health", Cabinet Office, webpage updated 31 December 2010, www.cabinetoffice.gov.uk

117 *As above*

118 *As above*

119 Science and Technology Committee, *The Government Office for Science Annual Review 2009* , HC (2010–11) 546–i, Q 4

his retirement in early 2010, a new CSA to the Home Office was appointed, but the role of GCSS remains vacant, although we note that the GCSS's function as head of the social science profession within the civil service is being covered by two civil servants.[120]

108. We consider that an understanding of human behaviour is essential in risk assessment, contingency planning and emergency response. **We are disappointed at the lack of focus on social and behavioural sciences in Government to date. We expect the newly established Cabinet Office Behavioural Insight team to provide input to risk assessment for emergencies.**

109. We may return to the topic of social science in Government in future. In the meantime, **we would like to know whether and when a Government Chief Social Scientist will be appointed to replace Professor Wiles.**

Conclusions

110. **Risk assessment underpins preparedness. In turn, risk assessment should be underpinned by the best available evidence. We were very disappointed to learn that the GCSA has had little involvement with what is a cross-Government process. It appears that, for both the volcanic ash emergency and the recent severe winter weather, the GCSA had been asked to provide advice after the emergency had happened, although we note with interest that the severe winter weather was not deemed an emergency. This is simply not good enough: scientific advice and evidence should be integrated into risk assessment from the start.**

120 Science and Technology Committee, *The Government Office for Science Annual Review 2009* , HC (2010–11) 546–i, Q 4

5 Communication

111. Communication must be considered at all stages of risk assessment and in response to emergencies. A fast moving emergency exacerbates existing communication difficulties even as it multiplies the need for fast and effective information for responders and the public.

112. Previous crises such as the Bovine Spongiform Encephalopathy (BSE) outbreak and foot and mouth disease have highlighted the undisputable importance of good public communication, particularly on risk. The *Phillips inquiry* into BSE highlighted the following lessons on uncertainty and the communication of risk:

- To establish credibility it is necessary to generate trust.
- Trust can only be generated by openness.
- Openness requires recognition of uncertainty, where it exists.
- The importance of precautionary measures should not be played down on the grounds that the risk is unproved.
- The public should be trusted to respond rationally to openness.
- Scientific investigation of risk should be open and transparent.
- The advice and the reasoning of advisory committees should be made public.
- The trust that the public has in Chief Medical Officers (CMOs) is precious and should not be put at risk.
- Any advice given by a CMO or advisory committee should be, and be seen to be, objective and independent of government.[121]

113. The Government and other organisations have to strike a balance between confidentiality and disclosure when preparing for, and responding to, emergencies: some information may be considered too sensitive for the public domain. One example is in the area of cyber security where specific vulnerabilities are not made publicly known for fear that they would influence the actions of attackers. The question of what information the Government is entitled to keep from the public (and Parliament) is, of course, much wider than our remit. However, we must point out that the Government has a duty to give the public information which they need to safeguard themselves, and in its policies and actions, the Government must be accountable to the public and to Parliament.

Principles of risk communication to the public

114. When a public risk is not communicated effectively by Government it can create mistrust and anxiety. As well as preventing this and raising awareness, the Government

121 *The BSE Inquiry: Findings and conclusions*, October 2000, Volume 1, Chapter 14, section 1301; see also para 137.

and other public bodies may also seek to encourage or discourage certain behaviours that could affect the outcome of the emergency response.

115. There is no lack of guidance to Government Departments on risk communication, including:

- *Communicating Risk*,[122] a toolkit to help with planning communication strategies and developing understanding of risk (Cabinet Office);
- *Principles of Managing Risks to the public,*[123] outlining five key principles applying to the handling of all types of risks to the public (Treasury);
- The *Orange Book*,[124] which establishes the concept of risk management and provides a basic introduction to the concepts, development and implementation of risk management processes in government organisations (Treasury); and
- *Communicating about risks to public health: pointers to good practice,*[125] designed to assist in the identification of public health issues which may create difficulties in communicating health risks and to provide guidance in risk strategies (Department of Health).

116. The Department of Health's guidance *Communicating about risks to public health: pointers to good practice* is useful in defining factors to consider when communicating risk, many of which can be applied beyond public health risks. The guidance makes the following points:

- Crisis conditions—combining time pressure, unexpectedness, and high levels of threat—almost always militate against effective decision-making. A key defence against crisis is to spot possible difficulties in advance although one can never hope to spot all the relevant issues in advance: there will always be a need to "firefight".
- A difficulty in risk communication is the difference between a "natural science" perspective and that typically held by a lay audience. Overcoming this is not merely a matter of explaining the science in lay terms—important though this is. An important difference is that scientists usually define risk in terms of effects on populations, while the lay audience is concerned with individuals. In addition, scientists usually will accept the existence of a causal link only once there is good evidence for it. Until then, links are "provisionally rejected". The lay view is much more likely to entertain a link that seems intuitively plausible, and only reject it if there is strong evidence against.
- Public perceptions of risk are influenced by "fright factors", meaning that some risks trigger more alarm than others. For example, risks are more worrying if perceived to be involuntary, arising from an unfamiliar or novel source, poorly understood by science and/or subject to contradictory statements from responsible

122 Cabinet Office, *UK Resilience: Communicating risk*, www.cabinetoffice,gov.uk

123 HM Treasury and Cabinet Office, *Principles of Managing Risks to the public,* www.hm-treasury.gov.uk

124 HM Treasury, *Orange Book: Management of Risks - Principles and Concepts*, October 2004

125 Department of Health, *Communicating about risks to public health: pointers to good practice,* January 1997

sources (or worse, from the same source). However, despite some common fright factors, "the public" is not a single entity. It is essential to consider different possible ways of seeing risks.

- The single most important factor in risk communication is probably openness. This involves not only making information available, but giving a candid account of the evidence underlying decisions. If there are genuine reasons for non-disclosure of data, the reasons need to be given both clearly and early on. There should be a presumption in favour of disclosure.[126]

117. The Government has established the following five principles of risk communication to the public:

i. **Openness and transparency**: Government will be open and transparent about its understanding of the nature of risks to the public and about the process it is following in handling them;

ii. **Involvement**: Government will seek wide involvement of those concerned in the decision process;

iii. **Proportionality and consistency**: Government will act proportionately and consistently in dealing with risks to the public;

iv. **Evidence**: Government will seek to base decisions on all relevant evidence; and

v. **Responsibility**: Government will seek to allocate responsibility for managing risks to those best placed to control them.[127]

118. We examine how the Government communicated risks posed by the swine flu pandemic to the public, taking into account the principles outlined above, in the next section. We also kept the principles in mind when looking at the SAGEs set up for swine flu and volcanic ash (chapter 6).

Swine flu

The "65,000 deaths" scenario

119. Of the four case studies we explored, the swine flu pandemic posed the most interesting example of risk communication to the public. The complex and constantly evolving situation posed a number of challenges for Government, particularly communicating scenarios and projections. After explaining the reasonable worst case scenario (covered in chapter 4), Professor Neil Ferguson, Director of the MRC Centre for Outbreak analysis and Modelling, said:

> we went from using, right at the beginning of the pandemic, that pre-existing reasonable worst case, to giving, effectively, what was an upper statistical confidence bound on our assessment of what the severity of the current pandemic was. That did

126 Department of Health, *Communicating about risks to public health: pointers to good practice,* January 1997

127 HM Treasury and Cabinet Office, *Principles of Managing Risks to the Public*, www.hm-treasury.gov.uk

> not, perhaps, communicate as clearly as it should have done [...], particularly to the NHS. Those estimates got revised really quite rapidly, so within a month we were down from about that 2% level closer to 0.4% case fatality. Six weeks later it was down to below 0.1%–one in a thousand case fatality. So the estimates went downwards over time. [...] that posed significant communication challenges for the Department of Health, the Chief Medical Officer and the NHS.[128]

In addition to the difficulties of communicating changing scenarios, Professor Ferguson noted:

> A further problem was that there was about a three to four week lag between the group I was involved in coming up with new reasonable worst cases, and then coming into the public domain in terms of getting through the DH and Cabinet Office approval process. So what was in the public domain as a reasonable worst case was already behind the evidence, given how fast the evidence was building up.[129]

120. On 16 July 2009, the Chief Medical Officer, Sir Liam Donaldson, held a press briefing that led to media reports suggesting up to 65,000 people in the UK could die from swine flu in a worst case scenario.[130] At that time, the number of actual deaths stood at around 30,[131] and by the time the pandemic was over in April 2010, the total number of UK deaths was 460. Dr Justin McCracken, Chief Executive of the Health Protection Agency (HPA), commented that:

> it shows how difficult communication is because it was not just the reasonable worst case scenario that was communicated to the press. It was, actually, the range of both the best and the worst. But, inevitably, I think the figure that the press focused on was the worst case scenario.[132]

121. We asked Dr McCracken if, in future, he would recommend giving a mid-range figure instead of a range including extreme scenarios. He replied that "the difficulty of giving even a mid-range figure is the degree of uncertainty that is associated with it, but I think there probably is a case for that". He continued: "I don't think you can escape from communicating a reasonable worst case scenario that you are going to use for your planning in your health care system, but I do think that more emphasis needs to be given to what I would call the more likely expectation."[133] We discussed the press briefing with Sir Liam, who told us:

> I spent a long time in that particular press briefing with the journalists, slightly short of pleading with them not to put out misleading information. Apart from one correspondent, they didn't contextualise the figure at all.

128 Q 5

129 *As above*

130 For example, "Swine flu could kill 65,000 in UK, warns chief medical officer", *The Guardian*, 16 July 2009, www.guardian.co.uk

131 "Swine flu could kill 65,000 in UK, warns chief medical officer", *The Guardian*, 16 July 2009, www.guardian.co.uk

132 Q 8

133 Q 9

> The modelling scientists would always say, "Well, even the 65,000 figure or figures like that held scientific water because those were the inputs that we had at the time", and then as they got more and more data, their number would come down and down and down. Unfortunately, that doesn't have much credibility with the public. They can't relate to that at all, understandably. So I think a great deal of care needs to be taken about the use of figures. I certainly felt that at the time. Even a back of the envelope calculation that I did suggested to me that we would get no more than a thousand deaths, but that was not the scientifically agreed figure. So I could hardly dissent from the bigger figure.[134]

122. There are three issues of concern here. First, it appears that, while scenarios were constantly being revised as more data became available, the communication of these updates were subject to delays, resulting in outdated information being provided to the public via government channels. Second, sensationalised media reporting may not simply be due to the press focusing on the worst case; we have misgivings about how clear the concept of the reasonable worst case scenario actually is, particularly as it does not emphasise the most likely situation. Third, the Chief Medical Officer, acting as "the messenger for the 65,000 figure which came from the scientific modellers"[135] was not confident in the figures he was communicating yet felt unable to dissent.

123. **If, following the GCSA's Blackett Review, the concept of a reasonable worst case scenario is retained, we recommend that the Government must make continual efforts to establish the concept of "most probable scenarios" with the public. While the Government should be open about the worst case scenarios being used by emergency responders, it should use the experience of the 2009 pandemic to emphasise the range and likelihood of various possibilities. While we do not expect this to remove all the problems associated with communicating risk and uncertainty, we consider that it may provide the public with a better sense of the likely risks.**

Information to clinicians

124. It is equally, if not more, important for central Government to communicate effectively with emergency responders. In the case of the swine flu pandemic we were alerted to the frustrations of clinicians by the British Medical Association (BMA), which stated that:

> Doctors felt overwhelmed by the volume of information about the H1N1 pandemic issued by various bodies [including Government]. Key advice was lost within the large quantity of emails received, which often duplicated information.[136]

125. Dr Peter Holden, giving evidence on behalf of the BMA, told us that the four key sources of information; the Royal College of General Practitioners, the British Medical Association, the Health Protection Agency and Department of Health, cross-linked their websites, but he considered that:

134 Q 40

135 *As above*

136 Ev 143, para 25

> we came unstuck because we were so keen to be up-to-date and offer timely advice, and it was a fast moving scene [...] I think what we should learn from this is that there is a review date on this advice, and you accept that the advice that may be on the website could be a few hours out of date in pure science terms.[137]

126. When communicating information in this situation, the organisations providing information to clinicians clearly had to walk a tight line between under-informing and over-informing clinicians. With hindsight, it is apparent that attempts to provide information in a timely manner were in fact overwhelming to doctors and insufficiently coordinated. We put the issue to the Sir Liam Donaldson, former Chief Medical Officer, who responded:

> I think [the BMA] are a little unfair. [...] We also had regular contact with the BMA GP committee. [...] I think the idea that we over-communicated with them is a little unfair because, really, at other times they were saying to us, informally, "We need to know more".[138]

127. We consider that the risk of over-information could be mitigated by a single online portal of information. For example, in the USA, the flu.gov website provides comprehensive government-wide information for members of the public and professionals on seasonal, H1N1 (swine), H5N1 (avian) and pandemic influenza.[139] It also includes links to specific information for families, businesses, and schools.

128. **We recommend that there should be a single portal of information for every emergency, along the lines of flu.gov in the USA. This should be of use to members of the public as well as emergency responders and should be the primary source of all information, linking to other websites as necessary. We consider that maintaining this portal should be the responsibility of the Lead Government Department, and should be located within its departmental website.**

From pandemic to seasonal flu

129. In paragraph 13 we mentioned the resurgence of swine flu virus during the 2010–11 winter—commonly the season for flu—and that the Government's vaccination strategy differed from when the virus first emerged in the UK. However, even during the pandemic the vaccination strategy changed. The initial strategy, in August 2009, was to vaccinate priority groups including pregnant women, frontline health and social care workers and people in at-risk groups over six months. In November 2009, phase two of the vaccination programme began and expanded to include children over six months and under five years. Professor Neil Ferguson, told us that:

> if you have vaccine available really quite early in an epidemic, then targeting the people who transmit the disease, and in this case had we been able to target all school-aged children, for instance, all the way back in August, then we probably

137 Q 13

138 Q 53

139 "About us", *Flu.gov*, www.flu.gov/about

> wouldn't have had an autumn wave to this epidemic. We would have stopped transmission.[140]

On the decision to expand the vaccination programme, he stated:

> I have to say that I was, perhaps, a little surprised by that. That was not something that went to the committee that I sat on, the SAGE Committee. It may have been discussed by other advisory groups in the Department of Health, but it was always going to be of marginal impact given that the epidemic was already largely over. I worried myself that it would lose credibility—that people would already view this not as a threat, so what was the justification for doing it?[141]

130. During the 2010–11 flu season, swine flu was being treated as a seasonal, rather than pandemic flu virus. There was particular media attention on the decision in 2010–11 not to vaccinate healthy children.[142] The Government received advice from the Joint Committee on Vaccination and Immunisation (JCVI). On 30 December 2010 the JCVI met to review its advice on seasonal influenza vaccination. It produced the following statement:

> JCVI was presented with data on the current seasonal influenza epidemiology, seroepidemological data collected during the 2009–10 pandemic, modelling of the impact of vaccination strategies during the pandemic, data on the effectiveness of influenza vaccines in the young and vaccine uptake and safety data.
>
> JCVI noted that a large proportion of those individuals with severe disease are in recognised risk groups for influenza but were not vaccinated. JVCI re-iterated its previous advice that all individuals in risk groups should be vaccinated as soon as possible, particularly those aged less than 65 years.
>
> The [JCVI] considered the issue of offering vaccination to healthy children either 0–4 years and/or 5–15 years of age. However, although there is a high incidence of influenza-like illness currently in these age groups, a significant proportion of this is due to other viruses such Respiratory Syncytial Virus. In addition, only a very small proportion of those with severe disease are in these age groups. Based on previous seasonal influenza epidemiology it would be hoped that influenza circulation will have subsided within a month. We do not believe that seasonal or pandemic vaccine should be used for these or other healthy person groups. The greatest gain will be achieved in increasing vaccine uptake in the clinical risk groups.[143]

The Government also stated that:

> No projections have been made of the number of deaths from swine influenza infection that may be prevented during the current influenza season by the current vaccination policy or an extension of that policy to include children under five years of age or other healthy age groups. Such projections, if conducted, would be highly

140 Q 16

141 *As above*

142 "Birmingham girl aged three dies from swine flu", *BBC News Online*, 12 January 2011, news.bbc.co.uk

143 HC Deb, 20 January 2011, col 969W (Anne Milton MP, Parliamentary Under Secretary of State for Public Health)

> uncertain as they would depend on a number of factors that are unknown or uncertain including, the existing immunity to swine influenza infection in different age groups of the population, the vaccination coverage in different groups of the population and how quickly immunity would accrue in these groups, and the effectiveness of vaccination.
>
> As with all vaccination programmes, JCVI will keep this matter under review.[144]

However, the JCVI also noted that the size of the current outbreak was inconsistent with the level of population immunity that had been suggested by research done during the 2009 pandemic, implying that the immunity levels of young children were lower that had been anticipated.[145]

131. In response to criticism about the lack of a national advertising campaign, Rt Hon Andrew Lansley MP, Secretary of State for Health, stated:

> We decided not to institute an autumn mass advertising campaign to encourage flu vaccination, because this would have wastefully focused on the entire population when only at-risk groups are being invited for vaccination. This does not mean that there was no campaign; GPs have been inviting those at-risk groups to receive the flu vaccine since October, and the lack of an advertising campaign this year has had no discernible impact on uptake of flu vaccine.[146]

132. **Although the Government response to seasonal flu goes beyond our inquiry, we were interested in the ongoing public concern over the risks of swine flu as part of the seasonal flu outbreak. This is unsurprising, given the fresh public memory of the pandemic and the Government's 2009–10 pandemic communication programme, as well as the absence of a seasonal flu information campaign in 2010–11. The Government should carefully consider the public's assumptions about swine flu (or any new flu strain) when communicating the risks of that strain in the context of seasonal, rather than pandemic, outbreak.**

133. We have concerns about the evidence on which the JVCI has based its advice to Government in relation to the 2010–11 seasonal flu vaccination programme. There is evidence that vaccinating children creates herd immunity[147] and it appears that in 2010–2011 the immunity levels of young children may not have been as high as originally anticipated. However, we accept that the evidence may not be clear-cut and that factors such as the efficacy of the vaccine in children and cost effectiveness must also be taken into consideration. **We recommend that the JCVI conduct a comprehensive review of the benefits and risks of extending influenza vaccination programmes to all children under five, drawing on the experiences of countries, such as the USA, that already have policies of vaccinating under fives.**

144 HC Deb, 20 January 2011, col 970W (Anne Milton MP, Parliamentary Under Secretary of State for Public Health)

145 Ev 164

146 "Most pregnant women have not had flu jab, Andrew Lansley admits", *Guardian Online*, 15 January 2011, www.guardian.co.uk

147 For example, Loeb *and others*, "Effect of influenza vaccination of children on infection rates in Hutterite communities: a randomized trial", *Journal of the American Medical Association*, vol 303 (2010), pp 943–50

6 Scientific advice and emergency response

134. In an emergency where scientific or technical advice is required to aid the emergency response, the Government may decide that a Scientific Advisory Group in Emergencies (SAGE) is required; this decision can either be made by the Lead Government Department (LGD) or the Cabinet Office in consultation with the Government Office for Science.[148] SAGE is usually chaired by the Government Chief Scientific Adviser (GCSA)—the volcanic ash SAGE was chaired by the GCSA—or a departmental representative. Co-chairing can occur; for example, the swine flu SAGE was co-chaired by the GCSA and the Chair of the Scientific Pandemic Influenza Advisory Committee (SPI), Sir Gordon Duff. Secretariat support is usually provided by the LGD, the Devolved Administration (DA), the Cabinet Office or GO Science.[149]

135. Each SAGE is emergency-specific. The swine flu pandemic was the first emergency where the SAGE mechanism was used; volcanic ash was the second. The main role of a SAGE is to ensure that there is a sufficient evidence base for decision making and to provide timely and coordinated advice. Because a SAGE acts as the main channel for scientific advice to Government in an emergency, this chapter mainly focuses on the two SAGEs in question.

Principles and codes of practices

136. Over the last two decades there have been great shifts in the way that Government treats scientific advice and as a result, several codes and principles have evolved. In this section, we set out some of the key principles and codes of practice governing scientific advice in general, before exploring how the situation changes in an emergency.

137. The Bovine Spongiform Encephalopathy (BSE) crisis in 1996 marked a significant turning point in the treatment of scientific advice. Following the outbreak, an independent inquiry was set up in 1998 to "establish and review the history of the emergence and identification of BSE [...] and of the action taken in response to it up to 20 March 1996; to reach conclusions on the adequacy of that response, taking into account the state of knowledge at the time".[150] This inquiry was led by Lord Phillips of Worth Matravers and thus became known as the *Phillips inquiry*. Published in 2000, it identified a wide range of lessons to be learned on the use of scientific advisory committees, the commissioning and coordination of research and the communication of risk to the public (some key recommendations are covered in paragraph 112).[151]

138. In 1997, the then Government Chief Scientific Adviser (Lord May) published *Guidelines on the Use of Scientific Advice in Policy-Making*; these have subsequently been revised, most recently in June 2010. The Guidelines "address how scientific and

148 Ev 95 [Government Office for Science and Cabinet Office]

149 Ev 97 [Government Office for Science and Cabinet Office]

150 *The BSE Inquiry: Findings and conclusions*, October 2000

151 *As above*

engineering advice should be sought and applied to enhance the ability of government policy makers to make better informed decisions".[152]

139. The relationship between Government and independent scientific advisers has at times been fraught with difficulties; the most recent clash being the 2009 dismissal of Professor David Nutt, Chair of the Advisory Council on the Misuse of Drugs (ACMD), by the Home Secretary. Following concerns raised by the scientific community and our predecessor Committee,[153] the Government developed the *Principles of Scientific Advice to Government*, which "set out the rules of engagement between Government and those who provide independent scientific and engineering advice." The Principles apply to "Ministers and Government departments, all members of Scientific Advisory Committees and Councils [...] and other independent scientific and engineering advice to Government."[154] They detail principles related to roles and responsibilities, independence and transparency and openness. [155]

140. The key guidance applying to the operation of scientific advisory committees (SACs) advising Government is the Code of Practice for Scientific Advisory Committees (CoPSAC, or the Code). During the time of our inquiry GO Science was in the process of updating the Code; the most recent version having been produced in 2007. In addition, SACs may adhere to their own individual codes of practice. The 2007 version of the Code includes the following guidelines of relevance to our inquiry.

- Scientific advisory committees should operate from a presumption of openness. The proceedings of the committee should be as open as is compatible with the requirements of confidentiality. The committee should maintain high levels of transparency during routine business.

- To ensure openness and transparency scientific advisory committees should seek to keep the public and stakeholders informed as they develop advice.

- The secretariat should ensure that the proceedings of the scientific advisory committee are properly documented so that there is a clear audit trail showing how the committee reached its decisions.

- The scientific advisory committee should develop procedures for handling confidential information, and communicate it to third parties, so that those submitting it know what to expect. Decisions on confidentiality should be exercised consistently with Freedom of Information legislation. Scientific advisory committees should be prepared to explain publicly why information is being withheld. Much information, which is confidential, may be sensitive for a relatively short time. When making decisions to withhold information, consideration should

152 Government Office for Science, *The Government Chief Scientific Adviser's Guidelines on the Use of Scientific and Engineering Advice in Policy Making*, June 2010

153 Science and Technology Committee, Third Report of Session 2009-10, *The Government's review of the principles applying to the treatment of independent scientific advice provided to government*, HC 158–I

154 "Principles of scientific advice to Government", *Government Office for Science,* www.bis.gov.uk/go-science

155 *As above*

be given to whether the documents could be released as soon as the sensitivity has passed and, if so, a future publication date should be determined accordingly.

- In order to provide timely advice to Ministers, scientific advisory committees should keep under review potential future threats, opportunities and key developments in their particular areas of responsibility which may also lead to revision of previous advice. Scientific advisory committees may wish to draw on or contribute to available horizon scanning resources in their parent departments when considering options for change in the remit, delivery or risk analysis for their committee.

- Scientific advisory committees should aim at having a transparent and structured framework to examine, debate and explain the nature of the risk. It is for committees to decide what form their risk assessments should take [...] Where a committee is asked to provide risk management options, it will normally be helpful for it to follow a formal structure based on recognised principles of risk assessment.[156]

Of particular pertinence to urgent situations such as emergencies, the Code states:

- A scientific advisory committee's advice should be in writing, and should be seen as independent of government. Where a situation is urgent, oral advice may have to be given but should be followed up by written confirmation of the advice.

- Where the nature of its work may demand a rapid response, the scientific advisory committee should agree any special procedures to be used for producing urgent advice where it has not been possible to go through the normal channels.[157]

141. We wished to establish whether a SAGE was required to adhere to the Code of Practice for Scientific Advisory Committees. We therefore asked Professor David Harper, Chief Scientist for the Department of Health (DH), whether any codes of practice specified how SAGE should act and he responded:

> there are codes of practice produced. Well, there are guidelines, principles and a code of practice which in fact has just been refreshed [...] These codes of practice and guidelines go back some way. I think the guidelines that have just been refreshed were published in 2007, and they are guidelines and codes of practice that are there to allow the framework to be created to preserve the independence of advice, which is very important given some of the changes that we are seeing currently in terms of our advisory non-departmental public bodies. So there are codes of practice and there is guidance there.[158]

156 Government Office for Science, *Code of Practice for Scientific Advisory Committees*, December 2007

157 *As above*

158 Q 45

142. When asked a similar question, the GCSA also failed to provide the clarity we sought.[159] **It remains unclear to us whether the Code of Practice for Scientific Advisory Committees applies to SAGE and we seek clarification on this issue.**

143. Notwithstanding the uncertainty, we have proceeded to examine SAGE's operation on the basis that the Code of Practice for Scientific Advisory Committees and the Principles of Scientific Advice to Government apply. The Government also helpfully shared with us the previously unpublished *Code of Conduct* and *Guidance for dealing with the media* given to SAGE members during the volcanic ash emergency.[160]

SAGE membership

Identifying members

144. The Department of Health's *Communicating about risks to public health: pointers to good practice* makes the following point:

> A common pattern of failure is of able decision-makers (and their advisers) becoming fixed on a particular set of assumptions. In the case of scientific assumptions, clues as to which assumptions to vary can be found by looking critically at the "pedigree" of key evidence—how it was generated and by whom. But sometimes even the highest pedigree assumptions turn out to be mistaken, and there is often a need to look at non-orthodox views. The argument is *not* that all views should somehow be accorded equal weight. Despite the attractions of a romantic view of science, most dissident views remain just that. But that should not stop one asking "what if the accepted view is mistaken?"[161]

145. SAGE is essentially a group of experts, supported by a secretariat, brought together to advise Government. The membership of each SAGE is specific to the emergency and the process of identifying and appointing members was of interest to us. According to the Government, when identifying SAGE members:

> Pre-existing scientific groups and networks will be utilised, where they exist and have appropriate expertise. Where existing groups do not exist, the GCSA or relevant officials would identify appropriate experts in consultation with National Academies, Learned Societies and other relevant professional organisations and institutions.[162]

146. As mentioned, the swine flu SAGE drew heavily upon the Scientific Pandemic Influenza Advisory Committee (SPI), with 16 of the 20 SAGE members having served on the SPI, including the SPI Chair and SAGE co-chair, Sir Gordon Duff.[163] The SPI, however,

159 Q 351

160 Ev 108–09

161 Department of Health, *Communicating about risks to public health: pointers to good practice,* January 1997, p 20

162 Ev 96

163 "SPI members' biographies", *Department of Health*, 24 September 2009, www.dh.gov.uk; "Declarations of interest by members of the Scientific Advisory Group for Emergencies", *Department of Health*, 8 March 2010, www.dh.gov.uk

had 37 members, which meant that over half of its members did not serve on SAGE. While a membership of 20 may have meant SAGE was less cumbersome, it raises the question of whether the full range of appropriate expertise was represented on SAGE. Professor Neil Ferguson, Director of the MRC Centre for Outbreak Analysis and Modelling, who was a member of both advisory groups told us that SPI was:

> a huge committee, I think it's 40–50 people, and has a huge range of expertise, all the way from the social sciences, through to virology, clinicians and, indeed, modellers. Clearly, in an emergency that is an impractical size of committee to operate. You need something which is smaller and more agile. I don't know precisely what process was used, but basically the people with most expertise to give and most prior experience of being involved in emergencies or responding to things were engaged in the SAGE group, and it still had a breadth of expertise from social scientists to clinicians, representatives from the NHS and modellers. It was really quite a balanced committee.[164]

147. Dr Justin McCracken, Chief Executive of the Health Protection Agency, considered that:

> we were fortunate, the Government was fortunate, in the sense that there already was a Scientific Advisory Committee on Pandemic Influenza and it was, therefore, able, quite easily [...] to identify relevant experts to form a scientific advisory group.[165]

148. Professor Sheila Bird, former Vice-President of the Royal Statistical Society and member of SPI, raised a concern about the membership of SAGE:

> there was a gap because there was not a statistician member of SAGE. The information, the consensus statements and so on, which went to SAGE, which are now in the public domain, show that percentages, be they fatality rates or whatever, were quoted in those summary documents without there being an annex which summarised the basic data that underlay those estimates. [...] If a professional statistician cannot appraise the precision of a percentage without knowing either its denominator or the standard error, then neither can anybody else.[166]

149. Dame Deirdre Hine noted in the independent review of the UK response to swine flu pandemic that she had:

> reflected at length on whether SAGE should contain a broader range of scientific disciplines to help it tackle a future pandemic outbreak. I have concluded that SAGE had a good range of expertise, although the emphasis on modelling [...] reduced the opportunity for a full contribution by other disciplines.[167]

She subsequently recommended that:

164 Q 20

165 *As above*

166 Q 23

167 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 4.41

> The Government Chief Scientific Adviser and the Department of Health should ensure that there is an appropriate balance of contribution in the Scientific Advisory Group for Emergencies for future pandemic outbreaks.[168]

150. The process by which members for the swine flu SAGE were identified seems clear to us, and we consider that it was fortunate that the Government was able to draw upon the expertise of the SPI. The need for SAGE to be smaller and more agile is understandable, although we emphasise that the GCSA and DH must be vigilant in ensuring an appropriate balance of expertise in future. We have concerns about the lack of a statistician on SAGE although it is our understanding that SAGE was informed by a wide range of sources, including the SPI's sub-groups, the HPA, Devolved Administrations and the European Centre for Disease Control and Prevention (ECDC).[169] **We ask the Department of Health to clarify how the gap caused by the lack of a statistician on the swine flu SAGE was addressed.**

151. While we were able to find details of the members of SAGE for swine flu fairly easily on the DH website, it was more difficult to identify the members of the volcanic ash SAGE. Several SAGE members had identified themselves as such in the written evidence they provided to us; but we did not have the full picture as no details had been published online or provided in the Government's written submission. In the end we requested the information from GO Science and were provided with a list of members to be kept in confidence. Further into our inquiry we became aware that the volcanic ash SAGE had set up sub-groups and we requested details of the sub-group members too. While GO Science was willing to provide the information when asked, we were puzzled that information on SAGE members had not been published, given that the emergency had been over for several months and members of the swine flu SAGE had been published.[170] We queried this with the GCSA, who stated:

> I am aware of no reason why we couldn't publish the list of members. I think it is just that we haven't. I don't think there is anything remotely sinister in that. It is just that the SAGE operations were much quicker, because the volcanic ash was there, and then it was gone. It was all working with limited resources.[171]

152. The GCSA added that "particular circumstances might mean that there would be some individuals it would not be appropriate to name".[172] **Although it may not be appropriate to name some members, we see no reason why the membership of SAGE should be kept wholly secret for civil emergencies. In line with the Code of Practice for Scientific Advisory Committees, which states that SACs should operate from a presumption of openness, we recommend that SAGE members and their declarations of interest are published once initial membership has been established.**

168 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 4.41

169 Ev 97 [Government Office for Science and Cabinet Office]

170 On 23 May 2010 the Volcanic Ash Advisory Centre at the Met Office declared the eruption stopped.

171 Q 352

172 Q 353

153. It appears that there were concerns amongst scientists and engineers over the transparency of the appointment process for volcanic ash SAGE members. Professor Bill McGuire, Co-director of the University College London Institute for Risk & Disaster Reduction, who identified himself as a member of SAGE, commented that "the nature of the invitation process was not clear".[173] Given the lack of a risk assessment and contingency planning for this particular emergency, we assume that the appointment process must have been reactive. Dr Sue Loughlin, SAGE member, confirmed this view and told us:

> Unfortunately, because of the lack of preparedness, SAGE didn't meet earlier [...] but when it did meet [...] it had a very good representation of expertise. The key issues were addressed, pointed out very quickly, discussed and debated. I would have liked to see even more people involved, but through time all additional people whose expertise was required were brought in.
>
> [...] On a slightly less positive point of view, as time went on, SAGE became slightly less focused but, again, I think that was partly because of the lack of planning in the first case, but the first few meetings certainly were very, very good. It would be good if, for future situations, there is a SAGE plan in advance so that it is already made up before the next situation happens.[174]

154. Time is of the essence in an emergency and the pressure to identify and appoint SAGE members quickly could lead to an initial lack of balance. An additional difficulty in the case of volcanic ash could have been that, unlike with pandemic influenza, there was no obvious existing SAC to draw membership from; there cannot be a ready-made SAC for every potential emergency that could hit the UK. **While an initial lack of balance on SAGE can be later addressed through the addition of members or formation of sub-groups, we consider that it would be desirable to strike a suitable balance of expertise from the start. The first step is to ensure that key experts are identified through the NRA process. We conclude that, if risks and Lead Government Departments can be identified in advance, the Government could also pinpoint possible expert advisers who may be called upon to provide advice in the event of an emergency.**

155. **We recommend that GO Science, working with Departments, develops and maintains a directory of scientific experts who can be called upon in emergencies. The directory should include information on expertise area, current security clearance and previous experience advising Government. We anticipate that focus should be placed on the risks identified in the NRA, although not exclusively. We conclude that having a SAC for risk assessment in the Cabinet Office, as we recommended above, could also assist GO Science in identifying members for this directory.**

International expertise

156. The Civil Aviation Authority (CAA) is the UK's specialist aviation regulator, with specific responsibilities for air safety and airspace regulation.[175] During the volcanic ash

173 Ev w31 [UCL Institute for Risk]

174 Q 93

175 "About the CAA", *Civil Aviation Authority*, www.caa.co.uk

emergency, the CAA brought international experts together "to find a solution that would help to open up airspace in Northern Europe that was affected by ash".[176] The CAA told us that:

> This group comprised representatives from regulators (e.g. the American Federal Aviation Administration, Transport Canada, and [European Aviation Safety Agency]), engine and aircraft manufacturers (including Airbus, Boeing, General Electric and Rolls-Royce), airlines (including British Airways), air traffic service providers, meteorologists, volcanologists, and geologists. In all, approximately 100 people from over 60 organisations participated in the work.[177]

157. The CAA drew on multinational expertise. In contrast, all the SAGE members and most of the sub-group members were UK-based. We note that the British Geological Survey and UK Met Office, both of which were represented on SAGE, liaised with the Icelandic authorities and scientists.[178] **International sharing of scientific data and expertise will often be pivotal to the resolution of an emergency. We recommend that the GCSA clarify how he ensures that SAGEs draw on international expertise and what formal role SAGE members may play in this.**

Reimbursing members

158. SAGE members are not remunerated for their time. The difficulties of serving on expert committees such as SAGE were brought home to us most effectively by Dr Peter Holden, BMA, who said that during the swine flu pandemic:

> The workload on [expert committees] was utterly phenomenal and we were all still trying to do our day jobs. This only ended just in time before some people would have broken. I'm afraid the Government has got to understand that if it wants these senior people to work on these committees, at a much earlier stage they have to be relieved of their routine duties.[179]

159. We asked the GCSA if he believed that SAGE members should be financially compensated for their contributions and he stated:

> it depends a little bit how long it goes on. Many of the people who joined the volcanic ash SAGE were making a personal sacrifice. Some of them were consultants, others worked for universities and others worked for research councils.[...] I don't know the answer and I think it will depend on the circumstance. For example, the SAGE for swine flu lasted for a very substantial period of time—a matter of many months. In that situation, if we are looking for an independent person to do it, some degree of compensation is going to have to be appropriate. Where it lasts for two or three weeks, it is less of a problem.[180]

176 Ev 161 [Civil Aviation Authority]

177 *As above*

178 Ev 126, para 57 [Research Councils UK]

179 Q 21

180 Q 356

160. This is a difficult issue to resolve. Financial compensation of SAGE members may compromise their independence, or, equally as important, their *perceived* independence from Government. This could damage public trust. On the other hand, the immense pressure put on SAGE members, who contribute their time freely, should be recognised. The Code of Practice for SACs states that "sponsoring departments are responsible for determining whether remuneration should be paid to members of scientific advisory committees and the level at which any remuneration is set".[181] The Government needs to have a clear policy on remuneration as this cannot be left to the discretion of LGDs when an emergency is unfolding. **We recommend that GO Science and the Cabinet Office develop an appropriate remuneration policy for future SAGE members by September 2011. We recommend that they also consider whether compensating SAGE members' employers would be appropriate.**

Operation of SAGE

Transparency and openness

161. As we have already outlined, SACs are normally expected to operate under a presumption of disclosure. Emergencies present extenuating circumstances, however, and the Code of Conduct given to volcanic ash SAGE members stated that:

> discussions and advice provided by SAGE will remain confidential whilst SAGE is operational. However, information may be released later under the government's principles of freedom of information.[182]

162. Redacted minutes of the SAGE meetings on swine flu were published on the DH's website in September 2010, following a Freedom of Information (FoI) request.[183] Referring to the volcanic ash SAGE, Dr Guy Gratton, Royal Aeronautical Society, explained on 3 November 2010 that:

> What was very hard to understand, particularly from outside SAGE, is why the organisation was treated with such secrecy. The composition of SAGE was never published and the minutes from the meetings were never available. So for anybody who sat outside of SAGE, and there were a great many people very intimately involved with the problem, it became extremely hard to feed into SAGE and to use it to contact other organisations affected by the volcanic ash problem purely because of the level of secrecy with regard to its construction.[184]

163. In December 2010, after we had finished taking oral evidence for this inquiry, minutes of the four volcanic ash SAGE meetings were published on GO Science's website.[185]

181 Government Office for Science, *Code of Practice for Scientific Advisory Committees*, December 2007, para 38

182 Ev 108 [Government Office for Science and Cabinet Office]

183 "Scientific Advisory Group for Emergencies (SAGE)", *Department of Health*, 14 October 2010, www.dh.gov.uk

184 Q 94

185 "Civil Contingencies", *Government Office for Science*, www.bis.gov.uk/go-science

164. During the course of our inquiry, we found it difficult to source information on the volcanic ash SAGE. More worryingly, it appears that the secrecy of SAGE's membership and operations posed a barrier to external scientists who wanted to contribute but were left outside the loop. Dr Loughlin, Head of Volcanology at the British Geological Survey, who served on SAGE, told us that:

> There was a lot of information discussed in SAGE which was not, for any reason, secret. It was about the way volcanoes work, the way meteorology works. All of this information should have been shared as widely as possible, as quickly as possible.[186]

165. **It is important that the existence of SAGE and how it can be accessed is made known during an emergency so that those with alternative, credible scientific views can contribute. Such input would need to be screened and evaluated, but that would be part of SAGE's challenge function.**

166. Given that minutes of SAGE meetings and papers produced by SAGE may not be published until after an emergency, the single portal of information we recommended in the previous chapter, for use *during* an emergency, would not be the most appropriate home for details of SAGE. **We consider that the Government Office for Science website should be the first port of call for information on every SAGE. We recommend that if GO Science provides the secretariat, details of members and minutes of meetings should be published on the GO Science website. If information on a SAGE is best sourced through the LGD, we consider that GO Science's website should link to the relevant Departmental webpage. It should be clear from GO Science's website where information on the SAGE is published, and how the secretariat can be contacted.**

167. **Although we accept that there are circumstances where a SAGE should operate in confidence, we see no reason why, after the emergency, minutes of meetings should only be released in response to a Freedom of Information (FoI) request. We recommend that all SAGE meeting minutes and other documents which would be made public following a FoI request are published immediately, in full or redacted form as appropriate.**

168. The need to ensure transparency of scientific advice to the greatest possible extent should not be put aside even in an emergency. **We are concerned that the SAGE mechanism operates under a presumption of secrecy rather than transparency and openness, and this was particularly and unnecessarily so during the volcanic ash emergency.**

Engaging with the media

169. The *Principles of scientific advice to Government* state that "any requirement for independent advisers to sign non-disclosure agreements, for example for reasons of national security, should be publicly acknowledged and regularly reviewed".[187] Volcanic

186 Q 95

187 "Principles of scientific advice to Government", *Government Office for Science,* www.bis.gov.uk/go-science

ash SAGE members were required to sign non-disclosure agreements.[188] We received written evidence from the Science Media Centre (SMC) which considered that:

> Government advisers must be free to brief the media (and therefore the public) as well as the Government—during previous crises some of the best independent scientists were quickly appointed to advise government by serving on SAGE (Scientific Advisory Group for Emergencies) committees. While some in government have assured the SMC that this does not disqualify these experts from briefing the media, that has not been made clear enough to those experts, many of whom have stopped speaking to journalists as a result of their appointment as an adviser. The SMC believes government must proactively encourage these scientists to continue briefing the media. [...]
>
> Some scientists sitting on these committees felt intimidated by being warned about the Official Secrets Act or asked to sign Confidentiality Clauses, which could serve not only to dissuade them from engaging with the media, but also from giving advice to Government in future.[189]

170. We have evaluated the guidance on dealing with the media that was provided to SAGE members, and believe that it is reasonable; it makes clear that SAGE members are free to talk to the media about their work as experts in their own right, excluding information on SAGE confidential discussions.[190] Notwithstanding the guidance, Dr Loughlin told us that with respect to confidentiality "there was some confusion amongst SAGE members about what they could discuss and what they couldn't".[191]

171. Another reason why engaging with the media may have been difficult was that scientific experts were under great pressure to deal with the emergency. For example, Dr Gratton explained:

> With regard to putting information out to the whole community, however you define "community", one thing was very evident. This was a huge problem. It involved an awful lot of people and virtually all of those people were working 18 or 20-hour days trying to solve it. That left very little capacity for anybody to then go out and start explaining to the media, to politicians like yourselves, to everybody else, what we were doing.[192]

172. As experts in the scientific issues of an emergency, SAGE members have an exceptional value as public communicators. **We recommend that SAGE and its secretariat have a responsibility to identify and support SAGE members willing to communicate scientific issues to the public during an emergency. We further recommend that the GCSA and GO Science, in consultation with Cabinet Office and external centres of expertise such as the Science Media Centre, develop suitable protocols, procedures and guidance for SAGE members.**

188 Qq 133–34

189 Ev w51 and w52

190 Ev 109 [Government Office for Science and Cabinet Office], Annex C

191 Q 95

192 Q 120

Independence

173. A key feature of Scientific Advisory Committees (SACs) is their independence from Government. This is essential for trust in the scientific advice provided to Government. The Royal Statistical Society raised a question about the independence of the swine flu SAGE:

> the [Scientific Pandemic Influenza Advisory Committee] SPI was, in effect, stood down on 4 May 2009 and did not meet thereafter until 10 September 2010. Formerly SPI subcommittees worked to SAGE but their remit as a subcommittee of an independent scientific advisory committee was, in effect, in abeyance.[193]

174. On the issue of SAGE's independence from Government, Sir Gordon Duff, Chair of SPI and co-Chair of SAGE, explained his view that the independence of SAGE had been safeguarded:

> The transition from what we call SPI, which was the preparedness committee, to SAGE, which was the wartime real committee for the pandemic, was done in a way where the independent academic voice, the independent scientific challenge, was retained, so SPI had three sub groups. One was called Modelling, which you probably know about; one was called Clinical Countermeasures, and the third was called Behaviour and Communication. Those sub groups were actually used by SAGE going forwards.
>
> The fact that I, as an independent, became co-chair of SAGE retains the challenge function. The challenge function is understood to be important but we also understand it to be only in the appreciation and interpretation of the scientific evidence. There is a distinction between that and its interpretation or translation into policy. So when it comes to challenging the scientific data and how it is being interpreted, I think SAGE had a very good and independent role in that and maintained that role throughout.[194]

175. **While we do not doubt Sir Gordon Duff's independence from Government in his role as SAGE co-chair, it is still not clear to us how independence of the swine flu SAGE as a whole was maintained, particularly as it included Government officials. It is difficult to evaluate the independence of scientific advice when the operation of SAGE is confidential.**

176. **We have stated previously that the ability to draw upon an existing SAC to form the swine flu SAGE was helpful. However, it must be made clear how SAGE retains a SAC's level of independence from Government. We conclude that clarifying a code of conduct and publishing the names of members of future SAGEs, with their declarations of interest, could only be useful in this respect.**

193 Ev 139

194 Q 45

Other sources of advice to Government

177. SAGE is intended to act as a channel for scientific advice to COBR in an emergency. In order to do this, SAGE receives information from different sources and experts outside of the committee. However, in the cases of both swine flu pandemic and volcanic ash, we found that there was uncertainty on the weight given to advice from SAGE compared to other sources of advice to Government.

178. The Joint Committee on Vaccination and Immunisation (JCVI) is an independent expert advisory committee that advises ministers on matters relating to the provision of vaccination and immunisation services. It comprises 17 members.[195] During the swine flu pandemic, JCVI advice on vaccines was not given directly to ministers but was routed via SAGE for endorsement, with the JCVI chair attending SAGE discussions about vaccination.[196] When considering the role of scientific advice, the *Hine Review* found that "there was frustration that advice from the Joint Committee on Vaccination and Immunisation (JCVI) was channelled through SAGE before presentation to ministers". It concluded that:

> the [JCVI] should report directly to the central emergency meetings in a future pandemic, although [SAGE] should be used at the appropriate time to provide its challenge function. This should be clarified in a revised COBR Response Guide for Pandemic Influenza by summer 2011.[197]

We sought the views of the then Secretary of State for Health, Rt Hon Andy Burnham MP, who told us that he "wouldn't overplay the role of SAGE" because:

> the JCVI probably were more important in terms of specific advice on treatment options. SAGE were often providing a broad context and information in which to make the decisions. They were providing specific advice, although [...] there was a split opinion around antivirals. You must remember that in the health context the JCVI has a crucial role in advising on vaccination and vaccination priority.[198]

SAGE was still considered to have some weight however; when asked about the impact of SAGE's advice, Sir Gordon Duff told us:

> My impression was that the scientific advice was taken extremely openly and given a lot of weight. I never heard a lack of response to the scientific advice. I'm not entirely sure that there was ever a time when the scientific advice was rejected.[199]

179. We agree that SAGE provides a useful challenge function for scientific advice to Government. We also agree with the *Hine review* that SAGE's challenge function "should

195 "Joint Committee on Vaccination and Immunisation", *Department of Health*, www.dh.gov.uk

196 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 4.27

197 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, p 9

198 Q 378

199 Q 47

not delay ministers from receiving timely advice on vaccination".[200] However, we consider that there would be difficulties in having JCVI and SAGE report to COBR separately; advice may be conflicting or uncoordinated and therefore we offer a proposal for future coordination of scientific advice. **While there will be scientific advice to Government from sources other than SACs, we see benefits in coordinating advice from SPI and JCVI for future pandemics. Given that the SPI advisory committee was effectively drawn upon to form the basis of SAGE membership, we consider that a future pandemic influenza SAGE should include members of the JCVI (in addition to the JCVI Chair) either as core members of SAGE or a sub-committee. This could speed up the process by which ministers receive advice on vaccination strategies while retaining the crucial challenge function.**

180. We heard that during the volcanic ash emergency, the CAA showed leadership despite the LGDs being identified as the Department for Transport and the Foreign Office (for the repatriation of British Nationals stranded abroad). The CAA brought together worldwide expertise and worked with engine manufacturers, airlines and others to develop safety rules and scientific certification with engine manufacturers. This initiative was seen as key to resolving the crisis.[201] The Royal Aeronautical Society stated:

> The CAA, with the Met Office and NERC close behind had the clearest understanding of a difficult and complex problem where data and scientific modelling were often uncertain. [...] SAGE clearly had good scientific literacy, but the relative secrecy of its operation was an obvious weakness.[202]

181. We examined further the relationship between SAGE and the CAA after Dr Elgy, Head of Licensing and Training Standards at the CAA, commented that "SAGE was very helpful in validating the work that we had been doing".[203] The CAA wrote to us and clarified that "there was no formal relationship between SAGE and the group of experts that had been assembled by the CAA".[204] The reason for this, according to the CAA, was that, while experts on the CAA group contributed their advice through meetings of SAGE, the timing of the later SAGE meetings (the first SAGE meeting was on 21 April 2009, the day UK airports re-opened) meant "there was no formal link between the two".[205] The CAA explained how SAGE validated their work:

> The SAGE meetings identified the problems causing the flight restrictions, and considered what options were available to address them. SAGE came to the view that the issues broadly fell into two areas: 1. How much ash was in the atmosphere and where exactly was it? and 2. How much ash could aircraft and engines safely tolerate?
>
> In focussing on these two areas and the ways in which these issues could be tackled, SAGE confirmed that the work that the CAA had already set in train was targeting

200 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 4.56

201 Ev w64 [Airport Operators Association], para 13

202 Ev 118, para 23

203 Q 93

204 Ev 161

205 *As above*

the right issues and objectives, thus effectively validating the approach taken by the CAA.[206]

182. It appears that the CAA showed strong leadership in identifying the key issues and sourcing the evidence required to resolve the question of how much ash aircraft and engines could safely tolerate. The view was put to us was that "the crisis was solved by the CAA demonstrating clear leadership and using scientific evidence to derive a workable solution to the problem of closed airspace",[207] and we found little disagreement, However, British Airways disagreed with the CAA's approach—we explore this further in paragraph 218. **Because of the CAA's groundwork and the relatively late formation of SAGE during the volcanic ash emergency, it appears that SAGE contributed little to scientific understanding of the key issue: the ash tolerances of engines and aircraft. We question how much additional knowledge SAGE added to enable airspace to be reopened.**

183. **While we take the view that there is merit in combining the forces of SACs such as SPI and JCVI under a SAGE for future influenza pandemics, we do not consider that the CAA's work on resolving the issue of ash tolerances of engines and aircraft during the volcanic ash emergency could have been carried out as quickly under the umbrella of SAGE, because of SAGE's more limited membership.**

184. **The SAGE mechanism has been used twice, and is therefore relatively new. We expect the Government to have evaluated the impacts that both SAGEs have had and whether SAGE's ways of working need improvement. We recommend that, in responding to this report, the Government provide us with its evaluation on the effectiveness of both SAGEs.**

Secretariat

185. The secretariat for the swine flu pandemic SAGE was provided by the Department of Health. The secretariat has been widely praised.[208] For example, Professor Ferguson told us that "the DH Secretariat for SAGE was truly excellent".[209]

186. The secretariat for the volcanic ash SAGE was more difficult to identify. When we asked Professor Brian Collins, Chief Scientific Adviser to the Department for Transport (DfT), why minutes of the volcanic ash SAGE meetings had not been published, he answered "there isn't a secretariat in the context of the way this particular SAGE group was put together because of it being led from No. 10 at that particular point in history".[210] When we asked the GCSA about this, he told us that "in terms of the way in which the Secretariat was underpinned, that was done by the Cabinet Office and my own office".[211]

206 Ev 161

207 Ev w50 [Manchester Airports Group], para 16

208 Cabinet Office, *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*, July 2010, para 4.64

209 Q 31

210 Q 130

211 Q 346

187. We are concerned that there may not have been a secretariat for the volcanic ash SAGE at all times. It was our understanding that the secretariat should be provided either by the LGD, as was the case for the swine flu SAGE, or the Cabinet Office and GO Science if the lead is unclear.[212] **The Government should explain who provided the secretariat for the volcanic ash SAGE.**

188. **Where the LGD is unclear or yet to be identified, we consider that GO Science should by default provide the secretariat to support a SAGE.**

Conclusions on SAGE

189. **We recommend that the GCSA either clarify what guidelines/codes of conduct apply to SAGE or, if no existing ones apply, produce guidelines governing how SAGEs should operate. The guidelines should address independence, transparency, confidentiality and the conduct of members, the Chair and the supporting secretariat. We recommend that the guidelines be published.**

Changes to the HPA and JCVI

190. The Health Protection Agency (HPA) plays a major role in supporting the UK preparations for, and response to, an influenza pandemic. It provides independent scientific and public health advice and operational support to the Department of Health, Strategic Health Authorities, the National Health Service, and other organisations. The HPA has specific responsibilities within England and Wales and cooperates closely with sister agencies in Scotland and Northern Ireland. In the event of a pandemic the HPA collates UK surveillance data for the purpose of providing regular updates to DH and the Civil Contingencies Committee (CCC).[213]

191. In October 2010 the Government announced that the HPA would be abolished as a Non-Departmental Public Body (NDPB), with its functions to be "transferred as part of a new Public Health Service (PHS)".[214] The HPA told us that, while they welcomed the Government's commitment to improve the focus on public health, they were concerned that "there is a risk that [the HPA's] advice will no longer be seen to be independent of Government unless steps are taken to preserve its independence."[215] They explained that:

> It is not yet clear how independence of expert evidence based advice will be preserved and accommodated within the PHS. This is critical in terms of retaining credibility and the trust and confidence of the public, health professionals and others working in the field of health protection—locally, nationally and internationally. Clearly if the integrity of advice provision were to be eroded, or perceived to be so, then the impact on our ability to influence, protect and improve public health could be seriously affected (in the absence of a recognisably independent expert source, the

212 Ev 96 [Government Office for Science and Cabinet Office]

213 Ev 132 [Health Protection Agency]

214 Cabinet Office, *Public Bodies Reform—Proposals for Change*, 14 October 2010, www.cabinetoffice.gov.uk

215 Ev 136–37, paras 1 and 10

> public could turn to other, potentially poorly evidence based and unreliable sources of information).[216]

192. In the same announcement, the Government decided that the JCVI will no longer be a NDPB and will be reconstituted as a DH/PHS "committee of experts".[217] The JCVI is an independent scientific advisory committee, and although it has been stated that the Code of Practise for SACs will apply to all SACs whether formal NDPBs or not, we do not know what evaluation has been conducted on the impacts of a potential loss, or perceived loss, of independent scientific advice. Both the HPA and JCVI will play a crucial role in any future influenza pandemic. When we queried the abolition of several SACs with the GCSA in an evidence session on GO Science's Annual Review, he told us:

> What I have actually got is a complete assurance that where there has hitherto been [a NDPB]—providing scientific advice, if the terms of reference of that are moved to the Department and you have [...] within particular Departments an advisory committee, those committees will still operate in exactly the way that is determined by the [Code of Practice for SACs][...] and by the principles for underlying scientific advice to Government, which were accepted by the previous Government and have been endorsed by the current Government and, indeed, incorporated in the Ministerial Code. To the extent that those are assurances, I am comfortable.[218]

193. While we are pleased that the GCSA is "comfortable" with the proposed changes, we have heard strong concerns to the contrary. **We recommend that the Government sets out how the independent advisory functions of the HPA and JCVI will be maintained. If any function of the HPA or JCVI is cut, we consider that a justification should be published.**

Use of Research Council resources

194. On 15 April 2010, during the volcanic ash emergency, a Dornier 228 research aircraft owned by the Natural Environment Research Council (NERC) was diverted from its planned programme and used to provide ash sampling capability for the Met Office, flying daily until 21 April to assess the location and nature of the volcanic emissions. The Dornier 228 was the only aircraft permitted to operate in UK airspace above 2500 feet until 20 April.[219] Research Councils UK (RCUK) informed us in September 2010 that payment of around £1.25 million for the cost of flights, repairs and consequential losses was outstanding from the Government.[220] The Royal Aeronautical Society noted that, because of this situation, there was "a risk that these resources will not be available be in a future emergency".[221]

216 Ev 136, para 4

217 Cabinet Office, *Public Bodies Reform—Proposals for Change*, 14 October 2010, www.cabinetoffice.gov.uk

218 Science and Technology Committee, *The Government Office for Science Annual Review 2009,* HC (2010–11) 546–i, Q 11

219 Ev 124 [Research Councils UK], para 32

220 Ev 126, para 53

221 Ev 118, para 26

195. The Rt Hon David Willetts MP, Minister for Universities and Science, told us in December 2010:

> I know there is an issue that has arisen on these specific exercises about the exact budgetary funding when NERC finds itself providing resource during the volcanic ash episode. During the crisis itself, it's common sense—people just get on with it. It's true to say that now there are some accounting issues that are still being resolved.[222]

196. Our understanding from informal discussions with NERC is that, to date, a significant part of the original debt is still outstanding. **We are concerned that the delayed reimbursement to NERC for use of the Dornier 228 aircraft has damaged trust between the Government and the research community, with the danger that there may be reluctance to make such resources available in future. We recommend that the Met Office, whom NERC supported, and the Department for Transport, the LGD, take responsibility for ensuring that NERC is reimbursed in full immediately.**

Security and scientific advice

197. As cyber attacks pose a national security risk, they are a concern within the defence and intelligence communities in the UK. Information tends to be classified within Government and confidential within industry. This could cause difficulties when coordinating with the civil sector. We considered whether, as a result of this potential barrier, academic experts may be deterred from providing scientific advice to Government.

198. There are four main levels of government security clearance: Basic Check, Counter-Terrorist Check (CTC), Security Check (SC) and Developed Vetting (DV). Developed Vetting (DV) is required for civil servants and others with substantial unsupervised access to sensitive Government assets.[223] The DV clearance process takes several months to complete.[224]

199. The security clearance requirements may pose problems for the involvement of independent scientists in the Government's cyber security agenda. Professor Sommer, Visiting Professor at the London School of Economics, noted that non-Government academics are relatively unlikely to have been through developed vetting (DV) but may simply be security cleared (SC).[225] Professor Anderson, Professor of Security Engineering at the University of Cambridge, explained that "many of the real experts in academia and industry refuse to get a security clearance, because of the toxic effects on international collaboration, academic publication and the free exchange of information".[226] Professor

222 Q 404

223 Her Majesty's Government Communications Centre, *Developed vetting: your questions answered,* www.hmgcc.gov.uk

224 "The vetting process", *Ministry of Defence*, www.mod.uk

225 Ev 129, para 12

226 Ev 131 [Foundation for Information Policy Research], para 4

Sommer explained that restriction on publication is a key concern because it is taken as a "measure of academic excellence and key to further promotion".[227]

200. Professor Bernard Silverman, Chief Scientific Adviser to the Home Office, did not share these concerns:

> I don't personally see security clearance as serious an issue [...] We fund research in a wide range of disciplines across counter-terrorism. That hasn't been a problem in attracting high-quality scientists to engage with us. We have advisory committees where some security clearance may be necessary for membership. Again, this hasn't been a difficulty in getting people to serve on these. [...] I would say that many scientists don't see this as a particular barrier.[228]

201. Dr Mark Welland, Chief Scientific Adviser to the Ministry of Defence, gave us an example of how the problem could be overcome: a Blackett Review was carried out on improvised explosive devices (IEDs) and the Government made it unclassified. Dr Welland considered that Government:

> should work in an unclassified way as best and as much as we can, and where we need to pull in that advice we can do so. [...] It was a combination of sensibly classifying material or unclassifying it, and accepting that one tries to engage in an unclassified way, especially with academics, but where there is a good reason [...] to engage in the classified area, then you can get those security clearances.[229]

202. **We consider that the Government must actively ensure that requirements for security clearance do not deter academics from providing scientific advice to Government.**

227 Ev 130, para 23

228 Q 310

229 *As above*

7 Coordination

203. In this inquiry we have looked at four very different case studies, involving a host of Government departments and agencies, independent advisers, private organisations and regulators. All of the emergencies we explored have the potential to cross political and departmental boundaries and so it is unsurprising that a recurring theme has been the importance of coordinating the emergency response. In this final chapter we look at coordination in more detail, specifically the Office of Cyber Security and Information Assurance (OCSIA) and international coordination.

Office of Cyber Security and Information Assurance

204. There are a range of agencies providing scientific advice on cyber security to Government and businesses. The Centre for the Protection of National Infrastructure (CPNI) advises organisations within the national infrastructure on security measures and provides technical support.[230] The Cyber Security Operations Centre (CSOC) was set up in 2009 to monitor the health of cyber space and co-ordinate incident response, enable better understanding of attacks against UK networks and users; and provide better advice and information about the risks to business and the public.[231] CSOC draws on expertise from the Defence Science and Technology Laboratory (DSTL) and is housed at the Government Communications Headquarters (GCHQ). GCHQ has an information assurance arm called CESG (the Communications Electronics Security Group); this is the UK's National Technical Authority for information assurance, providing advice and assistance on the security of communications and electronic data to central Government departments and agencies, the Armed Forces and the wider public and private sector.[232] In addition, the Government's written submission stated that "individual Government departments are currently responsible for the protection of their own systems and infrastructure".[233]

205. Following the publication of the UK's *Cyber Security Strategy* in June 2009, the Office of Cyber Security (OCS) situated in Cabinet Office, and Cyber Security Operations Centre (CSOC) were set up to provide strategic leadership in the cyber domain, monitor developments in cyber space, analyse trends and improve the collective response to cyber incidents.[234] The OCS has subsequently been renamed the Office of Cyber Security and Information Assurance (OCSIA), to reflect its role in the safeguarding of data rather than just the networks and systems that handle that data.

206. The OCSIA is responsible for:

- providing a strategic direction on cyber security and information assurance for the UK including e-crime;

230 Ev 102 [Government Office for Science and Cabinet Office]

231 Cabinet Office, *Cyber Security Strategy of the United Kingdom: Safety, security and resilience in cyber space,* June 2009, para 3.8

232 "About us", *Communications Electronics Security Group,* www.cesg.gov.uk

233 Ev 103 [Government Office for Science and Cabinet Office]

234 *As above*

- supporting awareness, training and education;
- working with private sector partners on exchanging information and promoting best practice;
- ensuring that the UK's information and cyber security technical capability and operational architecture is improved and maintained;
- working with the Office of the Government Chief Information Officer (OGCIO) to ensure the resilience and security of government ICT infrastructures; and
- engaging with international partners in improving the security of cyberspace and information security.[235]

207. The Royal Academy of Engineering was concerned that:

> At present, there is no one place in Government where responsibility lies, and different departments ask the same of advice of the same people. The role and resourcing of [OCSIA] needs to be resolved, clarifying whether [OCSIA] is merely raising awareness of this issue, or whether it will be setting out and enacting a cyber security strategy.[236]

208. Several of the witnesses we questioned supported the creation of the OCSIA, but warned that "unless the [OCSIA] has some teeth to enforce co-ordination across Government, being a mere observer in this game isn't going to be enough".[237] On whether the OCSIA was meeting its objectives we were told by Professor Sommer that:

> [OSCIA's] problem is that, when it was set up, it had either no or very little independent funding of its own. The individual members, as I understand it, continued to get their salaries from the organisations from which they came.[238]

209. When asked whether the OCSIA would enact and deliver policy, Dr Marsh, Deputy Director of the OSCIA, told us "there will be policy. It is also [...] very much about the strategic leadership being a focus for cyber security across Government as a whole".[239] On whether the OCSIA had "teeth", he said:

> We report to the National Security Adviser in the Cabinet Office, who then, obviously, reports directly to the Prime Minister. We have the Security Minister, Baroness Neville-Jones, in the Home Office. We have the support of the National Security Council for the cyber security work. So I think we have at least growing teeth to harness the activity across Government and certainly, without a doubt, this

235 "Office of Cyber Security and Information Assurance", *Cabinet Office*, www.cabinetoffice.gov.uk

236 Ev 150, para 4

237 Q 267 [Robert Hayes]

238 Q 268

239 Q 296

> Government's commitment is shown by making this budget available for cyber security.[240]

However, when we asked Dr Marsh how much funding was available for the OCSIA, he was not able to give us an answer.[241]

210. The Government clearly recognises the importance of cyber security, but, despite this and Dr Marsh's assurances, we are uncertain how the OCSIA will meet its objectives, particularly as we were unable to ascertain its budget. **In its response to this report, we recommend that the Government clarify the powers and funding of the Office for Cyber Security and Information Assurance.**

International coordination

211. International coordination is an umbrella term encompassing a wide range of activity, from data sharing to the development of new regulations. We have already touched on international expertise in the context of how SAGE works (paragraph 157). In this chapter we have examined three examples of where international coordination is particularly important in the three case studies where the emergency has clear implications beyond the UK.

Space situational awareness

212. A severe space weather event has not affected the UK in living memory, and as we heard several times from witnesses, there is a lot of "work in progress" to determine what the impacts could be.[242] It is clear that the effects of a severe space weather event could be wide-ranging. The Royal Astronomical Society (RAS) warned that "a severe space weather event will affect the whole planet; indeed it will affect the whole of our solar system".[243] Thus the ability to forecast, or predict, adverse space weather is an effort that cannot be undertaken by individual nations alone. Both the European Space Agency (ESA) and National Aeronautics and Space Administration (NASA) have established Space Situational Awareness (SSA) programmes.

213. Space Situational Awareness (SSA) is the understanding of conditions in space that are relevant to human activities. The objective of ESA's SSA programme is to support Europe's independent utilisation of, and access to, space through the provision of timely and accurate information, data and services regarding the space environment, and particularly hazards to infrastructure in orbit and on the ground. The SSA programme should enable Europe autonomously to detect, predict and assess the risk to life and property from the effects of space weather phenomena on space and ground-based infrastructure.[244]

240 Q 298

241 Q 303

242 Qq 157–59, 167, 178, 191, 196, 209–10, 215–16

243 Ev 113, para 37

244 "What is SSA?", *European Space Agency: Space situational awareness*, 26 January 2011, www.esa.int

214. There are concerns that the UK is only a minimal subscriber to ESA's Space Situational Awareness programme. Professor Mike Hapgood, Royal Astronomical Society (RAS), noted that "this greatly limits UK participation in, and influence on, the space weather elements of the SSA programme".[245] The RAS was concerned that "if this continues, it is likely that other member states will develop capabilities that outstrip those currently available in the UK."[246] Professor Paul Cannon, Fellow of the Royal Academy of Engineering, explained that:

> the Space Situational Awareness programme[...] is an ideal opportunity to leverage an international programme into a UK programme and vice versa. If we don't have a UK programme, then our ability to participate in the European programme will obviously be reduced. There is a good opportunity here for the UK. I think it is worth also saying that the UK has a long history in terms of the science in this area. It has a long history in terms of the applications of science in this area. So we are very well qualified as a country to move forward to the benefit of UK Plc.[247]

215. The British National Space Centre (BNSC) partnership was replaced in March 2010 by the UK Space Agency (UKSA). It was announced that the UKSA would bring together space activities and budgets, previously coordinated by the BNSC, from across Departments into one executive agency.[248]

216. **We recommend that the Government review the need for the UK to increase its participation in, and contributions to, ESA's Space Situational Awareness programme, following the outcome of the 2011 National Risk Assessment.**

Regulations on flying through ash

217. The International Civil Aviation Organisation (ICAO) sets standards and recommended practices for international civil aviation. Its ongoing mission is "to foster a global civil aviation system that consistently and uniformly operates at peak efficiency and provides optimum safety, security and sustainability".[249] ICAO guidance and guidance from the airframe and engine manufacturers is "to avoid flying in visible volcanic ash. That is ash that you can see".[250] The initial response to the presence of volcanic ash in the atmosphere above Europe and the UK was to close airspace.

218. There was some dissatisfaction with the implementation of ICAO guidelines. For example, British Airways, one of the world's largest international airlines, stated:

> ICAO guidance to aircraft operators is clear and unambivalent—avoid visible ash at all times. The areas of predicted contamination produced by the [Volcanic Ash Advisory Centre] model were vastly over-conservative: the Met Office has since admitted this. Blue skies prevailed over much of the predicted area of contamination

245 Ev w23 [MIST], para 20

246 Ev 113, para 39

247 Q 167

248 HC Deb, 23 March 2010, col 25WS [Commons written ministerial statement]

249 "ICAO Strategic Objectives 2011-2012-2013", *International Civil Aviation Organisation*, www.icao.int

250 Q 62 [Captain Tim Steeds]

> for the majority of the time that the volcano was erupting but this evidence was not taken into account by government agencies. They contradicted ICAO guidance and imposed unreasonable restrictions upon operators against established protocols.[251]

219. Captain Tim Steeds, Director of Safety and Security, British Airways, told us that his personal view was that:

> the senior management in the CAA expected too much of the Safety Regulation Group [a group within the CAA]. They should have asked the Safety Regulation Group to ensure that operators had considered the problem and were reacting correctly to it, rather than just closing the air space and inconveniencing everybody.[252]

220. The visibility of ash to the eye is a qualitative assessment, as Dr Gratton, Royal Aeronautical Society, pointed out:

> volcanic ash is not always visible at levels that are significant. That is fairly intuitive because aeroplanes fly at night and they fly in cloud, in neither of which are you going to see ash. [...] the fact that you can see or can't see the ash is not a reliable indicator; secondly, the level of damage that can be done [...] [and] actually you can fly through a significant level of ash, do damage, pick up a substantial maintenance overhead but without immediately endangering the flight. It is important to realise this graduation.[253]

221. Given the difficulties of determining visible ash, computer modelling was important for detecting the presence of ash. However, there was criticism of the accuracy of the Met Office computer prediction and the fact that its results were produced every six hours. This led to prohibition of flying for periods of six hours at a time which, in the context of the operational needs of airlines and airports, was arbitrary. It is clear to us that the ICAO guidance to avoid visible ash was insufficient. Because insufficient guidance was available to inform aircraft manufacturers and others of safe ash concentrations and little preparation had occurred for such a crisis, a proportionate emergency response was hampered. The Manchester Airports Group stated that:

> it was very soon evident that the ICAO volcanic ash plans were outdated and relied on assumptions that later proved not to have been based on scientific evidence. It was then clear that no scientific tests or certification had ever taken place to analyse and assess the ability for aircraft or engines to safely withstand flight in ash contaminated air.[254]

Rt Hon Lord Adonis, then Secretary of State for Transport, told us his view that:

> The question which needed to be asked, and involves a searching process of self-examination on the part of the International Civil Aviation Organisation and the

251 Ev 159, para 2.2.2

252 Q 101

253 Q 89

254 Ev w49, para 5

> European regulators, is why, before April 2010, they had not conducted the scientific work that was necessary to put in place a safe regime for flying through concentrations of ash. They are doing that and a new regulatory structure has been put in place.[255]
>
> [...]
>
> Work had not taken place on the estimation of what a worst case scenario might be in the case of a volcanic eruption, which is the reason why we had to put in place a new regulatory regime, literally, over the course of a long weekend.[256]

And Dr Ray Elgy, Head of Licensing and Training Standards at the CAA, told us that "there is work in place to improve co-ordination across Europe [...] within the UK, I am not sure that there is much that we could say would need to be improved. I think the big issue for us would be for Europe".[257] Concerns were also expressed about the involvement of the European Aviation Safety Agency (EASA),[258] to which the CAA will transfer some of its functions from 2012.[259]

222. We asked the former Minister why, putting aside the international aspect, the UK was unprepared for the volcanic ash emergency. He told us that it was "a question which needs to be asked of the Civil Aviation Authority because they are the regulatory agency. I never did get to the bottom of the answer".[260] **We are concerned that, when asked why the UK was unprepared for volcanic ash disruption, the former Secretary of State for Transport chose both to distance himself from, and to pass responsibility to, the CAA, a body for which he had ministerial oversight. This is unsatisfactory.**

223. The insufficiency of ICAO guidance meant there was a need rapidly to work with all relevant stakeholders to identify and validate new operating thresholds. Technical and scientific advances continually improve the capability of aircraft to operate safely in circumstances which had previously proved problematic. However, the volcanic ash episode showed that the air transport regulatory system, which must always take a precautionary view, cannot always be abreast of these new capabilities, especially in the face of unforeseen hazards. In addition, as this regulation is now made at European level, it is essential the UK is able to influence the review of regulations and guidance rapidly and with authority. **We conclude that it is essential that the Department for Transport and the CAA sustain the ability, in the face of any new hazard, to access the full range of science, engineering, operating and regulatory resources necessary to determine whether existing regulations are adequate and appropriate.**

224. **We do not agree that the closure of airspace imposed unreasonable restrictions upon operators. Given the uncertainties involved and the lack of prior risk assessment, it was necessary to take a precautionary approach until aircraft and engine tolerances to**

255 Q 360

256 Q 363

257 Q 61 [Dr Ray Elgy]

258 Q 100 [Dr Guy Gratton]

259 Q 101 [Captain Tim Steeds]

260 Q 367

ash had been identified. We expect that, if a similar situation occurred in future, the UK would be better prepared to conduct analyses and make decisions on an appropriate emergency response. However, the Government will need to resolve the following three policy and process issues: (i) the CAA's contribution to EASA's decision-making processes; (ii) the suitability of the Met Office's computer predictions and (iii) the involvement of airline operators in decision-making.

Data sharing during the swine flu pandemic

225. The World Health Organisation (WHO) is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends.[261] The WHO's Global Influenza Programme considers preparations for influenza pandemics and ways in which death and disease can be reduced.[262] WHO Collaborating Centres—institutes designated to carry out research in support of WHO programmes—are located around the world, including at the National Institute for Medical Research (NIMR) in the UK.[263]

226. The European Centre for Disease Prevention and Control (ECDC) is an EU agency whose purpose is to identify, assess and communicate current and emerging threats to human health posed by infectious diseases.[264] Both the WHO and ECDC contributed to SAGE discussions and the advice given to Ministers.[265] The UK also contributed to discussions at the WHO; we were told by Professor Neil Ferguson, Director, MRC Centre for Outbreak Analysis and Modelling, that:

> The World Health Organisation is a strange political body in some ways, but I would say that the UK is disproportionally represented. It was certainly true on the emergency committee. We had more members, advisers on it, myself included, than any other nation. Also that is true of the lower level committees. The United States and the United Kingdom pull well above our weight in that international co-ordination.[266]

The Government told us that, in addition to working with the WHO and ECDC:

> the UK had bilateral relationships with Australia, Canada and USA to facilitate rapid sharing of new epidemiological and clinical data on the virus as the pandemic developed.[267]

261 "About WHO", *World Health Organisation*, www.who.int

262 "About WHO Global Influenza Programme", *World Health Organisation*, www.who.int

263 "WHO Collaborating Centres for influenza and Essential Regulatory Laboratories", *World Health Organisation*, www.who.int

264 "About us", *European Centre for Disease Prevention and Control*, www.ecdc.europa.eu

265 Ev 97 [Government Office for Science and Cabinet Office]

266 Q 29

267 Ev 98

227. While it appears to us that international coordination was, on the whole, sufficient, Professor Ferguson highlighted one failing, which was that:

> while Governments and countries are happy to share analysis—their view of the situation—they are rarely willing to share the detailed data they are collecting in real time, or at least some of it. [...] we had very detailed data from the US CDC, data from Mexico and other countries. We couldn't share it with the other partners we were working with. We could only share a kind of synthesis. [...] it was not so much of an issue last year because it was relatively mild, but there were instances where, had we been dealing with something more serious, it could have posed some problems and we could have lost some efficiency about that inability to share raw data.[268]

He also suggested that it might have been helpful to share high-level documents such as the Cabinet Office's Situation Report (SITREP) with the White House and US Centres for Disease Control (CDC) and similarly for the US to share their high-level documents. He explained that:

> A lot of the information flowed in the informal ways, but the formal sharing of those confidential documents proved impossible. With time, we could have had those formal agreements in place to allow that even closer sharing. It was probably easier between the UK and the US than many other pairs of countries.[269]

228. **We conclude that there needs to be a better mechanism of data-sharing, particularly sharing of raw epidemiological data. We recommend that the UK, as a member state of the WHO, propose the formation of an international working group under the WHO to discuss how to share effectively epidemiological data between countries in the run-up to a new pandemic.**

268 Q 29

269 *As above*

8 Conclusions

229. There are three key phases of any emergency; preparation, response and recovery. Scientific advice and evidence can have a key role to play in every phase. We found that, although the Government generally seeks and acts on scientific advice and evidence in the response phase, it was not clear how science was used in the preparatory stages, particularly in the National Risk Assessment. The volcanic ash emergency of April 2010 was a clear example of how a lack of risk assessment and preparation can hamper the emergency response. To a certain extent, the Government is learning the lessons of previous experiences. We are pleased that space weather is currently being considered for the 2011 National Risk Assessment and that scientific advice is being integrated from the start. The Government Chief Scientific Adviser's review of some of the concepts used in risk assessment is also welcome, although his involvement is certainly overdue. However, **we are concerned that the Government's attitude to scientific advice is that it is something to reach for once an emergency happens, not a key factor for consideration from the start of the process. We conclude that scientific advice and an evidence-based approach must be better integrated into risk assessment and policy processes early on.**

230. The SAGE mechanism was apparently useful to Government, but we are not sure what codes, principles or guidance govern its operation. **We do not accept that SAGEs should be given a *carte blanche* to operate however they please just because an emergency is occurring. We conclude that the Government Office for Science should take responsibility for ensuring that all future SAGEs operate in a more organised, transparent and accessible manner and adhere to a published code (existing or new).**

Conclusions and recommendations

Lead Government Departments (LGDs)

1. We consider that, more important than having a list of pre-identified LGDs, it is essential to have a flexible and fast mechanism to ensure that the most appropriate LGD is appointed. One of the Cabinet Office's first tasks in an emergency should be to review whether the pre-identified choice is most appropriate. During a long-running crisis where the emergency evolves and the focus of the response may change (for example, from the initial response to recovery phase), COBR should review the lead periodically. (Paragraph 38)

2. We recommend that, in responding to this report, the Cabinet Office clarify how it makes the decision to appoint the first LGD if one has not been pre-identified. (Paragraph 39)

3. We recommend that a LGD/LGDs for a space weather emergency be identified alongside the publication of the 2011 National Risk Register. (Paragraph 42)

Risk assessment

4. We are surprised and concerned that the Government Chief Scientific Adviser (GCSA) had no direct involvement with the National Risk Assessment (NRA) process until recently. In addition, we are concerned that the GCSA's oral evidence appears to be at odds with the Government on an issue that is a matter of fact—either GO Science and the GCSA are involved with the NRA process or they are not. We consider that science should be at the heart of the NRA process and ask the Government and the GCSA to clarify this matter. (Paragraph 54)

5. Severe weather is already included as a risk on the National Risk Register. We are disappointed that it appears, from the Secretary of State for Transport's comments, that the GCSA had little or no input to the risk assessments that must have taken place on severe weather. (Paragraph 55)

6. The Government Office for Science, working with the Cabinet Office, should be involved at all stages in the NRA. We recommend that the GCSA should be formally involved in the NRA process at a high level. The NRA should not be signed off until the GCSA is satisfied that all risks requiring scientific input and judgements have been properly considered. (Paragraph 56)

7. We recommend that the Government Office for Science, while remaining a semi-autonomous body, be located within the Cabinet Office. (Paragraph 61)

8. We recommend that the Government clarify why no review of the risk of disruption to aviation caused by a natural disaster, including volcanic eruptions, was undertaken in 2009; and provide the evidence behind the decision. (Paragraph 65)

9. It appears that there may have been a breakdown of communication between the earth sciences community and Government. We recommend that the GCSA assess

whether this was the case and improve the mechanisms by which scientists can engage with the Cabinet Office. (Paragraph 66)

10. We are pleased that the Government is assessing the risks posed by space weather ahead of the next solar maximum. This is vital given that the Government believes the National Grid could be at risk. The Government should take all possible action to put in place and coordinate resilience measures across different sectors. (Paragraph 69)

11. We are disappointed that the GCSA has little involvement with the Domestic Horizon Scanning Committee in the Cabinet Office. We recommend that GO Science and the GCSA consider ways of assessing the quality of the Domestic Horizon Scanning Committee's work. (Paragraph 71)

12. We recommend that, in replying to this report, the GCSA clarify why SAPER was abolished and to what extent its functions, particularly in planning for emergencies, have been retained and by whom. (Paragraph 73)

13. We consider that the NRA would benefit from more scientific scrutiny. We recommend that a new independent scientific advisory committee be set up to advise the Cabinet Office on risk assessment. This committee should review the NRA, setting up temporary sub-committees as appropriate. Having an independent scientific advisory committee for risk assessment to review the NRA would improve public and parliamentary confidence in a necessarily unpublished document. The committee should inform the judgement of the GCSA in ensuring that all risks requiring scientific input and judgements have been properly considered in the NRA and support his greater involvement with the Domestic Horizon Scanning Committee. (Paragraph 74)

Reasonable worst case scenario

14. We are concerned that the word "reasonable" appears to be influenced by the need to find a reasonable level of public expenditure for contingency planning rather than outlining the worst scenario that might realistically happen, based on the best available evidence. (Paragraph 87)

15. We welcome the fact that the GCSA is reviewing the concept of a reasonable worst case scenario. We request that, if possible, the results of this review are sent to us and published before any policy change is adopted. (Paragraph 88)

The National Risk Assessment and Register

16. We conclude that it should be clear what criteria are used in developing risk comparisons, particularly when they cut across Government Departmental responsibilities. We recommend that the Government clarify the common methodology and scale for assessing the likelihood of risks that are used in developing the NRA and NRR. (Paragraph 95)

17. We are concerned that the development of the NRA and NRR appears to be a "top-down" process hindering the involvement and influence of local authorities. This

situation is unsatisfactory. We recommend that the Cabinet Office review its procedures to ensure that the input of local authorities is given full consideration and appropriate weight. (Paragraph 97)

18. If it is the case that access to the NRR alone is insufficient to allow local authorities to assess the potential impacts of risks to local areas, and access to the classified NRA is necessary, then we question the operational value of the NRR. We recommend that the Government conduct a consultation with Category 1 emergency responders, including local authorities, to evaluate how useful the information on the NRR is for risk assessment and emergency planning. (Paragraph 98)

19. We recommend that the Government review whether those with appropriate security clearance outside of Central Government have difficulties accessing the NRA, and put in measures to resolve the problem. (Paragraph 99)

Behavioural Sciences

20. We are disappointed at the lack of focus on social and behavioural sciences in Government to date. We expect the newly established Cabinet Office Behavioural Insight team to provide input to risk assessment for emergencies. (Paragraph 108)

21. We would like to know whether and when a Government Chief Social Scientist will be appointed to replace Professor Wiles. (Paragraph 109)

Conclusions on risk assessment

22. Risk assessment underpins preparedness. In turn, risk assessment should be underpinned by the best available evidence. We were very disappointed to learn that the GCSA has had little involvement with what is a cross-Government process. It appears that, for both the volcanic ash emergency and the recent severe winter weather, the GCSA had been asked to provide advice after the emergency had happened, although we note with interest that the severe winter weather was not deemed an emergency. This is simply not good enough: scientific advice and evidence should be integrated into risk assessment from the start. (Paragraph 110)

Communication

23. If, following the GCSA's Blackett Review, the concept of a reasonable worst case scenario is retained, we recommend that the Government must make continual efforts to establish the concept of "most probable scenarios" with the public. While the Government should be open about the worst case scenarios being used by emergency responders, it should use the experience of the 2009 pandemic to emphasise the range and likelihood of various possibilities. While we do not expect this to remove all the problems associated with communicating risk and uncertainty, we consider that it may provide the public with a better sense of the likely risks. (Paragraph 123)

24. We recommend that there should be a single portal of information for every emergency, along the lines of flu.gov in the USA. This should be of use to members

of the public as well as emergency responders and should be the primary source of all information, linking to other websites as necessary. We consider that maintaining this portal should be the responsibility of the Lead Government Department, and should be located within its departmental website. (Paragraph 128)

Seasonal influenza

25. Although the Government response to seasonal flu goes beyond our inquiry, we were interested in the ongoing public concern over the risks of swine flu as part of the seasonal flu outbreak. This is unsurprising, given the fresh public memory of the pandemic and the Government's 2009–10 pandemic communication programme, as well as the absence of a seasonal flu information campaign in 2010–11. The Government should carefully consider the public's assumptions about swine flu (or any new flu strain) when communicating the risks of that strain in the context of seasonal, rather than pandemic, outbreak. (Paragraph 132)

26. We recommend that the JCVI conduct a comprehensive review of the benefits and risks of extending influenza vaccination programmes to all children under five, drawing on the experiences of countries, such as the USA, that already have policies of vaccinating under fives. (Paragraph 133)

Scientific Advisory Group in Emergencies (SAGE): code of practice

27. It remains unclear to us whether the Code of Practice for Scientific Advisory Committees applies to SAGE and we seek clarification on this issue. (Paragraph 142)

SAGE: membership

28. We ask the Department of Health to clarify how the gap caused by the lack of a statistician on the swine flu SAGE was addressed. (Paragraph 150)

29. Although it may not be appropriate to name some members, we see no reason why the membership of SAGE should be kept wholly secret for civil emergencies. In line with the Code of Practice for Scientific Advisory Committees, which states that SACs should operate from a presumption of openness, we recommend that SAGE members and their declarations of interest are published once initial membership has been established. (Paragraph 152)

30. While an initial lack of balance on SAGE can be later addressed through the addition of members or formation of sub-groups, we consider that it would be desirable to strike a suitable balance of expertise from the start. The first step is to ensure that key experts are identified through the NRA process. We conclude that if risks and Lead Government Departments can be identified in advance, the Government could also pinpoint possible expert advisers who may be called upon to provide advice in the event of an emergency. (Paragraph 154)

31. We recommend that GO Science, working with Departments, develops and maintains a directory of scientific experts who can be called upon in emergencies. The directory should include information on expertise area, current security clearance and previous experience advising Government. We anticipate that focus

should be placed on the risks identified in the NRA, although not exclusively. We conclude that having a SAC for risk assessment in the Cabinet Office, as we recommended above, could also assist GO Science in identifying members for this directory. (Paragraph 155)

32. International sharing of scientific data and expertise will often be pivotal to the resolution of an emergency. We recommend that the GCSA clarify how he ensures that SAGEs draw on international expertise and what formal role SAGE members may play in this. (Paragraph 157)

33. We recommend that GO Science and the Cabinet Office develop an appropriate remuneration policy for future SAGE members by September 2011. We recommend that they also consider whether compensating SAGE members' employers would be appropriate. (Paragraph 160)

SAGE: transparency and openness

34. It is important that the existence of SAGE and how it can be accessed is made known during an emergency so that those with alternative, credible scientific views can contribute. Such input would need to be screened and evaluated, but that would be part of SAGE's challenge function. (Paragraph 165)

35. We consider that the Government Office for Science website should be the first port of call for information on every SAGE. We recommend that if GO Science provides the secretariat, details of members and minutes of meetings should be published on the GO Science website. If information on a SAGE is best sourced through the LGD, we consider that GO Science's website should link to the relevant Departmental webpage. It should be clear from GO Science's website where information on the SAGE is published, and how the secretariat can be contacted. (Paragraph 166)

36. Although we accept that there are circumstances where a SAGE should operate in confidence, we see no reason why, after the emergency, minutes of meetings should only be released in response to a Freedom of Information (FoI) request. We recommend that all SAGE meeting minutes and other documents which would be made public following a FoI request are published immediately, in full or redacted form as appropriate. (Paragraph 167)

37. We are concerned that the SAGE mechanism operates under a presumption of secrecy rather than transparency and openness, and this was particularly and unnecessarily so during the volcanic ash emergency. (Paragraph 168)

38. We recommend that SAGE and its secretariat have a responsibility to identify and support SAGE members willing to communicate scientific issues to the public during an emergency. We further recommend that the GCSA and GO Science, in consultation with Cabinet Office and external centres of expertise such as the Science Media Centre, develop suitable protocols, procedures and guidance for SAGE members. (Paragraph 172)

SAGE: independence

39. While we do not doubt Sir Gordon Duff's independence from Government in his role as SAGE co-chair, it is still not clear to us how independence of the swine flu SAGE as a whole was maintained, particularly as it included Government officials. It is difficult to evaluate the independence of scientific advice when the operation of SAGE is confidential. (Paragraph 175)

40. We have stated previously that the ability to draw upon an existing SAC to form the swine flu SAGE was helpful. However, it must be made clear how SAGE retains a SAC's level of independence from Government. We conclude that clarifying a code of conduct and publishing the names of members of future SAGEs, with their declarations of interest, could only be useful in this respect. (Paragraph 176)

SAGE and other sources of scientific advice

41. While there will be scientific advice to Government from sources other than SACs, we see benefits in coordinating advice from SPI and JCVI for future pandemics. Given that the SPI advisory committee was effectively drawn upon to form the basis of SAGE membership, we consider that a future pandemic influenza SAGE should include members of the JCVI (in addition to the JCVI Chair) either as core members of SAGE or a sub-committee. This could speed up the process by which ministers receive advice on vaccination strategies while retaining the crucial challenge function. (Paragraph 179)

42. Because of the CAA's groundwork and the relatively late formation of SAGE during the volcanic ash emergency, it appears that SAGE contributed little to scientific understanding of the key issue: the ash tolerances of engines and aircraft. We question how much additional knowledge SAGE added to enable airspace to be reopened. (Paragraph 182)

43. While we take the view that there is merit in combining the forces of SACs such as SPI and JCVI under a SAGE for future influenza pandemics, we do not consider that the CAA's work on resolving the issue of ash tolerances of engines and aircraft during the volcanic ash emergency could have been carried out as quickly under the umbrella of SAGE, because of SAGE's more limited membership. (Paragraph 183)

44. The SAGE mechanism has been used twice, and is therefore relatively new. We expect the Government to have evaluated the impacts that both SAGEs have had and whether SAGE's ways of working need improvement. We recommend that, in responding to this report, the Government provide us with its evaluation on the effectiveness of both SAGEs. (Paragraph 184)

SAGE: secretariat

45. The Government should explain who provided the secretariat for the volcanic ash SAGE. (Paragraph 187)

46. Where the LGD is unclear or yet to be identified, we consider that GO Science should by default provide the secretariat to support a SAGE. (Paragraph 188)

SAGE: conclusions

47. We recommend that the GCSA either clarify what guidelines/codes of conduct apply to SAGE or, if no existing ones apply, produce guidelines governing how SAGEs should operate. The guidelines should address independence, transparency, confidentiality and the conduct of members, the Chair and the supporting secretariat. We recommend that the guidelines be published. (Paragraph 189)

Changes to the Health Protection Agency and Joint Committee on Vaccination and Immunisation

48. We recommend that the Government sets out how the independent advisory functions of the HPA and JCVI will be maintained. If any function of the HPA or JCVI is cut, we consider that a justification should be published. (Paragraph 193)

Use of Research Council resources

49. We are concerned that the delayed reimbursement to NERC for use of the Dornier 228 aircraft has damaged trust between the Government and the research community, with the danger that there may be reluctance to make such resources available in future. We recommend that the Met Office, whom NERC supported, and the Department for Transport, the LGD, take responsibility for ensuring that NERC is reimbursed in full immediately. (Paragraph 196)

Security and scientific advice

50. We consider that the Government must actively ensure that requirements for security clearance do not deter academics from providing scientific advice to Government. (Paragraph 202)

Office of Cyber Security and Information Assurance

51. In its response to this report, we recommend that the Government clarify the powers and funding of the Office for Cyber Security and Information Assurance. (Paragraph 210)

Space Situational Awareness

52. We recommend that the Government review the need for the UK to increase its participation in, and contributions to, ESA's Space Situational Awareness programme, following the outcome of the 2011 National Risk Assessment. (Paragraph 216)

Regulations on flying through volcanic ash

53. We are concerned that, when asked why the UK was unprepared for volcanic ash disruption, the former Secretary of State for Transport chose both to distance himself from, and to pass responsibility to, the CAA, a body for which he had ministerial oversight. This is unsatisfactory. (Paragraph 222)

54. We conclude that it is essential that the Department for Transport and the CAA sustain the ability, in the face of any new hazard, to access the full range of science, engineering, operating and regulatory resources necessary to determine whether existing regulations are adequate and appropriate. (Paragraph 223)

55. We do not agree that the closure of airspace imposed unreasonable restrictions upon operators. Given the uncertainties involved and the lack of prior risk assessment, it was necessary to take a precautionary approach until aircraft and engines tolerances to ash had been identified. We expect that, if a similar situation occurred in future, the UK would be better prepared to conduct analyses and make decisions on an appropriate emergency response. However, the Government will need to resolve the following three policy and process issues: (i) the CAA's contribution to EASA's decision-making processes; (ii) the suitability of the Met Office's computer predictions and (iii) the involvement of airline operators in decision-making. (Paragraph 224)

International data sharing during the swine flu pandemic

56. We conclude that there needs to be a better mechanism of data-sharing, particularly sharing of raw epidemiological data. We recommend that the UK, as a member state of the WHO, propose the formation of an international working group under the WHO to discuss how to share effectively epidemiological data between countries in the run-up to a new pandemic. (Paragraph 228)

Conclusions

57. We are concerned that the Government's attitude to scientific advice is that it is something to reach for once an emergency happens, not a key factor for consideration from the start of the process. We conclude that scientific advice and an evidence-based approach must be better integrated into risk assessment and policy processes early on. (Paragraph 229)

58. We do not accept that SAGEs should be given a *carte blanche* to operate however they please just because an emergency is occurring. We conclude that the Government Office for Science should take responsibility for ensuring that all future SAGEs operate in a more organised, transparent and accessible manner and adhere to a published code (existing or new). (Paragraph 230)

Glossary

ACMD	Advisory Council on the Misuse of Drugs
BGS	British Geological Survey
BIS	Department for Business, Innovation and Skills
BMA	British Medical Association
BNSC	British National Space Centre
BSE	Bovine Spongiform Encephalopathy
CAA	Civil Aviation Authority
CBRN	chemical, biological, radiological and nuclear
CCC	Civil Contingencies Committee
CCS	Civil Contingencies Secretariat
CESG	Communications Electronics Security Group
CME	coronal mass ejection
CMO	Chief Medical Officer
CO	Cabinet Office
COBR	Cabinet Office Briefing Room
COMAH	Control of Major Accident Hazards
Conops	Concept of Operations
CoPSAC	Code of Practice for Scientific Advisory Committees
CPNI	Centre for the Protection of National Infrastructure
CRR	Community Risk Register
CSA	Chief Scientific Adviser
CSOC	Cyber Security Operations Centre
CTC	Counter-Terrorist Check
DA	Devolved Administration
DDoS	distributed denial of service
DEFRA	Department for Environment, Food and Rural Affairs
DH	Department of Health
DoS	denial of service
DSTL	Defence Science and Technology Laboratory
DV	Developed Vetting
ECDC	European Centre for Disease Control and Prevention
ESA	European Space Agency
GCHQ	Government Communications Headquarters
GCSA	Government Chief Scientific Adviser
GCSEA	Government Chief Scientific and Engineering Adviser
GCSS	Government Chief Social Scientist

GO Science	Government Office for Science
HPA	Health Protection Agency
HSC	Horizon Scanning Centre
ICAO	International Civil Aviation Authority
IED	improvised explosive device
JCVI	Joint Committee on Vaccination and Immunisation
LGA	Local Government Association
LGD	Lead Government Department
MOD	Ministry of Defence
MRC	Medical Research Council
NASA	National Aeronautics and Space Administration
NDPB	Non-Departmental Public Body
NERC	Natural Environment Research Council
NHS	National Health Service
NIMR	National Institute for Medical Research
NRA	National Risk Assessment
NRR	National Risk Register
OCS	Office of Cyber Security
OCSIA	Office of Cyber Security and Information Assurance
OGCIO	Office of the Government Chief Information Officer
PHS	Public Health Service
RAS	Royal Astronomical Society
RCUK	Research Councils UK
RRR	Regional Risk Register
SAC	Scientific Advisory Committee
SAG	Scientific Advisory Group on Pandemic Influenza
SAGE	Scientific Advisory Group in Emergencies
SAPER	Scientific Advisory Panel on Emergency Response
SC	Security Check
SEP	solar energetic particle
SITREP	Cabinet Office Situation Report
SMC	Science Media Centre
SPI	Scientific Pandemic Influenza Advisory Committee
SSA	Space Situational Awareness
UKSA	UK Space Agency
WHO	World Health Organisation

Formal Minutes

Monday 14 February 2011

Members present:

Andrew Miller, in the Chair

Gavin Barwell	Pamela Nash
Stephen Metcalfe	Graham Stringer
Gregg McClymont	

The Committee considered this matter.

Draft Report (*Scientific advice and evidence in emergencies*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 230 read and agreed to.

Annex and Summary agreed to.

Resolved, That the Report be the Third Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

Written evidence was ordered to be reported to the House for printing with the Report (in addition to that ordered to be reported for publishing on 13 and 20 October and 1 December).

Written evidence was ordered to be reported to the House for placing in the Library and Parliamentary Archives.

[Adjourned till Wednesday 16 February at 9.00 am

Witnesses

Wednesday 20 October 2010

Wednesday 3 November 2010

Wednesday 10 November 2010

Wednesday 17 November 2010

Wednesday 1 December 2010

List of printed written evidence

List of additional written evidence

(published in Volume II on the Committee's website www.parliament.uk/science)

List of Reports from the Committee during the current Parliament

The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

Session 2010–11

First Special Report	The Legacy Report: Government Response to the Committee's Ninth Report of Session 2009–10	HC 370
First Report	The Reviews into the University of East Anglia's Climatic Research Unit's E-mails	HC 444
Second Report	Technology and Innovation Centres	HC 618

Oral evidence

Taken before the Science and Technology Committee

on Wednesday 20 October 2010

Members present:

Andrew Miller (Chair)

Gavin Barwell	Alok Sharma
Stephen Metcalfe	Graham Stringer
Stephen Mosley	Roger Williams
Pamela Nash	

Examination of Witnesses

Witnesses: **Professor Sheila Bird**, Vice President (2006–09), Royal Statistical Society, **Professor Neil Ferguson OBE**, Director, MRC Centre for Outbreak Analysis and Modelling, **Justin McCracken**, Chief Executive, Health Protection Agency, and **Dr Peter Holden**, British Medical Association, gave evidence.

Q1 Chair: Can I, first of all, welcome our witnesses here this morning and thank you for agreeing to attend? You are aware of the terms of reference of our inquiry. We are going far beyond your particular areas of expertise, looking more generally at the way that scientific advice has both historically been dealt with by Governments in emergency situations, and then we are going to look forward to things that, perhaps, haven't been as serious yet, but we will see.

I start off by asking all of you to explain very briefly your organisation's role in both the preparation for and the response to the swine flu pandemic, and also it would be helpful if you would, as you go through, tell me whether you had much interaction with each other during that process, either before or during. Who would like to start? Perhaps Professor Ferguson.

Professor Neil Ferguson: My centre, which is funded by the Medical Research Council, was founded in 2007 as a translational science centre, which meant that we did theoretical research on the dynamics of epidemics, but we also promised that we would apply it to emergency situations in particular, and that was part of our remit. In the context of pandemic influenza we had a contract with the Department of Health that we would provide real-time analysis and modelling support for them. We also had pre-existing agreements with the World Health Organisation and CDC—Centers for Disease Control and Protection in Atlanta—to do similar sorts of activities, so very early on we were called in to assist in all three of those roles. I should say that that builds on a long history of us providing scientific advice in such outbreak emergencies dating back all the way to BSE (mad cow disease), and then the foot and mouth epidemic where, I and my colleague, Roy Anderson, were heavily involved, and then later the SARS epidemic. I interacted with many of the other panel members here today regularly.

Dr Peter Holden: Good morning. I am Peter Holden. I am the British Medical Association's lead on emergency preparedness. You have the details of the organisation in the written submission. I am one of the GPs' leaders. I am a working GP. I am also trained as a medical incident commander for major incidents. My job was, essentially, to operationalise and galvanise 10,000 independent businesses, the front line of the NHS, aka general practice. Yes, we had on-going dialogue three or four times a week with many of the organisations you are going to interview.

Q2 Chair: Mr McCracken?

Justin McCracken: Justin McCracken. I am the Chief Executive of the Health Protection Agency that was established in 2003 to protect the population of the UK from a wide range of threats, but particularly infectious diseases. So we were closely involved in supporting the Department of Health in preparing for the threat of pandemic influenza, working over the last five years, and obviously in the response to this pandemic. Our role encompassed disease surveillance so that we, the Government and, indeed, everybody, could have a good view of the progress of the disease both in this country and across the world. The provision of diagnostic testing to support the response both locally with the NHS and, of course, nationally in determining our policy and reference microbiology services so, for instance, to check whether the virus was developing resistance to anti-virals and so on. We also provided a lot of advice and operational support to the NHS and to Peter and his members in terms of the front-line response to the pandemic.

We provided information and advice to support Government decision-making based on the scientific work that we had done, and we provided advice to health professionals and the public in terms of appropriate response to the pandemic.

We also had an important role in development of vaccines, so we developed the seed strains which were used by the manufacturers to develop the vaccine. We then did trials of vaccine when it became available and, indeed, provided much of the evidence that supported the JCVI advice to Government around vaccine policy. We were involved in the modelling work, and our team worked closely with Professor Ferguson's people.

Last, but by no means least, we were involved during the so-called containment" phase—we had the operational lead in terms of the front-line response, working very closely with the NHS. So there is quite a wide range of roles.

Q3 Chair: Professor Bird?
Professor Sheila Bird: I was the Vice President of the Royal Statistical Society during the period of swine flu and was the Royal Statistical Society's appointed statistician member of the Scientific Pandemic Influenza Advisory Committee. As you are aware, that committee was in abeyance during the actual swine flu, and so my interactions during that time as a member of the committee were through email correspondence with colleagues in the Health Protection Agency and through the Chair to have input to the design of the FF100 cases and so on. My concern as a member of the committee had been on the use of representative sampling partly to reduce burden and to ensure that we had good surveillance designs.
One of my other roles at the Royal Statistical Society is in terms of public understanding of statistical science. And so the Royal Statistical Society was very concerned about the public face of the monitoring of the swine flu epidemic, and that occasioned our President to write to Sir Liam Donaldson and we were very pleased that some of the suggestions were acted upon.

Q4 Pamela Nash: Good morning. Thank you for joining us. I just wanted to ask each of you if you felt that the Government was as prepared as it could have been for the onset of swine flu?
Dr Peter Holden: In a word, yes. In fact, there was a step change in preparations, particularly for swine flu, in 2005. In fact, we were involved from the BMA side, as was the Royal College of General Practitioners with DH and various other organisations within DH from that step change, and things were progressing really quite fast. The pace of work through '07 and '08 was proceeding quite quickly. Indeed, we actually issued our first specific guidance to general practice before swine flu hit us. If we had had another four months we'd have actually been completely ready. So I think yes, it was, but you can never say you are 100% ready. If ever you have hit a major incident and you say you got it right, it's time to retire. It's never going to be 100% ready because you never know what; you never know when; you never know how long it is going to last, how quickly it will recede and whether it will come back again. So as with all preparedness, you have to have a skeleton plan. What clothes you put on the skeleton, be it a T-shirt and jeans or full mountaineering gear will depend on the threat you get, and you've got to be flexible.
Professor Neil Ferguson: Like Peter, I was heavily involved in the pandemic preparedness efforts at the Department of Health and the NHS from 2005 onwards. Those efforts were well progressed. I would say that most people in DH might say that it would have been helpful if the pandemic had waited another year. There were a number of work streams which were coming up to completion at the end of 2009 and weren't quite ready. I think one important point to note, though, is the reason we prepared so intensely for a pandemic nationally was the potentially extreme in terms of consequences but unquantifiable threat of a lethal bird flu pandemic. So I think nearly all the preparedness had focused on that worst case scenario, and indeed that's what warranted stock-piling of anti-virals and the huge investment of money, time and resources.
We had not considered as much as we might have done, first of all, how quickly we would be able to judge what the severity would be and how we would de-escalate the response to have a response proportionate to something less than that extreme worst case. I think that is really one of the lessons which, collectively, we are learning at the current time.
Justin McCracken: I think I would, by and large, agree with the other two witnesses, that the UK was very well prepared and certainly the WHO felt that we were among the best prepared countries in the world, and there had been a huge effort going on over about five years. Inevitably, that effort had prioritised what needed to be done so not everything was completely in place and ready. But, by and large, we were very well prepared and within what is always a resource-constrained environment, I think the degree of preparedness was excellent. So that enabled us, for instance, within days of the first case presenting in the UK, to have a diagnostic test capability at our Centre for Infections, and within a matter of a very small number of weeks we had rolled that diagnostic test right out across the country. None of that could have happened without the preparation that had been going on for some time. Although it is absolutely right that there are lessons to be learned because the pandemic that we got wasn't quite the one that we prepared for, I think the degree of preparedness was really very high.
Professor Sheila Bird: I would just add to that, that the prior analysis of those past epidemics was largely led by Professor Ferguson's team and was done to a phenomenally high quality. We knew as much as we possibly could from the analysis of past epidemics. I think also there was tremendous preparedness in terms of the virologists, as you have heard. I think internationally the UK's contribution to that is actually widely recognised.

Q5 Gavin Barwell: I want to pick up some of the comments that Professor Ferguson made, and ask a couple of questions about regional worst case scenarios. As a starter, how evidence based was the Government's reasonable worst case scenario for swine flu?
Professor Neil Ferguson: Can I, perhaps, pick up on that first? I think, maybe, it might be good to put that into context because the Department of Health had a preparedness plan for dealing with a pandemic. In that context, the reasonable worst case scenario, of course, is defined in advance of an event, and you are saying, "What should the NHS prepare for without any knowledge?" That reasonable worst case scenario was based on the mortality we saw during the 1918 Spanish flu pandemic—namely a 2% case fatality rate and a rather pessimistic, but I think reasonable, estimate of what's called the attack rate, what proportion of the people might get ill. I cannot, off the top of my head, remember the precise number of deaths, but it was intended to be a worst case for NHS planning assumptions.

Now, the term "a reasonable worst case" is, by definition, not an objectively definable term; it is a subjective term. One could take the other extreme, and I remember David King and Sir John Beddington challenging what we were doing by saying, "Well, if you look at bird flu, that has a 60% case fatality rate", so the reasonable worst case is, of course, that bird flu becomes transmissible and we get a 60% case fatality rate. That was felt certainly to be a worst case but almost unpreparable for. So from the point of view of something reasonable for the NHS to plan for and reasonable in terms of cost, that is why the Spanish flu example was used.

Moving forward to the pandemic, and this is where the concepts became muddied, we went from using, right at the beginning of the pandemic, that pre-existing reasonable worst case, to giving, effectively, what was an upper statistical confidence bound on our assessment of what the severity of the current pandemic was. That did not, perhaps, communicate as clearly as it should have done what we were doing, particularly to the NHS. Those estimates got revised really quite rapidly, so within a month we were down from about that 2% level closer to 0.4% case fatality. Six weeks later it was down to below 0.1%–one in a thousand case fatality. So the estimates went downwards over time. I completely accept that that posed significant communication challenges for the Department of Health, the Chief Medical Officer and the NHS.

A further problem was that there was about a three to four week lag between the group I was involved in coming up with new reasonable worst cases, and then coming into the public domain in terms of getting through the DH and Cabinet Office approval process. So what was in the public domain as a reasonable worst case was already behind the evidence, given how fast the evidence was building up.

I think it is perfectly valid to also ask why we didn't provide a best guess, a best estimate of what the fatality was. That did start to be done from about July-August onwards but was not initially felt to be the priority. That, again, caused a little confusion because the reasonable worst case got viewed as a prediction, which it never was. I have talked for long enough.

Justin McCracken: I agree with that. There is no doubt that the planning assumption that was built into the general pre-pandemic plan was well evidence based and was a good reasonable worst case assumption. I think there is no doubt about that at all. Then as the evidence developed of the particular characteristics of this pandemic it was a real challenge to develop—to, as it were, refine the planning assumptions—because the reasonable worst case was one end of the spectrum that was being used to drive planning assumptions through the health system. Of course, one of the complicating factors early on was that much of the early evidence was coming from Mexico, and the initial information, both about hospitalisation rates and case fatality rates, turned out, in the event, to be higher than the facts ultimately support because of biases in the data coming from there initially. So there were huge challenges for the modelling teams. I think the process that was used of getting the expert modellers from all the key groups together under the chairmanship of the Department of Health, to develop, broadly speaking, consensus views about what the projections were and, therefore, what reasonable worst and reasonable best case scenarios were to drive the evidence, was a good one. It is already accepted, I think, that one should re-look at the process in terms of how one develops planning assumptions, and Sir John Beddington, as I understand it, has initiated work in that area. Clearly, the communication of the reasonable worst case and, indeed, the basis for planning assumptions is a challenge that probably deserves a little bit more attention, despite the huge effort that was put into communication with, I think, by and large quite a lot of success, but in this one area, probably, there was more that could be done.

Q6 Graham Stringer: Does that mean the Mexican health authorities were not telling us the truth?

Justin McCracken: Professor Ferguson can probably answer that better me, but I don't think there is any question of their deliberately misleading us. I wasn't intending to imply that.

Q7 Graham Stringer: But the information was wrong? That is what the answer means, does it?

Professor Neil Ferguson: Yes. We worked with the Department of Health in Mexico in the early stages. The real problem is that all the surveillance was focused in hospitals so, by definition, if you look in hospitals, you see sick people. We knew. It was not a matter of us näively saying, "Well, this looks really serious because we are seeing deaths." From the very first instant, we anticipated that this would be the tip of the iceberg and there would be lots of mild disease in the community. We just couldn't say how many and, therefore, we couldn't put those deaths into context.

Justin McCracken: To give another example, we sent a team out to Mexico fairly early on in the event. We were identifying British tourists coming back from areas of the country and they clearly had swine flu at a time when the Mexican authorities were claiming that those parts of the country were disease free. Now, I don't believe that they were deliberately misleading us. They simply, as Professor Ferguson said, didn't have the surveillance in place to enable them to determine how widespread the disease was.

Q8 Gavin Barwell: I will just ask some follow-up questions while no one wants to come in. Thank you for your answers, because you pre-empted some of my questions about how the scenario was revised and some of the communication issues. I have two questions. What lessons do you think we can learn for the future both in terms of whether we should communicate just a worst case scenario figure or a range of potential outcomes? Also I was particularly taken with the point you made about the delay, this three to four week delay, from your group revising the figure to that revised figure actually coming into the public domain. Was it also taking three to four weeks from your group revising the figure for emergency respondents to get your revised figures?

Justin McCracken: May I answer the first point? Actually, the question is predicated slightly on a misunderstanding, but it shows how difficult communication is because it was not just the reasonable worst case scenario that was communicated to the press. It was, actually, the range of both the best and the worst. But, inevitably, I think the figure that the press focused on was the worst case scenario. I was at the press conference when Sir Liam Donaldson communicated the figures. I am pretty confident in my memory on that point.

Q9 Gavin Barwell: So in future would you give a mid-range figure from what you learned?

Justin McCracken: The difficulty of giving even a mid-range figure is the degree of uncertainty that is associated with it, but I think there probably is a case for that. I don't think you can escape from communicating a reasonable worst case scenario that you are going to use for your planning in your health care system, but I do think that more emphasis needs to be given to what I would call the more likely expectation. Others may have different views.

Professor Sheila Bird: Perhaps I could come in on that point. Of course, what was being given for each of the components was an extreme value. You can't multiply extreme values together unless you also multiply together the corresponding probabilities, and if you are not told what those probabilities are—Professor Ferguson referred to an upper figure of 95% confidence intervals—then you know that it is something that happens about three times in a hundred. If you multiply two of those together, then the joint rarity is actually nine out of 10,000, or 1 in a 1,000. And so that is the problem: if you are going to give extreme values you have to say how extreme each of these estimates is because the multiplication of extreme values has to be parallelled by the multiplication of the corresponding probabilities. As you would know if you were betting on the 2 o'clock at Newmarket that Hopalong was to come in on a 1 in a 100 chance, and also putting a bet on in York, on the 3 o'clock, that Sidekick was going to come in at 1 in a 100, the chance that both of those are going to be realised is 1 in 10,000. And so common sense as well as statistical science says, "Beware when you multiply extreme values."

Gavin Barwell: Thanks for the tips.

Dr Peter Holden: It actually gave us quite a major problem operationally in the consulting room. It is trying to get across to the public the concept of risk and the business of statistics. The whole problem with society is that it doesn't know how to live with risk, and it only reads what the press will print. It is about openness and communications. Certainly one of the issues we found with all this was that there is need not to panic everybody but, at the same time, there is a need to inform, and the question, is where does that balance lie? I happen to sit on PICO, the Pandemic Influenza Clinical and Operational Advisory Group from the CMO, and also EPCLAG, the Emergency Preparedness Clinical Leaders Advisory Group, and not even we had sight of the publicity campaign. So how on earth are we supposed, as front-line troops, to explain to people if suddenly something appears on a website? It is a problem of explaining to the public the whole business of risk and the whole business of statistics—so much so that the BMA is about to re-publish *Living with Risk* as soon as we can get it together because this is about that. It is about managing expectation.

I think the other thing we need to understand with these planning assumptions, and people can say that an industry was made out of this with these worst case scenarios, is that, on an operational front, we are operating with very little redundancy in the system. Therefore, we had to use the statistics to model different methods of how we would respond according to attack rates and according to mortality.

The other problem we've got is the just-in-time society. In 1957 most women didn't work; they stayed at home and looked after the children. In 2010, if we had had the same scenario, the health service would have been on its knees. Half its workforce is women. They would either have to choose between staying at home to look after the children because the schools had closed, or going to work. So we had to have all these scenarios. In an era of freedom of information, you have to be open. The problem is that the press only print what they want to print. I think that is where the Government has got to be quite clear in what it puts up on its websites, and it must put both sides of the argument. It's either both sides or nothing, and society will not tolerate nothing.

Q10 Chair: Those comments don't apply, I am assuming, to every risk that people face because people respond in a different way to the risk of a major disease problem from the world of medicine. Very few people take sufficient precautions against melanoma, for example. It is a risk they seem prepared to take.

Dr Peter Holden: Yes.

Q11 Chair: Is that a failing on the part of the medical professional in improving public understanding of risk, or is it that statistically it is impossible to communicate that in a way that is meaningful?

Dr Peter Holden: It's a bit of both, but it's also a little bit about the way the public views the learned professions and science. There is a temptation nowadays not to believe boffins and not to believe the learned professions. It is part of the way society has evolved. It is a communication issue, and it is one that we are seeking to re-address. Certainly in the medical profession, we resolved this year that we would completely revise and re-publish *Living with Risk*, because people have no concept about risk. That's what this is about. People had a concept that they were likely to get flu. What they didn't have a concept of was how bad it was going to be and what the results were.

I think the planning assumptions were right, and I saw most of them. I think they were right because even those of us who had spent time looking at this from an operational viewpoint had no concept of scale until we had looked at it and worked out what a 2% attack rate meant, and then all of the way down to 0.5%.

Q12 Gavin Barwell: I have a final question on this point about understanding risk. In our briefing we have the following sentence: "The Government's current risk assessment identifies as the 'reasonable worst case' a flu pandemic…with a clinical attack rate of 25% to 50% spread over one or more waves, and with a case fatality of up to 2½%." If I have understood that correctly, that is saying that is a pandemic which might kill about 1% of the population. "This is assessed to have a medium to high likelihood of occurring over the next five years." What is a medium to high likelihood?

Professor Neil Ferguson: Yes. The latter point, I think, is more questionable. Certainly the first description, I think, is perfectly reasonable. I would slightly challenge Sheila in the sense that that I don't think the 50% attack rate is at the 95% upper band. If you look at community illness, the 1968 pandemic had a really quite high clinical attack rate. It was probably close to that. The case fatality rate is more subjective; we don't formally use statistics. You can use statistics in a formal sense to try and estimate a case fatality rate but you are trying to estimate the overall attack rate in a pandemic, and that's even harder to do.

By late August we had a very good central estimate of what deaths would be in the UK. That was actually very readily calculable from what was happening in Australia, New Zealand and South Africa, in a rather simple way, but those estimates proved to be very reliable. Their pandemic was way ahead of ours. What lesson we learned is that it is probably more useful to try and project overall deaths, total numbers of deaths, than try to focus on multiplying two quantities together both of which are uncertain. So we have learned lessons there.

The other thing we are trying to focus on, more generally in terms of assessing risk early on, both in terms of ramping up surveillance and thinking about how to make better use of the data in generating estimates, is how could we do better next time in getting more reliable estimates of severity earlier on with less uncertainty? I am not sure whether that is possible, but certainly it would have been an advantage had we been able to do it.

Professor Sheila Bird: I think there are two points that I would hope that we would manage for the future. The first is to be clear about whether we are going to report suspect cases or virologically confirmed hospitalised cases. Different things happened in different parts of the United Kingdom on that. There is also, I think, a difficulty, in England at least, in being sure about the count of deaths because there is a gap in the registration system in England which does not apply in Scotland. In England there is no obligation that the very fact of death be registered if that death has been referred to the coroner whereas, in Scotland every death has to be registered within eight days of being ascertained, so that you know the fact of death, the date of death, the age of the person who died. You won't necessarily know the cause at that time. That may come later. But in England we don't have a complete registration system, which caused a great difficulty for our Chief Medical Officer, who had to make extraordinary personal efforts to try to establish swine flu deaths.

Dr Peter Holden: But there are enormous problems on the ground. People come in and think they have got flu, and they haven't got flu. How do you tell the difference between suspect versus confirmed? The confounder in this, of course, was the Tamiflu line. I laid a bet with my colleagues that it would take two days for the newspapers to tell you how to get Tamiflu and we were wrong—it was three. You answer the right questions, so you got your Tamiflu to take with you on holiday just in case. So that was a real confuser at the beginning. I don't know how we get round that.

Q13 Graham Stringer: Dr Holden, the BMA's evidence does not just refer to the difficulties in communicating with the public. It refers to the difficulties in communicating with clinicians, particularly about the use of anti-virals. How could that have been improved? In fact, doctors were reluctant to prescribe anti-virals to healthy adults, weren't they? Their advice was that they should.

Dr Peter Holden: Now it is all over, I will tell that I prescribed zero. This is the problem of getting a liberal, self-governing profession to understand that this is command and control. It is quite a hard concept to get across to people who are used to being their own boss, who are used to taking autonomous clinical decisions. I think where the problem comes is that most doctors, if a thing does not ring true, will ask questions, and they will say "Show me the science". That is a perfectly proper approach under normal circumstances. If it is abnormal, I think, actually, this is about trust. You have to trust the scientific advice you have had and you have to trust the system that has been built, because there is no place on final approach for five captains in the cockpit. So the confusion came in when we built the information cascade. It was built on the assumption of using the internet, which I think is a faulty assumption. If you lose your power supply, how do you get into the internet? That is just a starter for 10.

To try to ensure that everybody was singing from the same hymn sheet, the four big players, the Royal College of GPs, the British Medical Association, the HPA and DH, all agreed that we would cross-link our websites and make sure it was the same hymn sheet. I think we came unstuck because we were so keen to be up-to-date and offer timely advice, and it was a fast moving scene. I can't remember whether it was the 6 June or 2 June—this is not criticism of the HPA—but on that day two different versions of an algorithm came out, and that really confused people because they didn't know which they were working to. We should have said, "This advice is valid for 72 hours and will be reviewed." The fact that there may be something in the last 10 hours of that 72-hour block that is not up-to-date is bad luck. If you look at any major incident, no matter whether it is Tavistock Square, Hillsborough or wherever, you see that the key thing in managing it is communication. If that fails it goes down the pan. I think we all tried to be too up-to-date and, therefore, I think what we should learn from this is that there is a review date on this advice, and you accept that the advice that may be on the website could be a few hours out of date in pure science terms.

I think most doctors gathered fairly quickly that the places to look were those four websites, and they all carried the same information. Essentially, the HPA gave us the top line professional advice. The DH gave us the DH view on how we should operate, and that was informed hugely by the profession. The Royal College of GPs analysed what was there and put an international flavour on it. So you could look at all aspects. Now, many of us who are ordinary jobbing GPs found that all very interesting but actually we'd print off the nice coloured HPA flowchart that came out periodically because that would sit in your bag and in your consulting room.

There is a real risk of over-information here, and there is an argument that we should have one portal in these circumstances.

Q14 Graham Stringer: Right. So, effectively, the advice to doctors was to prescribe anti-virals. The doctors in Wales, Northern Ireland and Scotland weren't doing it, and there was a reluctance to follow that advice here. It was slightly worse than that. The advice to midwives on whether they should be vaccinated was different from the advice that doctors were given; is that right?

Dr Peter Holden: The midwives came out ex cathedra without telling anybody about this, and I think this was a free-thinking set of loose canons, bluntly, in their profession, and they were stamped on pretty fast because they had no evidence for what they were saying.

Q15 Graham Stringer: So how long do you think that advice was being given, which was different?

Dr Peter Holden: Probably under a week, I think, but once we found out about it, things moved extremely fast. Quite hard words were said at fairly high levels to the midwifery leaders that, "This is not helpful" because there was no science to what they were saying. I think the issue about Wales, Scotland and Northern Ireland is that we have a devolved administration as far as health is concerned, and I think that English doctors—English GPs—feel, not only in retrospect but at the time, that we were too trigger-happy with Tamiflu. I am open-minded about that. I was party to a lot of evidence that the ordinary GP wasn't. I think there was a genuine view that, if nothing else, if it would shorten the course of the illness by one day, that meant you got 10% more people back at work, and in a just-in-time society—this is what people forget—we were looking at dislocation. If this had really taken off, there are four days' food on the shelves, four days' fuel and seven days' pharmaceuticals. If the trucks don't roll, this nation doesn't work.

Professor Neil Ferguson: Can I, perhaps, just interrupt slightly? I think there was more consistency in the scientific advice than in the clinical advice to all three countries than perhaps was anticipated. It was always a scientific and clinical judgment that the people who should be prioritised for the use of anti-virals strongly are those people who were in the clinical "at risk" groups. I think the wording in England, at least—I think similar wording was used in Scotland and Wales—was that it was up to the clinician's judgment as to whether to use Tamiflu in other circumstances. The reason we went for both the National Pandemic Flu Service telephone hotline and a fairly liberal use of guidelines for using Tamiflu was because we were concerned that it would be difficult for GPs to immediately make a judgment as to whether somebody was in a risk group. The critical thing in a pandemic, for the use of these drugs, is to treat people as rapidly after they develop symptoms as possible. That makes triaging more challenging when you are dealing with, potentially, millions of cases. But the fundamental goal was to treat people most at risk of severe disease. In some sense, the treatment of other people was the means of trying to achieve the highest level of coverage of those risk groups as possible.

Q16 Graham Stringer: That takes me on to the point of vaccination, Professor Ferguson. The strategy on vaccination was to start with the most vulnerable and that was started on 21 October, and then on 19 November it was moved on to vaccinating children from six months to five years, I think. I received advice from some of my local health professionals that they disagreed with the national strategy. They thought it would be better to vaccinate the children first because you would increase your herd immunity. I've got two questions about that. The decision on 19 November to vaccinate children, was that a change in the strategy from the beginning? Secondly, would it have been better to start with children as soon as the vaccine was available?

Professor Neil Ferguson: Can I deal with the second of those questions in terms of prioritisation? There was a lot of discussion—not just in this country, but in the United States and the WHO as well—about which groups prioritise for vaccination. You are completely right that if you have vaccine available really quite early in an epidemic, then targeting the people who transmit the disease, and in this case had we been able to target all school-aged children, for instance, all the way back in August, then we probably wouldn't have had an autumn wave to this epidemic. We would have stopped transmission.

However, the reason we collectively advised on targeting clinical "at risk" groups is that it was always likely that we would be vaccinating in the teeth of the pandemic. In reality, by 21 October, which is when vaccination was started (though most vaccine wasn't delivered then), was approximately one week before the autumn wave of this pandemic peaked. In those circumstances, vaccinating the transmitters has very limited impact because a lot of the transmission has already happened and it takes vaccine between seven and 14 days to have an effect. So you are already on the downhill slope of the curve. What you can do in that case, though, is to reduce mortality in the people who are going to die in the tail end of the epidemic. That is the reason for prioritisation.

On the former point, and the decision to vaccinate two to five year olds, I have to say that I was, perhaps, a little surprised by that. That was not something that went to the committee that I sat on, the SAGE Committee. It may have been discussed by other advisory groups in the Department of Health, but it

was always going to be of marginal impact given that the epidemic was already largely over. I worried myself that it would lose credibility—that people would already view this not as a threat, so what was the justification for doing it? I felt that the justification in that context was a harder one to make for parents to vaccinate children in the general population. Clearly, in risk groups, if they enter into any of the clinical risk groups, they should be a priority.

Q17 Graham Stringer: That is interesting. Do I understand it correctly, that had vaccine been available earlier a different strategy would have been followed?

Professor Neil Ferguson: There could well have been. There is a lot of research and development going on about how we can speed up the manufacturing of pandemic flu vaccines. Currently they take six months to make and that is, basically, the timescale we had last year. If you could do it all in a month or two, and we were vaccinating in the summer instead, then the vaccination strategy may well have been quite different. That is not to say that we wouldn't have prioritised our clinical at risk groups, but there would have been, probably, a much bigger push to vaccinate school children before schools re-opened in the autumn. But we were never going to be in that situation, particularly given that vaccine was slightly delayed even compared with what we expected and only limited stocks were coming through in October. Most of the stocks came through later, and it made both epidemiological sense, from my perspective, and clinical sense to target those people who really had the highest risk of dying if they were infected.

Q18 Chair: Can I just pursue the issue about the different ways in which the nation states operate? There clearly are parts of the country—where Stephen Mosley and I live is an extremely good example—where the travel-to-work area is right across the border. Does it really make sense to have different health strategies to manage potential risk?

Dr Peter Holden: No. Disease does not respect political boundaries.

Q19 Chair: So why hasn't the medical profession made that abundantly clear?

Dr Peter Holden: We made it abundantly clear. The bottom line is that this is about political balls. That's the bottom line. Ministers were not prepared–you know. This was about countries reinforcing their independence in these matters. The medical profession always thought that a separate policy for each of the four countries was utterly crazy, and still think that.

Professor Neil Ferguson: There was a real attempt, at least at the high level, for co-ordination, though. The SAGE group, the Scientific Advisory Group, always had senior representatives dialling in mostly from Cardiff, Scotland and, indeed, Northern Ireland. Justin can talk to this. There was a real attempt to normalise surveillance protocols in the different countries. They were not always successful, but a lot of effort was put into that to try and get comparable statistics. They were not completely perfect, but I would say that if you have devolution, then that is an inevitable consequence. We are, at least, not in the Canadian situation where emergency management is really at the far extreme of that. So, from the point of view of dealing with emergencies, there clearly is a tension between command and control in devolved administration. I think the Canadian experience in the SARS epidemic in the provinces, which had a lot of autonomy which was then devolved down, was disastrous because they were basically unable to enact any sort of central control.

Justin McCracken: Perhaps I could just add to that. It is absolutely right that a huge amount of effort was put in right from day one to ensure, as far as possible, that there was consistency in approach right across the United Kingdom at all sorts of levels, so there were ministerial meetings, there were departmental official meetings and, indeed, the Health Protection Agency hosted daily teleconferences with health protection organisations right across the UK including the Devolved Administrations. So there was a huge amount of effort to make sure there was consistency. In, I think, the vast majority of areas, actually, the same approach was adopted at each stage in the different administrations. Anti-viral policy, when we moved on to the treatment phase, is something where there were differences, where decisions were made in the light, not just of the scientific advice from SAGE, as it were, the same to all ministers, but also the other factors which the different administrations had to take into account, such as capacity of health care system. My understanding is, first of all, that on the decision in England to offer anti-virals to all, I believe the Secretary of State did make it clear that that was a precautionary decision rather than one driven by scientific advice, and that it was also linked to capacity of the primary health care system in England, but I am sure there will be other witnesses who can help more on that point.

Professor Sheila Bird: I might just add that, on the design of the vaccine programme, as Professor Ferguson pointed out, if we were intending to vaccinate school children then, of course, the randomised controlled trials of vaccine would have had to weight their attention much more to children than to adults and senior citizens. And so the evidence base for the safety and efficacy of the vaccine also plays a part in public and professional views on the acceptability of that vaccine.

Q20 Stephen Metcalfe: You have mentioned SAGE a couple of times, which was obviously established once the emergency had been confirmed. How effective do you think SAGE was in advising the Government on swine flu? Did you think that the balance of experts on the group was correct and that they had a wide enough range of skills and disciplines to be able to come up with good advice for the Government?

Justin McCracken: Shall I start on that? I am sure colleagues will want to add.

This, I think, is the first time in an emergency that a SAGE has been pulled together as it was in this instance. This was a new part of the concept of operations in terms of the overall SAGE contingencies

response. My own assessment, having been quite closely involved in this event and having been involved from different perspectives in a number of other events is that this was actually a significant improvement in terms of the way in which advice can be delivered to Government. On the overall assessment of effectiveness of SAGE, I think, my personal assessment would be that it really was pretty good. Perhaps more importantly, I think, that Dame Deirdre Hine in her review was pretty positive about it.

I think in terms of the range of skills available to SAGE there was a wide range of different disciplines from modelling, virologists, epidemiologists and clinicians. So there was a wide range of skills available at SAGE. I think we were fortunate, the Government was fortunate, in the sense that there already was a Scientific Advisory Committee on Pandemic Influenza and it was, therefore, able, quite easily, if you like, to identify relevant experts to form a Scientific Advisory Group. So overall the advice was pretty effective.

If one were looking to see how could one improve for the future, I think being clearer about the limitations of what science could and couldn't do, particularly early on but also at other stages, would be very important, as would making sure that there was even closer joining up, as it were, between the scientific advice from SAGE and the public health advice from the Chief Medical Officer. By and large, that worked well but there were one or two instances where there were differences. I think those would be the two things that I would pick out.

Professor Neil Ferguson: I don't have much to add. I think there is always a balance. SPI was formed—the Scientific Pandemic Influenza Advisory Committee, to give it its full name. It's a huge committee, I think it's 40–50 people, and has a huge range of expertise, all the way from the social sciences, through to virology, clinicians and, indeed, modellers. Clearly, in an emergency that is an impractical size of committee to operate. You need something which is smaller and more agile. I don't know precisely what process was used, but basically the people with most expertise to give and most prior experience of being involved in emergencies or responding to things were engaged in the SAGE group, and it still had a breadth of expertise from social scientists to clinicians, representatives from the NHS and modellers. It was really quite a balanced committee.

I would agree with Justin that expectations of what could be done and what was achievable—for instance, in modelling, my own group, but also from the surveillance side—were perhaps unrealistic. That probably emerged from the fact that we had all been planning for this severe epidemic, where case diagnosis and estimating case fatality would have been easier, but we were dealing with something much milder, and that posed challenges. I would also agree with Justin that where it really fell down—I warned of this in advance because I have memories of the foot and mouth epidemic, where it was equally an issue—was the lack of apparent co-ordination between the Chief Medical Officer's operations and the Chief Scientific Adviser's operations. I would, frankly, have liked to see a committee co-chaired by both the Chief Medical Officer and the Chief Scientific Adviser. I think that would have aided consistency within the DH decision-making processes and with communication.

That is not to say that there wasn't co-ordination. Clearly, David Harper, the senior civil servant sitting on that SAGE group, talked to the Chief Medical Officer regularly and there was a lot of cross-briefing from the secretariat, but there was still a sense of disconnectedness. Clearly, it wasn't as bad as what happened in foot and mouth disease in 2001 with the Chief Veterinary Officer and the Chief Scientist barely being able to speak to each other, but had the situation been much more serious and we had been really facing something more like what we were planning for, those, let's call them, slight tensions and that lack of connectedness would have been much more serious and might have degraded our ability to give a coherent response.

Q21 Chair: Professor Ferguson and Dr Holden, please move out of the sun if you want to. It is not our intention to interrogate you quite in that manner.

Professor Neil Ferguson: Yes, it is quite bright.

Dr Peter Holden: I would actually echo what has just been said. I have one caveat and one additional point, because I sat on PICO, which was the clinical end of what were the three big committees. However, if you did just merge the three committees, the problem is, at the end of the day, the operational people—the guys who have got to deliver—and ourselves rely on the science. You mentioned about committees being too big. It was getting quite big at 24, and there comes a point where somebody somewhere has to make a decision.

There is one other point I would like to make about the expert committees in general. The workload on them was utterly phenomenal and we were all still trying to do our day jobs. This only ended just in time before some people would have broken. I'm afraid the Government has got to understand that if it wants these senior people to work on these committees, at a much earlier stage they have to be relieved of their routine duties. Any incident commander will tell you, "Divide your force in two and tell the first half 'Go home and go to bed for 24 hours. I'll call you then.'" You can't keep up indefinitely the pace that we kept up for nine months. I think there is a very real issue there for these very senior committees. They were working all the hours God sent. The meetings were being squeezed in between our other commitments—on the telephone, in person, and all the rest of it—and I think you really need to look at that, because we got away with it this time, but if that had gone on for 18 months you would have had people going sick—key people going sick.

Q22 Stephen Metcalfe: Having made that point to—

Dr Peter Holden: It is in one of our submissions. We don't make it quite as bluntly as I do. Normally I'm not allowed out without a choke chain round my neck.

Q23 Stephen Metcalfe: You mentioned the limitations that science has in these areas. I think, from what you said, you were confident that you were putting across the fact that this was all within the limitations of what you can predict and what you can say. Do you think those limitations were being heard by Government? Do you think they understood that as well, that there was enough two-way communication?

Professor Neil Ferguson: I think it was certainly understood by Sir John Beddington, who is a very eminent scientist. I think it was very well understood by Liam. I think there was a degree of frustration that more wasn't possible. In communicating to Ministers and COBRA and otherwise, it posed a significant challenge both for Liam and for John in saying, "Well, we've got the best scientific advice, but I'm afraid we can't really tell what you want to know." That's always a challenge. I think the limitations were well understood.

I mentioned before the agility of the policy-making process in emergencies. Clearly it is more agile than normally, but still, with the need for DH approval and Cabinet Office approval for revisions, how long it takes papers to get to ministers and the ministerial meeting cycle, that means that as you go further up the chain for approval, delays come into the system. That gives a potential for inconsistencies. I can remember one instance in June last year. We published a scientific paper on what our best assessment of the severity was from UK data. That coincided with Liam publishing updated reasonable worst case numbers. One was more up-to-date than the other, and it posed challenges. I got it in the neck, I think. I won't say from whom as I wouldn't be so undiplomatic. Those are the things which, if we think about a really major crisis where we have tens of thousands of people dying, we need to have greater policy agility and a better, more streamlined way of adjusting the operational response.

Another example about SAGE, and I am sure that Justin diplomatically might back this, is the containment policy which was adopted. There was limited scientific advice. SAGE had not been created when that policy was adopted. I might have advised that the name be different as we were never going to contain this virus. But the policy went on, I think, for a good three to four weeks longer than it scientifically and epidemiologically was justified, and it was posing a large burden on lab capacity and NHS responses. There were reasons for that. We can talk to them in a policy sense, but I think, again, had there been that greater flexibility and agility, we might have ramped down faster just as Australia and some other countries—including, frankly, the US—did. They did a rather faster job of ramping down their initial high level response and intensity.

Justin McCracken: Perhaps I could just follow up on that. Neil is absolutely right. First of all, the name "Containment" was a misnomer. It was never expected or intended that it could prevent the spread of the virus around the country. It was about delaying in order to enable the rest of the health care system to be more fully prepared for when there were a larger number of cases. It is absolutely right that the policy was pursued for longer than was justified by the science in terms of whether there was evidence of sustained community transmission, which was the trigger that had been decided.

Also, we hadn't anticipated the degree of variability there would be in terms of intensity of disease activity around the country. So we had hot spots in Birmingham and in London. Although I agree with the point about flexibility in terms of speed of policy making, a bigger issue was flexibility in terms of recognising that you could have different approaches in different parts of the country without being inconsistent. So if you have got a different situation on the ground, you don't necessarily want to apply the same policy right across the country. Undoubtedly, huge pressures were put on both health care and public health staff in the areas where there were hotspots. I think that is one of the areas that has come out of the review that has already been done, and that needs to be considered carefully in planning for the future, both recognising the need for the more flexible response but also having clearly agreed beforehand what the triggers would be to move from one area to another. As Neil will remember, there were lots of discussions about precisely what the trigger levels should be, because that was a bit of the planning that hadn't been completed.

Professor Neil Ferguson: Can I add one tiny thing to that because it may put into context why the UK was so conservative? This is a justification to some extent. It turns out that because we had the most advanced epidemic in Europe, the World Health Organisation's decision to move to phase 6, declaring a full pandemic, hinged on whether and when the UK declared it had sustained community transmission, because that would fulfil the slightly arbitrary criteria that the WHO set. So Department of Health officials and ministers were very conscious that the rest of the world were looking and, therefore, were being, I think, overly conservative in saying, "What is the level of evidence required to demonstrate this fact?" It went all the way through to mid-June when, in reality, I think there was a lot of evidence back in mid-May. I say that, because I was involved, as Maria Zambon was, in that emergency committee, so we heard both sides of it.

Professor Sheila Bird: If I can come in on the issue of the membership of SAGE, the science of statistics is about efficient data collection as well as about analysis. I think there was a gap because there was not a statistician member of SAGE. The information, the consensus statements and so on, which went to SAGE, which are now in the public domain, show that percentages, be they fatality rates or whatever, were quoted in those summary documents without there being an annex which summarised the basic data that underlay those estimates. Now, if I tell you that 11% of the population believes such-and-such, it matters whether I have surveyed nine people and one out of the nine told me they believed it, or whether it is a Gallup survey of a thousand. So I think that is important for us all, actually. If a professional statistician cannot appraise the precision of a percentage without knowing either its denominator or the standard error, then neither can anybody else. We need to know those essentials.

Stephen Metcalfe: Thank you very much.

Q24 Alok Sharma: Can I just turn to the question of how well the Government communicated scientific advice both to the public and also to the responders? I will read you a small extract from the BMA, who stated the following. I don't know, Dr Holden, whether you actually wrote this. They said: "Doctors felt overwhelmed by the volume of information about the H1N1 pandemic issued by various bodies, including Government. Key advice was lost within the large quantity of emails received which often duplicated information." Could I turn to you, first, Professor Ferguson, and just ask you, as a member of SAGE, did you actually feel comfortable in communicating openly with the media about the swine flu pandemic?

Professor Neil Ferguson: Absolutely. There were no restrictions put on me. I was asked to inform the Department of Health if I was doing so. I was so busy, frankly, that I actually did relatively little of it. It is very easy in such circumstances as an independent scientist to become a regular on media programmes. As you all know, even a five-minute slot on the *Today* programme takes nearly two hours out of your day to do. So I did it very infrequently. Overall, and I did talk informally to journalists on the phone quite a lot, I was quite impressed with the media coverage. There were some outliers but, generally, I thought the way the risk was presented was not inflammatory or exaggerated. It represented the uncertainty and it communicated policy decisions fairly well. What I am not privy to, and I had no sight of, was the torrent of emails that, I am sure, were going to GPs and clinicians in the NHS. I really just saw the public face of communication. I had a few concerns about the weekly CMO's briefings, similar to the Royal Statistical Society, in what they focused on and the presentation of certain numbers as if this was the number of cases in the country. I don't want to go into the technical details. I think those lessons have been learned, but you do need to have a consistent face for the media, and I was satisfied with the CMO being that role.

Q25 Alok Sharma: So you don't think, then, that SAGE itself should be providing advice to the public? I understand that you are now—

Professor Neil Ferguson: Individual members of SAGE did, myself included on occasion, talk to the media. I prefer talking to the media about things I feel particularly competent about rather than just acting as a generic source of scientific expertise to the media. That's an interesting question. Sir John Beddington and Sir Gordon Duff, the co-chairs of SAGE, did relatively little media work during the pandemic, and it was mostly the Chief Medical Officer. I think there are reasons to support having a single source, but maybe there were instances when a greater public visibility might have been good. Certainly it might have good that the public knew we existed and what we were doing, and that, perhaps, wasn't entirely apparent.

Justin McCracken: If I may, just to add to what Neil has said, I think there are two separate issues there. One is communication to professionals and, as Dr Holden has said, the four big organisations did try very hard to get our acts together. I think there are more lessons to learn about that because, quite clearly, despite all our best efforts, there was, frankly, an overload for front-line professionals.

The second point is to do with SAGE and the communication to the public. There was a huge effort put into communicating with the public. We had, initially, daily reports, then weekly reports. From, and I forget exactly when, a few weeks into the pandemic, the Chief Medical Officer instituted his weekly press briefings and we made sure that our weekly reports went out at the same time to avoid any confusing overlap. I think there would be benefit in considering—this links back to the point of closer communication between SAGE, the Chief Scientific Adviser and the Chief Medical Officer—linking some of the evidence that SAGE has considered to make sure that that is part of the same communication process. I think openness about SAGE, about who the members are, their conflicts of interest and the evidence which is presented to it, can only be helpful. I would distinguish between that and their advice to ministers in terms of policy; it would probably not be helpful to make that public contemporaneously.

Q26 Alok Sharma: So just following on from that, Dr Holden, whose job do you think it should be to co-ordinate the difference sources of scientific advice to clinicians?

Dr Peter Holden: I, first of all, would associate myself with all the remarks that have been made; I agree with them entirely. Yes, I did write that, or say it and it got reported. Normally, I believe in complete freedom of information. Part of my job as a doctor is to put a patient's fears at bay because they come in with information that they do not have the knowledge, experience or expertise to put into context, and context is everything. In a scenario like this, this is command and control. You have to accept that. I think, in fairness to ministers, that is why we have got four nation approaches. It is very fundamentally anti-democratic to go command and control, but if that is the survival of the nation, that's what we have to do. If you're in that mode, there is an argument that says that during the emergency there is a common portal of information in and out, to the profession and to the public. We will have the row afterwards. We have this sort of enquiry afterwards to sort out whether it was reasonable, but at the time there is not time for a discussion except among the experts as to what should be going out—what is reasonable. And at the end of the day under these circumstances, you've got to trust the experts. If we get it wrong/right, you can sack us later, but you've got to trust the experts. But I do think you very much risk a Tower of Babel unless you have the coms right. Coms are everything. Every major incident report that has ever come out of Parliament will tell you communications, in whatever way—whether there were not enough radios or we had too many sources of information—is where it goes wrong every time. So, yes, a single portal, I think.

Q27 Roger Williams: Perhaps I could ask Dr Holden a question. He said that the public have a very poor understanding of risk. I guess GPs, perhaps, have a very poor understanding of risk. I tell you a little anecdote, just to draw out the point. The daughter of a constituent of mine was showing symptoms of fever, upset tummy and pain, and was told not to go to the doctor's surgery because it was likely to be swine flu. The doctor then refused to come to visit because it could have been swine flu. In the end the constituent took her daughter to the district general hospital and in two hours she was being operated on for appendicitis. It is a two-way process between the public and the medical profession. I don't know if you would like to comment on that.

Dr Peter Holden: It certainly is, and there were other cases which will limit my comment because I am acting as an expert witness where there are legal implications. But I think what people need to remember is that general practice, in particular, is about balancing risk. If I took the "You can't be too careful" route, I could fill the hospital in two hours, never mind whether it is flu. It is about balancing risk. It is about common things being common and what's most likely in that patient, in that age group with those symptoms. I just hope the patient is better.

Q28 Roger Williams: Better now, yes

Dr Peter Holden: One of the problems is that there was a degree of confusion out there about whether you should visit or shouldn't. I took the view, as did quite a lot of my colleagues, that I came into medicine and I knew there was an infection risk and with infection risk comes the risk of harm to yourself. Many of us just got on with it. The reason that the advice was given about not visiting was, firstly, to dampen the public's expectation that a visit would always be forthcoming, because of the logistical problems, if the pandemic had hit us, of visiting everybody, because we could not have done that. There was not a chance in hell of doing that. So, yes, they got it out of perspective. It's a judgment call. I'm sorry for the patient.

Q29 Stephen Mosley: In your previous answers you talked a bit about the reactions of other countries. You have also talked a bit about the international dimension through things like the World Health Organisation. Do you feel that there are any elements of international co-ordination that could have been improved, and do you think there are any important lessons that we could have learnt from what happened elsewhere?

Professor Neil Ferguson: Could I start? I am sure Justin will follow up. There was a good deal of co-ordination. The World Health Organisation is a strange political body in some ways, but I would say that the UK is disproportionally represented. It was certainly true on the emergency committee. We had more members, advisers on it, myself included, than any other nation. Also that is true of the lower level committees. The United States and the United Kingdom pull well above our weight in that international co-ordination. I think, generally, the exchange of information through teleconferences, both bilaterally between countries and expert groups, experts such as myself included, and multi-laterally organised by the WHO, was excellent. The one failing, and we particularly experienced this, is that while Governments and countries are happy to share analysis—their view of the situation—they are rarely willing to share the detailed data they are collecting in real time, or at least some of it. So that put me in a position where we had very detailed data from the US CDC, data from Mexico and other countries. We couldn't share it with the other partners we were working with. We could only share a kind of synthesis. Again, it was not so much of an issue last year because it was relatively mild, but there were instances where, had we been dealing with something more serious, it could have posed some problems and we could have lost some efficiency about that inability to share raw data.

Justin McCracken: Just to add to that, generally, I do think that there was extremely good international co-operation and sharing of information. We heard promptly about the initial cases, once they came to the United States. From Mexico, obviously, information came through a little more slowly. We had really good co-ordination across Europe. I think we were very lucky that the flu expert at the ECDC, the European Centre for Disease Prevention and Control, is a former employee of the Health Protection Agency. He joined SAGE. We had very good sharing of information, much more broadly internationally, so we were able to send somebody to Australia to observe their flu season before we had our winter season here. There was very, very good sharing of information and, as Professor Ferguson has said, it is probably true that the UK played a very important role in that and really punched above our weight. Obviously, Neil has much better information than I have about the details of the raw data. I'm sure it would be preferable if more data could be shared more quickly. I think within the constraints of what is possible internationally, it is quite remarkable how much was shared how quickly.

Professor Neil Ferguson: Just going back, there is one thing which I think would have been helpful. In this country the Cabinet Office prepared a SITREP, a Situation Report, which came out initially daily and then weekly, which was a very useful synthesis of information, which my colleagues—I was out in the States a lot last year—would have been interested to share with the White House and CDC. Similarly, there were similar high level documents, situation reports from the US, which I also got to see which I think would have been helpful in the UK context. A lot of the information flowed in the informal ways, but the formal sharing of those confidential documents proved impossible. With time, we could have had those formal agreements in place to allow that even closer sharing. It was probably easier between the UK and the US than many other pairs of countries.

Q30 Stephen Mosley: Dr John McCauley, who is a Director of the World Health Organisation's Collaborating Centre has said that he was surprised that the WHO CC didn't have a representative on SAGE giving that international perspective direct to SAGE. Have you got any comments on that?

Justin McCracken: I was not aware of that comment, first of all. My perspective is that SAGE had very good information about the situation internationally, both that collected through the Health Protection Agency with our contacts, both formal and informal, with health protection experts around the world, and also through the direct input from the European Centre for Disease Prevention and Control. So my feeling is that SAGE at no stage lacked the up-to-date information about what was happening around the world.

Professor Neil Ferguson: I should say that Maria Zambon, who is head of the Centre for Infections in the HPA, was a member of the Emergency Committee of the WHO, and I advised that committee myself, and provided that international perspective. She just pointed out that John Skehel, who is the ex-head of the National Institute for Medical Research, which houses that WHO Collaborating Centre, was also a member of the SAGE group. So I would say that it was a slightly unfair criticism.

Professor Sheila Bird: I would like, if I may, to make two remarks on the international situation. Australia and New Zealand did a magnificent job in reporting in the *New England Journal of Medicine* on all of their confirmed swine flu cases that were admitted to intensive care. That paper was very valuable for us ahead of our second wave of infection.

The other remark that I would make is that almost every country, at the start of a pandemic, is doing virological testing to confirm its cases for a short period. Thereafter, there is overload on its virologists and it declares that, from a certain point onwards, we are not going to do confirmatory testing. Now, when WHO reports the number of confirmed cases around the world, it does not pay any heed to the fact that the United Kingdom was doing confirmation for six weeks, another country was doing confirmation for two weeks and another country was doing confirmation for 10 weeks. We would have a better appreciation of those numbers confirmed if people understood that routine confirmatory testing has to stop at a certain point because of overload, and the numbers of confirmed cases are not going to continue to go up because we're not doing the testing. That is not reflected in the international reporting, which is remiss.

Q31 Chair: My final question to you, if I may, is that, obviously, this particular emergency was nowhere near as serious as it had the potential to be. With hindsight, is it your judgment that there is sufficient scientific expertise within the civil service, or do you detect a problem? Secondly, would it be your view that things would improve if the Government Office for Science was located in the Cabinet Office?

Justin McCracken: Shall I start off? I am sure that my fellow witnesses will want to contribute. First of all, I can't think of any instance during this pandemic where any lack of or shortcomings in the quality of scientific expertise in the civil service were a limiting factor in terms of the scientific advice available to Government. I thought that the Scientific Secretariat to SAGE that was provided from the Department of Health did an absolutely outstanding job throughout. We talk about people being under pressure. They were under extreme pressure. So, in that sense, I do not think that there are problems in terms of quality or quantity. People had to work extremely hard. The Department was flexible at pulling in extra resource because it was in, as it were, crisis mode, but we would expect that to happen, I think. Equally, I'm not aware that the position of the Government Office for Science was a problem in terms of this particular incident.

Professor Neil Ferguson: I would reinforce much of that. I think that the DH Secretariat for SAGE was truly excellent. Partly because of the real investment in previous pandemic planning we had before there was a cadre of very senior civil servants in the Department of Health who had a very comprehensive knowledge of the science themselves and really were experts in their own right, and some very expert junior staff.

I would add to that. I think the creation, several years ago now, of the Civil Contingencies Secretariat in the Cabinet Office aided the response considerably as well, because now you have in the Cabinet Office a set of, maybe, less subject specialists but certainly people with a good scientific background in the understanding of risk and management of crises. The Cabinet Office briefing reports and situation reports were, I always thought, excellent documents put together by that team. So I think we are much better positioned now than, for instance, 10 years ago when I was dealing with foot and mouth disease.

In terms of location—I don't think it is my place to say—I can see advantages both ways. The home in BIS is relevant for the Chief Scientist's role as the face of science in British Government because that is where the Research Councils sit. Yet, in dealing with emergency response and in advising the Prime Minister, I could imagine that sitting in the Cabinet Office would be equally useful. I suspect that he spends half his time there, anyhow.

Professor Sheila Bird: I wasn't on SAGE but, obviously, the secretariat for SPI, many of whom transited to do the secretariat work for SAGE and were scientific staff in the Department of Health, providing the secretariat for all the Scientific Pandemic Influenza Advisory Committee and were excellent and, as colleagues have said, very well versed in the science.

Chair: Can I thank you all for very frank answers. We have slightly overrun because of the importance of your evidence. We may well follow up some of the questions in a little more detail. Thank you very much for attending this morning.

Examination of witnesses

Witnesses: **Professor David Harper CBE,** Chief Scientist, Department of Health, **Professor Sir Gordon Duff,** Chair of the Scientific Pandemic Influenza Advisory Committee, Department of Health, and **Sir Liam Donaldson,** Former Chief Medical Officer, Department of Health, gave evidence.

Q32 Chair: Good morning, gentlemen. Thank you very much for coming to see us, and apologies for running slightly late. The previous witnesses have given us a lot of food for thought and I am sure you will as well. We will try and keep this relatively sharp, if we can. You are aware of the scope of our inquiry. We, clearly, wanted to look at the expertise that you bring to this debate.

First of all, can I ask how well did SAGE function in particular in the swine flu epidemic? How were the members of SAGE identified? Was there a relevant balance of expertise represented or was there too much emphasis on modelling?

Professor Harper: Thank you, Chair, and thank you for the opportunity to come along and talk to you this morning. I think, maybe, if I could start, very quickly, just by introducing my colleagues, and then I will come to the question, if I might. On my right is Professor Sir Liam Donaldson, who was formerly Chief Medical Officer in the Department of Health, and on my left is Professor Sir Gordon Duff who, amongst other roles that he has been playing recently, was the Chair of the SPI Committee, the Scientific Pandemic Influenza Committee, and also co-chair of SAGE. I am the Chief Scientist in the Department of Health and also the Director General for Health Improvement and Protection. So if, maybe, I could start, then my colleagues can pick up some of the points in due course.

I think SAGE worked very well and it built on some of the lessons learnt from previous emergencies, not least going back as far as the foot and mouth disease crisis some years ago. Members were selected on the basis of their professional expertise and to try to cover a broad range of different interests, and in fact the majority of members were previously members of the committee that Sir Gordon chaired, SPI, and before that even members of the committee that I had chaired going back to 2005/2006, which was the Scientific Advisory Group set up to look at pandemic influenza preparedness.

When it came to establishing SAGE, the membership was discussed, of course, with the Government's Chief Scientific Advisor, Sir John Beddington.

Q33 Chair: When the committee was in session, there must have been instances where there was, at least, a minority view, dissent in the ranks somewhere. How were minority views or differences of opinion transmitted to Government?

Sir Liam Donaldson: Would you like me to answer that?

Professor Harper: Yes, of course.

Sir Liam Donaldson: I have two additional points to make, Chairman. The first one is a wider point about modelling, which isn't specifically the question you asked, but I do think that the role of modelling during emergencies, as compared to planning emergencies, is quite different. I think we did have some problems with the use of modelling data during the emergency, even though it was of enormous value when we were doing our plans before all of this happened, but I will just leave that aside.

On the meetings of SAGE, they were reported to the COBRAA Committee, the ministerial cross-government committee, every time it met, and the report was made by Sir John Beddington who was co-Chair of SAGE. My impression is that it was remarkable on how few occasions they disagreed. The only point I remember when there was quite a split in SAGE, and that was reported to the committee before COBRAA took its decision, was on whether anti-virals should be offered to all symptomatic patients or only high risk group patients. You can say, "Well, it's unfortunate that there was a disagreement", but the committee met, I think, something like 22 times, and there were only, really, one or two controversial sessions during that whole time. So I think that is pretty good for a scientific committee advising in a fast-moving emergency, but certainly the minority view was represented by Sir John before COBRAA took its decision.

Professor Sir Gordon Duff: Thank you, Chairman. May I revisit your first question, too, about the composition and the representativeness of SAGE or SPI, first of all? SPI, which arose from the previous Scientific Advisory Group that had started in 2005, was essentially a scientific group for preparedness for a pandemic. When I was appointed in 2008 as an independent chairman, one of my jobs was to increase the number of independent scientists on the committee. In doing that, I took personal advice from major institutions, including both the Royal Society and the Royal Society of Edinburgh. Most of the people on SPI were in fact independent academics at the top of their fields. When the pandemic arrived and the Scientific Advisory Group for Emergencies was set up, it was a smaller committee, the core of which had been members of SPI, augmented by one or two extra leading experts in necessary areas.

With regard to your second question, Chairman, which was how dissent or disagreement was dealt with, I think what Sir Liam said was absolutely correct. We worked always very hard to achieve a concensus on all the difficult points. We were, I think, remarkably successful in that I only have a memory of one occasion when a majority vote was taken and, as Sir Liam said, that was from a total of 22 meetings during a time when there were quite a lot of decisions or recommendations that had to be formulated.

Q34 Chair: Am I right in assuming, Sir Gordon, that you periodically orally briefed COBRAA?

Professor Sir Gordon Duff: Yes. I attended most of the meetings as an observer, and on one occasion where Sir John Beddington could not attend I did the briefing as well.

Q35 Chair: So Sir John gave the routine briefing?

Professor Sir Gordon Duff: Yes.

Q36 Chair: But you were present at all times?
Professor Sir Gordon Duff: I was present pretty much at all times, not actually at every meeting. On occasion when he could not be there, I deputised for him.

Q37 Chair: Sir Liam, you weren't on SAGE?
Sir Liam Donaldson: No.

Q38 Chair: Should you have been?
Sir Liam Donaldson: No, Chairman. I think there is a potential conflict of interest there. I was the UK Government's Chief Medical Adviser and I had a responsibility, I think, to represent and comment on the scientific advice that was coming through. I think there are dangers in somebody in that role being locked into the main Scientific Advisory Committee. Nine times out of 10, I would, obviously, completely agree with the scientific advice, but sometimes in the world of public health, there are minority views that some people try to portray as crankish views. If we look back, for example, to the BSE crisis, what we saw there was scientific advice coming through at one point, which was absolutely crucial, which said there was no risk to the public from BSE. Now, I think in that situation it is the Chief Medical Officer's role to say to the Government, "Well, that is the mainstream scientific view, but you need to be aware that there is a minority view which holds a totally different position," and to be able to explain in simple terms what the pros and cons of those are. Now, in the situation of the pandemic, there wasn't an occasion where I disagreed with the scientific advice, but I think it was important that I had that distance.

Q39 Gavin Barwell: Professor Harper, you referred in what you had to say about the lessons which have been learned from previous issues which were applied this time. What would you change about the operation of SAGE going forward? What have you learned from this particular pandemic?
Professor Harper: I think SAGE operated well, as I said, to start with. I think one of the issues is, really, to pay particular attention to the links that Sir Liam and Sir Gordon have just alluded to, to make sure that where there are sources of advice that we are able to have the discussions properly within the framework and anticipate any differences of opinion that are almost inevitable with any high quality scientific discussion to be able to accommodate those properly in the framework.
I think the other issue is really about communicating, and we might want to come on to this, or you might want to come on to it, later, communicating uncertainty, particularly with an issue such as pandemic influenza where, inevitably, in the early stages of the pandemic there will be great uncertainties. It is a new virus by definition. We don't know what the disease profile is. Sometimes getting across those messages requires particular communication skills, and I think, perhaps, SAGE could have played a different part in communicating to the professional groups out there so that we could help communicate some of those uncertainties.

Q40 Gavin Barwell: I have a question for all three of you. Going beyond just the role of SAGE, what lessons do you think the Government as a whole should draw from the pandemic, that it should apply to future outbreaks of pandemic influenza?
Professor Harper: If I start and then, I am sure, my colleagues will pick up. From very much a personal point of view, and I made this point in contributing to the WHO international review of how the pandemic was handled, I think there are three points that I would like to pick up. One is that within the UK we were able to adopt some containment. It was called "containment" in the early stages of the pandemic. Given you are the Science and Technology Committee, I should qualify that. It was always recognised that this, actually, was not containment. It was used as a shorthand for handling the initial phase of the pandemic. I think we have to be very clear in communicating that but also for the professionals involved in managing that initial phase of the pandemic, what the objectives are, what the scope of that phase might be. So that is one.
The other two are closely related, really. It is the flexibility that, I think, we should look very carefully at for the future; flexibility for local response, flexibility internationally as well, given the leading role that the World Health Organisation played in the pandemic and the declaration of the pandemic and the criteria that we used to go into the decision to declare a pandemic. Some of the flexibilities around those areas are very important indeed, and I think we need to pay particular attention to that. I think the third point, which is linked to what I've said already, is how to communicate properly the uncertainty, but particularly where modellers are helping us in planning assumption terms, but when we talk about reasonable worst case scenarios, what does that actually mean, and try to get that message across more clearly. I think those are the three areas that I would pick.
Sir Liam Donaldson: Thank you. I think No. 1 priority should be to get a vaccine which is broad spectrum, and then we wouldn't have any more pandemics and, ideally, one that was cheap and easy to produce so that it would give long-term protection against all possible strains of influenza. That isn't impossible but it is, obviously, well on to the horizon and requires a lot of research. I would qualify that by saying that it may seem a dream but there had been very little research done on flu vaccines until avian flu came along because it wasn't in the interest of the vaccine industry, who were selling a new vaccine every year, to do a lot of research. Now we saw quite a lot of breakthroughs in the creation of vaccines during the phase of planning for a possible avian flu-related pandemic, and I think we should push even harder now to get that bigger breakthrough.
The second thing is, just picking up Professor Harper's point on the public communication of risk, as the messenger for the 65,000 figure which came from the scientific modellers, is that there is a big question about the public understanding of science, clearly. I spent a long time in that particular press briefing with the journalists, slightly short of pleading with them not to put out misleading information.

Apart from one correspondent, they didn't contextualise the figure at all. The modelling scientists would always say, "Well, even the 65,000 figure or figures like that held scientific water because those were the inputs that we had at the time", and then as they got more and more data, their number would come down and down and down. Unfortunately, that doesn't have much credibility with the public. They can't relate to that at all, understandably. So I think a great deal of care needs to be taken about the use of figures. I certainly felt that at the time. Even a back of the envelope calculation that I did suggested to me that we would get no more than a thousand deaths, but that was not the scientifically agreed figure. So I could hardly dissent from the bigger figure. So public understanding, particularly of that aspect of science, I think is quite important. If you become the subject of ridicule it can undermine public confidence in your whole programme.

Q41 Chair: Sir Liam, you are just describing things in terms of conventional historic ways of communicating to the public?
Sir Liam Donaldson: Yes.

Q42 Chair: Surely, had you had, right at the outset, a single flu portal, perhaps discussions with internet service providers to flag that up as the key source of information, you could have out-manoeuvred the red-top editors and have done a better job in managing public understanding?
Sir Liam Donaldson: With due respect, I think we did do a pretty good job on communication throughout. We had weekly press briefings. You won't find many journalists/health correspondents who would criticise. They were very open.

Q43 Chair: You have just said that only one journalist contextualised your answer.
Sir Liam Donaldson: That was on one press conference, on one out of 30 press conferences.

Q44 Chair: Had you done it my way through a single portal you would have been able to contextualise it in advance of the press conference?
Sir Liam Donaldson: Well, yes, possibly. First of all, we were only told a couple of hours ahead of the press briefing that we were entitled to release that figure, so it would have been difficult. So that was my second point on that particular aspect of public communication.
The third one is that I think it would help to have more flexible vaccine contracts so that you aren't committed to so much expenditure based on a precautionary approach. I know that is quite difficult commercially to do that, but in the end we ended up ordering and paying for more vaccine than we actually used. So that would be my third point.
Professor Sir Gordon Duff: Chairman, if I might go back to Mr Barwell's question, which I think was not specific to the pandemic influenza experience but what was learnt from that that could be generalised. Of course, there are many things. I would say from where I was standing or sitting, the key thing was to have identified beforehand what the key information needs were going to be. In the period of preparedness you needed to make sure, as much as you could, that you would know what you needed to know and set up the machinery for acquiring it as rapidly as possible so that you could deploy your counter measures effectively. That is a generalisable situation. In the case of the pandemic it is all rather easy. The two things that we needed to know were how fast the virus was spreading, and how severe was the illness, with a sub-set of questions about were there special groups in each category, where it was spreading faster or it was more severe. I would think that that approach is highly generalisable across any national emergency.
With SAGE I think we did pretty well in getting hold of the information on the spread. It took us a little bit longer to get hold of the information on how severe the illness was. We probably ought to have some legacy, ability, to track what is happening in the hospitals at the early part of an epidemic or a pandemic.
Sir Liam Donaldson: Could I just add something very quickly, Chairman? The amazing thing for me, having dealt with other emergencies over the years was there were relatively few surprises in this one. We had done the planning in advance for a more severe form of the virus, which is what was anticipated, but there were very few things that were unexpected apart from the mildness of the virus. That surprised me a great deal, because normally in an emergency you are being hit daily with twists and turns that you have got to react to and you hadn't expected. There wasn't much of that in this pandemic.

Q45 Stephen Mosley: One of the key features of the scientific advisory committees is that they are independent from Government and provide independent advice in a transparent manner. There is an impression that we have got, as the Royal Statistical Society has said, which is that when the SPI was suspended and SAGE was convened, that independent sub-committee effectively was in abeyance. The question that I would like to ask is, why was the SPI Advisory Committee absorbed into SAGE, and did it manage to retain its independence, and are actually are there any codes of practice out there that specify how the SAGE should act independently of Government?
Professor Harper: If I, again, could maybe start and I am sure that Sir Gordon, as the Chair of SPI and co-chair of SAGE, will want to add to this. Coming to the last part of the question, there are codes of practice produced. Well, there are guidelines, principles and a code of practice which in fact has just been refreshed and has been issued for consultation, I think, just last month in fact, from the Government's Chief Scientific Adviser, Sir John Beddington. These codes of practice and guidelines go back some way. I think the guidelines that have just been refreshed were published in 2007, and they are guidelines and codes of practice that are there to allow the framework to be created to preserve the independence of advice, which is very important given some of the changes that we are seeing currently in terms of our advisory non-departmental public bodies. So there are codes of practice and there is guidance there. Of course, as

Chief Scientist in the Department, I work very closely with Sir John Beddington, as he works with other chief scientists and chief scientific advisers, to make sure that between us we have the right sort of relationships with our advisory committees and with our executive non-departmental bodies to be able to protect and preserve that independence. I think the one part of that I would question slightly is independence from Government. I think it is very important that we have independent scientific advice, scientific advice from independent scientists, however they might be defined, but scientists who are at the top of their profession, who have professional integrity and are able to play into that fairly extensive machinery across Government. Sir Gordon.

Professor Sir Gordon Duff: Thank you, David. The transition from what we call SPI, which was the preparedness committee, to SAGE, which was the wartime real committee for the pandemic, was done in a way where the independent academic voice, the independent scientific challenge, was retained, so SPI had three sub groups. One was called Modelling, which you probably know about; one was called Clinical Countermeasures, and the third was called Behaviour and Communication. Those sub groups were actually used by SAGE going forwards.

The fact that I, as an independent, became co-chair of SAGE retains the challenge function. The challenge function is understood to be important but we also understand it to be only in the appreciation and interpretation of the scientific evidence. There is a distinction between that and its interpretation or translation into policy. So when it comes to challenging the scientific data and how it is being interpreted, I think SAGE had a very good and independent role in that and maintained that role throughout. I never really felt anything other than that the scientific advice that was coming through was the best possible scientific advice based purely on an appreciation of the data available.

Q46 Stephen Mosley: The other element to that is actually transparency. The SACs' guidelines and their transparency, their published minutes. There is an impression that SAGE is a lot more closed. Do you think that SAGE should be a bit more open to external scientific scrutiny, and also when it comes to you giving advice to the Ministers, do you get the impression that they do listen to your advice and, if not, do they give you an adequate explanation of why they have made their decision?

Professor Sir Gordon Duff: They are good questions. The first one, the way that SAGE had to work, I think, we have to put it in context, so we are talking about a preparedness committee that was meeting two or three times a year to, as it were, an emergency committee that was meeting weekly at the beginning and with sub-meetings in between. So the people involved had to be prepared and in a position to give up that amount of time. It was essentially a full-time job for the first few months. So that put some constraints on who could participate and who couldn't. Also the rate of progress, the rate at which things were going, made it quite difficult always to be as open, or appear to be as open, as we would like. We were most of the time adopting interim positions on a daily basis and it would have been extremely confusing to put out SAGE deliberations until they had crystallised on a given point. I think that is quite an important distinction between what happened between SPI and SAGE.

What was the second part of your question?

Q47 Stephen Mosley: It was more when you were giving SAGE's advice to the Government and the Government listens to that advice, and if they then make a decision do they actually give you an adequate explanation of why they've made the decision they did?

Professor Sir Gordon Duff: Don't forget, I observed rather than reported to the triple C, except when Sir John Beddington couldn't. My impression was that the scientific advice was taken extremely openly and given a lot of weight. I never heard a lack of response to the scientific advice. I'm not entirely sure that there was ever a time when the scientific advice was rejected. So I'm not quite sure whether I can answer your question, was an explanation given when it was rejected?

Stephen Mosley: Okay.

Professor Harper: Perhaps I could just add a few comments to Sir Gordon's. I think on the openness and transparency, the principle is absolutely beyond doubt, and that's the way that we encourage all of our scientific advisory committees to operate in the context of publishing minutes and maybe public meetings and so on and so forth. I think there is a difference that Sir Gordon alluded to here in the operational nature of SAGE and in its primary function of advising Ministers directly. I think the risk that needs to be balanced here is when we want open and honest discussion between scientists in the context of SAGE, we need to be careful, particularly if you look at reasonable worst case scenarios, whatever they might be, that information isn't available to a wider audience in—it sounds strange to say—less controlled way. One of the key features that you've already been focusing on is the need to put information to people in a way that they can understand it, that they can contextualise it and that they can appreciate the situation. There is a risk that needs to be counter-balanced there with high level, often very technical, complex scientific discussions. If the information is immediately available, there is a risk associated with that in this operational sense, but I stress it is in the context of SAGE working through the pandemic itself.

As far as Ministers and Government is concerned and the advice that was coming from SAGE, I'm not aware, or I can't think offhand, as Sir Gordon says, of any occasion when there was a reluctance to accept SAGE's advice. Sir John, as you have just heard, or Sir Gordon, were present at the COBRAA meetings, at the Civil Contingencies Committee meetings, to be able to make the input directly as co-chairs or as Chair of SAGE. Ministers have, without exception, been, I think, completely committed to using the best science. Science based and evidence based policy making has been to the fore throughout pandemic influenza handling and long before that as well.

Sir Liam Donaldson: If I could just add, briefly, it is important not to forget when all of this was going on that the science was being used to make lots of policy decisions quickly. There was a huge amount happening across Government with different Departments doing things, but particularly in the NHS. So we would be having to decide, "Do we need more paediatric intensive care beds?", because if we didn't have enough then children might die. "What are we going to do with the GPs who are being overwhelmed in London and the West Midlands? How are we going to get the supplies of anti-virals out?" So all of these things were happening. What SAGE was doing was providing and underpinning, scientific advice for some of them, but there were other areas where there was no science available to aid the policy decisions, but certainly SAGE was not telling the Government or advising the Government what policies to implement. There was another step which was often played out within the COBRAA discussions on what to do about the scientific advice, which didn't always have clear cut answers to it.

Q48 Graham Stringer: Sir Liam, in one of your previous answers you talked about smarter purchasing of vaccines.
Sir Liam Donaldson: Yes.
Graham Stringer: How much do you think could be saved in the future by smarter contracts?
Sir Liam Donaldson: I probably couldn't put a financial figure on it, and Professor Harper might want to comment because he was primarily involved in this. I do think that substantial sums of money could be saved.
Professor Harper: Well, I certainly wouldn't talk about individual figures. It depends entirely on the context.
Graham Stringer: It would be much more interesting if you did talk about individual figures.
Professor Harper: It depends on the vaccine, on the circumstances. What I was going to say was that we must always remember that we are part of a global market, and what contracts are let need to be seen in that context, so it's not as though the UK is in some privileged position in negotiating with any of the manufacturers.

Q49 Graham Stringer: I understand that. But what applies to the vaccine, does it also apply to the anti-virals? Is there, potentially, a great deal of money to be saved here if we think hard about the contracts for future emergencies?
Sir Liam Donaldson: I believe there is, yes, but I couldn't put a figure on it.

Q50 Graham Stringer: On both anti-virals and vaccines?
Sir Liam Donaldson: Yes.
Graham Stringer: That is clear even if it is not quantified. Thanks. I want to go back as well, Sir Liam, to another one of your answers. You talked about the "65,000 deaths" scenario. The discussion about that has been addressed a bit, but I was surprised that you were only allowed to release that figure two hours before the briefing with the press. Can you give us some background into the discussion that went on to the releasing of that figure?
Sir Liam Donaldson: Yes. There were two elements to the cross-Government emergency planning meetings, as you probably know. There was an officials' group, and then there was the ministerial group and they met on the days that the ministerial group met. The officials' group had met earlier in the morning. So they had already considered the various matters that were going to be discussed by ministers, including reports from the scientific committee. So, essentially, given that we had a weekly press briefing, the COBRAA ministerial meeting on Thursday was receiving for the first time the data on these modelling estimates. So we had to decide whether we told the press about it on that Thursday's briefing, which was happening a few hours later, or whether it was held back for a later briefing. Our view, or the view of the Ministers, the two Secretaries of State for Health who chaired the committees, Alan Johnson and Andy Burnham, was generally to be as open as early as possible, because if it had leaked out to the media we felt it would be more sensationalised. Now, it was sensationalised but I did my very best in that press briefing to explain at great length to journalists the nature of these figures, how they arose and to contextualise it, but it was to a degree sensationalised.

Q51 Graham Stringer: Was part of the contextualisation the number of deaths that there had actually been at the time of that briefing, and what was that number at the time?
Sir Liam Donaldson: The number of deaths at the time of that briefing, I think, would have been less than 200. I can't remember the exact figure.

Q52 Graham Stringer: And that was part of the contextualisation?
Sir Liam Donaldson: It certainly was; yes.

Q53 Graham Stringer: Can we talk about communications within the medical profession itself? The BMA were critical in two ways, really, in their submission to this Committee. One was that they were being bombarded with information from all sides and, therefore, it was difficult for them to extract the appropriate information, and then, secondly, when it came to use of anti-virals, they were unaware, in spite of all that turbulence, of the evidence base, and their instinct was not to prescribe anti-virals to adults, who were otherwise healthy apart from having flu. Do you think the BMA's criticisms about the communications are fair?
Sir Liam Donaldson: I think they are a little unfair. We dealt, on the GP side, with the two main groups, the Royal College of General Practitioners, who we used very, very extensively to monitor the quality of the flu lines and the National Pandemic Flu Service, to talk to their members and fellows and give us feedback and criticisms which we looked at on a regular basis. We also had regular contact with the BMA GP committee. It is worth saying, just out of completeness, that the BMA relationship with the Department of Health was also contractual. There were protracted negotiations on payment for

administration of vaccines and for delivering services. So they were both acting as a professional body and a trade union, and we were dealing with them in two different contexts at the same time. But I think the idea that we over-communicated with them is a little unfair because, really, at other times they were saying to us, informally, "We need to know more."

Q54 Graham Stringer: That really is the point. It is both too much information in some places and not enough in other places. That is poor communication, isn't it?

Sir Liam Donaldson: I don't think the communication with them was poor. We contacted them formally through letters from me. They were contacted through their representatives who were regularly briefed. As the pandemic was emerging, they actually requested that we set up the National Pandemic Flu Service because they were overwhelmed in volume of work in the West Midlands and in London. So I felt our relationship with them was good.

Now, on the anti-virals, that is a whole subject in its own right, because the scientific evidence base for the use of anti-virals in a pandemic does not exist. There is some evidence about the use of anti-virals in normal seasonal flu but not the huge amount. So, to a certain extent, and we were guided by SAGE here, we were deciding policy with an incomplete evidence base. Further research is needed on all of that and, hopefully, after looking at some of the data coming out of the pandemic at greater length we will be able to say a bit more about it. But the issue, centrally, was whether to be very precautionary, because we knew that some people who had symptoms of flu and no other underlying conditions, like diabetes or heart disease, died, not many of them, but we are in the 21st century, and we don't want people to die if we can avoid it. We also knew that anti-virals would probably reduce the severity of the illness, so the precautionary approach was to use the anti-virals more freely.

Now, it is fair to say that some of the opinion within the BMA was, "Leave that to the clinical judgment of GPs", but you can't really win on that. If you are less precautionary and give the anti-virals less freely, then your risk is that some people would die. I am afraid that in a situation like that certainly my view has always been to take the precautionary line, and that's why I strongly felt that we should be using the anti-virals. There were children involved as well, and some healthy children had died, and I just wasn't prepared to see us take risks with children's lives and adults' lives.

Q55 Roger Williams: I have a few questions on the way in which there was co-ordination with the devolved Administrations, and perhaps I could ask Sir Liam really. How did you co-ordinate with the chief medical officers of the devolved Administrations?

Sir Liam Donaldson: I know them all very well and we were always on very good terms. There is a regular quarterly meeting of the chief medical officers to cover all areas of mutual interest, not just this. It happened before the emergency. So we've been very involved with them. I had been very involved in working with them on the plans before all of this started, and during the pandemic we had regular teleconferences, usually, because it was very difficult to get everybody together face-to-face with everything going on. So that was the main way that we communicated. Occasionally, I would have one-to-one telephone calls with one or the other. As you can imagine, in a situation like this there are quite a few trouble-shooting things that arise and you want to know what somebody else is doing and get their experience. Generally, I think it worked very well.

Q56 Roger Williams: Presumably, the scientific basis on the decisions was the same for all the four devolved Administrations. So how come we had different strategies arising in different places?

Sir Liam Donaldson: I think that is the point I was making earlier, Mr Williams. On the move between the science and the determination of policy, there was a little bit of an area there where judgment was required, and I think that explains some of the differences which were not major. There were big discussions, particularly about the presentation and the timing of the presentation of information to the public. There were some heavy discussions at times on that, but I think on the scientific decisions there were only, really, two or three areas where there were, initially, quite big disagreements and then everybody, I think, reached a consensus. One was on whether to offer the anti-virals on a more precautionary basis, and part of that was determined by the fact that in England we were getting many, many more cases, whereas in Wales, Scotland and Northern Ireland they weren't, and they could still run the anti-viral prescribing through a conventional GP system. That explained that. Then when we get into the territory of negotiating with the BMA about vaccine payments and so on, then, as you can imagine, there were elements of frustration in that and differences of view on how that should be handled.

Professor Sir Gordon Duff: With regard to that, after the early part of the pandemic when the efforts were aimed at using these counter measures to slow spread, once we had gone beyond that, all SAGE's advice on the use of anti-virals has always contained the scope for clinical discretion. SAGE would never have wanted to advise that a prescriber or a doctor should not be able to prescribe if, in their clinical judgment, it was going to do more good than harm, and at the same time they should not be forced to prescribe if, in their clinical judgement, it was going to do more harm than good. So that was built into the anti-viral advice pretty much as soon as we came out of the first stage of trying to slow things down.

Q57 Roger Williams: In the report that Dame Deirdre produced, I think one of the recommendations was that there should be a clarification of the way in which the devolved Health Ministers received the advice from SAGE. Was that a good recommendation? Why do you need the recommendation in the first place?

Professor Sir Gordon Duff: We would have welcomed the representatives from the devolved Administrations at any SAGE meeting. I have got a

feeling that there was an open invitation. Certainly by the time that advice was transmitted to Ministers.

Professor Harper: Maybe I could say a few words in response to the question. Certainly with our expert committees, including the likes of the Joint Committee on Vaccination and Immunisation, which was one of the key committees as we moved through the pandemic, the advice that was provided was provided to the devolved administrations in just the same way as to England and to central Government. For the ministers, all of the appropriate ministers from the devolved administrations were involved in the Civil Contingencies Committee discussions, usually, in fact, almost exclusively, I think, by teleconference, but they were certainly involved. They heard the presentations from Sir John Beddington, from Sir Liam, Sir Gordon and others. So they were in possession of the same basic scientific and evidence base.

I think what Dame Deidre said in her report in fact–I know what she said–was that the model that was created of having the four nations ministerial discussions outwith the main CCC or COBRAA discussions was a very good model and it helped improve the speed with which some of the key decisions needed to be taken. She has held that up as an example of how to work in the future as far as the ministerial collaboration around some of these key areas is concerned.

Sir Liam Donaldson: The other thing to say, Mr Williams, is, obviously, as you can imagine, behind the scenes there were occasionally disagreements, but one of the areas which I think we hit for the first time in the relationship with the use of scientific advice was that there were a couple of occasions where Ministers, particularly from the devolved Administrations, felt that they had been given the advice in a very cut and dried way, without the chance to debate it. That is quite a delicate area, you see, because some people would say, "Well, for politicians to become involved before the scientists have given their advice is political interference." So there was quite a bit of tension at one stage. From memory, it was about the policy on vaccination because some of the Ministers held the view that they wanted to vaccinate school children and then others didn't, and the advice coming from the JCVI was, "No, there isn't a case for vaccinating school children." I think there was a feeling amongst some Ministers of, "Well, they've just told us this now. They have made their advice public. We're left with a fait accompli and we want to hear why they have decided this before they start telling the public what they've decided." So there was a little bit of a row behind the scenes about that. But I take the view that it is healthy that there is some disagreement and debate in these situations and there is not just a passive reaction to everything. That is the sort of territory that we hit for the first time–the idea of scientific advice being made public before Ministers had actually taken the policy decision based on the science–and it was a tricky area. It was only in certain conditions that it arose.

Q58 Roger Williams: In the previous Parliament, I sat on the Environment, Food and Rural Affairs Select Committee, and we did some very good and enjoyable reports on avian flu both from its agricultural perspective and its wildlife perspective, but also on the possibility of it crossing the species barrier and becoming highly infectious in humans. I remember the term "highly pathenogenic", well, certainly making you feel very poorly, anyway. I got the impression that the approach to the swine flu thing was ramped up because we were expecting an avian flu outbreak. I just wonder now, having dealt successfully with the swine flu outbreak, although there are some reservations, obviously, are we better prepared for an avian flu outbreak that could possibly occur?

Professor Harper: I think we are better prepared. As many people have commented, going through swine flu is the best possible test of how well prepared we were. A number of lessons were learnt, some of which we have touched upon, but I am bound to say, again, as we have already said, in the early days of a pandemic, with a completely new virus, with an unknown disease profile, it would be strange to think that the initial actions that were taken would be very different. In some ways, I am sure, there are refinements that could be made and we could talk more about that if you wanted to. But I think the principle is to try as hard as we can to get as much time as possible to be able to characterise the nature of the disease and so on, and that is as part of the global community, so that applies wherever the pandemic emerges, and, of course, it's conceivable that it could emerge in this country. I think with avian flu, in particular, the risk is more likely from those countries where there is close proximity of humans and birds, domestic fowl and the like.

With the great uncertainty in the early stages of a pandemic, it is very likely that we would be taking similar courses of action to try to learn as much as we could, as quickly as we can, about the disease.

Sir Liam Donaldson: I was just going to say, quickly, that I think there are two sides to it. I think, first of all, it has been extremely valuable in anticipating what might happen with a more severe strain of the flu. I think the particular value has been in testing the capacity of the NHS to respond because, essentially, we had anticipated in the planning that the NHS would be overwhelmed. Hence, we had to have some way of diverting the pressure with the use of the flu line, which was very, very effective. There isn't a completely right answer to that because people will always say, "Oh, you're giving anti-virals to people that don't need it. People are just taking them. You'll promote anti-viral resistance", all of this. We were in some cases quite close to the maximum on our intensive care beds, particularly for children.

Before we had all of this, NHS managers could not picture what it would be like to have thousands of extra cases flowing in. Now they can picture it, but what we would ideally like to be able to tell them, if we had a more severe strain, is, would it be five times worse, would it be 10 times worse, would it be 20 times worse? That's the way we've got to think about it, because if that NHS capacity failed then people would be dying, lying out in the streets outside the hospitals.

The other side of the coin, I think, is from the public perception point of view. They have been through a pandemic, they were warned that this was something very different, it was a pandemic, and they have concluded, probably, that it wasn't so bad. So will everybody take another pandemic seriously? So I think there are two ways of looking at it.

Q59 Roger Williams: It seems to me that preparedness for another pandemic is dependent on surveillance. As you rightly said, it is areas where contact between humans and birds is more close than it is probably in the developed world. Is there anything we can do on an international basis to improve surveillance and pick up any possible beginnings of an outbreak that could have severe effects in this country?

Professor Harper: This was part of the preparation, anyway, given the risks from avian flu. You will all recall, I am sure, some of the big meetings that were held as part of the international approach. Some of them were called "pledging conferences", where part of the objective there was to increase the resource available to those countries most in need, and part of it, under the auspices of the World Health Organisation, was to try to improve surveillance in those countries that perhaps didn't have the quality of surveillance that we have in the UK and in some of the other more developed countries. So that was always part of preparation. It will remain a big challenge because resources are limited and they need to be targeted. In some of the countries of most concern, most at risk for the reasons that you have just indicated, there are issues around health systems generally. It is about capacity and capability in a very broad sense, so surveillance is very, very important. I think we are better placed than we were and the recognition of that is clearer. The World Health Organisation has this key leadership role to play, as do some of the other international organisations, notably, the Animal Health Organisation–OIE–and others because this is very much an animal/human concern that we have. So those discussions are continuing.

The point that Sir Liam has made is a very good one. Having been through swine flu and it turning out not to be as serious as maybe some had anticipated, I think what Sir Liam was saying about the public in the UK is equally true of communities globally. So to have governments putting extra resource into surveillance of zoonotic infections in a country that has a huge number of other pressures will remain a big policy challenge.

Sir Liam Donaldson: The only thing I would add, and this is going a bit beyond flu viruses now, is that the area I do think does need more attention is the risks arising from a deliberately man-made, engineered virus that would be released and whether we have the security and policing of laboratories and of students to know whether that could happen. I do think that is an area which needs to be looked at more thoroughly.

Professor Sir Gordon Duff: Could I just go back to the very beginning of what you said? It is undoubtedly true that it was the H5N1 experience in the Far East that was driving the planning assumptions or the worst fears of a highly pathogenic, highly transmissible virus–a new virus. The problem is that decisions have to be taken at the outset of a new influenza before you have all the information that you need. So you have got to commission the vaccine as soon as you have got a vaccine seed before you know how devastating an illness it's going to be.

At the beginning of our discussions Sir Liam brought up a concept that I think is very key to going forward, which is more research, more support for research, for a universal flu vaccine. It wouldn't necessarily have to be a perfect vaccine in terms of protection, but as long as it would reduce both the transmissibility and the pathogenicity, the virulence, we would have no further need to plan for huge pandemics.

Chair: We will see later on this afternoon the probability of funding that kind of research. Gentlemen, can I thank you for your attendance this morning. It has been an extremely enlightening session. There may be a few follow-up questions we would like to write to you about following on from your evidence. Thank you very much for your attendance.

Wednesday 3 November 2010

Members present:

Andrew Miller (Chair)

Gavin Barwell
Gregg McClymont
Stephen Metcalfe
David Morris
Stephen Mosley
Pamela Nash
Graham Stringer

Examination of Witnesses

Witnesses: **Ray Elgy**, Head of Licensing and Training Standards, Safety Regulation Group, Civil Aviation Authority, **Dr Guy Gratton**, Royal Aeronautical Society, **Dr Sue Loughlin**, Head of Volcanology, British Geological Survey, and **Captain Tim Steeds**, Director of Safety and Security, British Airways, gave evidence.

Chair: Can I welcome you here this morning and thank you for your attendance. We understand that Dr Guy Gratton will be joining us shortly. He is delayed, compliments of the Tube strike, but hopefully he will be with us shortly. At that point I will, possibly, re-run some of the questions that we start with for him. Could I ask the three witnesses, first of all, to introduce yourselves?

Captain Steeds: Good morning. I am Tim Steeds. I am the Director of Safety and Security at British Airways.

Dr Loughlin: Hello. I am Dr Sue Loughlin. I am the Head of Volcanology at the British Geological Survey.

Ray Elgy: Good morning. I am Ray Elgy, Head of Licensing and Training Standards at the Civil Aviation Authority.

Q60 Chair: Welcome everyone. First of all, a general question for you. How prepared was the Government for the volcanic ash incident?

Ray Elgy: Perhaps I could start, if I may. I think the scale of the eruption and the prevailing weather conditions at the time caught everybody by surprise. We were prepared as an industry for the volcanic eruptions in the sense that these had been anticipated and exercises are conducted on a regular basis every six months to cater for volcanic eruptions, but the scale of that particular eruption, combined with the very unique set of weather conditions that prevailed at the time, quickly demonstrated to us all that the plans that we had were not adequate for that particular eruption.

Dr Loughlin: Unfortunately, I don't think the Government was well prepared. It wasn't particularly a surprise to the volcanology community that something like this would happen, but somehow that message hadn't got through to Government. Fortunately, the volcano community is quite well prepared based on our experience of Montserrat. So the British Geological Survey was managing between 1997 and 2008 the Volcano Observatory in Montserrat. There is a very explosive volcano there, very dangerous, so there is a community in the UK of BGS academics and many students who have got experience through that eruption. That network is in the UK. It is very experienced and, fortunately, was ready to go when this began.

Also the British Geological Survey had been in communication with the Cabinet Office about geological and geophysical hazards in general, so when this happened the Cabinet Office did know who to call. At least we were into the loop very, very quickly and able to provide advice very sharply. So that was good.

Captain Steeds: From our point of view, the Government, which is a very broad term, obviously, was unprepared. They may have run exercises, but we'd never experienced before the mass closure of airspace, which was the reaction of the Government in this case. It is hard to believe that anybody had thought of the consequences of closing the airspace in the way that it happened. We operate worldwide. We operate where there are volcanoes going off somewhere in the world every day. We have procedures in place and crew are trained what to do if they encounter volcanic ash. We have never, ever experienced a mass closure of airspace of the proportion that we got in April.

Q61 Chair: But you have experienced closures of airspace?

Captain Steeds: When a volcano goes off, the ICAO recommendation is to close airspace in the immediate vicinity of the volcano, and that is regular, but it is a small amount of airspace. Then the normal procedure is for the relevant VAAC to publish what they forecast as the volcanic output and then for the operators to decide where it is safe to operate.

If you take Montserrat as an example, earlier this year, or was it last year, we did not operate into Antigua because Montserrat was going off. There was nothing from the UK CAA to tell us not to operate. So we have a case of double standards, if you like, because we operate under an Air Operator's Certificate issued by the UK CAA. They oversee our safety worldwide, not just in the UK. They oversee safety worldwide. When volcanoes go off in other parts of the world they have never expected us to do what they required us to do with this particular volcano.

Q62 Chair: Could I just push you a little further? Is the worldwide advice broad advice covering volcanoes full-stop or does it differentiate between volcanoes that produce clouds with different particulate size or the quirks that occurred because of the explosions coming through the ice in the Icelandic case?

Captain Steeds: The basic ICAO guidance and the guidance from the airframe and engine manufacturers is to avoid flying in visible volcanic ash. That is ash that you can see.

Q63 Chair: Full-stop?
Captain Steeds: Full-stop.

Q64 Chair: Dr Loughlin:, you are clearly saying that the Government could have engaged better with the scientific community. They knew who to ask because of the advice you had already offered the Cabinet Office on broad geological issues. How would you expect them to have done that?
Dr Loughlin: There was an inquiry following deaths that occurred in Montserrat. One of the recommendations following that was that a single Department could be responsible for Montserrat. It's a joint effort between DFID in the early days and then FCO. If a Department had responsibility for volcanic hazards and risks then that might have been one way the message could have got through, and lessons learned from Montserrat could have been passed on to our experience in Europe. The problem in Europe, of course, is that Iceland is not the only place that has volcanoes. So, although we are now getting to grips with potential impacts from Iceland, there are also other volcanoes to consider.
There are a number of issues which we can, we should and we will take forward from this point to make sure that we are better prepared for future activity. We have been rather fortunate worldwide in the fact that there haven't been large explosive eruptions in recent decades. This is particularly the case with Iceland. There's been a bit of a lull over the last 50 years in terms of activity, but levels of activity are picking up now and they have been increasing since about the 1980s. Iceland scientists have published pretty solid data suggesting that there is a 140-year periodicity to the volcanic activity and that we are heading now towards a peak. It is absolutely imperative that we work now to ensure that we are better prepared for next time and that we consider not just Iceland but also the other volcanoes in Europe.

Q65 Chair: Was that advice about the Iceland data made available to the Cabinet Office before the events?
Dr Loughlin: No, not by us, but I do know that there were other scientists who had made reference to volcanoes. So, yes, it should have been more explicit, I think. The situation should have been made more explicit, but we were working in BGS, in particular, to get a range of geological and geophysical hazards considered, not just volcanoes.

Q66 Chair: Do you have anything to add, Mr Elgy?
Ray Elgy: Yes, if I may, Chairman, just to respond to the point that Tim was making. The advice that's contained in the Contingency Plan for Europe is entirely consistent with the advice that is provided worldwide. So what we saw in Montserrat, for example, is entirely consistent but on a completely different scale. Airspace in the local area for Montserrat would have been closed and airlines would have had to route round that airspace closure. It is just the scale of the event here and the weather conditions meant that that particular area of closure where the flow rate was closed down to zero was much bigger and in a very complicated and complex piece of airspace.

Q67 Stephen Metcalfe: Good morning. Casting your mind back to earlier this year, at what point do you think it became an emergency, and by the use of the word "emergency" I mean in terms of the fact it had such an impact on the running of the country and the operation of the airlines? Was it clear straightaway who was actually in charge within Government, who was going to take responsibility for this? I know you touched on that. Did it take a little time to work out who was actually going to lead on this?
Ray Elgy: If I may start, it was clear to us probably in the early hours of Friday and probably even late Thursday, on the Thursday evening. On the Friday morning the CAA realised that the potential for this period of closure was that it could be prolonged and that it was covering a great deal of airspace. Therefore, we took the lead. We felt we were best positioned and were very well placed to take the lead in corralling experts from around the world. The CAA, as the independent regulator, has experts in economic regulation, the Met authority, airspace policy, consumer protection and safety regulation. We have a broad network around the world and we felt that we were very well placed, given that network, to take a leading role to draw those experts together, which we did from that Friday onwards. So very early on would be the answer to that question about at what point did we realise it was going to be something different to what we would normally have seen in other volcanic eruptions.

Q68 Stephen Metcalfe: And the role with Government? You, obviously, did take the lead?
Ray Elgy: Yes.

Q69 Stephen Metcalfe: Who were you then dealing with within Government and how did they formalise the fact that you were taking the lead?
Ray Elgy: That was with the Department for Transport.

Q70 Stephen Metcalfe: So it was Transport, right, okay?
Ray Elgy: Yes.

Q71 Stephen Metcalfe: Were there difficulties? Was there some conflict between who was taking the lead within Government? Was it clear that it was going to be a Transport issue straightaway or did the Cabinet Office get involved?
Ray Elgy: From the point of view of the CAA, we were looking after the safety of the passengers, looking at trying to re-open as much airspace as we could and we are well placed as the regulator to do that. From our point of view, from the aviation sector, it was clear to us that we were very well placed to take that role.

Q72 Stephen Metcalfe: Did it work? Do you think that you taking the lead and then working with the Department for Transport was the right relationship or could, in hindsight, it have been different?
Ray Elgy: No. I think the relationship between the CAA and the Department for Transport worked very well. We kept them closely in touch with what we were doing with developments and the rate of progress that we were making.

Q73 Stephen Metcalfe: Do you have any views on it?
Dr Loughlin: I think it was clear to us very early on that this was going to be a cross-disciplinary problem and that it would include several Departments, including DEFRA, the Department for Transport and so on. It was also clear, therefore, that the Cabinet Office would need to take a co-ordinating role. So although the Department for Transport was the main Department affected, yes, it was clear that the Cabinet Office would need to co-ordinate it across several Departments.

Q74 Stephen Metcalfe: In your view, did they get involved quickly enough?
Dr Loughlin: Yes. Given that there wasn't planning, it happened extremely quickly and they had a great deal of information and advice very quickly on that first day from a whole range of people. It got into gear extremely quickly, yes.
Captain Steeds: From our point of view, the main Government agency that we dealt with, clearly, was the CAA and with the Department for Transport. There was disagreement within the CAA, within the different departments at the CAA, as to how airlines should operate. The Safety Regulation Department, basically, viewed the worldwide previous experience as the operator making the safety case and operating or not operating as the right way to go.
The Directorate of Airspace Policy is the department which issues the NOTAMs from the information provided by the Met Office, which closed the airspace. There was clearly disagreement between the two because you may recall that on the Sunday we did a test flight. On the Friday we tried to do a test flight because if you looked out of the window you would see clear blue skies and yet we were being told that it was dangerous to fly.

Q75 Chair: Just a second. Mr Elgy, you are disagreeing with that. Can we be clear where your line of disagreement is coming from?
Ray Elgy: Yes. There was absolutely no disagreement within the CAA whatsoever. We were very closely aligned in all the sectors.
Captain Steeds: On the Friday we asked permission to do a test flight. The Safety Regulation Department was happy for us to do a test flight. The Directorate of Airspace Policy was not happy for us to do a test flight and it took until Sunday to resolve that issue. NATS were unable to offer us a service. You cannot fly into controlled airspace without an air traffic service. Clearly, over the Atlantic and above 24,000 feet you are in controlled airspace. So we had to have the Directorate of Airspace Policy tell NATS that they were to provide us a service. So there was a NOTAM out issued by one part of the CAA closing the airspace. NATS were, therefore, unable to offer us a service. Therefore, we were not able to get airborne to conduct a flight test. It took a direction from the Secretary of State to the DAP to tell NATS to give us a service so that we could do our test flight on the Sunday when we encountered absolutely no ash at all. So to me that is confusion within the CAA. I apologise if the CAA disagree.
Ray Elgy: If I may, perhaps I could set that in context. There were two issues. One is the airspace issue itself and the way in which that was being managed, but it became very quickly apparent that the solution to this would be an airworthiness one. That was about how the aircraft systems and the engines themselves could tolerate ash. As we said before, the international advice at that time was for all aircraft to avoid ash.
From an airworthiness point of view, we were looking for a scientific-based—an evidence-based—solution to this. We were making sure that any evidence and any flights that were taking place provided some test points that we could use to build up that evidence base. So the British Airways flight was absolutely key in that respect. It took place on the Sunday, as Tim has said. It was planned very carefully and co-ordinated with the test aircraft that flew a very similar route beforehand so that we could align the test results from an instrumented aircraft with the results, effects and any adverse effects that might have been observed on the British Airways one. There had been a number of flight tests carried out over the preceding days but they were on instrumented aircraft.
Clearly, there are a number of other issues that are quite important such as the characteristics of the particular aircraft and the engine systems. So the British Airways aircraft, the 747, was quite different in terms of those characteristics from any other aircraft that had been flying, and that provided us with a very useful test point and data point in the evidence that helped us to re-establish or to establish a new limit of tolerance with the aircraft and engine manufacturers.
Chair: Gavin, you have a query.

Q76 Gavin Barwell: Can I get some clarity on these issues? Are you saying that it is true that BA wanted to do this test flight on the Friday and they were turned down but that was because you wanted to do these instrumented flights first?
Ray Elgy: We felt that it was very important that any test flights—any flights—that took place were useful from the point of view of providing evidence. It was a question of making sure that we could get a test flight, an instrumented aircraft flying a route, that the British Airways flight could then almost mirror. The British Airways test flight did take place on the Sunday and was providing real-time data down links to Rolls-Royce who were monitoring the performance of the engines throughout the duration of that flight.

Q77 Stephen Metcalfe: Captain Steeds, you seemed to have wanted to come in a minute ago.
Captain Steeds: It's a complicated subject but I have to disagree with my colleague from the CAA. The fact

is that even now there has been no change whatsoever in the engine or airframe manufacturers' view on the tolerance. The engine manufacturers all define "visible ash" as "2x10–3g/m3". Whether or not it is 2x10–3g or 3 or 4x10–3g is, frankly, irrelevant. They define it as what you can see. There has been no change in that. The CAA have been pushing the engine manufacturers to come up with some other figure, 4, 5 or 6x10–3g, but it is irrelevant because the position of the OEMs—the original equipment manufacturers—is avoid visible ash. As you can't measure on the day exactly what it is that you are going to be flying through, having a different limit is, frankly, irrelevant. What we need to do is to have a policy where we can define and the Met Office can tell us where they expect visible ash to be and then we will avoid it.

Q78 Stephen Metcalfe: I have just one minor question. Obviously, this was taking place in the run-up to the General Election. Did that have any impact or any effect on the way the system operated, or was that just a side-show that we were all involved with but actually it did not affect the scientific advice that the Government was receiving? It is to all three of you, I suppose.

Captain Steeds: It didn't affect us at all.

Stephen Metcalfe: No.

Ray Elgy: Nor the CAA.

Dr Loughlin: It didn't affect the advice that Government was receiving but I think it did—

Q79 Stephen Metcalfe: How it used it, then?

Dr Loughlin: Yes. I think it did potentially affect, perhaps, response and times. I believe there was some delay and some uncertainty about funding and such issues which would not have occurred if there hadn't been an election.

Q80 Stephen Metcalfe: Because Government Ministers were pre-occupied in other areas?

Dr Loughlin: Yes, and I think there was just uncertainty about who will be dealing with the issue and so on, and what policy will be in future. Yes, I think there were some delays over that period.

Q81 Stephen Metcalfe: Finally, how do you think the situation could have been improved? Could it have been improved—the co-operation between the Departments and the Agencies involved? What would your advice to us be to improve that into the future?

Ray Elgy: There are two points there. If I may come back before I answer your question to the point about moving the engine manufacturers, the reason that the airspace restrictions were able to be changed was because we did get the aircraft and airframe manufacturers and engine manufacturers to change the limits from 2x10–4g/m3 by an order of magnitude up to the 2x10–3 that exists now.

To come back to your question, I think for next time the important bit will be to co-ordinate better across Europe from a European dimension. There is work in place to improve co-ordination across Europe. There is a new emergency crisis co-ordination cell that is being set up. So within the UK, I am not sure that there is much that we could say would need to be improved. I think the big issue for us would be for Europe.

Dr Loughlin: There are a number of things. Obviously, you will discuss, perhaps, in more detail the modelling in the next panel, but a key to the modelling is the source term at the volcano. There needs to be a great deal more scientific research into volcanic processes, into how magma is fragmented, what particle size distributions are produced by different volcanoes and different eruption types. There is a huge variety, even just in Iceland. There needs to be much more work on finding default values. Some work has been started on this in the USGS, but default values for source parameters that can be fed into models, particularly in the early days of an eruption, when observations can be limited, when there is a great deal of uncertainty, will enable the modelling to get off to a good rapid start. There is a great deal of work that needs to be done in volcano science in that respect.

It would be good, of course, if this was mirrored by advances in research in aviation on a risk basis and dealing with engine tolerances and so on, and also in the meteorology community. I mean dealing with the transport of material and deposition of material.

We are working very closely with the Met Office and we are working very closely across Europe now, so there are a number of initiatives and worldwide. There was a meeting, for example, in Geneva just a couple of weeks ago where we had representatives from six of the VAACs across the world comparing models, looking at what the next steps should be in improving model performance and getting good observations to back up and validate those models. All this work is going on and it will, of course, feed into the next crisis.

I think all of this is a great step forward but the momentum needs to be kept up. More importantly, the funding needs to be supplied. That is a key issue because this was not available to us on the shelf when this happened. That is partly because of limited funding in the past for this sort of science.

Captain Steeds: Could I ask you to repeat what the question was?

Q82 Stephen Metcalfe: Yes. It was really how the strategic co-ordination between departments and the agencies involved could be improved. What have we learnt, which I think is covered, and how will that be used next time to improve the situation, especially for perhaps people like yourselves?

Captain Steeds: Firstly, just clarifying what visible ash is, the engine manufacturers did not change their limit. They just defined what they considered visible ash was. So originally all the airspace where there was any possibility of any ash at all was closed. Then when the engine manufacturers said that visible ash is 2x10–3 that area was published. Subsequently, a time limited zone with no time limit was published as well, which was 4x10–3.

In regard to what would happen next time, our fear is that next time we will be in exactly the same position as we were last time because, currently, as far as we can understand it, the CAA would take exactly the

same line that they took last time and they would close airspace, whereas in the rest of the world the VAACs publish the information. There is one area of radius 120 miles over the volcano that is closed for a period of six hours until the VAAC broadcasts start coming out. It is not true to say that the area over Montserrat was closed. It was closed when the volcano goes off for six hours, and then it is down to the operators. Worldwide it is down to the operators to decide. Uniquely, in Europe, when the CAA closes the airspace Europe follows suit, but it is only in Europe. It hasn't happened anywhere else in the world. Our belief is that if the volcano goes off again tomorrow we will be in exactly the same position again.

Q83 Gregg McClymont: Can I relay to you a quote from British Airways and then ask Captain Steeds and then the other witnesses to comment on it. "Blue skies prevailed over much of the predicted area of contamination for the majority of the time that the volcano was erupting but this evidence was not taken into account by government agencies. They contradicted ICAO guidance and imposed unreasonable restrictions upon operators against established protocols." Can I ask Captain Steeds to comment on that?

Captain Steeds: That is exactly our view. If you looked out of a window on these days, these were some of the best summer days that I can remember. Yet, somehow, the Government managed to persuade the public that flying in clear blue skies was going to be dangerous. Actually, nothing at all changed and, all of a sudden, the Government changed their view and flying in those clear blue skies was safe. From our point of view it was safe all along. If there had been visible ash we would have avoided it.

Dr Loughlin: I think everybody is aware of the two major incidents that took place in the 80s, basically where aircraft had serious impacts from ash and engine failure. There were opportunities following that to develop thresholds for aviation. As far as I am aware those thresholds were not still in place when this crisis began. So there was an ad hoc requirement to come up with these thresholds very quickly, which is what the CAA facilitated. As far as I am aware, those lower thresholds were not in peer reviewed literature when this began. So it was a situation that had to be rapidly put into place.

In terms of the blue skies, there were test flights. It is unfortunate that Dr Gratton is not here, but the Natural Environment Research Council and FAAM, which Dr Gratton represents—he will speak for himself later, I am sure—did test flights through UK airspace. As far as I understand, and I am not the expert, usually, that did detect ash where the models suggested the ash would be. Yes, it was at very low concentrations but there was ash up there. There have also been incidents where there has been damage to planes—okay, not total engine failure—in areas where there has been no visible ash. So this is quite a complex problem and it is not as simple as looking to see whether there is ash there or not. There are also issues of gas as well.

I am not an expert on aviation but, as I understand it, visible and visual ash is another complex area. It depends also on conditions of course. It depends on clouds and it depends on visibility. If you are considering satellite remote sensing visibility of ash, that also depends on cloud cover conditions. It depends on the altitude of ash, whether the ash is water-laden, whether there is ice cover. So this is not a straightforward issue either—what is visible and what is visual ash. There was ash up there, it was low concentration but it wasn't a simple issue of coming up with a threshold. That threshold was a complex issue.

Ray Elgy: I agree entirely with Sue. The test aircraft did fly during those days when it was a bright blue sky. They did detect ash. There is work on-going now in the ICAO Volcanic Ash Task Force, which has set up a number of different work streams, one of which is on the science in particular. We have asked them and the people in that particular team whether or not it is possible for ash to exist in a clear blue sky and they have said they can't tell. They need to do a lot of work to establish that. So the fact that it is clear blue sky does not necessarily mean that there isn't ash up there at a level that could have caused some kind of adverse airworthiness effect.

Captain Steeds: Can I come back? Thank you. The ICAO guidance is to avoid visible ash. ICAO also has guidance on other issues. I would like to emphasise that the two well-known incidents where there have been engine failures have been where aircraft flew through the plume of the volcano, very close to the source of the volcano. ICAO guidance is to avoid wind shear. ICAO guidance is also to avoid thunderstorms and lightning strikes. You don't have authorities around the world closing airspace on the whole because there is wind shear—the USA does from time to time—or lightning strikes. It is left down to the operators.

No one is doubting there is ash because there are volcanoes going off, so there is ash in the atmosphere and aircraft fly through it. What is important for the travelling public is, is it safe to do so? There will be an economic impact on engine overhaul, but is it safe to fly or is it not safe to fly?

Since 2003, British Airways has recorded 5.71 million aircraft flying hours, 1.93 million aircraft cycles, 15.25 million engine hours and 4.3 million engine cycles. During that time our long-haul fleet has been subject to 726 engine shop visits and 635 APU shop visits. We have not found any mention of volcanic ash in any of the 1,224 main engine or 635 APU strip reports.

So no one is doubting that there is ash. We don't disagree at all that there is ash up there. The issue is, does it affect flight safety? And it doesn't. When it does we avoid the ash. We have a proven track record of being able to do that. Uniquely, in this case, the UK CAA closed the airspace and that caused mass disruption to everybody.

Q84 Chair: Just before we go on, can I welcome Dr Gratton. I want to enable you to catch up slightly. If you would be kind enough when the written transcript emerges if there are any other additional comments you would like to make following the evidence of the other three panellists this morning, I would be grateful if you would drop us a note.

Before we go on, I just want to catch up on my first question to the other panellists about the preparedness of Government for a volcanic ash incident. I want to probe you on that specifically in the context of your expertise as an aeronautical engineer. What are your thoughts, generally?

Dr Gratton: I think, in essence, we were not prepared. There were not plans in place for dealing with the contamination of British and northern European airspace by volcanic ash. The VAAC—the Volcanic Ash Advisory Centre—was certainly in place and able to predict the presence of it, but essentially all they were able to do was say, "It's there", and give an estimate of how much. There had been no prior preparation with regard to acceptable limits, how to promulgate that information. We really were making everything up as we went along for those first few days of the airspace closure.

Q85 Chair: Was it clear to you who the lead Government Department, Agency or Minister was?

Dr Gratton: The lead organisation—that with responsibility for aviation safety—was the Civil Aviation Authority. That certainly should have been the case. Early on in the process they took a very effective lead. There was some subsequent confusion as other Departments started to get involved rather than allow the CAA to maintain the lead that they had already taken. Essentially, in terms of technical decisions, airspace closure, where aircraft could and could not fly, that was with the CAA.

Q86 Chair: But given the multi-disciplinary nature of this challenge, shouldn't the Cabinet Office have taken the lead from the outset?

Dr Gratton: It is a very difficult question to answer because, as you say, it was very multi-disciplinary. The CAA, probably, still were the best placed organisation because they are a multi-disciplinary organisation. They handle engineering; they have scientists on their staff; they do handle the aircraft operational issues. So, within the industry, whilst there are some disagreements about specific actions, I think generally it is accepted that the CAA were the right people to take the main lead.

Q87 Chair: How would you have improved the co-ordination between Departments and Agencies if you had had the power so to do?

Dr Gratton: Probably by giving the CAA in the short term more power and more resources, actually handing over to them and saying, "Right, the Cabinet Office", or whoever is the relevant organisation within central Government, "should essentially back up the CAA, but tell them to get on with it", as the specialist regulator and the people with the expertise.

Chair: Back to you, Gregg.

Q88 Gregg McClymont: I guess this is a question for Captain Steeds, in particular but the other witnesses, too. I wanted to ask, finally, whether those two previous incidents were, maybe, misinterpreted by certain agencies? You mentioned that they flew over the plume of the volcano.

Captain Steeds: Yes. The two previous—the British Airways one down in Indonesia and the KLM one up over Alaska—flew right through the central plume. We are talking ash concentrations many thousands of times what we were talking in the clear blue skies over the UK. It is worth emphasising again that no one has ever died as a result of flying through volcanic ash, whereas people have been killed due to wind shear, people have been killed due to lightning strikes and all these are, in theory, within the remit of the CAA, but they pass the safety of those operations to the operators, which is exactly what they should do and it is exactly what they should have done in this case.

Q89 Gavin Barwell: I have two follow-up questions on this issue of whether it was safe or not and the points you have been making, Captain Steeds. We have got, in our evidence bundle, a quote from Research Councils UK, which is about this issue of payments to the NERC for the use of their research aircraft, which I may come back to later. In that quote, it says: "anticipated cost of repairs to the Dornier engines". Are these repairs completely unrelated to flying through ash or are those repairs because there was some damage to the engines of the aircraft? That is my first question.

My second one is in relation to the ICAO regulations that you have been talking about. What is the scientific evidence behind the assertion that it is visibility of the ash that determines safety or otherwise as opposed to particle size, mass, any other effect? What scientific evidence is that test of visibility based on?

Captain Steeds: I can't answer the first question because I don't know the answer. In regard to the ICAO regulation, as you call it, it is not a regulation. It is not even an ICAO standard. It is an ICAO recommended practice. So there is confusion when people say that ICAO required the airspace to be closed. ICAO standards did not require the airspace to be closed.

What is the scientific basis behind that? Per se, I can't answer that question, but ICAO is the originator of all basic operational regulation. The ICAO working panels on this will have reviewed the information thoroughly before they publish it. The engine manufacturers and the airframe manufacturers endorse that as a recommendation to avoid visible ash, because there is currently no method of accurately, in real time, measuring what is up there.

The Met Office use a model, the model is a good model, but it relies on accurate information as to what the volcano is putting out for the model to be good. In this case, the information for what the model was putting out came from a single source radar, which was not a bi-polar radar, in Iceland operating on the extreme of its range. So the output of the volcano was inaccurate. That was fed into the Met Office model. If you put rubbish into a computer you tend to get rubbish out of it. That was the case here. We got inaccurate data.

I have forgotten which day it was, but there was one day when the airspace was closed over the south of the UK and we had to stop operating again. We

complained to the Met Office and they went back and re-looked at what the output from the volcano was. They went back and put it into the model and, lo and behold, the airspace opened. You cannot blame the Met Office. They're doing what they have been asked to do. It must be difficult because you haven't got accurate information about what's coming out of the volcano.

What we need is real time data . If we are going to go down the path that is being suggested, we need to have a lot better information on what is coming out of the volcano. ICAO has purchased some radars which are being put up in Iceland—I don't know whether they have arrived yet but they are on the way if they haven't arrived—so that the Met Office model will get better information. Then on top of that we need to be able to update the model in real time. We are not there yet.

Ray Elgy: If I could come back to the point you were making about the two aircraft incidents that you referred to, they are not the only aircraft incidents that have happened in the past. There are at least eight others that I am aware of where engines have been adversely affected by volcanic ash. It is on that basis of global experience that ICAO has come up with the recommended standard. Clearly, volcanic ash and "avoid visible ash" as a criterion is not in and of itself sufficient, and the worldwide experience has demonstrated that. Captain Steeds is quite right. There have been no fatal accidents but there have been some very near misses.

The situation we are in at the moment is that we have got this new three-zone approach and that, again, has its limitations, and we recognise that. But that approach, combined with the visible ash criterion, is something that we are pursuing with the ICAO Volcanic Ash Task Force to put together a risk-based assessment that would enable us to be better placed in managing ash.

Again, to come back to the point I made earlier on, there were established criteria, internationally agreed, and to move from those we wanted evidence, and science-based evidence, in order to move from the established threshold up to something new. At the heart of what we were doing is passenger safety. We are looking after the interests of the passenger.

Dr Gratton: If I could come in there on the issue of aircraft damage and the issue of visible ash, there was an incident we have all studied a great deal in 2000. NASA own a DC8. It is a four-engined airliner they use for research. They inadvertently flew it through the efflux from an Icelandic volcano in 2000. I have actually spoken to the captain of that aircraft at some length. They did not see anything visibly. They knew they flew through those conditions because they had 40 scientists up the back and a lot of instruments telling them.

The first thing that tells you is that volcanic ash is not always visible at levels that are significant. That is fairly intuitive because aeroplanes fly at night and they fly in cloud, in neither of which are you going to see ash. That aircraft continued to fly. It returned to base but then three of the four engines on the aeroplane required rebuild. They quoted a rebuild cost of $3.2 million just on that one aeroplane. So it is indicative of several things. Firstly, the fact that you can see or can't see the ash is not a reliable indicator; secondly, the level of damage that can be done; but, third, which does support the approach which has been taken of these multiple levels, that actually you can fly through a significant level of ash, do damage, pick up a substantial maintenance overhead but without immediately endangering the flight. It is important to realise this graduation.

In Jakarta, frankly, they were very lucky to live. They had a very good crew and a fair bit of luck on their side. That could have turned into a fatal accident very easily but that was an extremely high level of ash. The NASA DC8 saw a much lower level of ash which did significant damage but did not immediately endanger the flight.

One of the big scientific problems that has not really yet been solved is exactly where the line sits between the NASA DC8 and Jakarta. Clearly, where a lot of the engineering work is going is understanding what your trade-off is. If I fly there, I get this operational advantage but it's going to cost me this many millions of pounds in subsequent repair bills on the aeroplane.

Captain Steeds: I don't disagree with what has been said except that it is proven from our figures, which I won't read out again, that we successfully operate worldwide and we avoid volcanoes and volcanic ash, and we have methodology for doing so. If we had ever encountered a strip examination where the engine manufacturers told us that they had found volcanic ash in our engines, we would have gone back, reviewed our procedures and made the necessary changes.

What happened in this case is interesting. There is, clearly, a scientific answer but we haven't got the answer. Yet we closed the airspace, we cost the airlines hundreds of millions of pounds and we cost the economy billions of pounds all because we haven't got a scientific answer. Yet we could safely operate, not without additional maintenance costs, perhaps, but we could safely operate without endangering passengers if we had used the procedures and the processes that we use everywhere else in the world.

Q90 Chair: I understood you to say earlier on that the industry is providing the new radar in Iceland.

Captain Steeds: No, ICAO.

Q91 Chair: Is there an argument for the industry to put some investment in there?

Captain Steeds: The industry is putting investment in. British Airways is working with Rolls-Royce and Boeing to put probes on a number of our aircraft—we are also speaking to the Met Office—so that we can research ash concentrations. Actually, if you are talking about air safety, ash is not the most significant issue at the moment. The most significant issue is frozen water at high altitude, which the scientific community, the engine manufacturers and the airframe manufacturers don't fully understand. It is more dangerous, in my view, than volcanic ash because you can't see it and we don't understand it.

Dr Gratton: If I could just compare those. Historically, iced water conditions are causing somewhere between one and 10 power losses per year across the world airline fleet. Volcanic ash is causing

a significant problem across the world fleet round about three times a year. It is true to say that the iced water content issue is perhaps a higher priority for global aviation safety. It is probably also true to say that we've been extremely lucky that neither has yet caused a fatal accident. Both certainly have that potential.

Q92 Pamela Nash: I would like to ask each of you how effective you feel SAGE was in advising the Government and how well the Government used that information?

Captain Steeds: I am sorry, but I didn't hear the first part. Whose advice?

Q93 Pamela Nash: SAGE—the scientific advice that was given to the Government.

Ray Elgy: From our point of view, SAGE was very helpful in validating the work that we had been doing. The first meeting of SAGE that the CAA attended was after the airspace had been re-opened and the restrictions had been lifted. Certainly it seemed to us to have the right sort of composition in terms of the expertise that it had drawn upon. It was very helpful from our point of view to validate the work that had been done and to help set the path for future research and work.

Dr Loughlin: Yes, I agree. Unfortunately, because of the lack of preparedness, SAGE didn't meet earlier than that, but when it did meet, I agree, it had a very good representation of expertise. The key issues were addressed, pointed out very quickly, discussed and debated. I would have liked to see even more people involved, but through time all additional people whose expertise was required were brought in.

SAGE is an excellent opportunity for getting experts, particularly on a complex problem like this, to speak directly to Government Departments. That is very, very important. It is also important that SAGE is open so that those experts can act as a kind of peer review within SAGE, so the discussion and debate is open and people are free to discuss, to criticise, if necessary, the issues openly. SAGE was a very good thing, particularly for that reason. In this case it really facilitated the inter-disciplinary aspect of this problem. It brought together people who had not worked together before, across the CAA, the Met Office and volcanology. Immediately, that bringing together of all this expertise triggered a lot of interesting science and research which was absolutely critical to the future handling of these sorts of situations.

On a slightly less positive point of view, as time went on, SAGE became slightly less focused but, again, I think that was partly because of the lack of planning in the first case, but the first few meetings certainly were very, very good. It would be good if, for future situations, there is a SAGE plan in advance so that it is already made up before the next situation happens.

Q94 Pamela Nash: Can I just push on that view? You mentioned that you felt it would have been better if there was further expertise as part of that group at an earlier stage. Do you feel that you did eventually strike the right balance and what expertise would you have needed?

Dr Loughlin: In terms of the scientific issues at the beginning we had the people we needed. Certainly we had the CAA there, we had the Met Office, we had the Departments and we had experts who we knew, across volcanology, covered the key things, so remote sensing and the modelling, from a volcanic point of view, from a resource point of view. We also had experts on aggregation, which is a key way of removing ash from the plume, which is a key scientific issue. So all of those things were tackled. But we could have gone further in managing the risk aspects of this situation.

Dr Gratton: I would like to add a point to that. It is clear that SAGE formed a vital function in informing Government and allowing the most senior scientists engaged in this to cross ideas and discuss where each other was engaged with the problem. What was very hard to understand, particularly from outside SAGE, is why the organisation was treated with such secrecy. The composition of SAGE was never published and the minutes from the meetings were never available. So for anybody who sat outside of SAGE, and there were a great many people very intimately involved with the problem, it became extremely hard to feed into SAGE and to use it to contact other organisations affected by the volcanic ash problem purely because of the level of secrecy with regard to its construction. It is very hard to see the justification for that secrecy given that, really, it didn't matter what you told the public. It wasn't going to change what the volcano did. It's not like a terrorist problem where you could see that case. The volcano is going to do its own thing and any amount of secrecy or openness does not change that, but openness certainly throughout the whole event was absolutely paramount. We really did find that the more everybody engaged shared their knowledge with everybody else, the better we were able to solve it. The moment anybody started behaving with any secrecy or saying, "This is my bit to solve. You're not involved", things did start to go wrong. I think the secrecy of SAGE did contribute to some problems in that regard.

Q95 Pamela Nash: Can I just put that to those of you who were part of SAGE? Do you feel that the secrecy was necessary and, if so, why?

Ray Elgy: From my point of view, the secrecy wasn't really apparent. We were invited to attend and we felt there was the right representation there. From an external perspective, I am afraid I don't have a view.

Dr Loughlin: From my perspective, no, I would have liked to see less confidentiality. I think the default should be that everything is open and made apparent. I think that is particularly important where uncertainty and risk is involved. One of the impacts that I personally had from the confidentiality is that there was some confusion amongst SAGE members about what they could discuss and what they couldn't. It's like Guy said. There was a lot of information discussed in SAGE which was not, for any reason, secret. It was about the way volcanoes work, the way meteorology works. All of this information should have been shared as widely as possible, as quickly as

possible. So there was a little bit of repetition that I felt had come about because Government Departments or others had felt unable to pass information on.

Ray Elgy: It is important perhaps to support that view in the sense that every decision that we took and all the rationale behind each decision we did publish to make sure it was open and transparent to everybody. So all of the decisions we took were recorded and published on our website.

Dr Gratton: Could I mention that a very major leadership was taken by a series of, inevitably, teleconferences—for instance, we couldn't fly to see each other—led by the Civil Aviation Authority. I was certainly a part of that process, as were several hundred other people right across the world. The way in which the CAA published absolutely everything, every bit of discord, every bit of disagreement on the data, all of the discussions, I think is absolutely exemplary and is a very large part of why we tackled the problem as effectively as we did.

Q96 Chair: Dr Gratton, do you think, with hindsight, it would have improved the degree of understanding between Government, SAGE and the airline industry had there been an engine manufacturer present?

Ray Elgy: Engine manufacturers were present at every stage.

Q97 Chair: They were present?

Ray Elgy: Yes.

Q98 Chair: They concurred with the general advice coming from SAGE?

Dr Gratton: I struggle to answer that because I wasn't part of SAGE, but certainly there were SAGE people who were part of the CAA conference and certainly all of the major engine manufacturers were part. The discussion was extremely robust and extremely constructive.

Q99 Chair: So how is it that there is a gap between what Captain Steeds is saying and the outcomes from SAGE if the engine manufacturers were present?

Captain Steeds: I was grateful to Dr Gratton for saying that this meeting was held in secret and the minutes were kept secret because I have been silent up to now because I have never heard of this and we were not involved. You would have thought that the scientific community would have wanted to interface with the operators because we were the ones who were affected by the volcanoes. We were the ones who were going to have to fly in this airspace if it was dangerous or not dangerous. Yet we appear to have been totally excluded from this group that was discussing it, which seems quite bizarre.

Q100 Stephen Metcalfe: Can I just pick up on that briefly? That seems to be the hub of the problem. Our investigation is into the use of scientific evidence and advice in emergencies which, presumably, is to enable the operator of the industry, whoever is affected, to carry on and to minimise the impact that emergency has on that operation, but that doesn't seem to have happened in this case. What we seem to have had is some very good science going on about potential impact—there is no doubt there was some ash up there—but it wasn't actually translated properly to the industry so that they understood, because they had a different view, which was that they could continue to operate using what they had already established as their code of practice. What we are trying to get to, I suppose, is, how does the Government decide who best to listen to when the industry is saying that the scientific advice that we were receiving wasn't necessarily how they might have liked to have seen it presented?

Ray Elgy: Can I answer that? In terms of the overall timescale, SAGE, as I said, didn't start to meet until after the airspace restrictions had been lifted. In terms of all the teleconferences that the CAA led and that Guy Gratton has referred to—certainly there were operators—industry was fully informed in all stages of those discussions and were contributing and participating in that debate. SAGE, as I said before, was helpful to us from the point of view of validating the work that had been done, but by that time all of the work to change the limits and increase the threshold had been completed and agreed. So SAGE wasn't instrumental at the outset in helping us to overcome the initial problem.

Dr Gratton: Just to discuss a little bit of the time line, the initial airspace closure occurred on the morning of Thursday, 14 or 15 April. On the Thursday and the Friday we were all desperately trying to get on top of the problem. There was also an expectation, because this is the way Europe is supposed to work, that EASA, the European authority, was supposed to take the lead in this. They didn't. They were, really, very inactive indeed.

By Saturday morning, the CAA had clearly come to the conclusion that somebody needed to take the lead and they were probably best placed to do so. So it was on the third day, the Saturday afternoon, that there was the first of the CAA's teleconferences. There were about 150 people on that from I think I counted seven countries. Certainly British Airways was there; Rolls-Royce was there; General Electric was there. So you have got the largest operator in UK airspace and you've got the two largest engine manufacturers. The Met Office was on board. The Natural Environment Research Council was on board, and certainly the CAA and the FAA, who have clearly got a lot of volcanic expertise, particularly with regard to Alaska. So that worked extremely well. SAGE came along a little bit later and was a much smaller group of very senior scientists. It was much less of the all players event that the CAA conference was.

Q101 Graham Stringer: Captain Steeds, you have been commendably clear in your answers and disagreements with the CAA. Can I just ask you, is your view that we don't need all these models? We don't need the CAA interfering. Actually the industry itself is best placed to look after its aeroplanes and passengers in the way that it has done since it started flying?

Captain Steeds: Yes and no.

Graham Stringer: That's a difficult answer.

Captain Steeds: We need regulation, and the CAA is a very good regulator in safety regulation. Can I just correct or disagree with what Dr Gratton said about EASA? At the moment the airlines operate under EU-OPS, which is European law published by the Commission and directly controlled by the Commission. EASA don't take competence for aircraft operations until April 2012. They do have competence for airworthiness. One might have expected them to be more interested in the airworthiness aspects, but traditionally volcanic ash has been an operational issue. So to blame EASA for not being involved in the operational issue is, I think, misunderstanding how the regulation is currently drafted.

Airlines operate under an Air Operator's Certificate. The Air Operator's Certificate is issued by the CAA currently on behalf of the European Commission. From 2012 it will be on behalf of EASA. The CAA is responsible currently to the Commission and, shortly, to EASA, for ensuring that operators operate within the regulation.

The regulation requires operators to have safety management systems and other bits and pieces but, basically, what we are talking about here is a safety management system to ensure safe flight in different conditions. The CAA doesn't have the expertise in all the individual bits that flow from that. What they are interested in, what they oversee and they audit is that you have a safety management system and it is effective. But if you get right down into the nitty-gritty about flying in volcanic ash, the CAA don't operate aircraft and they don't have the expertise in that area. Operators do. If you look at the worldwide statistics, we are talking about two serious incidents, maybe eight serious incidents, over the last 20 years.

If you talk about ice in the upper atmosphere, British Airways has 16 to 20 ice incidents a week. Now, we operate safely, overseen by the CAA, in these events. To think that the CAA is going to come in and tell you when the volcano has gone off exactly what you should be doing, I think is asking too much of the CAA. My personal view is that the senior management in the CAA expected too much of the Safety Regulation Group. They should have asked the Safety Regulation Group to ensure that operators had considered the problem and were reacting correctly to it rather than just closing the airspace and inconveniencing everybody.

Q102 Graham Stringer: So that was the "yes" part of the answer, was it? You are, basically, saying that you should have talked to the CAA and told them that you considered all the facts about the volcano and the decision should have been yours, and in these circumstances you would have carried on flying?

Captain Steeds: Yes.

Q103 Graham Stringer: So you are not interested in the big computer that the Meteorology Office has got. You are not interested in all the information coming in?

Captain Steeds: No, no.

Q104 Graham Stringer: It's irrelevant, is it?

Captain Steeds: No, it's not irrelevant at all. For example, when we didn't fly into Antigua earlier on in the year, that was not because of anything that had been output by the CAA. It wasn't because the airspace was closed over Montserrat. It was because we looked at the output from the North American VAAC and other agencies—WSI is one that we use—and we came to the decision that it was not safe to operate so we cancelled our flights. Actually, some other UK operators continued flying, but we decided it was not safe to fly. Indeed, in this particular event, some Scottish airports were open. Our information was that actually there was visible ash there and we wouldn't fly to them. We take the output of the UK Met Office, but the UK Met Office model at the time was outputting inaccurate data, not because the Met Office aren't good, but because the input into their model was inaccurate.

Q105 Graham Stringer: When you did your test flight on the Saturday or whenever it was, when you got permission to go, what were your objectives? What standards of measurements were you making? Were those standards of measurements in line with the ICAO standards?

Captain Steeds: To go back to the ICAO standards, there aren't ICAO standards. When somebody said "an ICAO standard recommendation", it is confusing the terms. The standards are the requirements and the recommended practice is what it is. It is recommendations. So it is the standards you have to comply with. The recommended practice is to avoid visible ash.

What we did on the Sunday was we inspected the airframe and we borescoped the engines before we flew. When you borescope, you have a look inside the engine and see what's there. Then we flew along where the VAAC forecast was telling us that there was significant ash. When we landed again, we carried out another examination and we found absolutely no evidence of any ash whatsoever.

Q106 Graham Stringer: The CAA at different times recommended closing airspace for six or eight-hour chunks of time. What was the evidence on which you did that? Why was it six or eight hours, because it is particularly inconvenient for airport operators and airlines to have such short periods? Were you completely relying on these models that the Meteorological Office was using?

Ray Elgy: In terms of the periodicity, the outputs of the model that is being used are generated every six hours. That explains the periodicity of it. There is a huge amount of data.

Q107 Graham Stringer: I am just trying to get that clear. So the time you were recommending closure for was based on how often the computer could turn out results?

Ray Elgy: The model is run and the output of that is generated four times a day every six hours. So, yes, we were relying upon that. There is a huge amount of data that is fed into the model and it has to be analysed and the output of that model is then validated against other information, for example, from satellite data,

from ground-based LIDARs, to help validate the output.
Captain Steeds is quite right. Some of the input data for that model was very difficult to quantify accurately, in particular the amount of ash that was being generated at source from the volcano. So the reason is that updates were given every six hours and the information promulgated—the information provided in the industry to the airmen—was on a six-hourly basis.
Can I also clarify that it's not the CAA that closed the airspace? Technically, what happened is that the air traffic service provider, NATS, zero-rated the airspace, so it wasn't actually closed. In fact there were general aviation flights operating in certain parts of the airspace, but they were zero-rating it for instrument flight rules.

Q108 Graham Stringer: On your advice?
Ray Elgy: No, on the basis of their own safety case. If I can go back to the point I made very early on, it is an extremely congested piece of airspace. It is one of the busiest and most complex pieces of airspace in the whole world. The ICAO recommended practice was adopted. It formed the heart of the contingency plan that was in place, and it was unthinkable, in our view, to move away from that recommended practice without some scientific basis.

Q109 Graham Stringer: So you were talking to NATS. In the NATS evidence here they clearly were not very confident in the information that was being fed into the Met Office computer. It says: "It is clear that data of sufficient granularity was lacking although we understand that accurately establishing the density and composition of the ash is the most difficult scientific challenge." So they had no idea what they were doing.
Ray Elgy: No, I don't think that is fair. There were limitations with the model. The model itself has been validated—

Q110 Graham Stringer: Let me finish. They had no idea what they were doing. They themselves didn't have the information and they were closing airports down for six hours at a time because that just happened to be how the computer turned out its results from the rubbish information that had been put in. That's extraordinary. That is just simply extraordinary.
Ray Elgy: No. That's not a fair reflection of the actual events.

Q111 Graham Stringer: But it is the description that you have just given to us?
Ray Elgy: No. What I am saying is that there is a model that was being used by the Met Office. That model has been used on many other occasions and is constantly validated, updated and corrected. It's been compared with other VAAC charts—

Q112 Graham Stringer: But it's not the model I'm questioning just at the moment. It's the rubbish that's going into the model. The NATS evidence given to this Committee says that they have no confidence in the information going in.
Ray Elgy: The input to the model was questionable. The major issue was the source data, the source input, i.e. the amount of ash that was being generated at the volcano itself. That was recognised and that is why other inputs were put into the model, such as validating the output against satellite imagery and against ground-based LIDARs.

Q113 Graham Stringer: How were the satellite readings standardised? What were they standardised against?
Ray Elgy: Again, there are limitations with the way in which satellite imagery can be used. So all of those—

Q114 Graham Stringer: So more rubbish information going in?
Ray Elgy: No.

Q115 Graham Stringer: We have just been to the National Standards Laboratory and they told us that there were no measurements made of the ash until the NERC plane went up. They also told us, when talking about something else, that when you put satellites into orbit they get bashed about a bit, so it is very difficult standardising anything from them.
Ray Elgy: Yes. The point I am making is that the model itself is valid and has been validated. The input information was questionable and we used all means available—satellite imagery and LIDAR—recognising that those themselves were not perfect, but the model itself has been compared to all the other models used around the world by other VAAC centres. Also the test aircraft that were being flown were used to validate the model and the output. It was looking to see whether the ash existed and in what composition.

Q116 Graham Stringer: So how accurate was it? We've heard previously that when BA flew their aeroplane the engines were fine when they were flying through space where the model from the Met Office had told them there was ash. You say it is validated. Plus or minus, how accurate was it?
Ray Elgy: The point that was made earlier with regard to the level of ash that caused engines to flame out within a few minutes is 2g/m3. The model generates a chart which delineates an area where the concentration is below 2x10–4. So we are four orders of magnitude away from the point at which we know that engines will flame out in a very short period of time, in a matter of minutes. So it was on that basis that we were saying, right from the outset, if we could move at least one order of magnitude closer to that point—

Q117 Graham Stringer: That's not quite the question I am asking. I'm asking how accurate was the information being churned out by the computer. How accurate was it?
Dr Gratton: I would just like to comment. We, here, at the table at the moment have all had significant sight of this and we could all discuss aspects of it, but I understand that in the next session you have the Met Office Chief Scientist. I suspect she is probably far better equipped to answer those questions than any of us.

Q118 Graham Stringer: That's as may be, but NATS actually took the decision. The CAA were involved in the process. I want to know how you assess the accuracy of what was coming out of this because this had a tremendous impact on the economy. It seems to me that you were working with rubbish going into a computer and, therefore, rubbish coming out.

Q119 Stephen Mosley More specifically, when you actually sent the flight up there to do the test, so the plane was actually there, testing these areas and the model was saying there was an ash concentration, what did the aeroplane actually pick up? What were the results of the actual flight when compared with the model?

Dr Gratton: I am in a slightly difficult position here because I was on that flight. However, what I was not involved in was the direct analysis of the data. Again, I am going to slope shoulders in the direction of the Met Office because Professor Slingo has had full sight of that data and will be able to give you a much better description of that and the data that was obtained. What I can certainly say is that, in general terms, we were definitely seeing ash and we were definitely seeing sulphate chemicals where the Met Office model outputs had told us we were going to find something. I would just make one other observation, which I think is particularly relevant to the British Airways and Virgin test flights. None of the British Airways and Virgin flights, and also a few days later there was an Airbus test aircraft out of Toulouse that came up over the north of Scotland, had instrumentation that was capable of detecting volcanic ash. With the aircraft that we did fly, what we saw was thin layers. So you might have a layer of ash a couple of hundred feet deep and then a couple of thousand feet of clear air and then another thin layer of ash. Without any instrumentation, you could fly from one end of the UK to the other and not know if you'd flown right through the most dense part of the ash or been in clear air all the way. You just couldn't tell, other than if you inspected the engines and they were damaged then you were probably in the concentrated part of the ash. It was a very difficult problem from that perspective.

Ray Elgy: If I could just come back to Mr Stringer on the model itself, what we were using is a model that was internationally agreed. It is comparable with other models around the world. There are inaccuracies in it and they were recognised. The best information that we had was used to feed into that model to get the best output that we could. There is work that's going on now to improve the model in terms of vertical granularity, for example. So the limitations of it are recognised, but we were working with internationally agreed standards and with a model that is comparable with any around the rest of the world.

Captain Steeds: Can I just clarify a couple of points? On day one it is true that NATS reduced the flow rate to zero. On day two going forward, or it might be day three going forward, it was the UK NOTAM Office, which is, as I understand it, part of the Directorate of Airspace Policy Office, which issued NOTAMs which closed parts of airspace. So it moved from being a zero flow rate, which you could understand NATS imposing because they didn't know what was going on on day one, to airspace closure imposed by a part of the CAA, just to clarify that.

In the comments about the test flights, it's true that we weren't certified. I beg your pardon—we were certified. We didn't have test equipment on board, but we measured the engines before and we measured them afterwards and we found nothing at all.

The Airbus A340 was instrumented. It was following a NERC 146. The NERC 146 refused to fly into the black area—the closed airspace—and turned round and came back. Therefore, the Airbus did the same. Airbus themselves were furious about it.

Q120 Stephen Mosley: At the time in April when all of this was going on, I was a lay person, a member of the public, and to me there did seem to be a great deal of confusion or lack of information coming out. I think we have seen that today as well. We've got the airlines. We've got Captain Steeds here, who is learning things today. He is learning things about SAGE etcetera which he wasn't aware of. How well do you think the information was disseminated by Government, by organisations like yourselves, to the public, to the airlines? How well do you think the level of risk and the reasons for the airspace closure were made available to the public?

Dr Loughlin: From the British Geological Survey point of view, we were putting out information daily, specifically about the volcano and the type of activity, particularly drawing attention to some aspects that relate to what we have just talked about, which is the great diversity of volcanoes, volcano types, eruption types, and why this particular eruption was responsible for some of the difficulties.

Just to go back to Montserrat again and also to discuss places like Alaska and Pinatubo, some of these other well-known volcanoes, these are short-lived explosions that last a few minutes to hours. They produce discrete ash clouds which then can be tracked as they move through the atmosphere. Also these kind of vertical single explosions have well-known empirical relationships that relate the height of the plume to the eruption flux. These are the parameters that go into the modelling. It worked quite well for these types of explosions at these types of volcanoes. The point about the Eyjafjallajökull volcano is that it was an eruption through ice—it was quite weak—that did not generate a vertical transient eruption cloud. The cloud carried on for weeks generating more and more ash. Also, it wasn't a vertical column so this empirical relationship between height and eruption rate didn't really stand as well. So the fact was that for this particular eruption it was very difficult to get these source terms right for what was, basically, a very weak plume. It was not this discrete body of ash that you could easily track around, which you get in places like Montserrat and also in Alaska and the like. So it was a very different type of eruption and it caused particular problems for the source terms of the modelling. So we were putting out information describing this type of eruption on our website.

But I would have liked to have seen more interaction between the volcanology community and airlines, I think. The CAA and SAGE did facilitate a conference

very early on. It's true that SAGE didn't meet until all these major decisions had been made, but once it did meet the CAA and SAGE facilitated a conference where the scientists and the airlines were able to get together and we presented some of the key science to airline executives.

Ray Elgy: The information that we provided as well was on the website. All the decisions we took and all of the evidence that was taken into account in coming to those decisions was published. On our website as well, we did publish information that explained what was going on and the reasons for it. We were also in contact on a very regular basis with all sectors of industry to explain to them what was going on so that they could then pass on the messages to their customers.

Dr Gratton: With regard to putting information out to the whole community, however you define "community", one thing was very evident. This was a huge problem. It involved an awful lot of people and virtually all of those people were working 18 or 20-hour days trying to solve it. That left very little capacity for anybody to then go out and start explaining to the media, to politicians like yourselves, to everybody else, what we were doing.

The position scientifically was changing very rapidly. The understanding was constantly being refined, and it was being refined by people who simply had very limited time to do additional communication. To be honest, I think, yes, there were failings in the scientific, engineering and aerospace communities' ability to communicate with the outside world and, to an extent, with each other. I really don't think you could have avoided that because, if people were taking time out to explain what was going on, then they would have been taking that time away from solving the problem.

For example, the Science Media Centre, which is based at the Royal Institution, which has an active role in pairing up scientists with the media in the event of a science-related news story, and I think does a really fantastic job, I think managed to find four people who weren't directly involved in trying to solve the problem and therefore had enough time. Those four people ended up working every hour available just trying to explain what was going on and keep their own knowledge up to date. Realistically, if you have another problem like this again, you're going to get the same difficulty simply because those who understand the problem are just too busy to talk about it for those few days, few weeks, until the emergency is subsiding.

Q121 Chair: I have just one very quick question and not more than a short sentence response, please. Given the fact that NERC is still owed money, do you think that has damaged the trust between the research community and Government, and will that impact upon future events like this?

Dr Gratton: Yes.

Chair: Thank you.

Q122 Gavin Barwell: This is really a wrap-up question. It seems to me from what we have heard from you this morning that the existing ICAO recommended practice doesn't seem to me to be based on clear scientific evidence. There is difficulty in getting accurate data about what's coming out of these volcanoes, there are different kinds of eruptions, and you were making the point, Dr Gratton, that we don't know exactly what level, what mass, what concentration of ash poses a risk in terms of long-term maintenance or actually to the safety of passengers and crew on aircraft. You've just been talking about some of the difficulties in relation to media handling. Given all of that, do you feel that the UK would be any better prepared if the same thing happened against next year?

Ray Elgy: Yes, I do. I think we are better prepared. We do have a new system in place. You made the point about existing guidance not being scientifically based and that's true to a certain extent in the sense that the advice is to avoid ash. There is a huge amount of work being led now by the ICAO Volcanic Ash Task Force to refine the model, to get better systems in place. Until that is in place and that work has been completed, then we will be left with managing any future situation with the system that we currently have in place, which is the three zones.

Dr Gratton: I agree with that, absolutely. The engineering work is continuing. There is a phenomenal effort that continues to be put in now that the world community has realised how big a problem this is. Clearly, it's going to go in two directions. One is better modelling and presentation of the model. The other is about the safety factors and the maintenance overheads. Inevitably, we played safe because, for all of the hundreds of millions of pounds that have been lost, that's not worth loss of human life. So we had to play safe. But that work is now heading towards reducing the safety factors, expanding the contaminated airspace that can be flown in for no maintenance costs, and it will continue to go in that direction. So, scientifically, we are going to be in a much better position.

I would just like to mention something that hasn't really been discussed. From an aeronautical engineering viewpoint the big issue is the aircraft engines. The numbers that we were using and that have defined the limits that still stand were, essentially, those agreed by the major aircraft engine manufacturers. I have never seen anything like this. Rolls-Royce and General Electric, two massive multi-national companies, both spend their entire lives fighting tooth and nail against each other in the market. They just pooled their engineering departments. They just put everybody together and said, "Work together. Share all the data. Solve this problem." It was really impressive to watch. I don't suppose we'll ever see it again, but it was great. That's where those numbers come from. Particularly from those two companies, they are from the best science that could be done by the world's two largest jet engine manufacturers. They were being pushed by everybody, by British Airways, by the CAA even, on how small they could get the safety factors, because the smaller the safety factor, the more airspace you can fly in. Ultimately, it was their advice, "This is as far as we are going and no further" on safety grounds to jet engines.

Dr Loughlin: Yes. I agree with what has been said previously. The science has moved forward a little but it is not a quick fix. The ICAO Task Force is critical to this, but it is going to take time before results come out of that work. But what has been achieved as a result of April is very strong networks, cross-disciplinary working, and that's all going to put us in a better position for next time.

The other thing that has happened is that, because of the lack of preparedness, there has been a huge educational effort needed this time around. Certainly next time around it will still be as busy as it was in April but we won't spend as much time, perhaps, sharing basic information and we will be able to move faster to the more critical issues.

Captain Steeds: I think we are better placed because we now have some better radar up in Iceland so the input into the VAAC model will be better and, therefore, the output from the VAAC model will be better. On the discussion about what the limit is, Rolls-Royce, GE and Pratt & Whitney all agree that it's 2x10–3. They allow you to fly in any areas, including the famous black zone, which the UK closed, if it is forecast because, like everything else, you get weather forecasts and then you get what actually happens on the day. The engine manufacturers haven't put any restriction on us flying in areas where there is forecast to be volcanic ash above a concentration of 2x10–3. Their recommendation to the airlines is to avoid visible ash. So, actually, despite Rolls-Royce, GE and everybody else working together, the recommendation that they come back to is the basic ICAO guidance material.

The UK has come up with three zones. You have the black zone, where it is a concentration greater than 4x10–3, and that is closed by NOTAM. Then you have a time limited zone without a time limit, which is an interesting concept, which is a concentration between 2x10–3 and 4x10–3. Then you have the area now up to 2x10–3 and everybody agrees that you can fly in that area without limit.

So am I confident that we have moved forward? My confidence is that with the purchase of the radar the output from the model will be better. Hopefully, that will help us. But, otherwise, I am less confident than my colleagues that we have actually made very much progress.

Dr Loughlin: Could I just clarify one thing. Unfortunately, the radar hasn't been installed yet. So we are still going to be dealing with uncertainty if we get an eruption in the next few months. But, having said that, the validation of the model, using planes, using ground-based remote sensing and satellite remote sensing, is absolutely critical. But I do think everybody clearly understands what the source-term issues are now and that will help in dealing with things in the interim.

Captain Steeds: Just for clarity on that, I believe I am correct in saying that Europe has moved the radar from Etna up. So we have some improvement in radar but we haven't got the final improvement.

Dr Loughlin: Yes, okay.

Chair: Thank you very much for your contributions. You will be interested to know that I flew around Montserrat when it first exploded in a naval helicopter, and I was told, "We can't get any closer, Sir, because it'll fall out of the sky", which was a salutary lesson. Thank you very much for your evidence.

Examination of Witnesses

Witnesses: **Professor Brian Collins**, Chief Scientific Adviser, Department for Transport, **Dr Miles Parker**, Deputy Chief Scientific Adviser, Department for Environment, Food and Rural Affairs, and **Professor Julia Slingo**, Chief Scientific Advisor, Met Office, gave evidence.

Chair: Thank you for attending this morning. Perhaps you would be kind enough to introduce yourselves briefly.

Dr Parker: I am Miles Parker. I am the Deputy Chief Scientific Adviser at the Department for Environment, Food and Rural Affairs.

Professor Collins: I am Professor Brian Collins. I am the Chief Scientific Adviser, Department for Transport.

Professor Slingo: I am Professor Julia Slingo. I am the Chief Scientist at the Met Office.

Q123 Chair: Our previous session with witnesses slightly overran because I think colleagues found some of the contradictions coming from them intriguing. You all three were at the heart of the matter. Who assumed leadership of this emergency and how did it evolve?

Professor Collins: My understanding is that the Prime Minister took the decision to call a meeting of SAGE and asked John Beddington, now Sir John Beddington, the Government Chief Scientific Adviser, to form up a SAGE group. I believe that was on the Friday. John sent a message to all the Chief Scientific Advisers and others whom he thought could contribute for names of people who could provide the expertise to form a SAGE meeting, and John chaired that first meeting on the following Wednesday. So it was the then Prime Minister's initiative. I should add, of course, that we were in purdah at the time when this incident occurred.

Q124 Chair: When the Cabinet Office was managing this, was there sufficient expertise there to deal with emergencies like this?

Professor Collins: You suggest that the Cabinet Office had been—

Chair: The Prime Minister himself.

Professor Collins: I see what you mean. I think that is exactly why he asked Sir John Beddington to create a special group around this particular topic because it was immediately seen that it was extremely complex. A large number of disciplines needed to interact with each other to understand the nature of the problem and what the possible solutions might be. That is why he went through John to get an external group of

people together, as you have heard in the previous evidence.

Q125 Chair: Had the Government been ignoring warnings about the potential risk from volcanic eruptions?
Professor Slingo: I will go back to your first question because I think it is important that the Committee understands that, as soon as the volcano erupted, as the agency responsible for natural hazard emergencies and well used to dealing with them, we immediately alerted the Cabinet Office, the CAA and the Civil Contingencies Secretariat, and we had a member of staff in the Civil Contingencies Secretariat within an hour. So that had all happened as soon as the volcano erupted. We were well aware of it by Thursday and looking at the meteorological situation and so forth. I was called by Sir John on Saturday and spent Sunday with him in the Cabinet Office.
The processes around natural hazard emergencies and our role as operating and providing the London VAAC got into gear very, very early on.
Professor Collins: That was separate from forming up SAGE.
Professor Slingo: Yes, but a COBRA was called and the Civil Contingencies Secretariat went into full activity immediately with our engagement and providing advice right from the word go. We immediately set our teams in place and the operational process of the forecasting, what we were doing about monitoring, etcetera, etcetera, all went into full swing by the end of that week.

Q126 Chair: Previous witnesses have suggested that the radar evidence that you were relying on from Iceland was not up to scratch. When were you aware of that and when were Sir John and others notified of that?
Professor Slingo: In terms of the radar?
Chair: Yes.
Professor Slingo: We don't rely solely on any radar evidence.

Q127 Chair: No. I didn't say you relied solely on it. I asked when you were aware that the radar that you were partly relying on was inadequate.
Professor Slingo: We have always known that in terms of quantifying the source would always be challenging. I think we need to be clear that at the start of this emergency the guidance from ICAO, which goes to the VAACs, is for the VAACs to advise on the ash/no ash boundary. Our duty to the VAAC is to say, "Is there ash there?", not "How much ash is there?" Actually, we were the first VAAC, and indeed the first Met, to have to start producing forecasts about ash concentration as opposed to where ash is. So the issues around knowing the source term really came to the fore as soon as it became apparent that we would have to move from ash/no ash, which is quite constrained by the meteorology rather than the source term, to concentration, which is constrained both by the meteorology and what's coming out of the volcano.
Going back to your question about characterising the source, we were in very close contact with the Icelandic Met Office, who were working with the Icelandic Earth Science Department, who are very experienced in Iceland volcanoes. We were talking to BGS. We had aircraft reconnaissance of the plume. We had satellite information about the plume. To be fair, it's not what is coming out of the volcano at the volcano that matters for us. It is what was about tens of kilometres downstream where the big stuff had dropped out and you were left with a fairly stratified plume with the ash that would actually influence airspace. That was what we were looking at all the time. We were not relying that strongly on the radar to tell us about the source because it can't. It's not designed to give all the information required.

Q128 Chair: But it has been replaced?
Professor Slingo: There is a new one. There is an Italian one that we talked about, which is en route and will be in place, I believe, next week.

Q129 Chair: In your written submission you mention six-monthly contingency planning exercises. Was the Government really unprepared? There do not seem to be any contingency plans for this event.
Professor Slingo: Yes, we have these six-monthly planning tests and they are done using the current weather conditions so we go through the process. I think when we talk about being unprepared we have to understand that the meteorology that was prevailing at that particular time was almost the worst possible situation that you could get meteorologically. I remember thinking, when it first erupted and looking at the weather maps, we're in some trouble here because this is not going to change for several days and the flow is bringing the ash almost directly over the UK. It's very unusual. So the combination of the nature of the volcano and the meteorology put us in a place that, with the best will in the world, even through a lot of six-monthly testing with the real weather conditions at that time, and testing all our processes and all our modelling, to anticipate an event like that in advance is very, very tricky.
That being said, if we were just required to provide ash/no ash guidance, which is what the London VAAC was required to do, we did a fantastic job. Despite what other witnesses have said—I have the evidence and we showed it at the CAA conference—the comparison between the model's forecast of the extent of the ash cloud and what we observed very clearly from satellites and from other ground-based observations was incredibly accurate. So I think we were doing a really good job with what we were required to do at that time.

Q130 Gavin Barwell: I have three questions for you about the working of SAGE. First of all, in terms of transparency, neither the membership nor the minutes of the SAGE meetings have been published. Why is that?
Professor Collins: I discussed that with Sir John Beddington about two hours ago. He, of course, is reporting to you later. There isn't a secretariat in the context of the way this particular SAGE group was put together because of it being led from No. 10 at that particular point in history. So John is well aware

that the record is not yet published. It is in preparation. I think you need to ask him whether there were factors that he felt were appropriate at the time that would have suggested it shouldn't be published.
Gavin Barwell: You didn't. We will do that.

Q131 Chair: Can you see any reason why it shouldn't have been in the public domain?
Professor Collins: I can see some sensitivities, yes, but I believe you should ask Sir John what they are.

Q132 Chair: I am asking you what your view is.
Professor Collins: I don't want to answer that question in a public domain.

Q133 Stephen Mosley: Did you have to sign non-disclosure agreements as part of your conditions?
Professor Collins: I am an adviser to Government so I don't have to sign a non-disclosure agreement.

Q134 Stephen Mosley: Did others?
Professor Collins: Yes.
Stephen Mosley: They did. Okay.

Q135 Gavin Barwell: My second question is about the timing of the SAGE meetings, so that the first meeting actually occurred on the day that UK airports re-opened.
Professor Collins: That was the Wednesday.

Q136 Gavin Barwell: 21 April?
Professor Slingo: Yes; that's right. The full SAGE met on Wednesday.

Q137 Gavin Barwell: There was a telephone conference the day before, I think?
Professor Collins: Yes, there was.

Q138 Gavin Barwell: The full meeting was the day they re-opened. Was there a reason that it took that time to get the SAGE meeting for the first time?
Professor Collins: You were involved before that.
Professor Slingo: As I said, I was involved with Sir John on the Sunday. We had discussions then, with myself and Sue Loughlin, whom you have just talked to, and we were asked to provide suitable names to represent the meteorology and the volcanology, particularly across academia and people who had not got vested interests. So by Monday I had provided Sir John with a list of names that I believed represented well the research aircraft community that you have heard from, from the academic community in terms of LIDAR technology, scattering processes, all that sort of atmospheric physics community and the meteorological weather conditions-type community. Sue Loughlin did the same on the volcanology. Those phone calls were then made on the Monday. There was a teleconference and that group met on Wednesday. It is hard to do it much faster than that.

Q139 Gavin Barwell: I will press a little bit on that. Obviously, the decisions that were being made in terms of shutting down UK airspace had a very significant impact on individual companies and on the UK economy as well. Is the time it took to identify those people perhaps an indication that this wasn't a risk that had been particularly anticipated? If you look at some of the other things that are on the Government's risk register, is there already drawn up a view that, "If this happens, these are the people we would get on to SAGE" and you would get a meeting quicker? Is that why it took a little time?
Professor Slingo: I think that's probably a fair comment, yes.

Q140 Gavin Barwell: My final question on SAGE is about the process for appointing people and whether you feel, with hindsight, that the right balance of expertise was on there from the start. I think we got the impression from our previous evidence session that, at least initially, there weren't necessarily people with engineering experience in terms of the operation of engines and what the tolerances might be.
Professor Collins: At the first meeting it is perfectly true to say, because those people were seriously busy dealing with their activity, and there aren't many of them, that at the first meeting they weren't present. Sir John and I had private meetings with the Chief Engineer of Rolls-Royce in the gap between the first meeting and the second meeting of SAGE. He was represented, as were the CAA engine experts, at the next meeting. So from that point on, as a result of identifying that that was a community we needed at that table, the answer is correct. Yes, we moved as quickly as we could.

Q141 Stephen Mosley: Having heard Professor Collins' earlier answer, my question is probably best off being pointed at Sir John Beddington when we talk to him. Can I just come back on something that we had in the first discussion? It was just the issue that Mr Stringer was raising about the difference between the model and the actual evidence, when you sent the aeroplane up there. We are told that you might have the answers as to the actual levels of ash that you discovered when you went up there. Could you just let us know? Did you find ash, what concentrations were they in and did they fit in with what the model was predicting?
Professor Slingo: When we moved on to having to talk about how much ash we believed was in the atmosphere, those measurements became crucial. From the point of view of was there ash/no ash, the reconnaissance flights in the early part of the emergency were finding ash where we expected it to be. As I have said, we then had to move to saying how much ash was up there. The other point about this particular event and the meteorology is that we had a high pressure system so the ash was layering. It was being stratified into layers with quite large amounts. So for us it was more about, "What's the peak concentration? What is the risk of exposure?". So we were required to talk about peak concentrations. So the red and black areas, which we have been hearing about, which were the 2x10–3, 2x10–4g/m3, those, not just from the aircraft but also from our ground-based instruments—this is LIDARs, aerosondes and so forth—all suggested that we were pretty accurate, within an order of magnitude, which, when you think about the range of values that you

could get in a situation like that, showed we were pretty close on the peak concentrations.

That was a very important point for us because, even if we can't characterise the source, we can back-calibrate the source by the monitoring that we had in place over the UK, from aircraft and, indeed, from satellite observations. There are ways—it is quite scientifically challenging—that you can retrieve concentrations. We had scientists working on that throughout this episode.

I think a fair assessment is that, for the peak concentrations, we were within at most an order of magnitude and probably better than that. So the ash was there. It was at the levels pretty much that we were predicting it to be. That is a remarkable achievement considering that we had to move from saying "Is ash there?" to "How much?" within, literally, five days.

Professor Collins: Yes.

Professor Slingo: I can assure you my scientists were working long hours with no breaks for several weeks. It was a very challenging period for us.

Professor Collins: Could I just pick up on a question that Mr Stringer asked earlier about accuracy of measurement? The accuracy, as you have just heard, order of magnitude, that was about as best you could achieve.

Professor Slingo: Yes.

Professor Collins: The margin between where the safety limit was set and where we knew ash damage would occur in an engine, as described by the consortium of engine manufacturers, who, you have just heard, got together to decide what that number would be, left another factor of 100 between what they saw as damaging to the peak concentration that the measurement that the Met Office had said. So we combined all those uncertainties together in that process within about 10 days of the volcano going up, from a standing start. I don't know whether that actually answers the question you were asking, but I felt it was relevant to the uncertainty that maybe you were left with.

Q142 Graham Stringer: I will come to a question I've not yet asked. Is this work peer reviewed and publicly available, where you say that you are accurate within an order of magnitude?

Professor Slingo: Of course it's not peer reviewed yet, because this was new science. The papers are being reviewed now in the literature, so we have a series of papers that cover the observations, that cover the models, that actually even cover some of the sensitivity tests that we have been doing with the models to try and look at the range of uncertainties that might have arisen due to not knowing the particle size distribution accurately and not knowing the vertical structure of the source term.

In terms of observational evidence, we were putting that stuff out on our website at the time along with the five-day forecasts of the plume concentrations that we were asked to do by Government. So all that information is freely available. The observations were on the website. So those of a scientific bent could have looked at them and seen evidence of this layering that I've talked about and some of the evidence for the sorts of concentration values.

Professor Collins: There was also an event that was held jointly, which you have already heard about, sponsored by the CAA and SAGE, which was attended by a very wide audience. All of the science and all of the considerations that SAGE had been talking about was discussed on that day. The airlines were there in force at the most senior level.

Q143 Graham Stringer: When you are talking about being accurate within an order of magnitude, what are you talking about? Are you talking about getting the level at which the ash was accurate so that you knew precisely where the layering was or are you talking about concentration?

Professor Slingo: I am talking about peak concentrations.

Q144 Graham Stringer: But not, actually, the location of it in a vertical axis?

Professor Slingo: We can't be entirely accurate about the vertical location because of the way the model is constructed and the computational cost. We could put many more vertical layers in. But, again, you have to say to what degree can you evaluate that and is that useful information? Later on, and actually during the whole event, we were looking at between what flight levels the ash was situated. That's fairly important information. But to say exactly in the vertical where these layers were a day or two ahead is extremely difficult, but, even with that, we have good evidence that the model was doing a remarkably good job. These layers were descending slowly towards the surface, the old ash layers, and the model was capturing all those processes. The meteorology is a major driver.

There is a key point here as well. Our global weather forecasts are, arguably, the best in the world alongside the European Centre for Medium-Range Weather Forecasts in Reading. The meteorology that drives the dispersion of the ash was actually a really key factor in also getting the concentration and the structure of this major ash plume right. The weather forecasts at that time were extremely good so it is the combination of state-of-the-art atmospheric dispersion modelling with state of the art global weather forecasting which gave us quite a lot of confidence in what we were doing and what we were saying.

Q145 Graham Stringer: The Royal Aeronautical Society, the Airport Operators' Association, British Airways and Manchester Airport have all criticised your lack of responsiveness to their criticism that the inputs into the model were poor. How do you respond to that criticism?

Professor Slingo: We know that the uncertainty in the source term is an issue. We were looking at that and adjusting it on a six-hourly basis with the advice we were getting from the Icelandic Met Office, the Icelandic Earth Sciences Department, BGS—

Q146 Graham Stringer: I don't quite understand that. There was a limited amount of source

information, wasn't there, from Iceland around when the volcano went off? How could you change that?

Professor Slingo: I think Sue Loughlin talked about the relationship between the height of the—there are various things. You can look at the height of the plume. You can also look at the lightning activity within the plume. We were also using that to give us some idea of the intensity of the volcano. We have satellite observations. We had information downstream, certainly coming into the UK, which would give us an idea of whether we had the mass amounts anything like right. As I said, we were in an order of magnitude on peak concentrations.

In terms of the changing nature of the source, the volcano was changing after the first eruption quite rapidly at times. We were re-doing our forecasts on a six-hourly basis and adjusting the source term as soon as we had any change in information about the activity. That, on occasion, meant that there were what appeared to be random changes in the forecast from one six hours to the next, but that's the nature of the beast you are dealing with. You can't forecast volcanic activity in the same way that you can forecast the weather.

Q147 Graham Stringer: I understand that. Maybe I am not making myself clear. The criticism was that the actual information from the source was poor quality going into the model.

Professor Slingo: Yes.

Q148 Graham Stringer: Those organisations, in all their submissions, are critical that you were unwilling to accept that the data input was itself inaccurate, not that the model didn't work.

Professor Slingo: I totally disagree. We have been very clear right from the word go that a major constraint on the accuracy of the ash concentration forecast has to be in the definition of the source term. We are all agreed. It's a major recommendation. At the Met Office we have done a major review of what happened during that emergency and one of our strongest recommendations is to get a better handle on not so much what's actually coming out of the volcano in the vicinity of the volcano but what exits finally in this contained plume that enters into the free atmosphere downstream of the volcano.

We have a couple of additional recommendations. One is that we need an aircraft that can really get into these plumes. With the CAA and DfT we are just completing the tendering process for fully instrumented aircraft, a civil contingency aircraft, that will be on 24-hour call, fully instrumented. It's a turbo prop. It's not a jet so it can fly where our BAe 146 could not fly safely. That will be ready early next year to go. So that will be invaluable in telling us to the north of Scotland what's coming our way because actually that is far more useful to us than knowing exactly what's coming out of the volcano at the volcano.

Then the other thing is that we have what we call "sondes" that can be launched from the surface or dropped from an aircraft which have a package of instruments on that look at aerosols. They look at particle sizes, composition, mass concentrations. At the time of this event we had three of those instruments available. They are research instruments. They were used, and that is part of the evidence that we had for knowing what the peak concentrations are. We now have 20. We can deploy those from the surface or we can drop them out of an aircraft through the plume. So, for me, we understand that that is a major constraint on the confidence of the ash concentration forecast and we are acting on it. So we've never denied that there was uncertainty there.

Q149 Chair: Dr Parker—I think this is more or less agreed—there are other areas where safety considerations are paramount where we expect the producer to collect data on behalf of Government. In this case, isn't there an argument for the airline industry collecting data on behalf of Government?

Dr Parker: If you are referring to the environmental issues—

Chair: Yes.

Dr Parker: No, they are not, really, because most of them are happening at ground level rather than at the upper layers.

Q150 Chair: So you see a difference between ground level activity and things in the air?

Dr Parker: Our concerns were entirely with what might have been deposited in water, in breathable air or on the ground.

Q151 Chair: I know that was your concern. On many of your ground-based activities you require industry to collect regular data and feed it into your models. Isn't there an argument that says the same should apply for the airline industry in terms of helping out on things like this?

Dr Parker: I find it difficult to see how they could. We were happy to get information from whatever source it was available, but in this case I am at a loss to know what it is they could contribute.

Q152 Chair: Did the BA test flights have a wider scientific value? Should we encourage them to do more of them?

Dr Parker: Again, I take your point but they didn't give us the sort of information which would have told us what the ground level conditions were going to be. So in that sense, no, they are not helpful.

Q153 Stephen Metcalfe: Very briefly, because I am aware of the time, firstly, do you think the current emergency is over, secondly, is it going to happen again, and, thirdly, are we better prepared and what have we learnt from the previous experience? That is for all three, really, I suppose.

Dr Parker: Okay. Very quickly from my end, in technical terms, it's only over when the Icelandic geologists tell us it's over. In terms of what was actually happening on the ground, we have had zero results in a long while. So we feel it's over in that sense.

Have we learnt a lot? Yes, a good deal, and it's been helpful in building up our knowledge of who are the right people to call on at the right time.

Are we better prepared? I think we had most of our preparations in place. We had a risk assessment based on an earlier volcanic explosion which related to the veterinary issues we might have faced. Our biggest difficulty at the time was finding somebody to analyse fluorine in grass samples. We managed that quite quickly. Yes, I think we learnt some useful lessons there.

Professor Collins: I think the answer for the particular volcano that erupted in April is yes because it isn't erupting now. Iceland is one of the densest parts of the planet with regard to where volcanoes exist. So will it happen again? Certainly. When? I haven't a clue, but it absolutely certainly will happen again.

Are we better prepared? My observation is that we were pretty well prepared in a lot of disjointed areas. What this episode showed us how to do, and quickly, was to bring those disjointed areas together in a very constructive and collaborative way to deliver as quickly as possible a solution that got us out of a situation that could have been unsafe and we didn't know, so we erred on the side of safety, to a situation that we now know to be safe, but we still need to do a lot more work.

Are we better prepared? Absolutely, because we now have that community working together and it is still continuing to work, as Julia has just said, on a number of the critical aspects were there to be another volcano in the near future.

Given the resource constraints, we, I think, have to look to the market, going back to the Chairman's question just now. We do have to look to the market just a wee bit more than perhaps we have done in the past to help us with the experience of what actually happens when aircraft fly through airspace which has got stuff in it, whether it is volcanic ash, ice or anything else. We need to get the science of observation in airspace better coupled to the experience of aviators who fly through it. That is a piece of work that, maybe, we haven't done as much of yet as we should do. In the current economic climate, if you say to anybody "Add to your cost base", that's not going to go down well, but, nevertheless, we ought to be addressing it.

Professor Slingo: Yes, the current emergency is over, but I think it would be wrong for us to take our foot off the pedal in terms of the research, the development of the forecasting capability, the monitoring systems, because, for sure, this was a wake-up call of how bad it could be. Next time, of course, the meteorology may be a lot more friendly. We may not be hit with such a difficult situation. There is no doubt, certainly within the Met Office, that we are pushing ahead with improving the forecasting process and particularly recognising the need to actually say something about concentrations now, which is going to be very demanding for us.

Q154 Chair: All of those three answers have financial implications—

Professor Slingo: Yes.

Chair:—yet we still owe money to NERC?

Professor Collins: We do because the NERC aircraft existed which, of course, had it not existed we would have been in much more difficult straits. It is worth considering that the fact that we put 30 years' worth of investment into atmospheric science, into meteorology, into modelling, into volcanology through our science base, gave us the ability to react very quickly. I agree we have a financial short-term issue to resolve but actually the fundamentals of continuing to invest in making sure we are not vulnerable in the future are probably more substantial and maybe slightly trickier. That's the current ICAO road map for what is happening. We are, from an aviation point of view, still working extensively and collaboratively on an international front to ensure that not just our airspace but European airspace, with respect to Iceland, is much better understood in these circumstances.

Chair: Thank you very much for your time.

Wednesday 10 November 2010

Members present:

Andrew Miller (Chair)

Gavin Barwell	Pamela Nash
Gregg McClymont	Alok Sharma
Stephen Metcalfe	Graham Stringer
David Morris	Roger Williams
Stephen Mosley	

Examination of Witnesses

Witnesses: **Professor Mike Hapgood**, Royal Astronomical Society, **Professor Paul Cannon**, Royal Academy of Engineering, and **Chris Train**, Network Operations Director, National Grid, gave evidence.

Chair: May I welcome you, gentlemen, and thank you for attending this session? Perhaps before we formally start you could introduce yourselves.

Chris Train: I am Chris Train, National Grid. I am the Network Operations Director for transmission in the UK, so my responsibility is for the day-to-day operation of the gas and electricity transmission grids. National Grid owns and operates the electricity transmission system in England and Wales and operates the transmission system in Scotland as being part of the Great Britain system operator. We also have business in the north-east of the US as well.

Professor Hapgood: I am Mike Hapgood. I work at what is now called RAL Space. It is the space part of the Science and Technology Facilities Council at the Rutherford Appleton Laboratory. I am Head of the Space Environment Group there. I have a wide-ranging interest in all aspects of space weather. My deepest interest is actually in extreme events and the physics behind those events. Also, I have a long involvement with the Royal Astronomical Society. I just stood down as vice-president in May this year and, obviously, contributed a lot to their evidence that came in.

Professor Cannon: Good morning. I am Paul Cannon. I am representing the Royal Academy of Engineering. With my colleagues we have 25 years or so experience of giving advice to MOD and ESA on mitigating space weather and similar space environment effects. Those apply to spacecraft, aviation and to radio systems.

Q155 Chair: Thank you very much. Can we start off by asking you how is scientific advice and evidence being used to assess the risk posed by space weather events and how this is being used to develop contingency plans?

Professor Hapgood: Shall I kick off? Over the last few months, I and others, like Paul, have been involved with talking to the Cabinet Office and others about those risks. We have been putting together an expert group to advise the Civil Contingencies Secretariat. At the moment we are bringing that group together awaiting some kind of formal blessing for it to be an official group, but at the same time we are developing a list of what we might call "reasonable worst case scenarios". Because space weather is rather complicated, there is a whole set of, maybe, several dozen of these scenarios of different features of the space environment.

Q156 Chair: Professor Cannon, do you want to add to that?

Professor Cannon: I would just like to extend that to say, as I said in my introduction, we have also been working very closely with the Ministry of Defence in this topic area over many years. At this hearing here today we are discussing these very large events, these major events, but over many years the Ministry of Defence has recognised the importance of the smaller scale events, day-to-day events, and even the types of events that we have experienced during the space era, shall we say, from 1960 through to today.

Chris Train: We have had recent meetings with DECC and relevant agencies to discuss the potential impacts of higher events than those that were experienced in 1989. In 1989 we had impacts on our system, and since then we have put in monitoring activities, measurement activities, on the network in terms of developing the contingencies. A critical part of that, I think, has been the early warning. There is additional analysis to do on the potential for higher scale events, higher impact events, on the system. We have kicked off a piece of work to better understand what the potential of such an event would be on the network.

Q157 Chair: That leads very neatly to the next point I wanted to ask. What is the actual risk? How likely is it that we will have a space weather emergency, how severe could it be and is the Government's contingency plan sufficiently robust?

Professor Hapgood: I think the easiest way to say it is that it's a work in progress, I am afraid. I can't give you a definite answer. We are trying to clarify what these worst cases are in different areas. With the Grid, we talk about it in terms of the rate of change of the magnetic field at the Earth's surface. Going back to the 1989 event that Chris referred to, we had a certain level. We believe the maximum risk is greater than that. In particular, there is clear evidence from a big magnetic storm, as we call it, in 1921 of a level maybe five times greater than we had in 1989. So it is that kind of thing. That is for the Grid risk, but—

Q158 Chair: Just on that, if we took the 1921 example where we have some data and applied it

today's infrastructure, are you saying we don't actually know what the impact would be?

Chris Train: At this stage we don't know what the impacts would be. All the work and resilience work that we've been doing to date has been with respect to the 1989 incident. So, following the heightened concerns about the potential for a bigger event, we are undertaking work to understand the impacts on our system. The impacts are very specific to the network as they are at the time. For example, the network is configured differently today than it was in 1989, so some of the concerns and issues that we might have had then are not the same in terms of the network as it is today.

It is also not necessarily relevant to correlate what happens, for example, on the Canadian Grid, where they have experienced problems, with the way that the Grid in the UK would work. So you have to do the very specific analysis around the potential impacts on the transmission system here.

Professor Cannon: I would like to concur with my two colleagues here. It is a work in progress and it is a particularly difficult work in progress. If I may, I will give you an example. GPS satellite navigation is pretty ubiquitous. It is not clear what would happen to the GPS system if we had a major storm, but it is particularly not clear what the impact would be in respect of the various systems that we have in this country. In fact, it would be very hard to ever be able to work out in detail what the impact would be.

Q159 Roger Williams: I have a few questions, really, to tease out the state of national co-ordination as far as these aspects are concerned. The Royal Astronomical Society has commented relatively unfavourably on the state of co-ordination in the UK compared with that in America and some of our European partners. How co-ordinated is the Government's approach to space weather activities?

Professor Hapgood: I am almost tempted, I am afraid, to say it is work in progress again. Since the evidence has been submitted, we have actually made some very interesting progress. There were the meetings here in Parliament in September over in Westminster Hall, and there was a workshop organised by the Cabinet Office the next day where a number of experts, myself, people from the British Geological Survey and a lot of people from industry as well as Government came. That was a really useful meeting getting people together. Within the expert community we had some discussions a few weeks ago and we were talking with the Cabinet Office last week. We are trying to set up an expert group that I would chair to actually bring things together and really try and focus in on what the science evidence is about the environment. Then we can feed that to the Cabinet Office, which can then feed it down into—I think the idea is—its sector resilience plans. So we are getting there.

Q160 Roger Williams: Do you think we need a new lead body to ensure that the co-ordination is working as well as it should, and should the UK Space Agency be that body?

Professor Hapgood: The experience in the US, which I would suggest to mirror, is more to have a co-ordination body. A number of groups are involved in the US; you have NASA, which everybody knows, but there is also NOAA, the National Oceanic and Atmospheric Administration. They have a very key role. There is also the National Science Foundation, the military and various organisations across the US Government. We need to bring those resources together at the moment. Trying to build a new structure would just divert focus.

Q161 Roger Williams: You mentioned the model in the USA. Is that something we should try to emulate?

Professor Hapgood: I think we need to customise it to what are our needs and capabilities. The idea of pulling together is, in a sense, what we've been doing behind the scenes in recent weeks, just trying to identify groups and bring them together. For instance, we have the Met Office involved in this group.

Q162 Roger Williams: You mentioned a number of bodies and agencies that are involved. Some of those are military and some of those are civil. For instance, some of the knowledge or information that the military might have may be classified, for instance, or restricted in some way. Do other bodies and agencies have enough access to that to make it a sensible response to any event that could take place?

Professor Cannon: I will take that, if I may. In the USA, which is a good example, there is interest in space weather. There is a need for space weather information both in the civilian domain and in the military domain. They operate separately but together. They operate as distinct organisations. Some of the information does not transition from one to the other and some of it does. Certainly, the civilian measurement instrumentation contributes into the military but, of course, some of the more applications-driven work doesn't transition back again. There is always a tension there. That's certainly true.

Q163 Roger Williams: Mr Train, would you like to comment on that?

Chris Train: From our perspective, it is about understanding the science and, therefore, the probability, the likelihood and the scale. Then we can look at the specific risks with regard to the energy supply industry and at the appropriate mitigating measures. Then we have co-ordination across the energy industry through the Energy Emergency Executive Committee, which I chair, which means that we then get industry co-ordination on the resilience plans and the actions to help to manage any emergency situation.

Professor Cannon: Can I just pick up on something that Mike said about co-ordination? One of the issues of space weather and understanding its impact is that, although we can sum it up in a couple of words and they are a useful couple of words in terms of the public, there are very many different aspects to it. I would not want to comment on the impact of space weather on the Grid because I just don't know enough about it. Then we have the impact of space weather on

spacecraft, aviation, radio systems, etcetera. No one person can actually have all of that knowledge.

Q164 Chair: We are in the realms of a lot of unknowns. Let me just quote from the Lloyd's Report just published yesterday. In the foreword, Tom Bolt, the Performance Management Director of Lloyd's, says: "Nor is space weather a problem that we can consign to the future, it is something we need to consider now. Scientists predict a spike in strong space weather between 2012–2015. In terms of cycles, we are in late autumn and heading into winter." Is this an insurance company exaggeration to persuade us to part with larger premiums or is it something that scientifically is a serious proposition?

Professor Hapgood: I think this is a serious proposition but you have to distinguish two things. There is the big event, which is really the aim, I think, of this inquiry, and, as Paul was saying, there are the more everyday effects. A lot of that report is focused on the everyday effects. Those everyday effects will become much more important over the next few years. In terms of response to business, that is really quite important.

The big event is also more possible. Over the next few years there is an increased risk of that. We would certainly expect a greater risk between now and 2015 than in, say, the subsequent five years and then the risk comes back. It is this question: when's the big event going to occur and how big an event do we prepare for?

Professor Cannon: Don't forget that we were heading towards the same climatology in space weather 11 years ago. This is an 11-year cycle. We are coming through to 2012 to 2013 and a peak at the Sun spot cycle, but there was another one of these 11 years or so ago.

Q165 Stephen Metcalfe: Could I quickly interject? You said that this is all work in progress, but there is an inevitability about suggesting that there will be a major event at some point in the future. I am not sure I picked it up earlier. Why is it that we are coming at this so late? We've known about solar weather for 150-something years, but now it only seems to be on the National Risk Register. What's happened? You also, I believe, just said that everyday events are going to become more important in the next few years. Could you also expand on that for me?

Professor Hapgood: I am sorry, but I have forgotten the first part of the question.

Q166 Stephen Metcalfe: Why are we coming to it so late or appear to be coming to it so late?

Professor Hapgood: I think it is more appearance. We have been talking about this for a long time. I have been involved in these activities for 15 years or so. We had a lot of discussion around the previous solar maximum, as we call it, 11 years ago. But then interest decays away. One of the big features about this is how it interacts with people's psychology. Because the cycle is so long, unless you are an expert and very deeply involved in it, most organisations tend to forget it during the quiet years of the solar minimum. We have had a particularly long—it is one of the scientifically interesting things—deeper and longer solar minimum than we have had for the previous hundred years. Now solar activity is rising again. We can see it coming over the horizon. It is helping to focus things. It is also the way the science and our understanding of the engineering impacts has grown hugely in the last decade. I think it is just a critical mass. We've reached that critical mass now.

Professor Cannon: I would just like to add to that—I don't disagree with any of that—in respect of the change in technology that we have experienced over the last 10, 20 years. One of the impacts of a major solar space weather event would be single event upsets in electronics. Electronic fabrication sizes have reduced, reduced and reduced and the currents that you need to actually flip a bit within the technology have reduced, reduced and reduced. As we become technologically more adept at providing clever gizmos and the like, then our resilience to the major space weather events reduces.

Q167 David Morris: Thank you for that. If or should the big event happen, are our international agencies, in co-ordination with ourselves, able to cope with it? Are you happy with the ESA being involved in NASA? Is there an international strategy that will come forward should something happen?

Professor Hapgood: There are two threads to what's happening internationally. One is what we call Space Situational Awareness. It is a phrase that's been developed to emphasise that we need to know what's going on in space because we have so much infrastructure up there, so many commercial and operational services that use space. It's about debris but it's also very much about space weather. So the US has been building a Space Situational Awareness programme for some years. In Europe it started under ESA at the beginning of last year. That is now proceeding. At the moment it is at the preparatory phase, seeing what can be done and trying to federate European assets to everybody's benefit. The UK is a member of that, but because of the way that the BNSC used to operate it couldn't actually get very much money so we are in at a minimum level because this is a generic space risk. The old system was not so good at handling generic issues across space. It was very good at specialist things like science, meteorology, etcetera. On the European level we have that.

The other thread is that the World Meteorological Organization is now getting involved. I am sure the Met Office will tell you more about that. We are trying to develop co-ordination through WMO, particularly in terms of identifying better what measurements need to be made around the world to know what is going on and how is that data exchanged. We have arrangements that date back to 1957 coming out of the science community because of the big programmes that developed in that era. They really now need to be modernised. That is being looked at, I guess is the right phrase. Again, I am afraid it is work in progress.

Professor Cannon: The first point to make, of course, is that we share the ionosphere, we share space, so we

really do need to work with our international colleagues.

I would also like to make the point that the Space Situational Awareness programmes, the European one, is an ideal opportunity to leverage an international programme into a UK programme and vice versa. If we don't have a UK programme, then our ability to participate in the European programme will obviously be reduced. There is a good opportunity here for the UK. I think it is worth also saying that the UK has a long history in terms of the science in this area. It has a long history in terms of the applications of science in this area. So we are very well qualified as a country to move forward to the benefit of UK Plc.

Q168 David Morris: Do you think that, currently, at this moment in time, the Met Office is doing a good job at predicting space weather?

Professor Cannon: The Met Office isn't really involved in predicting space weather. The Met Office has an embryonic programme in this area. I would say that the expertise for space weather in this country at the moment resides, primarily, in the Rutherford Appleton Laboratory, in BGS, the British Antarctic Survey and in industry, specifically QinetiQ. The university sector is also very good in this area. So we have got good back-up. I don't know whether Mike would like to say anything else in case I've missed out any groups.

Professor Hapgood: We've done a survey of the assets. There are something like 30 groups in the UK that are active in the area, including, as Paul says, the Met Office—it is very active, and it is trying to develop its programme. Again, it goes back to this point about co-ordination. We have a lot of people involved, we talk to each other and now we just need to find ways of co-ordinating ourselves better. Some of that is a bottom-up push from the expert community, but now we are also getting some pull from Government helping us with that, and that is a great thing.

Q169 Gregg McClymont: Can I pick up on something that Professor Cannon said earlier on, which was—I took it down—that you thought it would be very difficult to ever work out the impact of what one of these events would be. I want to broaden that out and ask, do you think this risk can ever be quantified?

Professor Cannon: Not wishing to make a joke of this, you could envisage a perfect storm, but a malignant perfect storm. Lots of the effects, actually, are relatively small, but if they all come together, you have a problem. I think that's the point I was trying to make. It's the integration of effects in one domain of society adding to another domain adding to another domain and then causing us problems. I do think it would be very difficult to completely understand what the effects will be of one of these storms, but there are common-sense strategies and quite technologically difficult strategies perhaps to mitigate the effects, and there are things that can be done.

Q170 Gregg McClymont: Professor Hapgood?

Professor Hapgood: How do we quantify the risk? One of the critical things is just building up the evidence base. There are two main aspects to that. We do have a lot of historical records of space weather events going back into the middle of the 19th century. The scientific community talks a lot about the 1859 event. A lot of mining of old records has been done and from some of that we have some quantitative data. However, a lot of it is more anecdotal but it sets a picture. There are a whole range of, maybe, 30 other events since 1859 that are only partially exploited. I think I've mentioned before the 1921 event. Our American colleagues have done some interesting digging into that, either of records from 1921 or records written later by people who experienced the event, particularly where a telephone exchange in Sweden was burnt down to the ground because of the currents induced by space weather in it. That's the historical base.

The other thing—I may be biased a bit—is doing the physics better. We understand the physics of how space weather works only roughly. It is to develop that, and particularly to understand how we scale that up to the big events. Is the physics that we see every day happening in space? You have to remember that space isn't empty. We have this very tenuous wind that blows from the Sun to the Earth and that is what brings energy from the Sun to the Earth in the form of what we call coronal mass ejections. That's what could cause the perfect storm, as Paul put it. So how do we understand that?

Q171 Gregg McClymont: Is it possible, having listened to what you were saying, that this is as much about, and absolutely justified in this sense, providing a rationale for space science research as for actually the potential risk? We know that academics across the land have to provide some sort of pragmatic and benefit-based calculus now.

Professor Hapgood: I know what you mean, but I think that it is the other way round. Certainly for me personally, and particularly over the last few years, the more I learn about the science, the more worried I get. The two big space weather events of my career were in 1989 and 2003. I had great fun because I could talk about it, and I could see the aurora and watch what was happening on various things. I think with the next one I will be much more worried because I know more. That knowledge is a worrying thing.

Q172 Gregg McClymont: Just looking at it as a layman, in 1989 it seemed relatively serious but not Earth-shattering.

Professor Hapgood: Yes.

Q173 Gregg McClymont: So I presume that the rationale for seeing this as a serious risk is the shift in technologies? A power outage in Québec for a small amount of time, although difficult for Québec, doesn't strike me as—

Professor Hapgood: I was saying about learning more. As an example, there were also a lot of problems in South Africa in the 2003 events, and that was subtly different in that it was not the big blackout.

We realised that it could happen in somewhere like South Africa, which is far from the northern or far southern regions where you have aurora, which is where we thought this would happen. The other thing about that was the impact of delayed effects. You had an accumulation of slow bits of damage in transformers and then, suddenly, in a few months they lost about a third or a quarter of the South African Grid and it had serious problems. I think 15 transformers died in a very short period of time. That caused them big problems. Like in 1989, that was another big wake-up call. There was another subtly different risk that we have to think about.

Q174 Gregg McClymont: Can I ask just one final question. A lot of this has been driven from America. Would that be a fair way to put it?
Professor Hapgood: Yes and no. The Americans had a big interest in that particularly because they have their military interest as well as their civilian interest. I think they are in the lead, but there is huge interest across Europe. As I have already said, we have a lot of capability in the UK, but we have our annual European meeting next week in Bruges in Belgium where about 300 people, some from the US, and a lot across Europe, will be talking about this. So there is a big interest, a big drive in Europe.
As to other countries, China started to worry about that because they are building their Grid, as everybody knows, and they are seeing problems. I think the Australians also have a very big interest in this area because they have a big country. They use all kinds of radar and radio communications, so they very much worry about the ionospheric area that Paul is expert on.

Q175 Stephen Mosley: When we have had incidents in the past—there have been problems in Sweden, Canada and South Africa—when we get a space weather incident, does it affect the whole planet equally or is it geographically isolated in certain areas? Are there areas more at risk or is it a case that it is the technology that is being used in certain areas that has caused a problem?
Professor Cannon: If we are just considering day-to-day events, then the high latitude regions, shall we say your Norways and Swedens in Europe, and your equatorial latitudes, plus or minus 20 degrees of the Equator, shall we say, are more at risk than the mid latitudes. We are learning how to mitigate those effects. One of your colleagues asked what models we have, and the answer is that we have models to mitigate those effects to some extent.
The big issue is that, if we end up having one of these really large extreme events, then all bets are off almost. The high latitude becomes the middle latitude and the equatorial latitude becomes the middle latitude, and we've got widespread effects. That's the worry.

Q176 Graham Stringer: Let's explore that, possibly with Mr Train first. The event in 1921 was five times greater than the one in 1989. How big was the Carrington event in 1859 compared with what we have had this century?
Professor Hapgood: We have a problem in that the instruments that existed then actually went off scale.

Q177 Graham Stringer: Right. So it was very big?
Professor Hapgood: It was very big.

Q178 Graham Stringer: What happens to the National Grid if we get something twice as big as the Carrington event?
Chris Train: That's the piece of work in progress, I think. In 1989 we had the event that had an impact on our network. We had two transformers that had problems. They weren't problems at the—

Q179 Graham Stringer: Was that in East Anglia?
Chris Train: East Anglia and down in the south-west also.

Q180 Graham Stringer: I am sorry. I don't want to keep interrupting. That slightly conflicts with what we were just being told about it being worse further north.
Chris Train: It's a general statement, isn't it, because part of it is depending upon the specific orientations of the Earth at the time with respect to the Sun about where the strength will be? From a Grid perspective, the induced currents, generally, would be an issue at the extremities of the network as the currents come ashore. Since 1989 we have better measurement on the system so we have been able to more generally get better data looking at the performance of the network on a more general basis. We are connected with international organisations that have a better understanding about effects on the different power grids through the other incidents.
In terms of looking at the specifics of an event of an order of magnitude bigger than the 1989 event, which was the highest event for us, that's the piece of modelling work that is necessary.

Q181 Graham Stringer: But that doesn't sound very reassuring. Will the National Grid be there if there is an event of the size of the Carrington event or bigger? Will we have electricity afterwards?
Chris Train: Will we have electricity afterwards? Yes, we will. What will be the impact of that event? There are a number of different things that have occurred since. One of the problems in 1989 and the evidence across other parts of the world is that particular configurations of transformers have more issues. So newer transformers have a bigger resilience to direct current induced. The size and length of timing of the induced current is a critical element. The issue that causes the damage on the transmission system is a heating of the core by the induced currents on the transformer. These events are quite erratic. Therefore, the longer it is, the greater a heating problem will be in the core. If they are very short bursts, then it is likely not to cause any damage. One of the things is that we need to better understand the potential impacts and the science. We have more data but we need to do the analysis.

Q182 Graham Stringer: But, actually, if we are whacked by something bigger than Carrington—the physics of induction is relatively simply, isn't it? What

is happening on the Sun may be very complicated and not understood. Induced current is something you learn at GCSE level. It will heat up the transformers and they will break, won't they? They will melt and we won't have electricity. I am not reassured, really, by what you say. If it's a short burst, we're okay. If it's a long burst, we don't have electricity.

Chris Train: You get a degradation at the core. It is not necessarily a catastrophic event.

Q183 Graham Stringer: But it was in Québec, and there were problems in East Anglia with much smaller events?

Chris Train: It was actually a different incident in Québec. They didn't have a catastrophic failure in Québec of a transformer. What they had was an unstable system that led to system tripping, which led to the collapse of their Grid. In that sense, it is looking at the different forms of impact on the network.

Q184 Graham Stringer: How much warning do you get of these events?

Chris Train: Obviously, we monitor on a daily basis the occurrence and the data of knowing when one has occurred. It is between one and three days.

Q185 Graham Stringer: I was thinking about the future rather than the past.

Professor Hapgood: One thing that often isn't said is when we have a very big event, we actually get at least some sense of it coming a week or so in advance because we will see a very large area of activity on the surface of the Sun, a very big Sun spot group. We have Sun spot drawings, photographs or whatever for all of these events back to 1859. So it is about the one certainty we have. We will see something appear on the edge of the Sun and then rotate into view. So we have that week when we can have a sense that something is coming. What we can't predict is the size of the effect it will give us, partly because will a CME, as we call it, a coronal mass ejection, actually hit the Earth, or will we be lucky and it will miss us? An event like that happened in November 2003. Also, a very important thing is the orientation of the magnetic field in that coronal mass ejection. If it points southward, we've got a problem. If it's northward, we are probably okay. That is really still very hard to predict.

Q186 Graham Stringer: You say you've got contingencies. Can you be more specific about what the contingencies are if you think there is a huge solar storm coming this way? What do you do?

Chris Train: In terms of the operation of the Grid system we would configure the system to its most resilient form and so increase the level of flexibility. If we had outages on the network, we would bring those back in wherever possible to increase that flexibility. We would carry more standing reserve on the system, which would help in a Québec-type scenario, to help to ensure the stability of the Grid. We might even consider switching out certain transformers if felt to be particularly vulnerable.

Q187 Graham Stringer: Just going back to something Professor Cannon said earlier and what you have told us about the warning system, Professor Cannon said that the British Antarctic Survey and other bodies were looking at this. In the written evidence, the British Antarctic Survey says: "The UK does not have a system of warnings or alerts in place. It is totally reliant on warnings provided by other countries such as the Space Weather Prediction Service provided by the NOAA in the USA which is not tailored to UK needs." That seems to be conflicting with the verbal evidence you are giving us this morning. Would you like to comment on it?

Professor Hapgood: I think, at this time, the Americans are very happy to collaborate. There is a long tradition of collaboration and I got a very clear message talking to Americans that that had actually increased, probably about the time Obama was elected, to be honest. I remember somebody coming to talk to me: the message is co-operation.

Q188 Graham Stringer: What the British Antarctic Survey seem to be saying—I don't know quite what this means; hopefully you do—is that the US systems aren't tailored to UK needs. What do you think it means by that?

Professor Cannon: If I may. A possible example would be that the US systems are for aircraft communications warnings and are tailored to flying over the contiguous US rather than flying over European airspace. So that would be one possibility or one reason for that statement.

Just coming back to your original point about whether we have a national system for alerts and the like, the answer is simply no. We have expertise in different areas in this country. The Met Office was mentioned earlier on, and it is doing a good job here in exploring the possibility of a national approach to this, but it could be that this isn't taken under the auspices of the Met Office. Perhaps it should be under the UK Space Agency, which was also mentioned earlier on.

Professor Hapgood: As we mentioned before, the European Space Agency has its Space Situational Awareness programme, which would very much be looking at things tailored to Europe. Many of the issues—not all of them—are tailored for Europe, such as those relating to aviation, because the so-called augmentation systems that help aircraft use GPS are focused on a European solution. For things like the Grid, I think we need a national solution because we have a unique configuration because we are on this island surrounded by seawater. That has a profound influence on how our Grid responds to space weather.

Q189 Graham Stringer: Just a final question. If things go wrong and you get induced currents and several transformers go out within the National Grid system, how many spares have you got?

Chris Train: We, obviously, do carry spare transformers on the network. We have about 885 transformers and we carry 17 spares for that amount, but in this kind of situation you are looking at what are the most vulnerable. We are talking about a network. So we would be looking at how we could configure the network if there was a problem. We

would also be replacing where we had a problem, so there is more flexibility than just the 17 spare transformers.

Q190 Graham Stringer: So it would be simplistic if more than 17 went out?
Chris Train: Not necessarily, because, for example, under certain circumstances we will move grid transformers from one part of the network where you have got other options for providing the power at that part of the network to another part of the network where you need it to have more resilience. So it is not as simple as you carry just 17 and if the 17 have gone, then you've got a power outage. We would manage the Grid and the flexibility of the Grid with respect to the needs on it. The resilience is higher than that number of 17.

Q191 Gavin Barwell: Can I start with Professor Cannon? You talked earlier about this concept of a perfect storm, a malign combination of effects, essentially. Graham has dealt with the issue of the Grid, but, looking at a severe space weather event, what impact could that have on satellites and as a result GPS and telecommunications?
Professor Cannon: It is a complicated answer and it will be caveated. The first issue would be concern about the integrity of the spacecraft themselves. Our estimate is that of the order of 10% of the satellites would be affected during a Carrington-style event. I have to tell you that that is somewhat less than in the literature, but this 10% is based upon analyses of spacecraft we have undertaken over many years. So 10% of the satellites would be affected.
This is a guess. This is an informed guess at this point—an informed estimate. Of those, some we would probably be able to bring back on line again. What happens is that you get single event upsets, charging effects on the satellite, and a consequence of that is that the satellite goes into crazy operational states. Sometimes they can be brought back on line. But, remember, if a lot of satellites are all in trouble at the same time, and this is the perfect storm problem, then one satellite is hard enough to bring back on line, but when there are a lot of satellites that you are trying to bring back on line it's hard work. So that is satellites in general.
GPS has been mentioned. As we mentioned earlier on, GPS is really integral to the country's infrastructure. We really don't know how resilient GPS is. The thing to remember is that GPS was designed as a military system by the Americans. We all use it now but it was designed as a military system. Consequently, GPS is much more likely to survive than the average satellite. Then, of course, we get to the problem of what happens to the radio signals as they propagate from these satellites down to the ground, etcetera. Here again, we have to caveat everything. I have to caveat my response. I should say that the higher the frequency that the signals are transmitted, the less effect you have from the ionosphere through which the signals are propagating; the lower, the more effect. Most telecommunication satellites operate at frequencies sufficiently high that the effects will probably be quite low. If we go to GPS, the signals really will be affected and there will be various effects, which we can come back to, if you wish. Depending on the level of accuracy that you require will determine how long the problems will persist for. So if you have a very accurate system, the problems may persist for longer. If you've got a system that doesn't require much accuracy, the problems will persist for a shorter time. We may be talking hours, days or possibly a week, but these are estimates. These are gross estimates: work in progress, as has been said several times.
Then for normal ground telecommunications infrastructure, Radio 4, etcetera, the effects will be minimal providing the power continues.

Q192 Gavin Barwell: Do you want to add to that?
Professor Hapgood: I think that was pretty comprehensive.

Q193 Gavin Barwell: Okay. Can I come back on one point of detail—the 10% figure? Is that to do with the distribution of the satellites around the Earth and those that are caught and those that aren't, or is it to do with different technologies, different ages of satellites, so some are more vulnerable than others?
Professor Cannon: Yes. It is a variety of things. It depends on which orbit they are in. It also depends on how old the satellites are. Certainly in terms of age—I didn't mention the solar arrays—but the power from the solar arrays will be impacted. The solar arrays are aged in this process. There is a luck aspect to all of this. All satellites are designed to fly probabilistically for a certain length of time. They will, sometimes, go down. It's luck or lack of luck.
Professor Hapgood: Paul has been saying about the business of recovering satellites, and I think there is a big issue to stress there. Satellites are designed to cope with these conditions. We have 40 years' experience. The key issue here is the operations teams, the engineers in the control rooms. It's making sure they have the information. They are really skilled people. They are often dealing with incidents several times a week on a spacecraft of one level or another. During a storm those incidents would be much more enhanced. So it is actually making sure that the engineers have the resources. As one of them once said to me, they design a spacecraft to survive these events but they want to know when an event is happening so that if a spacecraft misbehaves they do the right thing rather than the wrong thing. That control issue is very important here.

Q194 Gavin Barwell: This comes back to some of the earlier questions about the degree to which the UK is dependent on other countries for getting that information?
Professor Hapgood: Yes. I think a lot at the moment is through the US and Boulder, although I should emphasise that the US has this centre but they also collect a lot of data from around the world, including instruments that Paul and I run. In fact, the head of the centre is coming to talk to us at the end of the month, I should perhaps add.
Professor Cannon: Can I just emphasise something which I consider to be really important in terms of

GPS? Everybody worries about GPS and it is right to worry. In fact, it shouldn't just be GPS, we are talking about GNSS systems here—global navigation satellite systems—so Galileo falls into that group. GPS GNSS systems are used for timing as much as for navigation. We think we use it a lot for navigation because we've got our sat navs in our cars, but timing is really important for telecoms and various other applications. The absence of a GPS system, superficially, sounds as if this is a disaster, but I suspect it is not. The reason I suspect it is not is because a properly designed system will have what is known as a disciplined clock within it. That is, basically, an atomic clock that also has inputs from GPS. GPS gives it long-term stability. It is that disciplined atomic clock which will be able to run for hours, days, possibly even weeks and maintain good timing—

Q195 Gavin Barwell: So there is a contingency system there, essentially?

Professor Cannon: There should be a contingency. I think the question is, is that contingency in there? Technology would allow us to ride over many of these problems. My question is, has that been allowed for in our critical infrastructures?

Q196 Gavin Barwell: That brings me, quite nicely, on to my last question, which is to what extent has an assessment been done of whether these contingencies are in place? You have just said there should be contingencies. Do we know, for the critical bits of our infrastructure, whether there actually are contingency systems? Has that assessment been done?

Professor Cannon: The first thing to say is that the Government, the Cabinet Office, have got to grips with this pretty quickly. We have been looking at this over the last few weeks to months. The answer is that it is a work in progress. We keep on saying this. We really don't know. It's an important piece of work in progress but it's a relatively new identification of a problem. We can't just guess.

Professor Hapgood: My understanding is that within the Civil Contingencies Secretariat what you say will be taken forward in the coming months.

Chris Train: May I just also add from an energy industry perspective that we operate well-practised procedures around contingencies? Business continuity plans are co-ordinated across the piece. So we are well rehearsed in terms of managing any potential impact.

Q197 Gavin Barwell: You have just touched on my final question. I think we have got the work in progress picture of all of this, but what is the timescale for that work? You are saying that we are just coming to a high risk period. How quickly are these sort of assessments planned to be done? What is the future timescale?

Professor Hapgood: I suspect that you should probably direct that more towards the Cabinet Office. My understanding, certainly, of the inputs we are giving is that we have this month, November, to support the National Risk Assessment by defining what the environment is. Then that will be taken forward as part of the work for the 2011 National Risk Assessment.

Professor Cannon: That will probably be quick and dirty.

Q198 Pamela Nash: I would like to move on to the possible effects of space weather on aviation now. What research do you know of that is taking place to look at the effects on commercial aircraft?

Professor Hapgood: There is a variety of things. One of the most important things is the fact that aviation over the polar regions is most affected by space weather. One of my colleagues who couldn't be here today, Bryn Jones, has been involved in what is called the Cross-Polar Working Group, which has a sub-group on space weather. This is set up under the auspices of all the air traffic control authorities for the Arctic region, so Russia, the United States, Canada, Iceland, Norway and probably somebody else that I have forgotten. They have specifically had a working group looking at these effects and trying to develop recommendations. I believe they are very close now to having the stamp of approval and we might be able to see them. They are looking at what are the effects of space weather on radiation in terms of communications.

The radiation storms that we have talked about will cause radio blackouts of what we call high frequency radio over the polar regions. When those happen, aircraft are not allowed to fly within 8 degrees of the Pole if they don't have any communications to the control centre. You can't use ordinary satellite communications in that region. You can't see the spacecraft because it would be below the horizon.

People also worry about the effects of radiation on aircrew, but I think that communications is the really big issue. If you can't fly over the Pole, you have got to take a longer route, you burn more fuel, you spend more time in the air and you may have to carry fewer passengers and less cargo. So the airlines involved lose out both ways—they get less income and they spend more money. That is all being worked through. Basically, what is going to come out is a series of recommendations on how this is handled and this will, eventually, feed through the Americans into the International Civil Aviation Authority.

Professor Cannon: I think it is worth saying that aircrew are some of the most highly radiated workers in the world. If you sit up at 30,000 to 40,000 feet for a lot of the time you have a continuous background of radiation hitting you.

The annual limit for radiation is 1 mSv. Colleagues of mine at QinetiQ have calculated that, if you had been unlucky and flown from London to Los Angeles at the time of the time of the Carrington event, you would have actually received 10 mSv of radiation. So it is really quite a significant overdose. But, again, before we get headlines of, "This is a disaster", if you actually know that this radiation event is taking place, then what you have to do is reduce the height of the aircraft. Just coming down 10,000 feet will make an enormous difference in terms of radiation.

So we get back to the fact that it is good to have mitigation strategies—it is good to know that you know this is going to happen—and have good engineering strategies. For instance, a good engineering strategy—engineering strategies are good

in all of this, if you can come up with them—is that you have a detector on board the aircraft. The detector detects these particles and it alerts the aircrew. The aircrew have a concept of operations that allows them to then decrease their altitude.

Q199 Graham Stringer: Are you saying that all aircraft do have these facilities?
Professor Cannon: No, they don't.

Q200 Graham Stringer: Or they should?
Professor Cannon: They don't. There are groups of scientists and there are certainly groups of airline staff who would like to have those sorts of detectors.

Q201 Chair: But this has not come specifically out of concerns about space weather events. It's about general background radiation?
Professor Cannon: There is the issue of the background radiation and integrating up the dosage on the aircrew. But, also, if you had this type of detector, it would be able to mitigate the effects of one of these extreme events. I should point out that Concorde had one of these detectors on board because it was actually flying much higher than normal subsonic passenger airlines of today.

Q202 Pamela Nash: You have spoken about the radiation detection. Is there anything else any of you feel that the commercial aviation industry could do to prepare for an event from the information they have at the moment prior to those new recommendations?
Professor Hapgood: I think a lot has already been done. If you are flying over the North Atlantic one of the big issues, again, is space weather impact on communications. We haven't had much of this over the last few years because of the solar minimum. When we have a big solar flare on the Sun you will get one or two hours' blackout of radio communications. The international procedures for planes running over the Atlantic do already have provisions for that kind of thing and if the pilots use their main communication system there are procedures on how they then cascade back down to use other systems like satellite communications, which you can if you are flying at 50 degrees north, or even just talk from aircraft to aircraft.
If that event occurs, then the aviation control authorities will try and spread the aircraft out more to improve safety margins. All these contingencies are there, but if you spread the aircraft out you are simply going to have less volume of traffic going across the Atlantic, so there will be an impact there in terms of slowing down transatlantic aviation. The procedures are there for safety and that's the consequence.
One subtle issue that people are working on now is making sure that staff today are aware. Some people still in the system remember these events from 10 years ago. As I said earlier, because we have this 11-year cycle of solar activity, in a lot of organisations experience from one solar maximum may not be properly passed on to the generation looking after the next solar maximum. I think it is incumbent on experts like us to keep banging on a bit just to make sure that awareness is there and organisations pick up on this.

Q203 Pamela Nash: Finally, just to go back to something you said earlier, will it sometimes be possible to have about a week's advance notice of a space weather incident?
Professor Hapgood: For a really big event, we will have a feeling that it is possible. It is like seeing a storm developing in the Atlantic on a satellite image and trying to predict if it is going to cause problems for us.

Q204 Pamela Nash: I just wanted to ask if you think it would be likely that we would have enough warning to ground flights if there was an emergency and a big situation?
Professor Cannon: No, because the particles from the Sun, which cause problems on Earth to avionics and aircrew, as distinct from the communications, travel either at the speed of light or are certainly relativistic, that is they get here fast so we have got almost no warning at all. That is why I would subscribe to technological solutions to dealing with space weather in that context rather than a prediction and forecasting approach.

Q205 Pamela Nash: Thank you. Do you have anything to add?
Professor Hapgood: I largely agree with Paul but I think we need both, and I am sure I can push him to agree to that.
Professor Cannon: I am sure you can.
Professor Hapgood: The engineering must be your first line of defence. Build something that will withstand it, if you can do that at a cost that makes sense, but the second line is to maintain awareness. So if something does go wrong, at least you have got some idea.
If I can go back briefly to the Québec failure of 21 years ago, one of the reasons that really stands out about it is that the guys in the control centre did not know what was going on. They weren't aware of the risk. So they were sitting there, everything was running normally and it started to go wrong. In 92 seconds the whole grid collapsed on them. They just didn't know what had hit them. So that's why I think awareness is so valuable—to at least have some understanding of what you are facing.
Chris Train: I would concur with that. If you knew there was an event happening, you would understand that the alarms that you were then getting on the network were caused by that effect. Therefore, the control actions you took on the Grid would be different from those taken if you were not aware.
Pamela Nash: Good. Thank you very much.

Q206 Stephen Mosley: We have talked about the effects on national infrastructure. I believe, Professor Cannon, that you said that with modern microelectronics, as they get smaller, the voltages decrease and the effect of the induction effect becomes proportionately greater on that or the risk to that piece of equipment becomes greater. How will

that affect modern consumer goods, PCs and industrial equipment that have got microchips in?

Professor Cannon: It is not my area but I will speak to it briefly. The chip manufacturers are very well aware of these problems. If we are dealing with electronics for avionics flying at altitude, they are more likely to be affected by space weather impact, high energy particles, than ground level equipment. So the chip manufacturers will build hardened electronic chips to operate in aircraft; so that helps. They may actually have triple redundancy voting in the aircraft, so there will be a voting system in case one of the chips is actually impacted by the high energy particles.

At ground level the chip manufacturers are also aware of the possibility of this: "We really just don't want our PCs to fail." As a consequence, they actually test their new chip designs to make sure that they will operate for a period of time, which is rather long, I am sure, without any impact from these particles.

Mike might be able to say something because there is a facility at the Rutherford Appleton Laboratory for actually testing these chips on board.

Professor Hapgood: At the ISIS facility at the Rutherford Appleton Laboratory, which is the neutron source, a facility is being developed there called CHIPIR, which is chip irradiation. The idea is that people will be able to take chips along—I am not directly involved but I just know about it—and irradiate them. They will have a higher dose than you would have in normality, so the idea is that you will see the problems quicker. You will be able to scale things up to the real operational environment. The whole idea is to have a facility where you can actually bombard chips with neutrons, which is what you get on the ground or in aircraft during radiation. You aren't hit directly by the particles that come from space; the particles from space hit the atmosphere and produce great showers of neutrons, and that's what gets into chips in avionics and also in the systems on the ground.

I don't know if I am allowed to say this, but I will: there is also a briefing on these issues being organised next month, a kind of classified briefing, for UK industry. I think that is DSTL and QinetiQ.

Professor Cannon: Yes. It is hosted by QinetiQ at Farnborough.

Q207 Chair: That was extremely useful. Can I thank you, gentlemen, for your contributions. If, when you reflect on the written transcript, there are other things you feel ought to be added, please feel free to write to us. We realise we are in an area of a lot of uncertainties, but to enable us to make sensible judgments when we write our report we do need as much help as possible from the experts like yourselves. Thank you again for your attendance.

Examination of Witnesses

Witnesses: **Professor Brian Collins**, Chief Scientific Adviser, Department for Business, Innovation and Skills, **Phil Evans**, Director of Government Business, Met Office, **Paul Hollinshead**, Director of Science and Innovation Group, Department of Energy and Climate Change, and **Phil Lawton**, Downstream Gas and Electricity Resilience Manager, Department of Energy and Climate Change, gave evidence.

Q208 Chair: Thank you, gentlemen, for joining us. Now, this is going to be a fairly short sharp session because we know that Professor Collins has to be out on time. We will keep things succinct. If you have nothing to add to a question, please don't just contribute because you feel you have to. If you have something contradictory to say, obviously, it is helpful to hear from you. Would you, briefly, gentlemen, just introduce yourselves?

Phil Evans: I am Phil Evans. I am the Director of Government Services at the Met Office. I have overall responsibility for all the services that we provide to Government. That includes climate prediction and advice for a range of weather-based and environmental services and, more relevant to this inquiry, the National Severe Weather Warning Service. So out of our 24/7 operation centre in Exeter we provide the warnings you would expect of severe precipitation, wind storms, snow and the like. In addition to that, we provide warnings that are a little bit perhaps more unexpected. As you heard in a previous inquiry, that is information about the dispersal of ash clouds, information about the dispersal of pollutants. Also, very relevant to this, we have been providing advice to Government Departments about space weather for a number of years.

Professor Collins: I am Professor Brian Collins. I am the Chief Scientific Adviser at the Department for Business, Innovation and Skills.

Paul Hollinshead: I am Paul Hollinshead. I am the Director of Science and Innovation at DECC and David MacKay's deputy, who is the CSA of DECC.

Phil Lawton: I am Phil Lawton. I work in energy resilience at DECC. I should probably also say that I am on secondment from National Grid.

Q209 Stephen Mosley: We understand that the Government has started assessing the risk of space weather events. What do you think is the reasonable worst case situation?

Professor Collins: As you know, the occurrence of these events is relatively infrequent. At the moment we are working from the worst case event of 150 years ago as to whether or not that is a reasonable worst case or whether it is an unreasonable worst case because it has only happened once in that period, whereas there have been a number of other incidents. As a result of the group that has met once in September of a very wide range of people—there were about 45 people in the room—from industry, academia and Government, a group has gone away to assess the incidents that have occurred between that event, which is the most extreme that we know about, and what has happened in the meanwhile, to do some

statistical analysis to see whether we can make a recommendation to the Cabinet Office as to what a reasonable worst case might be. It might end up being where that incident was. I have heard it said just now—it is work in progress. So there is fairly urgent work in progress to report back in order that not only the National Risk Register can be updated next year but all the sectoral resilience plans for all the CNI, central national infrastructure, sector plans can be updated accordingly against that reasonable worst case. So we don't know the answer. We know what the one extreme is but we are working to see where is a sensible position that everyone can work from. I don't know if my colleagues want to add to that.

Paul Hollinshead: No. I agree entirely. That is exactly where we are.

Q210 Stephen Mosley: That was very complete. Thank you. You say that you want to update the plans next year based upon that reasonable worst case. Do you have any plans in place at the moment? Are there any civil contingency plans and how prepared are we for a major disruptive space event?

Professor Collins: You can kick off with that, Phil, because you're closer to the sharp end.

Phil Evans: I think to date the risk of space weather hasn't appeared on the National Risk Register; so in some sense it hasn't been treated in a cross-Government way. As we have heard from previous evidence, various affected sectors have been working on this for quite some time and have their own contingency plans and mitigation strategies in place.

Paul Hollinshead: Adding to that, in terms of the small events, obviously, National Grid have modelled 1989 and are aware of what to in that case. They are quite confident that any effects will be minor. The Civil Contingencies Secretariat also have plans that are linked to the disruption of UK energy supplies, which could be rolled out whether it was because there was a failure of the Grid for some other reason or due to solar storms. So there is some planning in place. I think the key thing here this morning is work in progress to understand what the reasonable worst case scenario might look like and then to understand the impact of that on the Grid as configured today and not as configured previously.

Q211 Stephen Mosley: Have the Government been engaging with the scientific community at the moment in preparing for an event, and have you identified people who might be willing to be members of a SAGE or something equivalent?

Professor Collins: Yes, most emphatically. As I said, there was a big meeting in the middle of September. I co-chaired it with the Civil Contingencies Secretariat. As a result of that, a sub-group of academic scientists are going away to form themselves up to make sure that not only the core skills that are identified for that meeting but any other additional skills, knowledge and expertise is made available. That's work in progress right now, again to report back—but before the end of the year—on that being a standby SAGE group to be called on instantly were we to be alerted to the fact that we needed such an expert group.

So we are, hopefully, ahead of the game by having the right people already working on what their situation would be, where their knowledge is good enough, where the international knowledge is good enough, because obviously this is a scientific discipline that is examined all over the world, and where there are gaps and what we should do about it.

Phil Evans: I think Mike Hapgood touched on this earlier. Literally in the last few weeks an expert group has been established that brings together the academics involved with this in pure research and those organisations that are involved in delivering advice and services to start to co-ordinate all of these activities and provide better input to CCS on this issue.

Q212 Chair: Although Professor Collins, you said there has not been any cross-Departmental work—I think that is roughly what you said?

Professor Collins: That meeting was the first instance that I had witnessed.

Q213 Chair: The expert group that has been pulled together will cover all of the disciplines that are necessary?

Professor Collins: Correct.

Q214 Stephen Metcalfe: I have to say that I am quite concerned about what I have heard here this morning. We do seem to be coming at this very, very late indeed. Bearing in mind we have had a 150-year history of these events—and we've got events in 1921, 1989 and 2003—why was it not identified as something that should have been on the National Risk Register? Do you feel we are coming at this late? Are we playing catch-up?

Professor Collins: To a degree I guess we are playing catch-up. The National Risk Register itself is a relatively recent invention of Government. To look at national vulnerability is also a relatively new thing to do. Clearly, the elements that go on that National Risk Register have been dominated in the short-term by those things that occur more frequently. Whether or not they have a greater or lesser impact the more frequently they occur, they are more likely to cause attention. So you might have expected the Civil Contingencies Secretariat—and you should obviously ask them—to be going down a list of things that they would be excited by, and those things which happen more often, even though the impact may be a little bit less, are the things that they have given higher priority to.

That said, the scientific community has been working on this subject for many, many decades. We actually have one of the best warning systems in Europe through the British Geological Survey's monitoring of geomagnetic activity, our space activities, our space science activities, and our collaboration with the United States in particular. To say that we haven't been getting ourselves in a position where we understand how to be prepared when Government want us to be prepared would be wrong. We have done that.

What we have not done is, as it were, throw the switch to say, "Now we need to get better prepared." The

incidents that have occurred in that period have caused a heightening of anxiety and concern, as does, of course, the peak activity that is coming towards us if the cycles continue in the next few years.

The second thing to note is a growing understanding of the interdependency of all our infrastructure on various assets. I actually have taken the responsibility from Lord Sassoon in the Treasury to study interdependency and resilience in critical national infrastructure. So I am leading an expert group right now. I have just left a planning meeting, which is why I was late coming in—apologies—to set up that programme and run it on the back of the Infrastructure UK programme announced by the Prime Minister last week.

Phil Evans: We have got an understanding of the processes that lead to space weather. We have got an understanding of the systems in isolation that would be affected by that. But just to reinforce that, the issue about the interdependencies in an increasingly interdependent society is something that really needs to be understood. It is perhaps not that surprising that the interdependency issue is one that we have not well explored because, as we have seen, using weather emergencies as an analogy, and there are a lot of common issues, the 2007 floods exposed the fact that we didn't really understand the interdependencies perhaps as well as we should and the risk of critical cascades in infrastructure. So it is perhaps not surprising that in space weather we are starting to explore that.

Paul Hollinshead: I would like to add something. There is no doubt in the past we have looked at lower level events and people have said there have been bigger ones. My understanding is that it was only this year that Charles Hendry was approached by Avi Schnurr to say that we think the realistic worst case is bigger than the ones experienced in 1989. That was June this year. By September there were expert groups being pulled together by the Cabinet Office to look at what a reasonable worst case should be, to ask, "What are you going to use instead of that?", and then to consider its impact.

From that perspective of having a high level view that probably it is time we had a different reasonable worst case, people have pulled things in quite quickly. Looking backwards, you can say, "In the past there have been these bigger events." The National Grid did modelling on the 1989 event and that was peer reviewed. As far as I know at least—though my colleagues know better—I didn't see any sign that somebody challenged it and said that we should be using something worse then. I think it is perhaps wrong to look back and say, "You've not been handling this correctly."

Q215 Stephen Metcalfe: We talked about the interdependency of the infrastructure. How well prepared is the UK and how would we cope with that failure of interdependent infrastructure caused by space weather, or do we not know that yet?

Professor Collins: We don't know that yet. That is why it is a very urgent and high visibility programme. I've mentioned the lead Minister but a number of Ministers in a number of Departments are extremely concerned that the outcomes of this piece of work are visible and made available, particularly to industry because most of that infrastructure is run by the private sector, not by the Government directly. They are heavily engaged with helping us deliver that understanding of what we've got and, as importantly, what we invest in going forward so that we, as it were, invest out the vulnerabilities of those interdependencies. We will have to have interdependencies but they must not become vulnerabilities. We are going to try and flush them out. I am sorry, but it is going to keep on sounding like work in progress. It is regarded as very urgent work in progress and you will find it is quite visible in the literature right now.

Q216 Stephen Metcalfe: Having started this piece of work now—it's work in progress—how resilient do you think the infrastructure is to space weather? Where do you think the greatest damage could be caused?

Professor Collins: I think the elements that are to do with the exploitation of the signals that are derived from GPS are probably the ones that concern me most. It is actually not so much the location signals, but the timing signals that cause everything to be synchronised and work coherently. Previous evidence said good engineering design would have made sure that back-up systems and resilience were built in. Those sorts of parameters and instances are usually the things that get dropped off the specification of engineering systems when costs are being examined. So I would not be as sanguine as I think our colleague was that, whilst it is good engineering practice, good engineering practice was adhered to in enough situations. For me the area that I would be most concerned about is those things that depend on timing. That is all our telecommunication systems, our banking systems and quite a lot of our navigation systems, not through where we are but timing to collocate things, in particular air traffic control.

I am not saying anything that is safety critical has not properly got resilience in it, because once you put the safety case in it has to go in. When it is not safety critical or security critical then we may find vulnerabilities, were we to have a space weather incident. That is my informed judgment. But, as I say, it is work in progress and we are trying to examine very quickly where we have those critical interdependency vulnerabilities and to understand then what to do about it, what the immediate remedial measures could be.

Q217 Stephen Metcalfe: You touched on communication there. If communication was affected by space weather, how would the Government communicate with business, emergency responders, citizens?

Professor Collins: Of course, we have a number of different telecommunication systems available to us. The ones that are mostly going to be affected are the ones that are based on mobile, which has become ubiquitous. We have a very robust and resilient land-based, wire/fibre optic-based telecommunication system. We might just have to be where we are

supposed to be rather than walking around with Blackberries and mobile phones all the time, which is a lifestyle issue that we've become used to in the last 15 years. Our emergency communication systems do have the proper resilience built into them; all the systems that blue-light services and others use are already intrinsically independent of a breakdown in GPS.

Q218 Chair: Are you satisfied that that extends to areas where local government takes the lead—emergency planning centres around COMAH sites, for example?
Professor Collins: That is one of the areas that the Committee which met in September asked people to go away and examine. I don't have enough evidence to say "yes" to you, Mr Chairman.
Chair: I'll go and look at ours.
Professor Collins: But I do have enough evidence to know that we are examining it and as a matter of urgency.

Q219 Stephen Metcalfe: Just picking up on the point the Chairman made about engaging with the private sector on these issues, again, I suspect the answer is going to be that it is a work in progress. How are you finding the private sector? Are they willing to engage in this—
Professor Collins: Enormously.

Q220 Stephen Metcalfe:—or are there sensitivities?
Professor Collins: They are enormously willing. Of course, there are sensitivities, but everyone realises that their markets could be significantly affected by these sorts of incidents. So it is a collective, collegiate view. No one wants any of this to happen to anybody else because they themselves have business interdependencies, never mind technical ones. We are having hugely collaborative talks both nationally and internationally because, of course, a lot of our infrastructure is owned by companies whose bases are outside the UK. It is important that we can do this internationally.
Paul Hollinshead: Our record at the National Grid is that there has been good engagement with industry on the problem.

Q221 Gavin Barwell: I will direct my question to Mr Evans initially at least. When you were introducing yourself you said a little bit about the Met Office's role in this area. A number of the people who have submitted written evidence to us have expressed concern about UK reliance on NASA and on the NOAA in the USA. Do you think we have sufficient national capability in worst case weather prediction?
Phil Evans: The reality is that there is always a significant amount of international dependence. There certainly is in terms of weather forecasting, for example. We couldn't do what we do without the global exchange of data. As we mentioned in our evidence, we are in the latter stages of signing up a partnership with the NOAA Space Weather Prediction Centre. Actually, part of that is relying on the capability and expertise it has got, but part of that is also starting to develop capability and expertise ourselves and the use of that partnership to improve the mutual level of resilience between both organisations. I would say you can't avoid a certain amount of reliance on other countries because this is a global and international issue.

Q222 Gavin Barwell: Just pressing you a little on that, I completely take the point about importance of international co-ordination. For example, the Royal Astronomical Society said in its evidence to us: "It is timely to establish a more co-ordinated approach to space weather as has been done in other countries, notably the US…but also our European partners such as Belgium, France and Germany." In other words, there is definitely a suggestion there that we are a bit behind the curve in this. Is that something you would accept?
Phil Evans: From what I have seen, it has been a consistent thread through a lot of the evidence that there is clearly a case for better co-ordination and bringing the various strands of this together because, academically in the research domain, it is hugely complicated. You link into that the need to provide operational services and advice. It's quite a complicated domain so there is definitely a need to bring that together and definitely a need to improve the information that we provide to the public sector and the private sector.

Q223 Gavin Barwell: Professor Hapgood, who gave evidence to us in the previous session, argued in his evidence that the UK should have greater participation in the European Space Agency's Space Situational Awareness programme. Is that something that you would support?
Phil Evans: I am not completely familiar with the area so you will have to caveat slightly what I am saying, but I think there is a real need for layers of co-operation and collaboration around this. We are doing that. Things are moving very fast in terms of improving co-operation and collaboration within the UK. I think that needs to extend to within Europe and internationally. All of these things are starting to happen. Some of the issues need a domestic response. Some of the requirements, sensitivities and risks in the UK will probably be UK-specific and some will be generic. So there is a need to tailor some of the science and the services available, whereas some other issues are common internationally.

Q224 Gavin Barwell: To move on to the point that you were keen to focus on, which is bridging the gap between space weather events and actual operational implications for particular agencies in terms of the effects that those outputs may have on their systems, how are you looking to do that, to provide that advice, and who would you see as the main recipients of that advice?
Phil Evans: To explain a little bit where we are at the moment, we provide a certain amount of advice, warning and information particularly to the defence area. That's almost entirely derived from both open and closed sources of information globally, so we already use the NOAA and the Space Weather Centre in defence. The partnership we are about to sign up

to with NOAA is key in developing that operational capability. Clearly, this will need to be done in partnership with all the other players because there are a lot of players in academia across the country and also those organisations that provide operational services, like the British Geological Survey. Then we need to start better improving the link between the science, the operational service delivery and the sectors that are impacted by this. Who they are I think will come out more clearly from the sector impact assessments that will be carried out as a consequence of the National Risk Assessment.

Q225 Gavin Barwell: In the situation where we had a severe event, say one of similar severity to the event 150-odd years ago, what systems have you got in place to get that advice to those agencies in an environment where we are hearing communications could be significantly disrupted?
Phil Evans: One of the big drivers of what we do as an organisation is about providing emergency specific advice and warnings. So the facility we have in Exeter is highly resilient, with back-up power supplies, all those sorts of things. It is about as resilient an operational facility as you will find. However, if you are talking about something of the scale of the Carrington event, then, as a previous witness said, all bets are off to some extent. We are starting to look at the impact of space weather events on our infrastructure and our ability to deliver services.

Q226 Gregg McClymont: Can I ask about what advice DECC's Scientific Advisory Committee has given on risks to the electricity distribution network in particular?
Paul Hollinshead: As far as I know, David MacKay pulled the group together and they made their input to the Cabinet Office meeting on 21 September, I believe. I am afraid the advice, at the risk of sounding repetitive, really is that, first of all, we need to understand what a reasonable worst case scenario is and its kind of effects. The second is that we need to work with National Grid to repeat the kind of modelling that was done using the 1989 event to understand the risks and vulnerabilities of that, so that has affected what is being done. As I understand it, the target is that by quarter 2 of 2011 National Grid will have completed their initial assessment of the vulnerability so that we can feed it into the National Risk Assessment and start thinking about sensible mitigations. The advice has really been pulling together relevant experts to form the questions we need to answer, and then start cracking on with the work, because at this stage, as many colleagues have said, we need to understand it better in order to give an informed view.[1]

Q227 Gregg McClymont: In terms of forming these questions, can I ask who is on the advisory group? Is there a mixture of engineers and scientists?
Paul Hollinshead: From what I understand the members of the SAG in DECC include not only specialists such as the ones you will be interviewing here but industry people from the National Grid. I am not sure if we pulled in any US colleagues or international colleagues. Essentially, what DECC pulls together in its SAG is a team of people with the right knowledge to give advice.

Q228 Gregg McClymont: What is the appropriate mix for that kind of advice?
Paul Hollinshead: I am afraid I don't quite know what the first SAG mix was. The appropriate mix has got to be a mixture of the sort of people you have had here. It is people who understand the solar events on the weather, people who understand the Grid, people in the Civil Contingencies Secretariat who, maybe, understand mitigations and that sort of thing. I am afraid that I have not actually sat on the SAG, so I don't know.

Q229 Gregg McClymont: Do you know if there are other records of the meeting? Are there minutes of the meeting we referred to?
Paul Hollinshead: Yes, there are, I believe.

Q230 Gregg McClymont: Can I ask also about the ownership of the electricity Grid given that it is in private ownership? Does that present any problems? We heard already from Professor Collins that the private sector is extremely enthusiastic about being involved in this planning. I guess it is worth raising the question whether there is any impact on co-ordination.
Paul Hollinshead: David's view, when I discussed this with him, was pretty much that that's not been the case. We've found industry eager to engage. We've not seen a problem there in terms of engagement. In practice, I haven't seen any problems caused by that. People seem willing to engage on this issue, to understand it, and decide what the most appropriate response is.

Q231 Gregg McClymont: Do you think at any point in the future that there could be any conflict of interest? Is it easier because it is all futuristic at the moment?
Paul Hollinshead: I think that is very difficult to say until we see the assessment. Obviously, once you start to look at the size of any particular mitigations and get into action, it might be possible there is more debate on that. Again, everyone wants to address this problem correctly. Ofgem's regulation of the National Grid will seek to improve any co-ordination anyway. At the moment I can't foresee any difficulties.

Q232 Gregg McClymont: So, in the future, we couldn't see a private sector enterprise having an incentive to provide a particularly robust network so that it is able to promote itself on the basis that its network is more robust to a space emergency than any other?
Paul Hollinshead: Maybe. That is an issue for them, quite frankly.

Q233 Chair: Can I just press on some of the issues that face the Grid? In the supply to nuclear power stations, for example, contingencies have been engineered in, dual supplies and so on. What scale of

[1] Note by witness: US experts did support SAG work.

event, going back over the events we have discussed this morning, would it take to put one of those stations at risk, in other words, take out both supplies to the station?

Paul Hollinshead: With apologies, Mr Chairman, the answer is that we don't know until we do the work. I can talk about the Canadian experience where they had nuclear plants that went off the grid for a bit and were brought back online as a result of the 1989 scale of event. Therefore, I would assume that we could cope with that scale of event, but I wouldn't know what would be required to, shall we say, knock those stations out or even what would be required to mitigate knocking it out until the work has been done.

Phil Lawton: Could I just add to that? That contingency is in the design of a nuclear power station. They have their own gas turbine generation that they could start.[2] So the loss of off-site power is just one step towards a problem. It's not an enormous problem in itself.

Q234 Chair: Is this an issue that has ever been raised by the Nuclear Inspectorate?

Phil Lawton: Not that I'm aware of. I know there are nuclear power stations where, essentially, they have two connections to the Grid. You take one out for maintenance at times because you have to, so, clearly, at that point you are relying on one and any one piece of equipment can fail. It is a risk that they are familiar with.

Q235 Alok Sharma: Can I just turn to the UK's research base in space weather? Are you satisfied that we are sufficiently prepared for a space weather emergency in the UK or do you think there are some gaps that need to be filled?

Professor Collins: This is going to sound like a cracked record.

Q236 Alok Sharma: Work in progress?

Professor Collins: However, what we are addressing, and I was at a meeting first thing this morning discussing this with the Director General for the Research Base, Professor Adrian Smith, are the criteria for which elements of the research programme need any sort of special attention in the forecast period of which we've just heard the announcements in the Spending Review, in particular with regard to capital equipment, to ensure that the criteria for those types of investments are properly understood. Over the next few weeks we will be putting in place a process by which we examine the significance of various chunks of research and capital spend in research with regard to national need. This, clearly, has to be national resilience in its biggest sense, but this element of it—space weather—clearly has to be part of the assessment criteria for that sort of research activity. To say, am I happy? Not yet, but that's part of the process by which we, at least, attempt to get it into a proportionate position with regard to everything else.

Q237 Alok Sharma: So, Professor Collins, you basically alluded to funding. Is there any Government Department that funds R&D in space weather or not, or should there be a Government Department that is funding this R&D?

Professor Collins: Okay. Space weather, per se, is, I think, seen as the purview of the research councils and the academic community and the facilities that they look after. Any individual Government Department should then do some work on the resilience of its infrastructure where it is pertinent. I know that the Department for Transport is doing a little bit of work, in particular on GPS, which I alluded to earlier. My guess is that MOD is doing quite a lot, not only with the Met Office but in other places. That is happening because you have heard that. I think you will find that the Departments individually are doing work in those areas where they consider that their responsibilities would be affected by space weather.

Q238 Alok Sharma: I presume they are co-ordinated, are they, in some way?

Professor Collins: Yes, absolutely.

Q239 Alok Sharma: In the case of an emergency, do you think the Government would have sufficient funds in place to cover the cost of commissioned research, because I think what we understood is that this was an issue during the volcanic ash emergency with the use of the NERC aircraft?

Professor Collins: The difficulty I have with answering that question is, as has been said, that this is a global phenomenon. So the assets that you need to give yourself warning—most of the really valuable ones—are space-based and have only recently been launched by the Americans. We are very closely in touch with the alerts that come from those systems, in particular the high velocity particles that we heard about earlier. To do that nationally is not something that we could think about affording. Affording the management of the proper relationships with those countries that do have those assets seems to me to be a really useful investment and at a very, very low price compared with the value that comes from it. So we are very keen to maintain those sorts of relationships.

Q240 Chair: Following that comment, what sort of collaboration is going on between DECC and sister organisations elsewhere in the world? Given that a significant amount of the Grid is owned and managed by companies that are global themselves, what degree of international co-operation is there?

Paul Hollinshead: As you have heard, there have been various workshops. Government Departments, including DECC, have had discussions with the US members and have been provided with a perspective of the risk to US-based power infrastructure. So we've got the US perspective on their risk to their power structure. We have been talking to Sweden and also engaged with the EU, looking at this issue of raising awareness and preparing for geo-magnetic storms. Of course, as you heard earlier, there are links not just from DECC but in terms of countries monitoring these effects. In terms of DECC the work has been about talking to other Governments about their networks but also hearing from the space experts about what they think this reasonable worst case will look like and

[2] Note by witness: Some stations use diesel generators rather than gas turbines.

what its potential effects are so that we can insert it into the modelling. But there has definitely been collaboration.

Q241 Graham Stringer: All the evidence this morning has been about problems created by the Sun ejecting materials. Some of the written evidence talked about the problem of cosmic rays generated from exploding stars in other parts of the galaxy or other galaxies. What sort of order of magnitude problem is that compared with the events we have been talking about and what contingency plans have you got?
Professor Collins: There are two parts of the asset base that you have to consider. The solar storms that we have just been hearing about are powerful enough to have an impact on the surface of the Earth. They will also, obviously, impact satellites. If they impact satellites, it will be relatively short-term things that impact individual satellites or constellations. The longer term irradiation from deep space is much more likely to slowly degrade satellite assets, but from my understanding of the science it will have negligible impact on the surface of the Earth. So the gradual degradation of satellites with long, planned lifetimes—tens of years or 30 years—is a thing to worry about, but we've known about that for a long time. So all the satellites that are put up with that sort of lifetime in mind are designed with internal circuitry, structures and shielding such that those sorts of damages just don't happen.

Q242 Stephen Metcalfe: It has, obviously, become clear this morning that we don't have a reasonable worst case scenario yet and that that is being worked on.
Professor Collins: Yet.

Q243 Stephen Metcalfe: Who will decide on that? Who will make the final decision on what it is that we should then start preparing for? And is it possible that, once a reasonable worst case scenario has been identified, it is difficult to mitigate that and so, therefore, you won't use that and you will come back down the scale and find something that you can mitigate against and work with?
Professor Collins: Sir John Beddington may not like me for handling this one this way, but I suspect, as the Senior Government Adviser, and this is a pan-Government issue, it will ultimately be for him to make a recommendation to the Minister responsible for approving that situation. My understanding is that Baroness Neville-Jones is responsible for space security within the National Security Plan because this is as much a security as a resilience issue.

Q244 Chair: This isn't just about space security. This is about terrestrial security as well.
Professor Collins: Sure.

Q245 Chair: Surely, this is right at the top. This is a Prime Ministerial issue, surely?
Professor Collins: I was going to go on to say that there is an element of it which is to do with national security, which will go that way. I would not like to guess whether the Prime Minister would want to take the decision himself or delegate it, but I would imagine he would want to take it himself, so yes. My feeling is that the science evidence of what is a reasonable worst case will be produced under the tutelage of Sir John Beddington.

Q246 Chair: And you would expect that to cover national security, communications, ground-based systems?
Professor Collins: Yes; all aspects. That is why it has to go to him because there is no clear departmental lead. That is why I was hesitating slightly to say that, beyond him, I wouldn't like to second guess whether the Prime Minister would like to take ownership of it himself. We are well aware that he is briefed on the matter but whether he would like to take ownership of that decision it's not my place to suggest.

Q247 Stephen Metcalfe: Just to follow up on that, if I may, if a reasonable worst case scenario is of the magnitude of the Carrington event, which I think I have heard this morning would be difficult to handle, what happens then? What do you do? Do you go away and start re-working it?
Professor Collins: I am sorry. If it were on the Carrington scale?
Stephen Metcalfe: Yes.
Professor Collins: Then you would need to look at what the impact would be in terms of investment to provide a proportionate level of resilience to such an event. Then we would have to look to various places to see how we funded it, because there is clearly a Government view but there would also be a commercial view because it will affect markets very significantly. So the insurance industry may want to take a view on how much it wants to see investment in resilience in commercial sectors in order to make sure that various services and sectors are properly protected. Yes, there would be a very profound impact were you to end up with something that looks as difficult as you said it might be. What we are trying to do at the moment is to be objective about that and not let those factors disturb where we think the probability would lie.
Chair: Thank you very much indeed for your time, gentlemen.

Wednesday 17 November 2010

Members present:

Andrew Miller (Chair)

Gavin Barwell	Pamela Nash
Stephen Metcalfe	Graham Stringer
Stephen Mosley	Roger Williams

Examination of Witnesses

Witnesses: **Professor Ross Anderson** , Professor of Security Engineering, University of Cambridge, **Robert Hayes** , Senior Fellow, The Microsoft Institute for Advanced Technology in Governments, **Malcolm Hutty**, Head of Public Affairs, London Internet Exchange (LINX), and **Professor Peter Sommer**, Visiting Professor, London School of Economics, gave evidence.

Q248 Chair: First of all, may I welcome you, gentlemen, to this morning's session on cyber security? Perhaps you would like to introduce yourselves before we start off.

Professor Sommer: My name is Professor Peter Sommer. I am from the London School of Economics and the Open University.

Malcolm Hutty: My name is Malcolm Hutty. I am the Head of Public Affairs at LINX, the London Internet Exchange.

Robert Hayes: I am Robert Hayes. I am a Senior Fellow with The Microsoft Institute for Advanced Technology in Governments.

Professor Anderson: I am Ross Anderson. I am Professor of Security Engineering at Cambridge, and I also chair the Foundation for Information Policy Research.

Q249 Chair: Thank you, gentlemen. May I start with some broad questions? How likely is a disruptive, large scale cyber attack that will cause an emergency on a national scale?

Professor Sommer: Shall I start? Obviously, the subject of your inquiry is much narrower than cyber security, as it is often spoken about and, indeed, as it features in the current Government policy. The categories you may want to think about are loss as a result of accident or bug of computer services critical to central and/or local government activity; loss or compromise of large quantities of critical Government data, including data about citizens which should be held confidential; loss as a result of accident or bug of computer services only in the private sector but part of the critical national infrastructure; deliberate attacks on computer services critical to central and/or local government activity; deliberate attacks on computer services owned in the private sector but part of the critical national infrastructure. So cyber attack is only a small part of it. The most likely problem at a national level is probably not cyber attack but poor system design and poor management. In that context some of us welcome the expansion of the role of the Office of Cyber Security to include the Office of Cyber Security and Information Assurance.

In relation to cyber attack, I don't know what my colleagues here think, but my view is that in order to perpetrate a prolonged serious attack at the level where it is going to affect the national health, if you like, then a huge amount of effort is required. The recent Stuxnet worm exploit, or whatever you want to call it, seems to me to be an indication of the amount of work that is required in terms of identifying exploits, writing attack code, carrying out specific research so that your attack is going to be targeted is really quite considerable. As a result, notions that one bloke with a laptop computer is able to have the effect of a missile attack is grossly mistaken.

Professor Anderson: A number of scenarios are thought of in terms of large-scale disruption or cyber attack. There is concern, for example, that there might be an attack on critical infrastructure such as the bulk power transmission system. That's probably not a huge risk yet but it will become one in time as things become more computerised. There are also concerns that there might be a failure of, or an attack on, the internet. The most likely cause of a disruption of the internet that would interrupt network service for, potentially, a few days would be software failure associated with the transition to IPv6, although we have seen indications that some foreign states have a capability to disrupt the routing fabric should they choose to do so. It would not be rational for them to do so but, of course, it is not always the case that all states are rational.

Robert Hayes: Perhaps this is a slightly long answer to a short question. I think the element of risk is a combination of impact and likelihood. I probably agree with what has been said, the risk of a concerted attack which would have a fundamental effect on the whole critical national infrastructure of the UK would require significant effort probably at a state level and is, therefore, politically unlikely. I would make a distinction inasmuch as there is a difference between cyber attacks and other types of attack. If I see a nuclear weapon that I decide to copy, then I need centrifuges and plutonium, but if I see a cyber weapon and I decide to copy it, such a weapon is, after all, a sequence of 1s and zeros. For example, we have concerns about Stuxnet, which is a really good example of a weapon that could, in part, be copied and used either by criminal enterprises or for an ideological basis. So I would come down a level from the fundamental attack on the critical national infrastructure to a more localised attack using, perhaps, already available cyber weapons for ideological, organised crime or disruptive purposes. The risk of that certainly is high and could have a localised effect on critical national infrastructure.

Malcolm Hutty: I would largely endorse the comments made by Professor Sommer earlier. As to the risk of attack, there are ongoing attacks, but the risk of an attack that would have the scale of impact that you describe would indeed require, as the other speakers have said, an enormous amount of co-ordination, not just in terms of the amount of work required to prepare and craft that attack but also in target selection. My industry, the internet industry, is designed to be capable of isolated failure and to tolerate isolated failure without having anything like the scale of impact that you describe and that you are inquiring into with that question. In order to perpetrate something like that, you would need to perpetrate not just one attack—not even just one attack like Stuxnet—but a whole series of attacks very carefully co-ordinated together and very carefully planned. The internet is designed to be resilient against these kinds of things. So we, essentially, have a layered defence strategy for this, which includes not only the preparations that individual businesses have within their own network planning and network defences, but architecturally, because the internet is designed so that if you take out one service provider, one system, it should not have a national scale impact.

Q250 Chair: Just going back to the observation that Professor Sommer made referring to Stuxnet, I am sure you will be aware of other issues that may produce similar risks. Will things change over time or is it the case that Government have over-hyped the risk?

Professor Sommer: Would you say the last bit again, please? I didn't quite catch that. You have a microphone but I can't hear what you are saying.

Q251 Chair: The acoustics are appalling in this room. Apologies. Will things change over time or have the Government over-hyped the risks?

Professor Sommer: I think it would be extremely foolish to make any predictions in this area. So, although there seems to be a fairly universal agreement among us that problems are frequently overblown, particularly in popular accounts, that is not a good reason for saying that there should not be extensive scrutiny of events that are going on in the internet. There are plenty of people within Government who are watching these things and it may well be that things do change.

One other thing you have to watch for, particularly in relation to public debate, is that the language is often very ill-disciplined, and that causes confusion. People talk about an attack. Most of us can say we are attacked every day. Large organisations can say they are attacked several thousand, maybe several tens of thousands, times a day, but most of those attacks are entirely trivial. If you want to boost the statistics, all you have to do is say, "Oh, well, my anti-virus software stopped a large number of these events but we will put them as statistics." Those statistics are still important but to equate those events with the sort of things that are going to have a national impact is a gross misjudgment, it seems to me.

Professor Anderson: I expect that things will get steadily worse over time. The reason for this is that all sorts of industries, services and systems are going online. All sorts of devices that used to be done are requiring computers and communications, and most of the engineers who take stuff online are in too much of a hurry to make profits to sit back and think about what the downsides might be.

Q252 Chair: These are your views that I have heard on things like smart metering?

Professor Anderson: Indeed so. One industry after another has been disrupted by the internet and security is usually an afterthought, after things go online. In addition, you've got the usual collective action problems with which politicians are familiar from many fields, only they work on a global scale. The internet being global means that there is less incentive than there used to be for Governments to do anything and Governments have, in fact, less power to do anything about most of the problems that arise than was the case in the old-fashioned world.

Q253 Chair: So that is an argument for some caution before we allow major pieces of infrastructure to be put online, such as the Grid?

Professor Anderson: It is an argument that, where we have industries that are already regulated, the regulators should become more IT aware. Having regulators that are staffed entirely by specialist economists is not adequate. Regulators such as Ofgem, Ofcom and all the others should have people on their staff who understand IT and can take a modern view of the risks that an industry might be sleepwalking itself into.

Robert Hayes: If I can perhaps just focus on the risk, I would tend to agree with what Ross has just said. With no action, the situation is likely to get worse. However, there are opportunities for action that could mitigate the risk. Those, I think, are at three levels. There is action needed at an industry level in terms of better looking for identity and attribution. There are things that Government can do. For example, we would very much like to see Government endorsing some sort of digital credentials as a means of people having better assurance when they use internet services that what they are getting and who they are talking to is what and who they purport to be. If you look at the current targeted attacks, most of which are through targeted emails, a better understanding and attribution would make a significant difference to that level of attacks. That is something we think Government generally could do more on.

We also think there is an element of responsibility at the consumer level. We don't allow cars to drive along the roads without a valid MOT certificate and insurance, but we do seem to be quite content for someone to have an internet-enabled machine connected to the critical national infrastructure with no protection whatsoever. Those three levels work together.

The last one is that, for a company like Microsoft, we deal with pretty well every country in the world, and we often find that regulation/legislation contradict each other and that is really unhelpful for a company like us, who genuinely want to help Government better defend themselves. We often find ourselves

entangled in incoherent approaches from different countries. So we would welcome international level discussion on this issue as well as domestic.

Malcolm Hutty: Mr Chairman, if I may further simplify your question and then criticise it for being oversimplified, it sounded a little like a popular discourse that says, "Are we facing a national catastrophe from cyber attack or is the Government over-hyping the problem?" That would be a false dichotomy. In my view, a national catastrophe from a cyber attack would require such an enormous amount of effort and, indeed, the skills and intentions of another party that put it out into the bounds of an extreme planning scenario. None the less, it does not make it inappropriate for Government to take action to protect against it. So, to say that it is over-hyped can be taken as criticising efforts to raise the profile within Government of the importance of working in this area.

It is appropriate to do a certain amount of work to protect against even extreme scenarios, but, even setting those extreme scenarios aside, I have said earlier that the internet is designed to withstand failures, to tolerate failures, without resulting in utter catastrophe, but it is still worth protecting against outcomes that fall short of being utter catastrophe. It is appropriate that Government should be working on this and should be working with industry. I would think that the first area of work is for those who actually operate infrastructure and, indeed, for other people who operate systems to protect themselves. Government are one of them as well in their own right. Government have a further role in looking to see where standards can be further enhanced to fill in the gaps that private interests alone might not fully cover, but private interests alone do cover quite a lot. It is appropriate for Government to facilitate that work and co-operation between industry actors. I wouldn't call that over-hyped, but sometimes, if the newspapers require a little bit of colour to justify worthwhile work that needs to be done to protect us against genuine, serious and costly problems that fall short of national catastrophe, then so be it.

Chair: You have criticised my questions before in other forums.

Q254 Gavin Barwell: This is a slightly tangential question. If I have understood you aright, what you are basically saying is that the likelihood of a large-scale attack that had national impact would require a significant amount of planning, perhaps some intelligence as well, so that it was targeted properly and, therefore, could probably only come from another nation state and one with a reasonable level of resources behind it. Therefore, it is judged fairly unlikely politically. In the event that such a thing happened, how confident are you that we would know where that attack originated from and would know that quickly? One of the questions in that scenario is not just that we knew we were under attack but that we knew where the attack was coming from.

Professor Sommer: You have put your finger on one of the big problems of cyber war—cyber attacks. The big feature that makes it different from other ways in which war can be carried out is that attribution, as it is called, is extremely difficult. There are things in the margins that one might be able to do to make life a little bit easier but not very much. So your normal state of affairs is going to be that you are attacked and you can't really use the doctrine of retaliation or deterrence. What that means is that Government have to focus on resilience—in other words, protecting their systems but, equally important, having well worked-out plans for recovery.

You will have seen in your other work within this study something of the work of the Civil Contingencies Secretariat who look at a variety of scenarios and try to work out how they are going to spin out. Under a cyber attack, what you have to worry about is not only the initial event but how it might cascade onwards. With that sort of work, doing the contingency planning, you can never forecast completely what is going to happen, but the fact of having done contingency planning, expecting certain levels of back-up, certain levels of managerial preparation to be there, helps you in almost any of these events. It is one of the most important things that you can be doing in this arena, much more so than doing what the Americans are doing in setting up exotic cyber commands with rooms full of VDUs and people looking busy, though one is not quite sure—I hope this is not going to sound too violently anti-American, because I am not really—what their purpose is.

Malcolm Hutty: I am not sure that I take completely the same view. I am not a defence specialist. I draw a distinction for the Committee between being able to attribute the sort of an attack to a high level of certainty that justified a public statement that this was indeed the perpetrator of a state-sponsored attack and could be treated, say, as an act of war for that kind of retaliatory response, and knowing that to quite a reasonable degree of confidence from an intelligence perspective. I would say, rather than saying that we need to retreat to an entirely defence-oriented posture in the way that Professor Sommer just described, that what we are really facing is a situation where any state-sponsored attack would fall into the area of a covert operation. So it could not be necessarily publicly identified and publicly attributed and responded to in that fashion in the same way as ground troops crossing a border. None the less, that doesn't mean that we would be entirely ignorant of the likelihood of an attack. When there are covert operations, one assumes that there is the opportunity for covert responses as well, and, indeed, not just in terms of military or pseudo-military cyber responses but also diplomatic responses, economic responses and so forth.

One thing we need to remember when talking about cyber attacks on critical infrastructure is that we are talking about destroying something that is valuable, and destroying something that is valuable, even in your opponent, if it is part of their economy and it is something that supports their economy, is not necessarily going to be the response that you would want to go for anyway.

Professor Anderson: I do not agree with the proposition that cyber attacks will necessarily be unattributable. Some may be done in a covert way but

even these attacks can mess up. For example, a couple of years ago one of my students helped the Dalai Lama's private office clear up a malware infestation which was clearly the responsibility of actors operating on behalf of the Chinese Government. We had no hesitation in attributing that to Peking for the simple reason that Chinese diplomats made clumsy and blatant use of the intelligence product, thereby removing the deniability that they had hoped their operations would lead to.

Given that we are operating in a field which is new, with which Governments don't in general have much facility and with which national leaders and senior military leaders are largely baffled, you can expect that covert operations will very often foul up.

The second point is that a number of operations that we could envisage would, by their nature, be difficult to do on a covert basis. Suppose, for example, that you wanted to bring down the internet for a couple of days in order to create alarm and despondency while starting a conventional war somewhere else in the world. There are various organisations that could do that by broadcasting lots of bogus routes. Google could do it, for example, but they wouldn't because it would just cost them advertising revenue. The Chinese Government could, but if they were to order China Telecom to advertise tens of thousands of bogus routes, it would be crystal clear to everybody who had done it. In a scenario like that, the attribution is just as clear as if tanks had rolled across the border or warships had crossed the Taiwan Strait. So it is a much more complex question than you might think and there is the possibility of deterrence and there is the possibility of retaliation even using kinetic means in some scenarios.

Professor Sommer: The problem is how long it takes you to do the attribution. I read the paper *Information Warfare Monitor*, wasn't it, Ross? The problem is how long it takes you to do the attribution and to be certain of it and that is, I would suggest, going to take rather longer than is appropriate if you are in a battle situation, when you do need to retaliate quite quickly.

Q255 Chair: Can we move back from that and pose a question about, in a sense, how we should use the nation's resources, how we should prioritise them? Clearly, in all forms of cybercrime there is a continuum from the low level amateur right up to some highly professional organisations that are designed to do a huge amount of damage. Should we be more concerned with tackling low level, everyday cybercrime and how does that continuum work? How does that low level cybercrime pave its way towards the more serious attack methods that can be developed?

Professor Anderson: A problem here is that the global cybercrime ecology, in effect, creates a swamp within which the crocodiles of national intelligence agencies, terrorist organisations and so on can swim. Depending on which agency you work for, you might consider that your job is to drain the swamp, to shoot the crocodiles or to genetically engineer especially fierce crocodiles for your own side's use. There is, of necessity, going to be a tension between these. It is difficult to see what mechanisms we have in Britain to enable policymakers to get the balance of priorities and of funding right.

Robert Hayes: If I may, I think I'd go back to a previous answer. There are things at Government, industry and the consumer level that need a change in behaviour. Those changes in behaviour will actually mitigate the low level cybercrime to the higher level cyber attacks because, whether it is a low level cybercrime attack or a high level attack, it is using a lot of the same vulnerabilities and these same attack vectors. So, by increasing the level of defence in depth across systems from consumer to enterprise to Government, it would have a significant effect against all elements of cyber attack.

Professor Sommer: I am not sure I went all the way with what Ross Anderson just said. I think the most important thing in response to your question is this: one of the most important vectors for attack is the botnet when large numbers of "innocent" computers are taken over and harnessed to mount the attack. Those innocent computers belong to consumers who have not protected their machines properly. So, in terms of making it a higher level priority of the UK Government to educate the public, say, through *Get Safe Online*, which has its activity week right now, I understand, there is a benefit immediately both to the consumer and to the country and to the world as a whole because you are, hopefully, reducing the number of machines that can then be taken over and harnessed to mount these large attacks.

Q256 Graham Stringer: I would like to follow up what Professor Anderson said about knowing who the enemy is or was. We have no idea, do we, who produced Stuxnet?

Professor Anderson: We can surmise that it was someone who didn't like the idea of the Iranians refining uranium.

Q257 Graham Stringer: Yes, but that could be a lot of people, couldn't it? The fact is that we don't know. Regarding the latest most sophisticated attack, there is nobody in your world who, apart from informed speculation, has the faintest idea who did it.

Professor Anderson: We have got some idea of the amount of labour that went into it. It appears from the code that it took six people five months to write it.

Q258 Graham Stringer: That is not a lot. A medium-sized business based in Burnley could produce that amount of resources, couldn't they? You don't need the Chinese economy to do that.

Professor Anderson: But a couple of the vulnerabilities that they used, which were initially thought to be zero-day vulnerabilities turned out to be vulnerabilities that had been used in other malware once people went through their logs and looked. So it appears that whoever commissioned the creation of this software had access to some skilled people whose business was writing malware or who were very skilled in the art of detecting malware, disassembling it and understanding it. So there was definitely some specialised resource there. There were also, clearly, people who had expertise in industrial control systems and who were able, presumably, to get hold of enough

devices that they could set up a network in their offices on which they could test the particular attacks using programmable logic controllers. It looks like it was an effort that was funded to the order of £1 million or thereabouts.

Q259 Graham Stringer: Which still isn't a lot of money in the world economy as it is. What I am really trying to get at is that, normally, if you are dealing with risk assessment, one, you know who the enemy is and, two, you know how much they are spending, or, to use your analogy, we know the size of the crocodiles or how many crocodiles there are out there. But we have no idea, do we, of the number or size of the crocodiles?

Professor Anderson: Well, we do what we can to monitor the underground economy. My point is that, if more effort were put into draining the swamp, into gathering intelligence on people who do things like writing malware and on trying to chase after them, arrest them and close them down, we would have a better idea of the resources that were potentially available to the other side. I must say, in this, as in other areas of conflict, you cannot rely on watching the other side's budget. Bin Laden, apparently, boasted that the 9/11 attacks cost him less than $500,000, and yet cost America trillions. The 7/7 bombings here were done on a total budget of a few thousand pounds, which I presume is small enough that any of us could have put it on our credit cards.

If you can do a good cyber attack on a budget of £1 million, that brings it into the same category. It is not the sort of threat that you can necessarily stop by simply worrying about, for example, terrorist finance.

Q260 Graham Stringer: That brings me to the next point. We are exploring what is going on out there and looking at the unknowns. What we can know, I don't know if we do know, but what we do know is the resources that the Government are putting into cyber security. In your opinion or anybody else's opinion, are we putting enough money into cyber security even if we can't actually measure exactly what the enemy is doing?

Professor Anderson: We have never put enough into combating cybercrime over the quarter of a century or so that I have been interested and involved with this subject. The Metropolitan Police and others have had the greatest of difficulty in sustaining e-crime or cybercrime units, which are forever getting closed down, merged into other organisations or diverted from their purpose. We can understand the institutional reasons for this. Firstly, cybercrime isn't well understood. Secondly, people in power tend to be shielded from it because they have secretaries to operate their computers. Thirdly, and perhaps most importantly, it is completely globalised.

If a bad man in St Petersburg sends out 1 million phish this morning, London is 1% of the Internet, so 10,000 of them arrive within the Commissioner of the Met's area, so the temptation for him is to say, "We'll let the FBI do the heavy lifting. They will have seen 200,000 of these." Because this is a globalised problem—industrial scale petty crime, as it were—no police force wants to step up to the plate. Therefore, it requires national and, indeed, supranational efforts to make a dent in it.

Q261 Graham Stringer: A quick order of magnitude: twice as much, 10 times as much, 100 times as much is put into cyber security? What should the level be?

Professor Sommer: Part of the problem is that I don't think we know, really, what the budget is. We know what extra money is going to be put in but the budget is partly within CESG, which is the defensive part of GCHQ. A very small part of it is within the police. Another part is within the Cabinet Office. Some of the things that you might call cyber security appear in other budgets as well. One is being absolutely strict about it. It is very easy to say that we are not spending as much. I am sure I am very happy with a statement along those lines, but I don't actually know how much there is and how it is being spent. For obvious reasons, part of that is hidden away. Perhaps as part of your inquiry—and you may be able to ask that of your next lot of panellists when we step down—we don't really know how much is being spent or how it is being spent. That is the difficulty with your question, it seems to me.

Q262 Graham Stringer: The other resource that Government have is scientific advice. Does the Government use their scientific advice well to protect us from cyber attacks?

Professor Sommer: My experience is that the people in the security community who are interested in this sort of thing go along to the open conferences, they read the papers, they come along to seminars, they will talk to you quietly for clarification and they give every impression of being up with the professional and academic literature. Obviously, as an outsider, you don't really see what is going on so you don't actually know how far they are keeping up. There does seem to have been, certainly in my experience over the last 15 years when you have met individuals or organisations with a variety of names, a steady set of people who are keeping up with these things who are very interested. As I said, how it moves forward from policy into action is not something I am in a position to judge.

Q263 Graham Stringer: Does that mean you cannot judge whether Sir John Beddington's review of security was effective, well used or not, or can any other member of the panel tell us?

Professor Sommer: I think Ross was on it but I was on a previous panel and one of the things about it is that you do talk to people. Over a number of years a whole variety of these exercises have been carried out under various terms of confidentiality. You have quite free-ranging discussions, though, on the whole, those of us in the outside world tend to be giving more than those who are on the inside of the security world. It is very difficult to gauge how effective it has been. You just know they talk to you. They talk intelligently and there is every sign that they have understood what you have said. In the nature of things, you can't actually say, "Oh, the following week an announcement was made", or you could see an entity

appearing, and say "And that's got that particular problem sorted." It doesn't work like that.

Q264 Graham Stringer: Professor Anderson, was the scientific advice well used in the Beddington review?

Professor Anderson: There were about a dozen of us thinking about what the UK should do in terms of cyber security. I was, I believe, the token person there without a clearance. Most of the other people were from agencies and Government contractors. I think that we did a reasonable job, although I have not seen the final report yet. Certainly the drafts that I saw were sensible and incorporated a lot of useful ideas. I hope that they were useful to our colleagues in the Cabinet Office in checking it in to the Treasury.

The question that follows from that, of course, is whether the money gets spent wisely. There is the issue not just of scientific advice but of engineering and technological advice because this has always been the big soft spot with the Civil Service. The Civil Service and IT just don't seem to mix. This has been a problem way back since the 1970s.

Q265 Graham Stringer: I am not sure if it does mean that, but does that mean there is too much focus on electronic attack and not enough on physical attack?

Professor Sommer: We don't actually know, of course.

Professor Anderson: It is difficult to say what the priorities of agencies such as GCHQ are because we see their work product only infrequently. However, it is possible to see a general drift of policy on cyber security in terms of how the Government, for example, manages cyber security in their own operations in terms of the effort that is put into things like cybercrime and in terms of a hundred and one other small signals. The concern I have is that cyber security is overly biased towards attack rather than defence. This is a systematic problem worldwide and it can be observed more closely in Governments where the relative expenditure on attack and defence is more transparent, perhaps because there are different agencies involved. Again, the mechanisms should be clear to everybody who has some experience in politics. If you are the director of an agency and you discover, for example, a vulnerability that you could report to defend your own people or exploit to attack the other side, the institutional incentives for you will be to keep that quiet and prefer attack over defence.

Q266 Stephen Mosley: We have seen that there are a large number of groups and institutions that are providing advice to the Government in particular. Looking through my briefing notes, I see the CPNI, CSOC, DSTL, GCHQ, CESG and OCS, of course. Do all these sources, in your opinion, provide co-ordinated advice to Government or do they sometimes conflict?

Robert Hayes: Can I, perhaps, leap in on my coherence thread? We strongly support the creation of OCS and hope that OCS actually provides the co-ordination between the agencies you have just outlined. We have a relatively unique global situational awareness because of where we operate and our networks. Bear in mind there are now 1.3 billion Hotmail addresses, to give a scope of the type of infrastructure we run.

We often find that the assets that we do have that engage with Government in this space are pulled in too many directions. If you then superimpose that internationally, it becomes very difficult for us to help coherently. So having a single point of contact within the UK Government who can co-ordinate and facilitate activity will be hugely helpful to us being able to maximise our potential help.

Q267 Chair: Just going back to Professor Anderson's point, do you believe it is important that that office does co-ordinate right across the spectrum including managing issues around the lower level crimes that might be very diluted in the UK but need international co-ordination to address them?

Robert Hayes: I spent over 30 years in the Government before I joined Microsoft. My experience tells me that unless the OCS has some teeth to enforce co-ordination across Government, being a mere observer in this game isn't going to be enough.

Professor Sommer: Again, it is a good question. Those of us who interact with these people are never quite sure. You can meet individuals, they are all very knowledgeable, they are all very interesting and quite often you will see them in the same room at a brainstorming session or whatever it is. It is a puzzle to me quite what the relationship is. I think we do need a level of co-ordination. The OCS was designed, as I understand it, to bring together representatives from either all or most of these entities, but perhaps the person to ask about its future is Steve Marsh in the next session.

Q268 Stephen Mosley: You have both said what you want to see from the OCS. Does it actually deliver that? Is its mission clear and does it bring everyone together in the way that you would hope it would?

Professor Sommer: Its problem is that, when it was set up, it had either no or very little independent funding of its own. The individual members, as I understand it, continued to get their salaries from the organisations from which they came. Again, one will have to ask Dr Marsh what has happened since the review and the funding was announced, but certainly talking to officials from there about what they wanted, they wanted their own funding at the very least so that they could set up projects and investigations so that they could suggest policy. It was set up originally as a scoping exercise. You had a change at the general election. You then had a further delay because they had to fit in with the Strategic Defence Review, so it is probably only in the last couple of weeks that they have been able to do anything very much and formulate their plans. I am as interested in the outcome as you are.

Q269 Stephen Mosley: That sounded like a "No" as the answer. Professor Anderson, we have heard that there is some sort of—I could use the word "conflict"—issue between the civil and defence

efforts, effectively. Do you think they should work together more, share more, or do you think there should be a greater emphasis on the civil side rather than on the defence side?

Professor Anderson: Given GCHQ's culture, there is no prospect of collaboration. They keep everything very deeply classified and hold it very close, unlike, for example, the NSA in the USA, of which they are, in effect, a local franchise, which is very much more open about much of its security research. Researchers like myself resist getting a clearance because, if you get a clearance, you may be told something that is of no consequence but is stamped "Top Secret" and then you are sterilised from the point of view of ever publishing again on a range of subjects. This is a policy that many of us hold to. It means, in effect, that you have two separate communities: the civil community and the defence community.

Within Government things are further complicated by the fact that outside the defence community there is no source of technical expertise. Offices as diverse as the Cabinet Office, the Information Commissioner's Office and the Metropolitan Police don't have their own engineering staff. As a result, they end up being beholden to Cheltenham for advice. So how the ecology then proceeds is that civil researchers such as ourselves end up working with firms like Microsoft, Google and so on and so forth and see our remit as being a global one rather than a national one because that's how we can get our ideas deployed and have impact.

If you want to change this, then you would have to move to the kind of set-up that we find in Germany, for example, where the defensive information security mission is lodged in a separate agency which reports through a separate Minister from the offensive mission. That would be a very useful change to happen. I don't see it happening here short of a cyber attack which convinces the Prime Minister that GCHQ is incompetent and things need to be fixed.

Q270 Stephen Metcalfe: Can I just backtrack a little bit to when we were talking about a cyber attack on the critical infrastructure? How would we know when that had started? Would it be an instantaneous thing, and in 10 minutes the whole thing would be over and then we would be left picking up the pieces? Is that a reasonable best worst-case scenario, as it were, to look at?

The purpose of our investigation is advice in an emergency. We talked right at the beginning about the fact that we could take advice before, we can have something in place to pick up the pieces, but is there anything that can be done while it is actually happening or is it just we'll know when it has happened?

Malcolm Hutty: Perhaps I might take that question, speaking from the perspective of the operator community in telecommunications, at least in the internet area. We establish working relations with Government so as to ensure co-operation between private sector operators and Government and amongst the private sector operators themselves. That is a key part of the defence. I understand Professor Anderson's perspective on that but it is coming very much from an academic-oriented perspective. The operator community does not necessarily share that point of view.

We like to be able to share information confidentially amongst ourselves both in preparation and in response, to be able to share that confidentially with Government as well, which means organisations like CPNI. There are several. So, in the case of an actual attack in progress, for example, within the telecommunications industry—I can't go broader than that; I know this inquiry goes much broader than that—there are established procedures that, if you believe you have an emergency, not an attack, that is overwhelming your capability to respond and you believe this is something that has a wider impact than just your own commercial impact, you can call upon the support of others so that they can start to respond to that and assist you with that. That means other private sector network operators and ensuring that Government are fully briefed and can be brought into the picture while things are in progress.

That is used in certain examples. For example, that procedure was used in the Buncefield fire. It was used in the 7/7 attacks to co-ordinate response while that was in progress, and it is exercised as well on an annual basis. That is not something that is necessarily all that visible to the academic community. By that sort of sharing, I am referring there to the Electronic Communications Resilience and Response Group, which is publicly known about but its work is not open to the public. There are other groups as well which are also known about.

For example, the Network Security Information Exchange is a group that consists of the senior network managers of network operators and CPNI. It is convened by CPNI. That's not a response group. The EC-RRG is a response group and the NSIE is more preparatory. Well, it is not so much preparatory but it offers general information-sharing in advance. Its purpose is to allow network operators to share on a wholly confidential basis information about incidents, about vulnerabilities and other factors that contribute to the planning towards information assurance and network security, to share that amongst themselves and to share that with CPNI and, hence, Government, but on a very trusted basis. This is, in short, the kind of closed community that Professor Anderson is complaining about being too closed.

From our perspective, we very much welcome that. We think these kinds of structures and relationships are extremely important. It builds personal relationships as well so you know who to pick up a phone to. It also allows companies to get past the confidentiality issues that Professor Anderson finds difficult for his work to make sure that this isn't a problem for ours. So, for example, in the Network Security Information Exchange, in order to join that group, the companies have to sign an NDA that authorises their own staff to share information on a basis that information received cannot necessarily be disclosed into the business. Members of that group can share information with their peers so that they can learn from that, learn from the experience and build on that. That would simply not be shared if that became shared within the business that your peer is

working for directly. Some of this information might be market-sensitive, for example.

It is very important that trust relationships can be established and maintained to a high level of confidence in order to achieve the maximum benefit from the learning that we have from on-going incidents, from vulnerabilities, from, in fact, briefings from Government and so forth.

Professor Sommer: There is also the framework of the computer emergency response teams or CERTs. They were set up originally in response to the first big internet worm back in 1988, something like that. It has been going for a long time. There is a Government CERT. Individual large companies have CERTs. It is an international movement. They have international conferences, and I have spoken at them. The UK CERT people appear there and are involved. Those are the people who would have the skill and the informal networking links that Malcolm Hutty is referring to which would attempt to ameliorate an attack if it went on.

Also while I have the floor, I ought to say that I am security cleared and I have not had the dilemmas that Ross is fearing I might have.

Robert Hayes: To answer your question, it is highly unlikely that if you knew where to look you wouldn't see evidence of an attack being mounted. If I can unpick that, if I have a new stealthy aircraft I can fly that over my territorial airspace and be reasonably assured it is not being seen. But actually the cyber domain is very different from other domains because companies like us and the internet providers, we actually own it, so this is not a natural domain. What we have seen is people test their weapons, they test them in a live environment and those weapons tend to make machines and systems fall over.

The problem from a national perspective is that you need to look at this globally to get the sufficient intelligence to start to make the inferences about what is happening. Again, the industry offers a unique perspective that can help Government in doing that. One of the conundrums for companies like Microsoft is how do we help nations defend themselves without inadvertently offering nations an opportunity to attack, because every vulnerability is also a potential attack vector. So there is a very interesting tightrope that we have to walk along about how we can do that. Again, I come back to my previous point—having one trusted point of contact with Governments where we can have all the right non-disclosure agreements signed and we can do it, really helps us. The answer is that there is an awful lot of information out there. It's just not always visible.

Q271 Stephen Metcalfe: From what you have all said, I think the relationship between the private sector and Government is quite well developed and working well. There is always, probably, room for improvement, but there are no barriers particularly between the private sector and Government, and, if there are, how might we break some of those down?

Professor Sommer: A lot of it is highly informal. Malcolm spoke about various loose structures. On my observation of academia and also with industry the relationship is fairly informal. There are sometimes formal structures but my own experience is that, certainly for the last 10 years or so, officials in what is now CPNI—it has gone under different names—have tried to make informal contacts with people sometimes through the think tanks of one sort or another, through various sorts of events. Quite a lot of it is done on that sort of basis rather than saying, "Oh, look, we'll give you an organisation chart showing how it all works."

Is it effective? Like most things to do with security, you only know that it has been ineffective when something has gone wrong.

Malcolm Hutty: When it comes to information-sharing between Government or the state and industry, the relationships between the private sector, CPNI and Cabinet Office do work well, but there is an area where industry does find certain barriers and that's in sharing information with the police. It is our experience that when we raise issues with the police, they will invariably take the information, thank us for it and go away, but there is no sharing coming back in the other direction. We do speculate as to why this might be and what the root causes of this are.

There is a lot of feeling within the operator community that some of the points that were made previously about the difficulty of ensuring adequate funding for policing in this area and ring-fenced funding for policing in this area have led to a situation where the police understand that they simply do not have the capacity to respond to all the things that they might like to and therefore do not comment back as to what they are doing on an issue that you have reported because it just hasn't made it through the triage. That is not necessarily something that it is comfortable to be very open about. It does leave industry feeling a little left out in that there is information that we can give to help the police. It is not always possible to have the same kind of relationship on the level of policing matters and where that is appropriate on the cybercrime stuff that we do in the planning for more serious attacks or other emergency planning with CPNI and Cabinet Office, which is a different space. Maybe that is natural—

Q272 Chair: I think we will move on now, if we may. The point is well made, Mr Hutty, although I am sure you would agree that there are areas, such as child abuse, where there are very high levels of co-operation between the two sides.

Malcolm Hutty: There are high levels of co-operation in the various strands of approach to the child abuse problem.

Q273 Roger Williams: In the written submission that we have had put to us the quality of direct engagement between Government Departments and agencies and the research base is said to be limited. In particular, Professor Anderson said that Government Departments pay very little attention to the research base and what access they have is filtered through intermediaries. Could the rest of the panel tell us how strong that relationship is between Government and the research base? If it is your view that it is limited, how could that be improved?

Professor Sommer: I disagree with Ross's insight. It depends what sort of level of engagement you are looking for. Mostly people within the intelligence community are not researchers. What they want to do is to take the benefit of the research and translate that into what they do. As I said earlier on, when I speak to them my experience is that they have read the literature and they do attend sometimes quite specialist conferences on intrusion detection systems, for example, technical burglar alarms for computers, if you will. If they don't understand or if they want to know a bit more, they will take you on one side and then you treat them in more or less the same way as an academic colleague or a high-level journalist and say, "It works like this, and, by the way, there are these other things that you might like to have a look at", to which they then say, "Thank you very much." They don't engage in joint research projects or, if they do, I'm not aware of them. At that point I would start to have the sort of concerns that Ross was expressing—that we could get a little bit too sucked in. At the moment, all they are looking for is advice and general discussion. My own experience is that they are pretty engaged.

Professor Anderson: My experience is different. With many of the fields in which I have been active in research in the past 15 years there has been little or no interest from agencies and Government Departments in the UK despite the fact that there is often very considerable interest from their counterparts in the USA. For example, one of our achievements over the past 10 years has been developing security economics as a discipline. Many things that go wrong fail because people have the wrong incentives, and this is particularly a problem in the Internet where things scale globally and you have classic collective action issues.

I don't recall any UK Government people coming along to relevant workshops, ever. In the USA, on the other hand, security economics has become one of the three top priority research areas in information security. They are spending something of the order of $50 million on it this year. By comparison with the engagement that we see in the USA, where, to be frank, much of the heavy lifting is done in information security, the UK agencies appear to be not interested, not engaged and pursing their own traditional agendas.

Q274 Roger Williams: What does the Government's decision to scrap the Institute for Web Science say about the Government's approach to these matters, given the fact that web science could help us understand evolving cyber capabilities?

Professor Anderson: I have no knowledge of that.

Professor Sommer: I am not quite sure what web science is but I think it seems to be a re-labelling as a convenient way of raising funds for a particular group of academics. There is nothing wrong with it. As academics, we do that all the time. Naturally, I deplore any withdrawal of research funding anywhere. I am not about to take to the streets about it, let's put it that way.

Q275 Roger Williams: Academics are always keen to accumulate and have access to more data. In particular, as far as cybercrime statistics are concerned, how can that data be more publicly available without compromising national security?

Professor Sommer: It is not only a problem of availability. It is defining what it is that you are trying to collect. If you look at the way in which most crime statistics are collected, it is by reference to breach of particular offences. If you look at the Computer Misuse Act 1990 there are fewer than 100 charges each year since it ever came into play, but there is a reason for that. The Computer Misuse Act was designed as a fill-in bit of legislation and it is CPS policy that if you can possibly charge, say, fraud, extortion or whatever it is, which is a rather easier and more jury-friendly type of charge, then you will go for that rather than an offence under the Computer Misuse Act. That means that there are an awful lot of things that you would probably want to call cybercrime but those numbers are not collected at all. In previous studies, I did some work for the National Audit Office and I asked the Home Office if they could be doing something about it. We talked to the Crown Prosecution Service and I also talked to the police. The police have crime reporting systems, and I said, "Do you have a field in the forms that are filled in which refers to a computer element?", and they said, "Well, some of us do and we are thinking about it."

Your big problem is, first of all, defining what you mean by a computer crime and then you have the problem of collecting the data. So there is a myth that someone somewhere is sitting on some statistics which would be immensely useful. I don't think they exist for that reason. But if this Committee wanted to make a recommendation along those lines, then I, personally, would welcome it.

Professor Anderson: In our research we have not found great difficulty in getting access to data feeds from companies who are involved in combating technical bad things on the internet. We have published a number of papers on what you might call the econometrics of wickedness. On the other hand, as far as it affects individuals, there is a particularly severe problem with online crime reporting in that about three years ago ACPO, the Home Office and the banks did a deal to the effect that fraud should be reported to banks rather than to the police. This was great at massaging the crime figures downwards but it has meant that police statistics are no longer particularly useful as a source of enlightenment.

There is, however, a source of data to which I would refer the Committee, which is the British Crime Survey Third Annexe, which came out, I think, in June or July this year. There, the researchers, who are funded by the Home Office, go and ask 44,000 people every year whether they were a victim of crime. The synopsis of what they found is that about 1 million people last year were victims of traditional acquisitive crime such as burglary and thefts of and from vehicles, and somewhere between 2 million and 3 million people were victims of more modern crimes, such as credit card cloning, disputed electronic banking transactions, online lottery scams and so on

and so forth. The data are not collected with sufficient precision to know precisely how many of these had an online element but we suspect that that would be most of them.

The implication for policymakers is that online crime now appears to be most of it. If the police are devoting almost of their attention to a minority of crime, and a declining minority of crime, while the online element keeps on increasing, then that is clearly a very serious misallocation of resources. If it continues, then, ultimately, it would call into relation the social contract, if you like, between the citizen and the state of obedience in return for protection. If the state cannot protect its citizens against globalised online crime, then what's it good for?

Q276 Gavin Barwell: I want to return, briefly, to the issue of security clearance on which some of you have expressed some views already and slightly divergent views about how much of a problem that is. Certainly when it comes to assessing the threat to top-secret assets, does the requirement for people to have DV—Developed Vetting—mean, essentially, that the Government have to rely solely on scientists working in their own agencies and do not have access to the necessary independent advice?

Professor Anderson: This is one of the reasons why Government should be more open in its dealing with INFOSEC and why I would be in favour of civilian Government INFOSEC being handled by an agency other than GCHQ, as is the case in a number of other countries. There is also the issue of getting advice on technology as well as science. The history of government is littered with failures of large IT systems, and one of the flip sides of that is that, if Ministers have no access at the policy level to people who understand IT, then it is not just that they will start projects that don't work but they won't get advice where advice is what's needed.

Professor Sommer: Most of these things are not top secret. I suppose the most sensitive material I have seen was the outcome of various risk assessments and what you get from that, obviously, are areas where, at the moment, the UK Government aren't terribly good and you wouldn't want to publicise that.

What happens is that if you are up to my level, which is security cleared, you fill in a form, elements in the form are checked, and in my case I also have my premises physically checked because I might have material overnight which is sensitive. It is a whole different thing being DV'd. I would have thought you only needed operational knowledge there, if you were looking at an ongoing exercise. I think that would be the cut-off point. In terms of giving advice and seeing perhaps some of the outcomes of that advice in terms of an assessment, security clearance is probably enough. Again, that is simply my perspective as someone from outside the Government community. No doubt you will be putting the same or a similar question to Dr Marsh and his colleagues, who are obviously within the security fold.

Malcolm Hutty: If I may give a perspective from the network operator community, the most sensitive information that I come across in the course of the discussions to which I alluded earlier is vulnerability information, but the most highly classified information with which I have been presented is threat analysis. There is a reason for this discrepancy. The threat analysis comes from Government but the vulnerability information comes from the private sector. In our hands it is not classified. It is only classified once we have handed it over.

Robert Hayes: If I may add as well, I actually take a different view. I think there are sufficient forums for industry to share information with Government on an unclassified level. I do hold security clearances and I do feel it is appropriate, when we are talking at an individual threat level, that those are held under closed conditions. I have to say I wasn't aware of this being an issue.

Q277 Gavin Barwell: We have discussed previously the relatively low risk of a major national emergency. Do you think there is a case for getting some more independent scientists DV cleared so that they could be consulted in those circumstances?

Professor Sommer: Could you repeat that? I am sorry, but the acoustics are working against us.

Q278 Gavin Barwell: As I understand it, in terms of DV clearance, the issue is that it takes a long period of time. It takes two to three months to get the clearance. So, if you had a situation where you had a major attack of some kind—we have already discussed that it would be relatively unlikely—and the Government wanted to get more independent advice, do you think there is a case for getting some people pre-cleared, as it were, so that in those circumstances there could be people who are brought into the loop?

Professor Anderson: If a seriously bad thing happens, then the Government should contact the people who are experts on the matter and it would be extremely foolish to stick to the rituals of classifications and clearances—which, after all, exist in large extent to cover Ministers' backs and to protect officials from criticism. If a bad thing has happened that's tearing up the national infrastructure and Professor Bloggs of Leicester is the guy who knows about it, you should speak to him even if he is a former member of the Communist Party.

Q279 Pamela Nash: I want to ask each of you how important do you think it is to involve the public in the planning for any sort of emergency caused by a breach in cyber security?

Professor Sommer: You are asking about involving the public in planning for an emergency as opposed to the earlier question, which related to involving them in education because you would want to help the public to protect themselves and also the point you were making earlier that vulnerable computers owned by the public can be used in an attack?

Q280 Pamela Nash: Yes. I think it is also about planning the response and also in building resilience in the community.

Professor Sommer: We don't do very much involvement of the public for any of the other civil contingencies as a general argument, I suppose, in terms of preparing the public in terms of expectations.

For example, we know that routinely we get floods in this country, that various areas are going to get flooded and people know that. They know that in a given period, although they might be flooded out, they may have to do without electricity but they have a reasonable expectation that something is going to happen for them within a day or two.

I suppose there could be an argument for saying that most cyber attacks don't last very long and, for the reasons that you have heard, the internet is pretty resilient. There should be good back-up systems so you may lose your internet connectivity, you may lose your ability to talk to your bank, the sort of things that are going to worry the public, but probably things will recover quite quickly and there is no need to panic. There may be an argument for that.

Robert Hayes: Personally, I would prefer to see the resources directed at educating the public to bring their systems up to a minimum level of defence. I think that would be a better use.

Professor Sommer: I am sure that's right.

Malcolm Hutty: I agree as well.

Professor Anderson: I have a difficulty with saying that information security problems can be fixed by telling the public to do stuff. When I go to conferences and I see people talking about how to fix the insecurity of the internet, you see the banks saying that the Government should do something, the Government saying that people should be more aware and so on. Everybody is, in some sense, passing the buck.

As a practical matter, people aren't going to do stuff. People have busy lives. People buy computers and they expect them to work. So one needs a fairly sophisticated view of what you can rely on the public to do. The main thing that the public does in an emergency is that they are the fourth emergency service. If a bomb goes off while you are walking home tonight, you'll get your first aid probably not from an ambulanceman but from somebody who just happened to be walking by on the other pavement. Therefore, it is considered to be a good thing to encourage lots of people to get first aid certificates, whether in the Boy Scouts, at school, at work or whatever.

What is the equivalent for a cyber attack? The answer is we don't know. It depends on what the scenario is going to be.

Malcolm Hutty: I wouldn't be dismissive about the importance of encouraging the public to raise their own level of protection. I accept that this does not fix the problem, but this kind of problem is not fixed: it is managed. The better people are protected, the lower the level of problem that they have and the better able we are to concentrate on more esoteric things. The public is better protected when the public helps to protect themselves. Therefore, they should be encouraged to do so.

Q281 Pamela Nash: It is quite interesting that you have differing views about human behaviour and what we should expect from the public or the Government. We actually have a quote here from yourself, Professor Sommer, saying: "A great deal of security planning and engineering relies on an understanding of how individuals by themselves and as members of a group behave." I take it that that was more looking at the motivations of those who are attacked—

Professor Sommer: I think that refers much more to research areas. The temptation is to think that with cyber security what we want is better encryption and better intrusion detection systems. All of those things are important. The social science aspect of it, criminology, human motivation and the economics that Ross Anderson was talking about, all of these are important research areas in understanding the nature of the problem and how you are going to manage it. Since you are giving me the opportunity, I do think it is rather a pity that Government research funding is going largely just into the hard sciences because the social sciences have a significant contribution in areas like this.

Q282 Pamela Nash: Just to be clear, you think the Government should place more importance on the human behaviour aspect and social science?

Professor Sommer: It is certainly an element. You say they should be doing more. The problem is that we don't actually know quite what the balance of effort is. Based on conversations I have had with people in the agencies, in the communities that are interested in this sort of thing, they are specifically interested in those matters. The London School of Economics is a social science school. It is not a hard science school. We have had a fairly regular stream of officials coming along, sitting in the back of our public seminars and being interested in these matters. So I know there is interest.

As with some of the other questions you have been putting to us, it is very difficult to assess how far what is undoubtedly an interest gets translated into action.

Robert Hayes: If I might give an example, we run a tool called the Malicious Software Removal Tool which comes as part of Microsoft Update. We have recently cleaned the Zeus password-cleaning virus, which is a bank password-stealing virus. We found that, of the many hundreds of thousands of machines that we cleaned, over 40% had either no anti-virus protection or anti-virus protection that was so out of date as to be useless.

We and other companies offer free anti-virus. So there is an education piece whereby causing people to adopt behaviour and just to say to them, "Make sure you have got anti-virus and that you apply the patches supplied" would make a significant difference in this area. Again, it wouldn't just make that difference in the crime; it would make it in terms of the botnet approach to critical national infrastructure. We would welcome anything that says, "Why don't people do that?", because these are easily available resources. Is it a publicity issue, is it an education issue, or what else do we need to do? As long as that situation exists, there will continue to be risks which, frankly, don't need to be there.

Q283 Pamela Nash: Do you think that there is a level of software to protect people's home computers available for free at the moment? Is it not just the cost that prevents people from using them?

Robert Hayes: I suppose you would expect me to say this because of who I work for, but my home

computer is protected by Microsoft Security Essentials, which is a free anti-virus programme and uses Windows Firewall, which is a free programme that comes with Windows. I consider that for my own personal protection to be perfectly adequate. There are a number of other companies who offer free services as well. I don't see cost being an issue. I think it is an issue of how we encourage or motivate people to take the protection that is available and can make a difference.

The other part of it again is patching. I am really pleased to see that GCHQ over the last couple of weeks have really emphasised this. If you apply the patches that companies put out, you will make your machine safer. We do it automatically but not everybody does. Again, we need encouragement for industry to make that process more intuitive. I can see my colleague on the right raring to have a go at me on this. There is a role for industry to make this as intuitive as possible. We do understand that people do just want things to work rather than have to have a degree in computer science just to get their home computer to work.

Professor Anderson: There is a bundle of interesting policy questions around the issue of whether Microsoft should ship anti-virus free with every machine. A safety-first person would say that it would be ridiculous if vehicle manufacturers made seat belts available for free with every car but did not actually fit them so you had to go to the trouble of going to the garage and asking for them and then bolting them on before you had seat belts.

I won't talk about the Microsoft issue. I think it is best simply to say that what we should be aiming for is for systems to be safe or secure by default. However, there are very often strong commercial incentives for firms not to make systems secure by default. We have written, for example, about Facebook. If you use Facebook, you are not Facebook's customer: you are Facebook's product. Facebook sells your personal information to advertisers. So the incentive on Facebook is to create an environment in which you are comfortable with sharing lots of personal information. The defaults that are set for Facebook, which 90% of people just go with, share information much more than most people would intuitively imagine would be the case.

What will eventually happen? Perhaps in 15 years' time the EU will get its regulatory act together and will tell Facebook what the privacy settings are to be by default on each web page. There is a problem there in that regulatory action takes a long time. The EU has only just now got round to telling Microsoft to give people choice of a browser and that was in response to Microsoft stamping on Netscape's toes back in 1995.

So a fundamental problem here is that we need safe defaults, companies have strong incentives not to provide safe defaults, and regulatory action, while possible, is way too slow to be effective.

Chair: Can I choose that as a moment to stop? This could go on for a long time and I would have loved to develop that exchange between Professor Anderson and Mr Hayes. I think that would have been intriguing but not relevant to our inquiry. I thank you, gentlemen, for attending.

Examination of Witnesses

Witnesses: **Professor Bernard Silverman**, Chief Scientific Adviser, Home Office, **Dr Steve Marsh**, Deputy Director, Office of Cyber Security and Information Assurance, Cabinet Office, and **Professor Mark Welland**, Chief Scientific Adviser, Ministry of Defence, gave evidence.

Chair: Thank you, gentlemen, for coming this morning. You have heard the earlier panel. As you know, particularly you, Dr Marsh, we had a very helpful briefing by your colleague in the Cabinet Office before we started this inquiry, for which we are extremely grateful. I am going to ask Stephen Mosley to start.

Q284 Stephen Mosley: When we asked questions of the previous panel, we asked them what they thought the worst-case scenario would be and how likely that would be. We heard from the private sector and academics what their response was. Could I ask exactly the same question to you to give the Government's response and does that response differ from the private sector angle?

Dr Marsh: Good morning. As we heard in the earlier session, when you talk about cyber attack there is a whole spectrum of things that we may be talking about. At one end you've got the high volume/low individual impact attacks, the cybercrime, and when you take those together you can aggregate those into something which is a substantial risk. You can go through the more sophisticated attacks which lead to economic damage. From our point of view, it is those two things which are most significant in terms of economic damage to the nation as a whole.

When you move up into the low likelihood but high impact events—I think there we are talking about emergencies, in particular—you may still have a substantial risk because the impact of a successful attack would be large but there is a low likelihood of that happening. There is also a big uncertainty around what that likelihood would be because it is tied into the capabilities and the intent of the attacker and the vulnerabilities in the system. In fact it can even be hard to work out what the impact is because of interdependencies amongst different systems.

From the Government point of view, we would say that the main concerns that we have currently are around the cybercrime and the cyber espionage, the economic espionage aspects, damage to the UK. We can't ignore the fact that there may be more large impact/low likelihood attacks and we need to do something about those but we need to keep them in proportion. We are largely in agreement with the discussion in the earlier panel about the impact and the overall risk of those various scenarios.

Professor Silverman: I don't have much to add, expect I thought the earlier panel were very good at the way they set out the landscape. I noticed Professor Anderson's reference to the crime statistics, which are the same as my view of the issue. So I thought, to my mind, the evidence we got from the earlier panel was exactly the kind of way that we would want to assess things, and I would agree with them.
Professor Welland: I agree in general. From a Ministry of Defence perspective, clearly any attack that affected our ability to defend in any forum immediately would be an issue. In the longer term, any cyber attack of any nature that compromised our ability to defend in a future conflict would be a major issue.

Q285 Stephen Mosley: We had the National Security Strategy published last month. Sir John Beddington's Review of Cyber Security was fed into that. How did that process work and how much attention was paid to Sir John Beddington's work when the National Security Strategy was drawn up?
Dr Marsh: It certainly did feed into it. I was part of that review group as well. We selected a range of academic and industrial input into that group. I think Professor Anderson probably underestimates his influence. He was there not just because of his experience in this field generally but precisely because of his work on the economics of security. What we were trying to do, in particular, was to expand beyond just the technical view of cyber security and look at some of these broader issues such as economics and behavioural science as well. Certainly that was a very useful contribution into the Strategic Defence and Security Review. We still have some more output from that review group to take forward. We have set up another working group to map out the research that is going on across the UK that is currently trying to identify gaps which we will look to fulfil as time goes forward. We also got some good recommendations that are coming out of that original work and we would hope to take those forward as well over the next year.

Q286 Stephen Mosley: Last week we looked at the threat to the infrastructure from natural disasters, in particular space weather. One of the things that came out of that was a threat to microchips and to electronic infrastructure basically. Have you considered the threat to our cyber infrastructure through natural causes as opposed to deliberate action?
Dr Marsh: Not in any great detail at this stage. Clearly, it is an issue that is being taken forward in other areas.

Q287 Chair: We kept hearing the phrase "work in progress" last week. It's more work in progress, is it?
Dr Marsh: Yes. That's still fair. I believe the effect now is going to be stronger, if you like, on the power Grid which clearly underlies a lot of what we are trying to do in cyber space anyway, perhaps rather more so than on the telecoms infrastructure side because of the change in technology. Many years ago you had long wires that were carrying telecommunications signals around the country and they would suffer in the same way as the power Grid does, but with the move to fibre optics you no longer get the same impact over that long range from space weather. Clearly, there are short-range weaponised effects that may take place as well, but they are much more localised and wouldn't be on a national level. It is still fair to say there is still work in progress. It is one of the things we need to look at.

Q288 Chair: One would hope that it would be more than just work in progress in the case of the Ministry of Defence. Is that a fair assessment?
Professor Welland: Yes.
Chair: I am not going to push you any further, for obvious reasons.

Q289 Graham Stringer: Is there a sort of cyber-Manhattan Project out there anywhere? Is there a belief that there is a game-changing development if a quantum computer was developed by another country which would be able to get straight through the encryption on all our computers in a matter of seconds? Is that something you consider?
Dr Marsh: No. Clearly, we look at quantum computing, as many people do, but even if it were to fulfil the theoretical potential that is there at the moment, I don't believe it would be that much of a game-changer. There are, basically, two main classes of encryption. There is what is called the public-key encryption, where quantum computing potentially raises the possibility of much more rapid decryption of those systems, but there are other forms of encryption that are more resistant to quantum computing. There would need to be a change. You would need to extend key lengths or change the underlying algorithm, but there is much more to cyber security than just encryption. Encryption is a part of it but the whole malware, anti-virus-type systems are not affected in that way. It is something, again, we need to keep an eye on but I don't believe it is a game-changer in that sense, certainly not in the short term.

Q290 Graham Stringer: The Public Accounts Committee, the National Audit Office and the Cabinet Office have all written reports over the last 10 years to say, in round terms, Government are useless when it comes to ordering and using computer systems. Why should we believe they are any better when dealing with security?
Dr Marsh: I would say it is probably over-optimistic to imagine that they are usually better. We are procuring large IT systems for a whole range of issues. We build in the security that we believe is necessary. The threat landscape has changed very rapidly over the years. We need to react to that as that change happens. I think it is fair to say that we are not always as good at that as we would like to be, often because we are tied into contracts where people haven't thought much about those changes early on in the process. It is also worth remembering that Government are a very broad spread of organisations. Some are much better at security and protecting their systems than others. Clearly, once you get into the high end classified systems we believe we are very good at building the security into those. I suspect

when you get further out into the wider public sector there are organisations that are not as good as others at building that security in.

Q291 Graham Stringer: Along the same line, really, we have had academics here, we have had the private sector and now, you are the Government before us. Where is the most expertise? There are clearly barriers. Some doors are open and some doors are not open? Who has the most expertise in this? Is it Microsoft and Google, is it Government or is it the academic world?
Dr Marsh: There is a variety of different sources of expertise. You have expertise in particular areas. For example, the network operators are going to be particularly expert in understanding their systems, their architectures and how to protect those networks. Microsoft, clearly, is expert in Microsoft products. In Government, we have a particular expertise on some of the higher end attacks as well. I think there are very good areas of expertise in different areas and we do bring those together whenever possible. We heard about the information exchanges, for example, that CPNI have been running very successfully for a number of years. We have other bilateral and multilateral forums where we meet with companies and academics. I think the interchange of expertise is actually quite good.

Q292 Roger Williams: Various Government Departments and agencies will have an interest in cyber security. The danger is, I guess, that they would go their own way without a co-ordinated approach to it. The Office of Cyber Security was set up to provide strategic leadership. Can you give us an idea of how co-ordinated Government are in their approach to these matters at the moment?
Dr Marsh: I think they are becoming better co-ordinated. As you will have been aware, cyber security reaches into a range of different areas. It's not just about technology. It can be about diplomatic issues, it can be defence issues, it can be economic issues. So there are reasons why a whole range of Departments across Government need to pay attention to this. It doesn't make sense in that situation, for example, to try and centralise the response to cyber security because you are taking the cyber aspects out of the standard policy developed in those departments. What we have tried to do with the Office of Cyber Security is to ensure that those cyber security aspects are fed into other Departments.
What we did find over the last few months as we were building the programme for the Comprehensive Spending Review is that some Departments have less capacity currently to respond to cyber security issues than others. One of the things we are trying to do in the programme is to build that capacity going forward. The co-ordination has definitely helped in that OCSIA, as we now are, and our sister organisation, the Cyber Security Operations Centre, are both intrinsically multi-departmental and are drawing people in from different organisations. That has been very helpful in breaking down the barriers between different departments, but it is still early days.

Q293 Roger Williams: Could you give us a specific and practical example of that that we could understand?
Dr Marsh: In terms of the co-ordination?

Q294 Roger Williams: Yes; in your role in achieving that?
Dr Marsh: Certainly. The Cyber Security Operations Centre, for example, is now producing analyses that look across a whole range of different Departments and different issues. So we are joining up the work on cybercrime, for example, state threats and so on. We have been able to do that in a way that was difficult to achieve beforehand.

Q295 Roger Williams: Has that work been completed now or is it another on-going?
Dr Marsh: That is continuing. Those analyses are a continual thing, but that analysis process is working a lot better than it has been in the past.

Q296 Roger Williams: There has been some uncertainty as to what the role of OCS should be or could be. Is it an awareness-raising body or is it going to enact and deliver a particular policy on cyber security?
Dr Marsh: There will be policy. It is also, I believe, very much about the strategic leadership being a focus for cyber security across Government as a whole. What we don't want to do is to replace mechanisms which exist already and which already work very well. We are not taking away any work that CPNI or CESG is doing. All we are trying to do is to make sure that those activities are part of a coherent whole that drives them forward.

Q297 Roger Williams: What about mechanisms that don't work particularly well?
Dr Marsh: Did you have any specific mechanisms in mind?

Q298 Roger Williams: No. You said that we have mechanisms that do work well. What happens if you come across a mechanism that doesn't work very well? What are your powers? What can you do about those sort of things?
Dr Marsh: We report to the National Security Adviser in the Cabinet Office, who then, obviously, reports directly to the Prime Minister. We have the Security Minister, Baroness Neville-Jones, in the Home Office. We have the support of the National Security Council for the cyber security work. So I think we have at least growing teeth to harness the activity across Government and certainly, without a doubt, this Government's commitment is shown by making this budget available for cyber security.

Q299 Roger Williams: Have you identified yet a mechanism that isn't working very well?
Dr Marsh: There are mechanisms out there that aren't working that well. There is industrial engagement, for instance. Although there has been a lot of good work that CPNI has done through the information exchanges, we recognise that it is not widely scaleable. Because they are reliant on these fairly

small groups of people, building these trusting relationships takes time. It is difficult to scale out. Actually, it may not respond as quickly to some of the imminent threats as we would like. So we are exploring other routes with industry to see if we can bring together essentially a broader range of industry with more real-time situation awareness, effectively getting a better understanding of what is going on in cyber space and finding better ways of feeding that information out that does not compromise the commercial sensitivities of the organisation's product.

Q300 Roger Williams: I guess one of the greatest difficulties must be in co-ordinating Government between civil and defence capabilities because some of these things, quite naturally, are not available in a more public form. How do you address those particular difficulties?
Dr Marsh: I am not sure that is quite as big an issue as it may sound. What has helped us recently has been this formation of the National Security Council where they are taking a very broad view of what national security means so that the economic prosperity and the more traditional national defence—the national security elements—are brought together in that forum. That has been a very powerful mechanism for getting these broader issues around cyber security in particular on to the table.

Q301 Chair: Do you agree with Professor Anderson that the NSA is more open than GCHQ?
Dr Marsh: No, I don't think I do.

Q302 Graham Stringer: Why not?
Dr Marsh: My experience is that across the community generally we have a wide range of contacts with academics, industry and the research elements of industry as well. I have not recognised security clearance, for example, as being a barrier to that.

Q303 Chair: The other issue I want to touch on—you heard in the earlier panel discussion about budgets—is that there are quite complex budgetary structures within the police, within your own office and within individual Departments. Have you an idea, an order of magnitude, of the overall budget that HMG have for cyber security and what is your own budget?
Dr Marsh: It is difficult exactly to draw a boundary round the cyber security, if you like, because it feeds into a whole range of different policy areas. So the announcement in the Comprehensive Spending Review was that there would be £650 million of new money for cyber security. Of course, that is in addition to what we already spend on information assurance across the public sector. We estimate that as being around 4% of the total ICT budget. That is, again, averaged over the public sector. It is higher in what we call the high-threat departments. It is lower in the wider public sector. That is with the current IT budget of something like £16 billion a year. It is of the order of another £600 million a year that we already spend on information assurance protection for Government systems. Cyber security itself relies on the existing intelligence collection mechanisms, so there is an element there which you could say is contributing to the overall cyber security budget. Of course, once we get into diplomatic activity, defence activity and so on, then there are other contributions in that as well, but at that point it is very hard to say this is drawing a boundary around what cyber security is. It is just part of what Departments do as their business as usual.

Q304 Chair: If you can't put numbers on it, perhaps I can ask a specific question of Professor Welland. Following Sir Edmond Burton's report relating to the missing laptop in Birmingham and the recommendations in there about training, how many MOD personnel, uniformed or otherwise, have received additional training as a result of that report?
Professor Welland: We have a total of 350 people in the Ministry of Defence who have been trained in cyber security. I can give you a budget as well. The R&D budget in the Ministry of Defence is £6.5 million a year. So we have a number of people trained in cyber security and we have a modest budget.

Q305 Chair: That is quite a small number in terms of the overall personnel?
Professor Welland: These are nominally cyber security trained people, so they are specifically trained for cyber security and are responsible for that.

Q306 Chair: I am more interested in going a bit further. I specifically referred to Sir Edmond Burton's report, the recommendations of which were a bit like what Mr Hayes was saying about how we need a better educated public.
Professor Welland: Yes.

Q307 Chair: That equally applies to every member of the Services who touches a computer?
Professor Welland: What I can tell you, as a member of the Defence Board, is that Sir Edmond Burton's review on that missing laptop and his recommendations have been fully met by Defence. Even at the working level, you can see a significant change in an attitude to cyber security across Defence. That is both civilian and in the Services.
Dr Marsh: I don't have a breakdown for the MOD or Departments specifically, but I do have some figures here about the training on data security and, by the end of December of last year, over 450,000 public servants had had specific training on data security. We now have over 9,000 information asset owners across the public sector and more than 150 senior information risk owners. So the data handling review certainly was a wake-up call, if you like, and Government have responded appropriately.
Professor Welland: May I just add that, in response to Sir Edmond Burton's review, everybody in the MOD had to undergo some basic IT training and security training? That was mandatory.

Q308 Chair: When you say "in the MOD", everybody in the Departments?
Professor Welland: In the Services and civilian.

Q309 Pamela Nash: I want to ask you to go more in depth about the Government's relationship with the private sector. How successful do you think the Government have been in engaging with the private sector so far?

Professor Silverman: The Home Office Scientific Development Branch has a big exhibition every year and this year cyber security is going to be one of the main themes. We have a very good record, particularly with SMEs. We have quite a good percentage of work that goes to SMEs. We have a lot of experience working with the private sector in other security areas and we are very optimistic that we can do so in the cyber area. Obviously, this is an issue which has to be addressed by everybody and it is not going to be Government investment that will solve it. Private sector involvement, as in other security areas, will be extremely important and we are doing all we can to facilitate that.

Dr Marsh: This is of particular concern in that a lot of the critical infrastructure is owned and operated by the private sector so we have been particularly interested in the relationship there. As Mr Hutty said in the earlier session, there is the Network Security Information Exchange that brings some of those people together but there are others as well. We have a particular telecoms group that the Department for Business, Innovation and Skills operates and that specifically exists to consider emergency response if there is disruption to the telecoms network of any sort. We also have a strategic level group of chairmen and CEO level amongst telecoms operators in what is called the Telecommunications Industry Security Advisory Council. It is a model that we are looking to extend as well now into other critical infrastructure sectors.

Another thing that is worth registering is the announcement a few weeks ago by the Prime Minister at the CBI Conference of the National Infrastructure Programme, which is again designed to improve the resilience of critical infrastructure in the UK, and cyber security is an element of that which we will also be taking forward with those various infrastructure sectors.

Professor Welland: We have a number of mechanisms but I would like to highlight one which is the Centre for Defence Enterprise. This is a mechanism by which the Ministry of Defence seeks to engage with academia and particularly SMEs. We do that in an entirely unclassified environment. It is a very effective mechanism for addressing some of the issues that Professor Anderson mentioned. So we make a real effort to de-classify our problems and pose problems in a completely unclassified way. To date, we have had 1,600 applications into this programme. We have funded £10 million-worth of projects with about a 12% success rate, and we have had specific programmes, specific calls, in the cyber area and they have been extremely successful in engaging in a different way with a much wider supply base, academic as well as SMEs.

Q310 Gavin Barwell: You will have heard the discussion about security clearance in the previous evidence session. Can you tell us to what extent there is a need for scientists to have security clearances when advising the Government on planning for cyber emergencies and what level of clearance is necessary?

Dr Marsh: I believe that a lot of the statutory security clearance isn't required. A lot of the research activity that we were needing in cyber security is perfectly general. It doesn't get into the more sensitive aspects that clearance might be required for. A lot of the academics we deal with don't have security clearance; some do. From my point of view it is not a big issue. If they do require clearance, then, unless they are working continually with top-secret information, the standard level of security clearance is sufficient. That provides access to occasional top-secret material and that should be fine. But, as I say, a lot of the research really doesn't need access to sensitive information.

The sensitivities are generally around vulnerabilities that organisations might have and their commercial sensitivities about releasing that, or because the information has come from sources that need protecting as well. It is the standard reason why you might want to protect information. Generally, as Professor Welland said, you can sanitise the problem so that the research can take place without needing to get into the difficulties of handling and processing secret information.

Professor Silverman: First of all, let me say that Professor Anderson's views are clearly considered and sincerely held, but I don't personally see security clearance as serious an issue as he does. Security clearance is important to protect information.

We fund research in a wide range of disciplines across counter-terrorism. That hasn't been a problem in attracting high-quality scientists to engage with us. We have advisory committees where some security clearance may be necessary for membership. Again, this hasn't been a difficulty in getting people to serve on these.

I don't want to argue with Professor Anderson—it is not appropriate—but I would say that many scientists don't see this as a particular barrier.

Professor Welland: Let me make a general observation about the Ministry of Defence and how I try and run the S&T programme. I look increasingly to pose problems in an unclassified arena for the reasons I alluded to earlier. You can do that. We don't do as well as the US does. I agree with Professor Anderson in that respect. You can pose the problems in an unclassified arena, but there are cases, about which you have already heard, where you do need to protect information and protect how that information might be used. So you need to have that.

One of the interesting approaches that Sir John Beddington has developed over the last year are these Blackett Reviews. When we set those up, the plan was to make them unclassified. I led one which was on IEDs, which is an extremely sensitive—an extremely sensitive—part of the business of the Ministry of Defence. We made it unclassified. We have had a number of meetings with academics. As the academics have come forward with more and more information, as they have moved into areas which are sensitive, we have simply got some security clearances for a few of those. Curiously, and this has helped, it has not affected the dynamics of the group.

My view is that we should work in an unclassified way as best and as much as we can, and where we need to pull in that advice we can do so. In the Ministry of Defence we have a group of academic experts who we can call upon. Some of them are cleared; some of them are not. Some members of my Science Advisory Council—DSAC—chaired by Sir Peter Knight, are cleared to the highest level, some at a lower level.

It was a combination of sensibly classifying material or unclassifying it, and accepting that one tries to engage in an unclassified way, especially with academics, but where there is a good reason—and there needs to be a good reason—to engage in the classified area, then you can get those security clearances.

Professor Silverman: I would like to support everything that Mark says from my own point of view.

Q311 Gavin Barwell: Just to clarify this, both Professor Sommer and Professor Anderson in their written evidence felt there was a problem here.[1] All three of you are saying that, in your experience, doing your jobs, you don't find it difficult to get the advice or the research that you want carried out by independent academics? It is not a problem that you come across.

Professor Welland: You do what I have just said. You have to work to understand what really is classified. If you have a culture where because a little bit is classified, the whole thing becomes classified, clearly, you have removed all of that element of the programme from open access. So you need to understand. There is an onus upon Government and Government Departments to understand what does classification mean. If I am wanting to expose this more widely, let me be quite clear about what needs to be classified and what bit I can—

Q312 Gavin Barwell: But provided you take the approach that you are outlining, as far as you're concerned there isn't a problem?

Professor Welland: On the evidence that I have from working on a day-to-day basis with academics, with DSAC and with this Blackett Review, which is now in its third review, I do not see that as an issue, but it needs to be managed.

Professor Silverman: I would like to add that it is important to be able to do this, not least because there are people who are not prepared to be security cleared, which is entirely their privilege. These people have a great deal of expertise to offer which is important. Professor Anderson says he is in this category, so I can give him as an example.

The other reason for trying to get everything as unclassified as possible, as Mark has explained, is precisely that: if there are people who feel uncomfortable, they can still feel comfortable about giving advice which is so sorely needed. But the short answer is that we don't see it as a problem.

Q313 Gavin Barwell: I think you are saying that there are people who have this concern but you think by working in the way that you have described it is not a problem?

Professor Silverman: Yes.

Q314 Gavin Barwell: I have just a very quick question, Chairman, to Dr Marsh. In the Government's submission you said that the "OCS also worked with the Research Councils and with the Technology Strategy Board and individual departments to ensure a co-ordinated approach to research and development." Can you tell us a little more about how that works?

Dr Marsh: Yes. It is still early days, but we have just had our second meeting of a co-ordination group. Our intention there, as I say, is to try to map out the landscape of cyber security research across the UK over the next two or three months so that we can then go into the next financial year with some gaps identified, if there are gaps, and see how we might fill those research gaps.

Before the Office of Cyber Security was set up, there had been engagement with academia and industry, particularly through the Technology Strategy Board which was, for some years, running a programme that invited research proposals from consortia of academics and industry on specific topics that were of relevance to Government. So there are a number of things underway on privacy and identity, some on understanding complex systems and the interdependencies between them and so on. That's still in progress.

Q315 Chair: I have a few quick questions, if I may. First of all, do you agree with perhaps the siren voice of Professor Anderson in respect of the increasing number of things that are becoming online services?

Dr Marsh: Absolutely.

Q316 Chair: The example I cited was of his views on smart metering and so on.

Dr Marsh: Yes.

Q317 Chair: Do you see that as a big issue? Are Government taking it seriously enough?

Dr Marsh: It is definitely a big issue. I think we are beginning to take it seriously. Again, it is patchy, in the same way as it is with the private sector—some people get it; some people don't. Really, our job is to raise that general awareness and make sure that security is built in at the start of that.

Q318 Chair: That leads me into the next thing, which is the engagement of the public in planning for a cyber emergency. In my area, we have just had an emergency planning exercise around a supposed crash of a plane in the River Mersey close to a COMAH site and so on. It is a bit difficult to model that in the cyber area, but, if the public haven't got it, how are we going to encourage them to play a more active part in the complex equations that are needed to bring all of the tools at our disposal into practice?

Dr Marsh: Again, I would agree with the discussion in the earlier session that there is perhaps less engagement required from the public while an emergency is in progress in cyber space, but there is

[1] Note by witness (Dr Marsh): I don't believe Professor Sommer raised this as an issue, just Professor Anderson.

a greater need to engage them beforehand so that their machines are as protected as they can be. That means that they are not taken over and herded into these so-called botnets and those machines aren't used to form part of any attack on a particular infrastructure. So there is a need to raise awareness amongst the public of how they can protect themselves, how they can do things more safely online and how they can stop their machines being used to attack others. I also agree with Professor Anderson that that can only go so far. You can raise awareness but industry needs to make doing the right thing from the security point of view easier. We need to look at other ways of countering criminal activity. It is very difficult now, even for people who understand what they are doing on the internet, to recognise some of the more sophisticated attacks. If we improve the general level of security, I think we can get rid of many of those attacks but the reality is that that will just push some of the criminals into the more sophisticated form of attacks.

Q319 Chair: Where is the right balance between withholding sensitive information and communicating risk to the public?
Dr Marsh: I am not sure that it is necessarily a balance between withholding sensitive information because a lot of the time the advice about protecting the system isn't sensitive. You download the latest patch from Microsoft and that's sorted that particular vulnerability. You don't have to go into the sensitivities of where that vulnerability was first discovered or which particular company might have been hit by that activity. So I'm not sure that that is quite the balance that we particularly worry about. I think perhaps it is more a balance between getting people to take reasonable precautions against the risk but not actually frighten them off what is a very useful, valuable, socially important activity of being on the internet nowadays.

Q320 Chair: All three of you can answer this, but I know it is, perhaps, in a sense, more relevant to Professor Silverman. Finally, in this whole area of risk there is a complicated psychology about getting people to respond to risks.
Professor Silverman: Yes, indeed.

Q321 Chair: I take risks myself and risks are imposed on me by "them". The obvious one to look at is the way in which the public and, indeed, the media responded to, say, the King's Cross rail crash versus the number of people dying on the roads.
Professor Silverman: They all got on bicycles and as a result—

Q322 Chair: Indeed. Does the Government attach enough importance to understanding behavioural and social science, and how does the Government use social science in cyber security?
Professor Silverman: There is the Cabinet Office Behavioural Science Unit. I think the whole issue of how people perceive risk on the net is something on which I would come back to ask Dr Marsh to comment. In a way, it is not just for the Government to assess how risk is perceived. Many people who lose as a result of cyber attacks are people like banks, internet retailers and so on. So the issue of how you persuade people that they are actually at risk without frightening them off is not one just for the Government to look at. It is one for everybody to look at and it is one that we will have to look at going forward.

Q323 Chair: Is the Behavioural Science Unit looking specifically at these issues? Just for example, on a daily basis, somebody falls foul of the Nigerian scam and its many variants. Interestingly, scams like that get through some fairly sophisticated firewalls as well because they keep varying the language that is used. Surely, there must be a role for the behavioural scientists in working with the technical experts in this particular field?
Dr Marsh: Yes, I would completely agree with that. To be honest, we have not done enough on behavioural science so far. Over the years people have concentrated on the technical response. We have been trying over the last three or four years through the Technology Strategy Board and elsewhere to bring in this broader range of issues. For me, that almost defines the difference between cyber security generally and information security specifically. So we need to do more on behavioural science, we need to do more on the economics, we need to do more on forming relationships and so on. We absolutely need to bring in this broader scientific base, not just the technical response around the machines or networks themselves.
Chair: Gentlemen, could I thank you for your attendance.

Wednesday 1 December 2010

Members present:

Andrew Miller (Chair)

Stephen Metcalfe
Stephen Mosley
Pamela Nash
Graham Stringer
Roger Williams

Examination of Witness

Witness: **Professor Sir John Beddington,** Government Chief Scientific Adviser, gave evidence.

Q324 Chair: Good morning, Professor Beddington. As you know, we are continuing to gather evidence on our inquiry covering scientific advice and evidence in emergencies and we have spoken several times about this issue. How closely does the Government Office for Science work with the Civil Contingencies Secretariat in preparing for and responding to emergencies?

Professor Sir John Beddington: Good morning, everybody. The answer is that it has varied a little bit but, if we look at the current situation, it is fair to say that we are linking in rather more closely than we did, shall we say, two years ago when I first started.

In terms of the particular emergencies that I have been involved in via SAGE, in the case of the swine flu outbreak, we linked in with the Cabinet Office and the Civil Contingencies Secretariat in a regular way. They were organising the SAGE together with the Department of Health. In the case of the volcanic ash outbreak, it was very closely from day one.

Currently, one of the things that we are engaged in with the Civil Contingencies Secretariat is looking into the future. Space weather is one of the things you are looking at and we have been having discussions with them. We have also been having discussions with them about some of the more generic issues—for example, reasonable worst case scenarios and so on. It is fair to say that we are linking in rather closely and more closely than we were two years ago.

Q325 Chair: Do you assess the quality of the Cabinet Office's horizon scanning function?

Professor Sir John Beddington: We are getting involved in that; in terms of assessing the quality of it, no. It is fair to say that we—that is, including John Beddington—certainly did not think that the volcanic ash was a particular problem until it happened. I think 20:20 hindsight and looking at the frequency of volcanic activity in Iceland would indicate that we should have looked at that and thought of it as a potential problem. That we didn't, as I say, is 20:20 hindsight. But what we are engaged in now is doing some serious horizon scanning. I have just gone out to a Blackett group—and I will explain in a moment what the Blackett group is—to ask them about horizon scanning and what are the black swan events, the high impact, low probability events and, in a sense, looking forward into it. In terms of saying was there anything missing from previous Cabinet Office assessments, clearly, we should have thought about volcanic ash. I think that space weather is an issue that is going to be coming up. I think cyber security is an issue that is going to be coming up. In a sense, there is some degree of prescience shown by this Committee in looking into the future also.

The Blackett group, very briefly, is a set of groups that I bring together to look at particular aspects of scientific advice, bringing in and tapping in the academic and industry communities on a variety of areas. This particular group is dealing with the black swan events. I have gone to that group and said, "Look, can you think in your own different areas where we should be looking or may be missing potential emergencies from our current Risk Register?"

Q326 Chair: Again, perhaps using the power of hindsight, would it be better if the Government Office for Science was located in the Cabinet Office?

Professor Sir John Beddington: It is a question I have been asked many times, including when I was interviewed for the job. My answer to that is that there are advantages and disadvantages. In particular, the major advantage is the close proximity of the Government Office for Science with both the Science Minister and also Adrian Smith's team, who, until yesterday, were working essentially on the Research Councils, the research base, but from now on are working on both the higher education area and innovation. We are co-located. My office is about 50 metres from Adrian Smith's, and I think that is a very substantial advantage of getting joined-up Government.

In terms of access to the Cabinet Office, my reporting line is to Sir Gus O'Donnell and we do link in on a very regular basis with his office, the Civil Contingencies Secretariat and so on. On balance, I would say the location, in proximity with Adrian and his team and David Willetts, probably outweighs the advantages of contiguity with the Cabinet Office.

Q327 Stephen Metcalfe: If we could just go back to the identification, comparison and assessment of risk for a minute, could you talk us through the process of exactly how and when you contribute to that process of identifying and assessing those risks? I know you have touched on it but could you just expand on that a bit?

Professor Sir John Beddington: I would say recently, and only relatively recently, have we been engaged in assessing the risk; we have reviewed it. We have a number of groups. In the counter-terrorism area, I have a group of Chief Scientific Advisers who meet with others from the agencies on that, so we have

been looking in that field. In terms of the basic civil contingencies risks outside the CT area, not a lot has been done in the first couple of years. The first emergency I was involved in was the swine flu. The second one was the volcanic ash. I think now we are working rather more closely than we had hitherto. The issues that came up, for example, from the volcanic ash were that the Cabinet Office asked us to look forward. We've had the one volcanic explosion. They asked us to assess what are the likely possibilities of volcanic eruptions in Iceland of varying degrees of severity and try to assess the risk form in that way. That was an activity that SAGE took on and provided advice to the Cabinet Office at that stage.

Q328 Chair: When did that occur?
Professor Sir John Beddington: It was probably in the last one or two meetings of the SAGE group on volcanic ash.

Q329 Stephen Metcalfe: Maybe I didn't quite understand your answer, but, so that I am clear, are you saying that you hadn't, until the volcanic ash incident, been involved in setting up the national risk assessments?
Professor Sir John Beddington: No, not directly.

Q330 Stephen Metcalfe: You weren't having an input into that at all?
Professor Sir John Beddington: I had not had it initially, no.

Q331 Stephen Metcalfe: Who would now make the final decision? You now having become involved and made recommendations, who is going to make the final decision about what makes it on to the national risk assessment?
Professor Sir John Beddington: I really don't know, I'm afraid, Mr Metcalfe. The discussions are at the Secretariat level. If there was any debate about that issue, quite how that would be resolved I couldn't say at the moment. Perhaps Baroness Neville-Jones might be able to enlighten you on that. It may be that the National Security Council would make the final decision, and I input into that through the Senior Officials Group.

Q332 Stephen Metcalfe: Does it surprise you that you don't know? Considering that now you are having an input, it does seem quite important. This whole investigation is based on how the Government uses scientific evidence and advice.
Professor Sir John Beddington: Yes. I suppose what I am thinking, Mr Metcalfe, is that by and large you would expect a consensus to go forward, so it would be a decision by them with a consensus coming in from the scientific advice. In the event of some disagreement about what might constitute a risk, I would obviously have to get involved, although I have not encountered such an event. But my working assumption has been that, by and large, we would discuss this, there would be a reasonable consensus agreed and that would go forward. In a sense, the decision of what went on to the National Risk Register might be a relatively bureaucratic activity rather than a debate.

Q333 Stephen Metcalfe: Are you confident and happy with the system that the Government is now operating?
Professor Sir John Beddington: The thing is that the Cabinet Office own the National Risk Register and the national risk assessment. It is their responsibility, so I should imagine that Sir Gus O'Donnell would be the person who ultimately might have the final say, but obviously Ministers would need to endorse that.

Q334 Stephen Metcalfe: You have, I think, covered this matter. You said you have set up a horizon scanning group.
Professor Sir John Beddington: Yes.

Q335 Stephen Metcalfe: How do we deal with the "unknown unknowns", because that is, it appears to me, where the volcanic ash incident came from?
Professor Sir John Beddington: Yes.

Q336 Stephen Metcalfe: It wasn't even on the risk assessment. Are you confident that there is a system now in place that is going to identify the unknown unknowns but, I suppose, by their very nature, there are always going to be some that we just ain't thought of?
Professor Sir John Beddington: I won't debate the semantics with you of how could you ever detect unknown unknowns, but in terms of trying to widen the discussion—and I think what we did was important—if we had thought about volcanoes in Iceland we should have picked it up. I did an analysis, again post hoc, saying that, looking back over the last 100 years or so, there has been an eruption about every four years. I believe there were some studies that the British Geological Survey had put together towards the tail end of March of this year which indicated that there was some potential there, but that was, again, fairly late in the day and it was of the order of two weeks later that we had the particular ash.
In terms of looking forward into the future, clearly what we are trying to do is widen the group of people who are having to think about that. By widening it to include a number of people from industry and from academe and posing that question to them, I hope we will actually be able to cover it. I think space weather and cyber security are two things that hitherto had not been on the national risk assessment or the register. There will clearly be work in progress to get both of them on.
Where are we now? Are we going to come up with an unknown unknown which has suddenly become a known unknown? We will have to see, but the bit of this process that I am involved in will be a fairly wide consultation amongst both academe and industry.

Q337 Stephen Metcalfe: Do you think the matrix that we use to assess risk—the impact versus likelihood axes—is a useful tool? Do you think that helps or is that a distraction because it means we are not looking necessarily at the most useful bits?

Professor Sir John Beddington: I think it is a useful tool, but there are some issues with it. In the Blackett group that has been debating the black swan issues, one of the areas that we can say is that you have a point on that matrix. These are logarithmic scales so they are fairly robust to having a point, but, if you think about a number of events, the ones with less impact are likely to be more frequent. If you think about it, the reality is probably that you have something shaped a bit like a banana for any individual event—a banana sloping downwards in that direction. But I think the point and the way in which it is used in the national risk assessment seems to me to be reasonably well covered in that. This is work in progress and when the Blackett group reports we may be making some suggestions about changes. I think it is a useful tool. It is a way of prioritising and indicating what are the high impact, high likelihood events, which are the ones that are obviously of major concern. It has largely identified those, although in the case of the volcanoes we didn't.

Q338 Stephen Metcalfe: Do you think the Government understands how that works and its limitations?
Professor Sir John Beddington: In the conversations I have had with Ministers, yes, I think they do.

Q339 Graham Stringer: Is the reasonable worst case scenario evidence based, or is it a balancing point between necessary budget constraints and the precautionary principle where you load everything in? Can you objectively show how you come to the worst case scenario?
Professor Sir John Beddington: To the extent it is partially evidence based, it is quite difficult to come in any particular scenario to what is a reasonable worst case because in fact the very word "reasonable" implies there is something that is going beyond what would be pure analytic judgment. Following the swine flu outbreak and the inquiry by Dame Deidre Hine, I have been charged with developing ideas on how we could calculate the reasonable worst case scenarios in a variety of situations. The Blackett group that I have referred to is working on that at the moment and I have a couple of people who have made comments on what was the reasonable worst case scenario in the case of swine flu, but that is very much work in progress. In terms of simple things, suppose you had all the information. What you don't want to have as a reasonable worst case is something that is so unlikely that it is one chance in 100 million or something of that order. Clearly, one of the wrong ways of calculating in a reasonable worst case scenario is, therefore, to assign each individual parameter to one of its extremes—let's say one chance in 100 or something—and then say, "Let's take all the extremes of those parameters and that comes up with a reasonable worst case." That is not a reasonable worst case. That is a very low probability event. To an extent, we are often in a situation where there is insufficient evidence to quantify all aspects in terms of those probabilities. Therefore, it will ultimately rely on some degree of judgment. But, as I have said, I have been asked to look at it in the case of swine flu and I am sure we will generalise from that.
In the case of the volcanic ash eruption, we were asked to look at what might be a reasonable worst case and, historically, we looked at one of the larger volcanoes in Iceland erupting with associated ejection of not just volcanic ash but also sulphur dioxide and things of that sort.

Q340 Graham Stringer: Is it constantly under re-assessment? I gather from your answers, both to Stephen and myself, that these scenarios are being regularly looked at. Is that the right conclusion we can draw?
Professor Sir John Beddington: It is important to assess them as more information comes in. Let's take the case of something that we are working on at the moment, which is space weather. What would be a reasonable worst case for a space weather event? The worst event that we have any documentation for is the so-called Carrington event occurring towards the end of the 19th century. Whether that is a reasonable worst case is under active debate at the moment because there seemed to be a coincidence of a couple of low probability events in that Carrington event. Clearly, we need to be examining it. As the evidence of space improves, we should be in a position to better quantify the probabilities. In some cases, and in many of the natural phenomena, you are looking back at the historical record which is necessarily incomplete.

Q341 Graham Stringer: Can I just ask you a couple of questions particularly about how the swine flu epidemic was responded to? We corresponded about that.
Professor Sir John Beddington: Yes.

Q342 Graham Stringer: I was getting advice, which I passed on to you, that to increase the herd immunity it would be better to start with children rather than the most vulnerable.
Professor Sir John Beddington: I am sorry. Could you repeat that?

Q343 Graham Stringer: I was getting some local professional advice that it would be better to start vaccinating children to increase the herd immunity rather than starting with the most vulnerable. You wrote back and said that was not the conclusion you were coming to. When we had Neil Ferguson before us, he said two quite different things. One was that if there had been vaccine available he believed it might be the case that you would start with children to increase the herd immunity, but, secondly, when children were eventually vaccinated, he thought it was too late and that it was a waste—not his words—to have done that then. Do you think you could explain the thinking and tell us whether, if we have an epidemic again, the thinking will be different?
Professor Sir John Beddington: Yes. I think I understand. I have not seen the detail of the evidence you refer to but I think I understand what the issue is. In the case of conferring herd immunity, you want to get as many individuals who are immune to a particular infectious disease as quickly as possible. In

terms of contact rates, children have very, very high contact rates, so vaccinating children, where a vaccine is available and you are trying to confer herd immunity, makes a lot of sense.

In the case of the actual swine flu outbreak we had, first of all, there was a fairly substantial delay before the vaccine became available because of manufacturing issues and so on. But, also, as we were moving towards the end of the swine flu and were beginning to understand it in a rather better way, we realised that the ratio of people who were showing symptoms to the people who, essentially, had the virus but did not display symptoms, was quite substantial. Therefore, vaccinating children at that stage was not necessarily the appropriate thing to do. I think that is what Neil Ferguson's reasoning was.

Q344 Graham Stringer: The final part of my question is, would you advise a different approach if there was a likelihood of a new swine flu epidemic?

Professor Sir John Beddington: The concern we have is that pandemic influenza is, first of all, highly likely and it is high impact. So, in a sense, in terms of the previous discussion with Mr Metcalfe, it is important to recognise that a new strain of influenza is likely. I still think that the big concern is not a swine flu but a bird flu—H5N1. It exists. There is transmission from animals to humans and a very high mortality rate associated with that. That, I would say, would be a reasonable worst case, that bird flu might move and start transmitting from human to human. In such a situation it would have to depend on the availability of the vaccine, the level of mortality rates and so on. I don't think there is any generality that I would seek to make.

One of the issues, however, and there is some generality here, is that substantial use of antivirals also has the ability to provide temporary immunity within the pandemic, so both the use of the vaccine and also antivirals might be an appropriate thing. However, without the details of the actual dynamics of the pandemic, it would be very hard to give you a general answer, Mr Stringer.

Q345 Pamela Nash: Do you feel that the scientific capability in the Civil Service at the moment is sufficient or enough to cope with emergencies like those we have been discussing in this session?

Professor Sir John Beddington: It would depend on the emergency, obviously. The way it works at the moment in terms of providing science advice—and I guess you have heard this several times before so I will be relatively brief—is that, depending on the emergency type, there will be a lead department or—if there is no lead department or if, in fact, the effects are going across a number of departments—I would be asked to chair a SAGE. I have chosen, on the two occasions that this has happened, one, to chair it with somebody who was a medical expert, in the case of Sir Gordon Duff on the swine flu, and the second I chaired just myself. We then pulled together from the academic and industry community a set of experts who were prepared to sit on the SAGE and help. Some of them will be Government scientists, others will be from the research council community and others will be independent either in industry or academe.

We are fortunate in the sense that we have a very substantial and skilled research base. We have a lot of very good scientists and engineers, including social scientists, out there in the community. I won't say it is a plethora of riches but there is a very substantial resource to call upon. I wouldn't guarantee that this would not be a problem. It would depend on the type of instance. If you had a multiplicity of incidents where, let's say, a chemical or a radiological phenomenon was occurring in 15 places around the UK, there would be almost certainly a strain on the resources to assess what was happening. But I don't feel a considerable problem at the moment in terms of that capacity. It would not be the first worry I would have.

Q346 Pamela Nash: You mentioned that you have chaired SAGEs before when there has not been a clear lead department. On the volcanic ash incident we know that a secretariat was not provided to the Department for Transport. Is that right and should the Government Office for Science have done so?

Professor Sir John Beddington: What happened with the volcanic ash was that it was clear it was becoming a problem. I was in contact with the Cabinet Office Civil Contingencies and it became pretty clear that one of the key issues was going to be scientific. That was all happening the weekend after the first event. So I pulled together a team of scientists and engineers to work and started the SAGE. We expanded that slightly. There is a Chief Scientific Adviser in the Department for Transport, Brian Collins, who was intimately involved from day one in these assessments. In terms of the way in which the Secretariat was underpinned, that was done by the Cabinet Office and my own office. It was happening within a very short time, so one had to do that.

In terms of funding, there is an issue that, in due course, needs examining because we are using the scientific community and the research community, and the research councils provided some of their infrastructure. For example, the Dornier aeroplane was used to assess what was going on in the ash. That probably needs to be thought through in some cases. In the case of the pandemic influenza with swine flu, clearly the lead department was the Department of Health. They provided the secretariat and appropriate research funding to develop projects on a fast timescale. We need to be pondering that. This is not an issue that is clear cut. In the case of the volcanic ash, we were lucky that we had very able people who were prepared to commit their time. If it had gone on for longer, we would have had to think very, very seriously about how we could provide funding to deal with that.

Q347 Chair: Can I just push you a little further?

Professor Sir John Beddington: Please.

Q348 Chair: All the SAGE people you referred to are independent people who have been brought in with the relevant expertise from outside. Would it not help the core activity of planning for emergencies if

you had a stronger base of people with scientific experience at the heart of the Civil Service?
Professor Sir John Beddington: I think you know my views on that, Chairman.

Q349 Chair: Let's have them on the record.
Professor Sir John Beddington: I think it is enormously important to have core scientists and engineers, including social scientists, in Government. As you know, I have managed to persuade Government to appoint chief scientific advisers in each of the main science-using departments and also in some of the ones which don't use science a great deal. So that's almost complete. As you are well aware, the only major Department of State that does not have one is the Treasury.
Also, in terms of the way in which we have been working with the science and engineering community in Government, we have set up the Government Science and Engineering Community with 3,000 plus members. We meet with them regularly. The aim here is to raise the profile and the utility of people who have this appropriate training within Government.
There is a second question which is of interest, and I would again describe that as "work in progress". As we look through future potential, looking at the Risk Register, for example, and we say, "What are the potential emergencies?", there is a lot of merit in thinking in advance of having a *Yellow Pages* for the group of scientists who would be the sort of people that you would want to bring in to an emergency. For example, if we had a space weather emergency, at the moment, we could compile a list of people whom we would want to be involved as we dealt with that. That is something I need to be thinking more about. In the case of swine flu, it is fairly clear and I think we've got a good group of people. In the case of volcanic ash we did. But it would probably be arguably more efficient if we had a group of people who were aware that we might expect them to be involved if this particular emergency came about. That is work in progress, I am in discussion with the Cabinet Office about it and we may start to have that for particular risks.

Q350 Pamela Nash: One of the criticisms that we have been given in the written evidence that has been submitted to the Committee is that often scientific advice that is given to Government is filtered through civil servants who may not have any scientific expertise before it gets there. Is that an assessment you would agree with?
Professor Sir John Beddington: I wouldn't say it's my experience. First of all, having a chief scientific adviser in every Department should mean that they are related. They can interact with their policy people and provide fairly coherent advice. My job, ultimately, if there is some sort of confusion, is to say, "Look, you are misunderstanding the science advice." Obviously, in taking particular policy decisions, science is only one of the factors that Ministers and senior civil servants would take into account, with legal, economic and ethical factors, arguably. Those are other considerations. It isn't always that the science advice would be the pre-eminent piece of information and evidence that would be required. The discussions that led to the *Principles of Scientific Advice to Government* underpin that fairly well. The fact that that is now established in the Ministerial Code provides some degree of certainty that scientific advice would be going through to the heart of any particular policy.
Pamela Nash: That's good news.

Q351 Stephen Mosley: Can we just move on to the operation of the SAGE, in particular its transparency? Are there any protocols, codes of practice or principles that guide the transparency of the SAGE, and do you, in your own opinion, believe that SAGEs tend to operate under a presumption of secrecy rather than disclosure?
Professor Sir John Beddington: This is something we need to be thinking about. The first thing is whether people are happy to be identified as providing advice on SAGE. That will depend on individual decisions. Should we be doing that? We need to re-examine it. On the way we have dealt with it historically, it is very important that we don't in any sense muzzle people who agree to be on SAGE. One of the things we have said is that, if people wish to talk to the media or give out information on the basis of their scientific expertise, they are welcome to do that. They are welcome to tell people they are sitting on SAGE, as part of it, but they shouldn't in any sense indicate either that their views are the views of SAGE or that they are using information that has been obtained via the SAGE process. In terms of the actual operation of an emergency, there are going to be confidentiality issues which are quite important. Effectively, SAGE is reporting to the COBR Committee[1]. This is making policy, I suppose, on the hoof, which is why it is operating in that way. So some degree of confidentiality is absolutely essential at that stage in the operational time.
Subsequently, after this has gone through, we should be examining quite what could be made out. Are the minutes available? Are the scientific papers available? Should we be thinking about minutes which would identify individuals? Should we be thinking about minutes that are rather bland and, for example, rather than saying, "Dr X made the point", we just say, "The point was made." Those are things that we are actively thinking about.
There have been two exemplars of SAGE to date. My working bet is that they always come in April, so what's happening in April 2011 I don't know. But we need to be addressing these issues. The basic principle is that, wherever possible, this scientific advice should be out there for assessment by the wider community. Dame Deidre Hine, in her recommendations, indicated she thought it would be important that, for example, during an emergency, I brief the wider scientific community on particular actions. That is an interesting suggestion which I am very happy to examine. If we had an emergency tomorrow, would I do that? I'm not sure. It would depend on the emergency. But the idea and the basic philosophy is that we should be as transparent as we possibly could to ensure that the wider scientific and engineering community can

[1] Cabinet Office Briefing Rooms Committee

comment and that we should certainly, post hoc, try to get as much information out as is felt to be appropriate within the obvious constraints of confidentiality.

Q352 Stephen Mosley: It is fair to say that, as a Committee, we found that the SAGE for the swine flu was more transparent than the information that came out from the ash cloud. We asked Professor Collins about that. We asked him why the membership hadn't been published and why the minutes hadn't been published. He said, "You're going to have to ask Sir John." So, Sir John, now you are here.

Professor Sir John Beddington: Okay. It's known as a hospital pass, isn't it, in the rugby world? Thank you, Brian Collins. It happened very quickly. I don't see any reason why the members should not be identified and we can examine that with the Cabinet Office. I am aware of no reason why we couldn't publish the list of members. I think it is just that we haven't. I don't think there is anything remotely sinister in that. It is just that the SAGE operations were much quicker, because the volcanic ash was there, and then it was gone. It was all working with limited resources. There is no reason that I can see whatsoever for not publishing the names of the individuals on it.

Q353 Chair: Would that be a universal rule or can you envisage circumstances where that wouldn't apply? For example, if we were dealing with a space weather event, one could envisage the need to call in expertise from the Ministry of Defence that perhaps you would not otherwise.

Professor Sir John Beddington: Yes, and the agencies as well. You couldn't generalise from a SAGE. For example, I was not Chief Scientist then, but, when the Litvinenko affair was operating and there was emergency scientific advice going in, it was unlikely that one would seek to identify all members of the science advisory team that was providing advice there.

I think it would be a general view that, if possible, we should, but obviously the particular circumstances might mean that there would be some individuals it would not be appropriate to name. For example, we have amongst the chief scientific advisers' cadre a chief scientific adviser to the security services. Such a person might very well sit on a cyber security issue but, for obvious reasons, one would not seek to identify them.

Q354 Stephen Mosley: Fair enough. I know that the Government has said that it is the intention to publish a volcanic ash SAGE by the end of the year. Is that still going to be the case?

Professor Sir John Beddington: As far as I am aware, yes. Certainly that would be my aim.

Q355 Graham Stringer: How do you guard against conventional thinking within a SAGE or, for that matter, how do you guard against vested interests?

Professor Sir John Beddington: Vested interests is an easier question to answer than the first one, so I will answer that first, Mr Stringer. I think with vested interests people are expected to indicate any conflict of interest, any activity. For example, in the operation of the swine flu SAGE, one or two members indicated a declared interest in a particular discussion. They said they felt it was inappropriate for them to comment because of potential conflicts of interest.

How do we guard against conventional thinking? You can't guarantee that, but what we can try to do is to challenge it as much as we can. The Blackett reviews that I have been setting up are a way of going beyond what might be termed more conventional thinking and bringing in completely different people. The aim of the Blackett reviews is to have people who have hitherto not been involved in these particular areas, but often in an area which involves some degree of secrecy, and briefing them on the public domain because the science and the engineering questions are not highly secret or highly confidential. But the application of them and the individual ways that they might work through Government would be subject to some degree of confidentiality. So, in that way, we are trying to generate, I suppose, fresh thinking.

You can't guarantee that you won't always have the conventional answer, but the way we saw, for example, in the volcanic ash, two completely different communities starting to work together in the SAGE was very interesting. You had the community of the volcanologists and you had the community of the people who did meteorological modelling. They very quickly gelled together. They were raising questions of each other. I thought it worked very well. In a similar way, the third group that was involved in the volcanic ash SAGE were those dealing with engineering issues, such as what the effect of ash might be on an engine. There was a challenge coming over from the geologists and the Met Office people to that community of engineers. So I think a multiplicity is one way of trying to guard against it. Clearly, you can't always ensure that it happens but that is what I am attempting to do.

Q356 Graham Stringer: Should members of SAGE be financially compensated?

Professor Sir John Beddington: I alluded to that a little while ago, and I think it depends a little bit how long it goes on. Many of the people who joined the volcanic ash SAGE were making a personal sacrifice. Some of them were consultants, others worked for universities and others worked for research councils. That question needs to be examined. I don't know the answer and I think it will depend on the circumstance. For example, the SAGE for swine flu lasted for a very substantial period of time—a matter of many months. In that situation, if we are looking for an independent person to do it, some degree of compensation is going to have to be appropriate. Where it lasts for two or three weeks, it is less of a problem. But that is the thing we have got to examine. I can't imagine making a career on being a member of SAGEs, but we do need to think about that.

Q357 Graham Stringer: Can we go back to the volcanic ash and the operation of SAGE? Didn't SAGE really just act as a rubber stamp to what the CAA were doing because they didn't meet until the aeroplanes were flying again, did they?

Professor Sir John Beddington: There were a number of problems which SAGE needed to look at. The first one was to understand how well the model that was used by the Met Office in their advice on volcanic ash was working, what the structure of it was, was it reasonably accurate and was it fundamentally misconceived? That was the first question that, in a sense, SAGE had to look at. We then had to think about characterising the sort of ash there was. Ultimately, it would need to be used to assess what the result might be on engines.

We invited the CAA to attend SAGE. So somebody from the CAA attended and we worked fairly closely with the CAA in our discussions. We were not taking it as a rubber stamp. The CAA has the responsibility for regulation. At first, it essentially said that the presence of any ash whatsoever would mean that no flying was allowed. That was, as it were, the start of the emergency. The Met Office's model was able to indicate the presence or absence of ash. That produced contour lines on maps which would close down airspace.

The second move was in a discussion between the Department for Transport, the CAA and the engine manufacturers indicating that the first approach could be relaxed. Again, issues kept coming up about whether the NAME[2] model that was used by the Met Office would enable that degree of additional detail. That was, again, a discussion which was beyond the CAA's competence. In a sense, they were getting information from the Met Office and it was part of SAGE's job to say, "Is this information reasonably robust to the levels of accuracy that they wanted?"

Q358 Graham Stringer: I will finish with two questions in one, if I may. I don't think you have dealt with the timeliness or lack of timeliness of putting together SAGE, because the CAA had allowed flying by the time SAGE first met. Does that indicate that SAGE wasn't put together as quickly as it should have been to deal with those issues? The second question I would add is this. When we had British Airways here with the CAA, there was an absolute conflict in terms of their attitude as to what should have happened. Basically, BA thought they should have flown when they thought they could fly, because that is what they did in the rest of the world. The CAA used the forecasts from the meteorologists. Would you do things differently next time? Would you come down on the CAA side or the BA side?

Professor Sir John Beddington: I don't think I would come down on either side for the following reason. The basic physics of the issue are fairly clear. The current regulations allow flying based on the degree of concentration of ash. The whole point here is that it is not so much that the concentration is important but it is the duration of the flight within that concentration. If you go through a particular concentration of ash for 20 seconds, it is vastly different in the effect on engines than if you fly through it for two hours. So the fundamental structure of the regulation is problematic. These were the regulations. This is the sort of thing that will take some while to change because it involves legislation and so on. But in terms of the basic physics of it, it seems to me to be important to be thinking about individual flight plans, and how long a particular flight would go through a particular concentration of ash or a varying concentration of ash.

We then move to the problem of whether the models that the Met Office have allow such a calculation to be made. That's work in progress, but that's the way we should be thinking about going forward rather than changing, in any fundamental way, the way that our advice was prepared.

Q359 Graham Stringer: And the timing of SAGE?

Professor Sir John Beddington: We pulled it together. The volcanic ash event happened. I remember I talked very quickly to the senior scientists involved—Julia Slingo from the Met Office, Sue Loughlin from the British Geological Survey and, obviously, the Civil Contingencies Secretariat and the Department for Transport. We had a meeting on the weekend. We then started to pull together some discussions from SAGE, pulling together an appropriate group of people. The first meeting, where we were all together in a room, was preceded by a whole series of fairly detailed discussions. We probably could have done better but in the case of volcanoes, with the benefit of hindsight, we should have realised there was a volcanic ash threat and been able to implement this thing much more quickly than we did. That is accepted. I don't think, given the circumstances, there were unacceptable delays.

You mentioned the fact that BA had a very different view. One of the things that we did was to hold a conference, which I chaired, for the airline industry in which presentations were made by a number of people, including the Met Office, on what their model actually did. There were members from all the major parts of the industry, including BA, in the audience, and they were able to show from satellite information and the predictions of the model that the model was predicting pretty well the satellite information on the concentrations of ash. I think that was quite important. There were discussions—the CAA had convened the meeting—but that sort of openness within the community was really quite helpful.

There is a problem in terms of generalising from activities on volcanic ash everywhere in the world, in the sense that the skies around the north-east Atlantic are significantly more crowded. If you encounter a volcano and you are flying in south-east Asia, you can actually go round it. To an extent, that is also possible in the USA. But in the north-east Atlantic, around western Europe, the concentration of aircraft and flight paths means that the amount of space you have to manoeuvre in is very substantially lower.

Chair: Can I thank you very much for your attendance this morning?

[2] Numerical Atmospheric-dispersion Modelling Environment

Examination of Witnesses

Witnesses: **Lord Adonis**, former Secretary of State for Transport, and **Rt Hon Andy Burnham MP**, former Secretary of State for Health, gave evidence.

Q360 Chair: Good morning. Lord Adonis and Mr Burnham, you were both senior Ministers in the previous Government, at the heart of Government, and both had the unfortunate responsibility of dealing with two different but difficult circumstances. We want to press you about that in the context of our inquiry. As you know, we are also looking horizontally across the way that science advice is used in emergencies and looking forward at events that might happen in the future as well. In your experience, were you content with the Government's process of risk assessment and contingency planning? Perhaps you could separately answer that. Who is going to start?

Lord Adonis: Would you like me to start in respect of the ash cloud? The response of the regulator in the scientific community, once the ash cloud crisis had started on 14 April, was, I thought, exemplary. All of the agencies involved—the Civil Aviation Authority, NATS, the Met Office, the Department's own advisers and the European regulatory authorities—were immediately galvanised into action on addressing this fundamental question, which is, what is a safe regime for flying through concentrations of ash, given that the previous regulatory rule was that any concentrations of ash were not safe for planes to fly through? Or, rather, the rule was, in those words which are engraved on my mind, "Avoid, avoid, avoid". Regulatory authorities in European Member States should not allow planes to take off if there are any notable concentrations of ash.

The issue, which is one that the regulatory authorities have been reflecting on and need to reflect on more, is why this rule was in place in the first place. Of course, it clearly isn't the case that it's not safe to fly through concentrations of ash, as you have just heard Professor Beddington say. It is possible, and indeed it proved possible within the course of six days, to put in place a regulatory regime which made it possible to fly through concentrations of ash. The problem was that the International Civil Aviation Organisation, which had set the standards to which individual European regulators were operating, had a rule which essentially prohibited flying through concentrations of ash and did not go to the next stage of looking at a safe regime for flying through ash were ash present in the atmosphere.

My own view, as I look back on it, is that ICAO—the International Civil Aviation Organisation—should have done this work beforehand because, although volcanic eruptions in northern Europe are rare, they are not unprecedented. The Icelandic volcano which erupted in April causing this huge disruption has erupted before. From memory, it was previously in the 1820s, and it is next door to another volcano that has erupted more frequently. The question which needed to be asked, and involves a searching process of self-examination on the part of the International Civil Aviation Organisation and the European regulators, is why, before April 2010, they had not conducted the scientific work that was necessary to put in place a safe regime for flying through concentrations of ash. They are doing that and a new regulatory structure has been put in place, but, if there are any other safety issues of a similar kind which could come from their field, it would be very helpful if they had done the work on this before rather than what actually happened, which is that the work on it had to be done after the volcanic eruption had taken place.

Andy Burnham: Chair, I had the misfortune of arriving at the Department of Health three days after the World Health Organisation declared H1N1 swine flu to be a global pandemic. If nothing else, it confirmed that the political timing of the right hon. Member for Kingston upon Hull West & Hessle is immaculate, as in all things. So it was a very difficult situation to arrive in.

There was, I think, a difference between the situation that Lord Adonis has just described, in that the world health community had anticipated this situation for some time and, indeed, plans had been based on a more severe virus—H5N1 or bird flu—so we were in some senses well prepared because of that. Indeed, I remember as a junior Health Minister going to many meetings on pandemic preparedness and, perhaps, at times thinking, "Why am I sitting here doing this? Isn't there something more important I could be doing?" However, in terms of your question on contingency planning, we were extremely well served as Ministers by the depth, the quality and the range of planning that had been conducted over many years across the Government in this country. That placed us in an extremely strong position when it came to the crunch.

I remember the immediate question that was on everyone's mind was the vaccine. I know you might want to get on to talk about the contracts that we had for vaccine, but I was immediately clear that we were at the head of the queue for vaccine. I can only say to you that, sitting where I was at that time, to be in that position was a position of immense reassurance because it was a new virus, there was emerging evidence about it from around the world but we didn't know. It turned out to be a mild virus but severe in some cases, and that was in many ways the challenge of swine flu because it wasn't mild in everybody. We mustn't forget that 450 or more people died from swine flu. So that was the challenge. In terms of contingency planning, I would say it was excellent, although clearly there are lessons that we can learn.

Your second question was on risk assessment. The issues I would flag up there, as they relate to SAGE and the scientific advice we were getting, is how best to assess the reasonable worst case scenario in an emerging situation as epidemiological evidence about the virus is emerging from around the world. How possible is it to gather that information and then produce reasonable worst case scenarios in an evolving situation, recognising that the figures are, possibly, going to change as more is known about the virus?

The second point would be how to communicate those figures when it is a moving situation and when, perhaps, the media doesn't understand or doesn't give people space to explain why figures have changed. I noticed Professor Sir Liam Donaldson spoke about that issue to you, and I think that is a very real learning point that we must all face up to as part of it: how to assess those reasonable worst cases in a proportionate way as evidence emerges in an evolving situation, and then how to communicate it. For me they are crucial things and I wouldn't say that we have got the right answers although I can give you the best of my experience.

Q361 Chair: In the two cases—the "reasonable worst case scenario" is a phrase which keeps coming back in our evidence sessions—Mr Burnham, you were assessing that against pressures from the Treasury, the costs that were being incurred in preparing for what could have been a much more serious pandemic, and in Lord Adonis's case, there were huge pressures coming from the commercial world outside that were asking for a different measure to be used. So "reasonable worst case scenario" is an important tool, but do you perceive any alternative way of dealing with these things?

Andy Burnham: I don't actually, no. The Department of Health had a phrase that they used when I arrived, and I find it reassuring on one level but not on another. They used to say, "Hope for the best, plan for the worst." I was never quite happy with the first part of that phrase. The fact that we did take the precautionary principle has got to be the right thing to do. I'll give you an example. There was a big debate in the summer of 2009 about the use of antivirals and should they be given to all symptomatic patients or just given to those, perhaps, most at risk or those with the most severe symptoms. I think it was the one occasion where there was a difference of view within SAGE.

If I take your question, you are perhaps leading me to say to what extent cost was then driving those decisions. It was not, actually. At the time, as always, you have an eye on the cost, but I was receiving advice and the Chief Medical Officer was saying to me that he felt, on the basis of the opinion within SAGE and his opinion, it was right to adopt a treat-all strategy, given that we were dealing with a new virus. As I have just said, it was a new virus that was proving to be severe in a small number of cases, attacking the respiratory system of young children with disabilities, for instance.

In those circumstances, when we were just finding out, of course I felt I had no choice but to say that we go with the treat-all strategy. I wouldn't say the cost was not a consideration but, at that point, public safety absolutely takes precedence over cost.

Q362 Graham Stringer: Did he make it clear to you, as he made it clear to this Committee, that there was no evidence base for the use of antivirals in an epidemic?

Andy Burnham: What was made clear, Graham, was that there was a difference of view about the—

Q363 Graham Stringer: You have said that before, but he came to this Committee and said, "There is no evidence base for the use of antivirals during an epidemic", in those words. Did he make that clear to you?

Andy Burnham: Yes, that was made clear, absolutely, because—obviously—it was an unprecedented situation. There was talk of side effects. The Chief Medical Officer said to me that even among GPs there's a difference of view. It seemed to me that the right thing to do in that situation was to take the precautionary approach because, in many ways, the lack of an evidence base further reinforced the need to go down the precautionary route.

Lord Adonis: I think there is a fundamental difference in these two cases. In the case that Mr Burnham has just been talking about, the reasonable worst case scenario was, thank goodness, not remotely realised. In the case of the ash cloud, a situation far worse than any worst case scenario that had ever been prepared for literally arrived overnight with the ash cloud and the whole of northern European airspace being closed for successive days leaving millions of passengers stranded.

On the part of the regulatory authorities, work had not taken place on the estimation of what a worst case scenario might be in the case of a volcanic eruption, which is the reason why we had to put in place a new regulatory regime, literally, over the course of a long weekend. It would have been a good thing if it had taken place on the part of the regulatory authorities but it hadn't. My answer to your question is that I think it is a very good idea to make assessments of reasonable worst case scenarios.

In the case of the ash cloud, I think that would have required international regulators—because, of course, aviation is, by its nature, an international business—to have put in place a safe flying regime in respect of concentrations of ash. It is very telling that in the guidance from the International Civil Aviation Organisation, which is the guidance which led to the closure of European airspace, the opening sentence of that guidance in respect of ash concentration is as follows: "Unfortunately, at present there are no agreed values of ash concentration which constitute a hazard to jet aircraft engines." Those are the opening words. It would have been a jolly good thing if there had been some agreed values and if the regulatory authorities had sought to establish them. So I am fully behind the process of setting worst case scenarios. In the case of the ash cloud crisis, it means that regulators have to look at areas which may be very remote contingencies, like swine flu epidemics, but ones that could well occur and in respect of which they have to have regulatory regimes in place.

Andy Burnham: Could I just make an additional point, Chairman? I agree with Lord Adonis. It is right to make these judgments, particularly in a fast moving and an evolving situation. You have to because the public services need to understand what might be coming. The purpose here is partly about public confidence but it is about preparedness on a much wider field than just in the health service because, obviously, we were looking at local government and schools. There was a very big potential impact.

The question for me that arises is how to do this, in a freedom of information world, in a way that doesn't alarm the public and lead to headlines which, quite frankly, mean that you might lose some kind of control over the situation.

Q364 Chair: But that happened?
Andy Burnham: No, I wouldn't say it happened. But I would say that, in the summer of 2009, as cases of swine flu were climbing on a spike that was just unbelievable to watch—and the west midlands was the first place to feel the pressure—it was quite a frightening moment. When you are putting new figures into that situation as people are experiencing a very real change on the ground, the question for me is to what extent a scientific committee can think about public presentation. But that is crucial because that does affect the ability of services to deal with the situation before them because the more there is a sense of concern, the more that public services will be overwhelmed in a disproportionate way.
The one moment I would just pick out for you is when I made a statement to the Commons. I am trying to remember the exact date, but it would have been July 2009. It was at the point when things were getting quite worrying. We had a long debate in the Department of Health about whether or not I would give a figure for a reasonable worst case scenario in terms of number of new cases per day. I had a SAGE range that was just massive. It went from a very small number to an incredibly large number. After prolonged debate I used the phrase, "We could be looking at around 100,000 cases per day."
At the time that changed people's view of the situation, but it was very much in the middle of the range that SAGE had given me, from memory. It wasn't at the far end of the reasonable worst case scenario. Towards the end of July, we got up towards 100,000 or more cases per week, so we got well up into the big numbers but we didn't get close to that figure.
Given that I had been given those figures in a Cabinet Committee, I wanted, and I think Alan Johnson did too, to put figures into the public domain. I think the Committee should ponder this question so that you can give further help to Ministers in the future. You are making judgments on the spot because you don't want a newspaper to say, "They are withholding figures that say there could be this x thousand number of cases", because then it would be sensationalised and it would be a secret paper given to a Committee. Equally, you don't want to alarm the public.
In the end, Liam Donaldson and I agreed that the publication of that figure probably actually helped to snap public services more on to the front foot in terms of getting ready, and it probably helped get everybody into the right place to deal with what was before them. This is an absolutely crucial question, I think.

Q365 Chair: I agree with you. It is a crucial question. So you were aware that there are limitations on the use of "reasonable worst case scenario" in the context of the way it might be interpreted outside?
Andy Burnham: In a freedom of information age you have to think about that, don't you?

Q366 Chair: Yes. Did you take any advice either through SAGE or other sources, from behavioural scientists, about how best to handle that?
Andy Burnham: We debated it pretty endlessly in the CCC committee. The four UK Health Ministers debated it in a telephone conference. In the end, Chairman, it became a matter of political judgment, I have to say. I made a decision about the figure I put into the public domain. There were no guidelines for me to say what I should and shouldn't say. I come back to the point that SAGE can have a discussion, but when they are actually putting it down in black and white on a paper that is going to a Cabinet Committee in an FOI age, you've got to think about what you do with that information. I took the view in this situation that we had to be as open and transparent with the public as we possibly could be so that we didn't lead to any sense that there was information being withheld. Looking back, I would say that it was quite a precarious judgment to make.

Q367 Chair: Lord Adonis, clearly, you have said to us that international agencies were ill prepared, and that opening sentence you read out illustrates it extremely well. But we, as a nation state, are part of the international community. We can't cop out. Why were we so unprepared?
Lord Adonis: That is a question which needs to be asked of the Civil Aviation Authority because they are the regulatory agency. I never did get to the bottom of the answer. I haven't seen your list of witnesses and I don't know whether you have called the chief executive or the chair of the Civil Aviation Authority, but the key question is: Why the threat of volcanic ash over north European airspace? The point that the chief scientific adviser made previous to this hearing is a very important one. It is because of the concentration of flight paths in northern Europe that the ash concentration is such a big issue because you can't go around ash clouds, as in the United States or in Asia. It is why the potential risk to flights of ash concentrations hadn't been taken into account as a risk factor to safe flying in Europe.
The answer, which was always given at the time, and one that I think is worth probing, is that volcanic eruptions don't take place. "This is an act of God." Of course, on one level it was an act of God, and there haven't been any recent volcanic eruptions. The issue for those whose job it is to reflect on these events and plan for the future is to explore whether in fact there should have been a higher level of readiness given that volcanic eruptions are not unprecedented in Northern Europe. As I said earlier, they have taken place. The particular volcano that erupted and which caused the ash crisis has a pattern of eruptions over the last 600 years.

Q368 Chair: We've heard from Sir John about the science advice, but you never had any advice from your civil service that said, "Minister, it's your job to predict this"?
Lord Adonis: It manifestly wasn't my job to predict it. It was the job of the regulatory agencies to have in place a safe flying regulatory regime in respect of this hazard, concentrations of ash, in the way they do for

many other hazards. For example, a big issue that they are constantly dealing with is bird strike. There are rules in place for how one deals with a bird strike, what are acceptable levels, and a whole lot of others. For fog and almost every conceivable weather eventuality there is guidance and rules in place. There wasn't in respect of concentrations of ash.

As I say, the reason that was given at the time is, "Volcanoes don't erupt in Northern Europe", which, as a general rule, is true, but in fact there is a pattern of volcanic eruptions from these volcanoes in Iceland. If one could rewind the clock, that should have led the regulatory authorities, in my view, to have worked with ICAO to prepare in advance for what were agreed values of ash concentration constituting a hazard to jet aircraft engines so that we weren't faced with the wholesale closure of airspace. It wasn't a particularly productive use of my time to start asking those questions in these six days, though, because that was a historical question. We were dealing with a crisis in real time. The issue which I had to confront as Transport Secretary was working with the regulatory authorities, with the aircraft manufacturers—and with my European colleagues, because this was a Europe-wide issue—to put in place a regulatory regime that would establish, in the judgment of the scientific advisers to those regulatory authorities, safe concentrations of ash which would permit flying to resume.

Q369 Stephen Mosley: Mr Burnham, you have answered pretty much everything I was going to ask because I was going to ask about risk and communication with the public. I have one question, though. I know that Dr Peter Holden from the BMA has expressed a concern that there was, maybe, too much information out there and that sometimes it could get confusing for people if there were multiple sources of information. I know that in the US the Government set up a flu.gov website that was a single source of information for both the public and for medical professionals. Do you think something like that in the UK would be a sensible way forward as a way of getting a single source of information?

Andy Burnham: We could certainly look at that as a model. We tried something similar in that we instituted, as the situation developed, a weekly press briefing with the chief medical officer. We built an expectation that that was the place where the most dependable figures would be given and the context for those figures would be provided. I think that is important, too. It is not just about figures. It is also about the wider context in which those figures are given.

One of the things, in terms of this question of communication, is that I went to the first couple of those with Liam Donaldson but, in the end, I decided to remove myself from them because the presence of a Minister or politician just upped the ante. I could see it. It immediately became a thing of, "Oh, well, let's get them on the back foot on something or other", whereas when Liam did them it tended to attract the scientific correspondents rather than the political correspondents and it led to a much more balanced coverage. It was a deliberate decision. In the first two weeks in my job I went to them. I felt I had to be taking a grip, blah-blah, and all of that. But, actually, I realised that the more sensible thing was for Liam to do it in a non-political, not super-charged environment where the figures could be given in context. Whether we could build on that approach and have a single portal approach is a very good question.

Communication is very important in a transport situation, of course, in terms of whether people add to the problem by doing something that you don't want them to do, but in a health situation it is utterly crucial because alarmist reporting can lead to more people going to GPs, more people ringing NHS Direct and more people ringing the national pandemic flu service. Keeping that balanced tone in reporting was fundamental to the ability of the NHS to cope with what was before it, and understanding that balance is a very complicated business.

Q370 Stephen Mosley: Moving on to the ash cloud, one of the things that we saw in Committee was that there was a big gulf between British Airways and the CAA in terms of what they thought the appropriate response would be. What levels of communication were there between those organisations and Ministers at the time?

Lord Adonis: There was constant communication. Once the airspace was closed, there was constant communication between the airlines, the Civil Aviation Authority, NATS and the Department for Transport. Indeed, it was a very productive relationship, although, of course, British Airways and the other airlines were making very clear in public their view that it was safe to fly. Let's be more precise. What they said was that they believed it was possible to identify safe flying paths through the ash cloud by identifying areas of lower ash concentration and paths which didn't involve long flight paths through those areas of low concentration. They believed it was possible to do that and they were making that view very loud and clear in public.

They were also working very hard behind the scenes on establishing what was a safe flying regime. For example, very rapidly after the closure of airspace British Airways got test flights in the air, as did KLM. Indeed, KLM got their test flights up before British Airways. Other European airlines did the same. There was Met Office monitoring equipment on Met Office planes and on the commercial planes as well. All of the data that came from those test flights by the airlines and the test plane sent up by the Met Office fed into the scientific evaluation that then led to the revised advice which was adopted by all of the European safety regulators in a co-ordinated manner, which differentiated between different levels of ash concentration, that significantly narrowed the no-fly zone and made it possible to re-open the good parts of northern Europe airspace.

So, although, as you rightly say, British Airways was very vocal, as were the other European airlines, about the need to revise the safety regime so that flights could resume over a good part of northern Europe, they worked closely and productively with the safety regulators to make available the data and information that were crucial to revising the safety regime.

Andy Burnham: Could I just make a supplementary point? It does refer back to the single portal question that Mr Mosley asked. The closest we had to that was the Health Protection Agency, which, in the early stages of the pandemic, provided a surveillance function across the country in terms of how the virus was spreading and also drew in information from its counterpart bodies around the world. That was very helpful in those early stages and helped us to begin to map how quickly this virus was developing.

It is important, if the Committee is taking evidence from the Government, that you ask which body would do this function in the future, given that, I believe, the Health Protection Agency is no more. It was something that I relied on heavily in the early days. I went to visit the Health Protection Agency in the West Midlands who were co-ordinating a cross-agency response to an incredibly difficult situation that grew out of nowhere. They were, obviously, responsible for the containment phase of the response. It is really important that questions are asked as to how the Government would plan to operate that early containment surveillance function in a further pandemic, given that the Health Protection Agency has ceased to be. As shadow Health Secretary, I was beginning to ask that question. I don't believe it has been adequately answered yet, but for me it is a crucial question on which the Government needs to provide clarity. I think a pandemic is as likely today or tomorrow as it was then. We have had swine flu and people think, "Oh well, that's the pandemic for the next 20 years." Obviously, it is as likely there'll be a new one and at any time.

Chair: We have taken a little longer than we intended, but there are a few more short, sharp questions we want to ask you.

Q371 Pamela Nash: Lord Adonis, you have already touched on the Civil Aviation Authority's lack of previous information on what could happen in a volcanic ash emergency. You have also spoken about British Airways and how quick they were to put up test flights. Do you think that airline operators should have more of a role in deciding when it is safe to fly if they have more up-to-date information?

Lord Adonis: They play a key role. The regulatory regime, which is an interactive process between the airlines and the safety authorities, is constantly undertaking risk assessments in respect of the whole range of potential risks to flights, so they do play that role—and they did play that role in this case. The key issue here was that the contingency planning hadn't taken place because none of the safety authorities or, indeed, the airlines themselves regarded it as a contingency that there would be a volcanic eruption that would lead to an ash cloud that would therefore mean, adopting ICAO's guidelines, that European airspace had to be closed. The problem in this case was not that the structures were not in place. As soon as the ash cloud struck, the airlines, the aircraft manufacturers—who also played a key role—the safety authorities and the scientific advisers to my Department all worked 24 hours a day to put in place a regime that would enable flights to resume. The issue in this case is simply that this hadn't been regarded as a contingency before the Icelandic volcano erupted.

Q372 Pamela Nash: I would like to ask you a couple of questions on Government co-ordination. There have been criticisms of the Department for Transport that they did not take a lead as soon as they should have on the volcanic ash issue. How would you respond?

Lord Adonis: I don't think that is a fair criticism at all. From the moment that the Department was advised that airspace was likely to have to close because of this eruption, all of the relevant agencies and authorities and all of my then advisers in the Department swung into action. I don't believe that more could have been done more quickly. Indeed, you can see that by looking at what happened in other European countries too. We all worked in parallel on this crisis and almost all north European countries re-opened their airspace on the same day. There was a bit of a debate about whether we should have opened on the morning or the afternoon of the day when the new regulations were put in place. Because of the need for the Civil Aviation Authority's board to meet—because it was that board which had to put in place the new regime under which NATS had to operate—it took a few hours for that process to take place, but that was a proper decision-making process. Indeed, quite a number of countries didn't open their airspace until after the United Kingdom did. So I don't think the criticism of the authorities is fair from the point when the crisis struck.

As I say, the issue that the ash cloud raises is whether adequate risk assessments had been done by the international safety agencies before the ash crisis.

Q373 Pamela Nash: Just quickly, Mr Burnham, you spoke a little bit about trying to get an approach across the UK in response to swine flu. Does the fact that health is a devolved issue prove an obstacle both in planning for this and for the response?

Andy Burnham: No, I certainly wouldn't say it was an obstacle. It presented a challenge in terms of the different natures of the health systems across the UK. It was clear to me that much depended upon the personal relationship that we began to develop between the four of us, and we did. Edwina Hart, Nicola Sturgeon, Michael McGimpsey and I—the four of us—began to develop quite a good relationship. I think that was crucial because we were dealing with some very difficult stuff in a very urgent situation. That carried us through.

If I could make a suggestion to the Committee, it would be this. We had the CCC, which had old Uncle Tom Cobleigh and everybody in the debate, which has its function, but the crucial engine of this thing was the four UK Health Ministers. We were doing our thing by telephone call whereas CCC had all of the paraphernalia of Government behind it. In fact, it would have made more sense for us all to meet face to face somehow every week, the four Health Ministers, because we were the ones doing the day-to-day operational stuff. That relationship was crucial to the proper handling of the crisis. We managed it, we found a way, we got through it and we made it work.

If I could, I would just like to make a couple of very quick comments. I want to pay tribute to the Department of Health—in fact, the Cabinet Office, the Secretariat and everybody. We were tremendously well served, not just during the crisis but by the planning that had been done before it. I attended a meeting of 12 Health Ministers in Washington in October or November 2009, where all of the other Health Ministers were saying that they had absolute pandemonium back home in terms of the clamour for vaccine. On the TV screens in America at the time there were queues round blocks of people fighting for the swine flu vaccine. It was just chaos. However, because of the orderly way in which we handled it, with SAGE giving advice about priority groups and a queuing system, it really worked well. We had a grip on the situation and we handled it without causing any public alarm. We were the only country, it seemed, that had that benefit.

As a very final thought, the structure of the NHS is crucial to the manner in which we responded. The chief executive at the time used to say, with a glint in his eye, that we had gone into what he called, "command and control mode". He quite liked the idea of being in command and control mode, which perhaps shows the top-down instincts of the NHS.

I would also ask a question. Sometimes the NHS can respond better than other health systems elsewhere because of the ability to put a message out quickly that is then followed up. In the new NHS that is being created, would it be as efficient if it is a much more atomised, localised system? Localism is everything, we are told. Actually, I don't agree with that, personally. I think the strength of the NHS is the ability at times for it to do exactly what is needed to be done. In this case, again, I was hugely well served by that.

Q374 Stephen Metcalfe: Recognising that we are short of time, I want to turn to the role of SAGE. But just before I do that, Lord Adonis, you very much tried to put the responsibility for having identified the volcanic ash cloud on to the Civil Aviation Authority and the international authorities. Do you not think that Government has a role in identifying risk and making sure that those risks are on the register?

Lord Adonis: For the purposes of this discussion, I take the Civil Aviation Authority to be part of Government. They are the regulatory authority established by Government for the purpose of ensuring that we have a safe flying regime.

Q375 Stephen Metcalfe: Did you ever query with them whether they had identified risk?

Lord Adonis: I, myself, did not question whether they had a safe flying regime in place in respect of ash concentrations for a volcanic eruption, no.

Q376 Stephen Metcalfe: No. I accept that.

Lord Adonis: That is the answer, I am afraid, to that. I wish I had. If I had had better predictive powers, I would have had them into my office immediately after my appointment and said, "Can you tell me, if there is a volcanic eruption, what your plans are?" Unfortunately, I didn't have that foresight.

Q377 Stephen Metcalfe: But were you identifying them? Was the idea that there were risks within the Department that might come up? Was that a topic that was discussed with you and your advisers, "What are the risks to our Department?", and was that something that was being looked at?

Lord Adonis: At the official level these discussions do take place, but I am not aware of them having taken place in respect of ash, which is the key issue. The big issue, to come back to it again, is that it simply hadn't been identified as a contingency, so it was completely different from swine flu. What we were faced with was a crisis caused by an eventuality which, beforehand, had not been regarded as a contingency.

Q378 Stephen Metcalfe: Our investigation goes slightly wider than just swine flu and volcanic ash. What we are looking at is how the Government use scientific advice in an emergency and what preparation they have made for that, such as, "Was there a general risk assessment?" But could you give me examples of where SAGE has advised you in either role, either specifically within the two areas that we are talking about or perhaps at other times, and whether that advice was useful? Did you ever reject any SAGE advice that was given to you?

Lord Adonis: No, is the answer to the second question. In respect of the first, if I can answer it more generally, in dealing with eventualities in respect of terrorist attacks, my advisers were constantly making risk assessments—constantly—and had to do so in what were very difficult circumstances. In my time as Transport Secretary, you will remember we had the serious attempted bombing of the plane from the Netherlands, and that was a constant preoccupation of advisers to the Department.

Andy Burnham: I wouldn't overplay the role of SAGE, necessarily, because in our context, the JCVI probably were more important in terms of specific advice on treatment options. SAGE were often providing a broad context and information in which to make the decisions. They were providing specific advice, although, as I mentioned, there was a split opinion around antivirals. You must remember that in the health context the JCVI has a crucial role in advising on vaccination and vaccination priority. I would encourage you to look at those two together. But no, we didn't. I think David Harper said, when he gave evidence to you, that Ministers always based decisions on the scientific advice. Perhaps that wasn't the perception of Ministers but, believe me, at all times, all four UK Health Ministers said, "We will be guided by the science. We cannot go outside the science or the scientific advice." We stuck to that as an absolute 24-carat principle throughout swine flu.

Lord Adonis: If I could echo Mr Burnham's point, it wasn't SAGE which I dealt with in respect of terrorist threats. It was TRANSEC, the transport safety organisation, which, of course, has very high level scientific and other advisers in guiding its work.

Chair: A final question, Graham.

Q379 Graham Stringer: Andy, you said that you and the Health Ministers from the other countries in

the UK were guided by the scientific advice. There was a dispute, wasn't there, in terms of order of vaccination? Some of the other Health Ministers wanted to vaccinate children first rather than the most at risk. How did you deal with that?

Andy Burnham: There was a difference of opinion both on use of antivirals and—I wouldn't say it was huge—different perspectives on what we should do vis-à-vis vaccination. We often took that and then put it back to the JCVI and said, "We have a different perspective." We asked the JCVI for clarification a couple of times, asking them to take into specific account feelings that Ministers had. If I can say this, you and I spoke at that time around children and whether or not there should be a schools' vaccination policy.

Graham Stringer: We did.

Andy Burnham: It was clear that schools were the engine of spread, weren't they? The schools broke up for the summer. In Scotland, of course, because the schools broke up a little earlier, immediately the cases flattened in mid-July. For us, it was at the end of July. So the role that schools were playing was clear.

We, as Ministers, all of us, based on the discussions we were having in Parliament—not everybody felt as strongly about that—asked and pushed JCVI a couple of times again to advise us whether this was the right thing to do. The very clear advice that came back was, "No, don't vaccinate otherwise healthy children. That is not a proportionate response to the situation we are in. We are dealing with a mild virus. Yes, it's severe in some, but get the vaccination quickly to those at most risk of developing serious illness or at most risk, even, of death." As I said before, there were kids with severe disabilities who had complications with their respiratory system. They were clearly at more risk, as were pregnant women. Bear in mind, we did not have an unlimited supply of vaccine. What we had had to go first to where the risk was. I think we were, in the end, advised very well. The tendency was—all of us reading the newspapers—"Oh, look at schools. Why don't we vaccinate schools?" It was a natural politician's response, if you like. This was an area, I think, where the scientists had it absolutely right. They saw that there was a limited supply of vaccine. In the conditions of swine flu, where it was a mild virus for most people, some wouldn't even notice they had had it, some would have a very mild cold, but in some cases it was dangerous. That was the challenge of swine flu, if you like: mild in most but severe in some.

In those circumstances, it was clearly right to have a priority group system where the available vaccine went to those groups in order. I think it was a classic example of where the scientists absolutely had it right and potentially some of the political response had it wrong.

Q380 Graham Stringer: Andrew, there was a general election going on when you had your crisis. How did that affect it?

Lord Adonis: Not at all. I'm sorry, I mean that I didn't do any campaigning while this was going on. I had more important things to attend to.

Andy Burnham: It took me off the campaign trail as well.

Lord Adonis: I, personally, as Minister, was on this every waking hour from the moment I was phoned on a campaign visit to be told that we had this ash cloud. It was explained to me what this meant and that it would lead to airspace having to be closed. At the moment that was said to me, I realised that we faced a national emergency and I came straight back to London. In my waking hours I didn't leave my office until we got the airspace re-opened.

So far as the Government was concerned, we behaved in full operational mode with no impact whatsoever caused by the election. I don't believe, if the crisis had struck at any other time, that we would have reacted any differently. Indeed, it continued after because, although the immediate crisis was over after six days, I was still spending a good deal of my time dealing with the after-effects, in particular, some of the consequential decisions that needed to be taken in terms of European regulation right up until the moment when the Government changed hands. Two days before the general election, I spent the day in Brussels at the European Council with European counterparts when we put in place a whole set of arrangements for handling the regulation of ash concentrations and how a new regulatory regime, which was then temporary, would be made permanent. That process, as I say, continued until the change of Government and it was, as far as I could see, entirely seamless.

Andy Burnham: Now I know why you cancelled that visit to my constituency.

Lord Adonis: I am glad to say that Mr Burnham got re-elected without my help. He may have needed help, but I wasn't there.

Q381 Chair: Can I thank you very much for your attendance this morning? It has been an extremely useful session. Thank you.

Examination of Witnesses

Witnesses: **Rt Hon Baroness Neville-Jones**, Minister of State for Security, and **Rt Hon Mr David Willetts MP**, Minister of State for Universities and Science, gave evidence.

Q382 Chair: Good morning, and apologies for running a little late. We have just had a couple of very interesting sessions to start with. Baroness Neville-Jones, this is the first time we have asked you to appear before us. Welcome.
Baroness Neville-Jones: Yes, Chairman; thank you.

Q383 Chair: Mr Willetts is a regular. We are coming to the end of our evidence sessions on this area and there are some important questions on which we would like to press you. Do Ministers now take the final decision as to what goes on the national risk assessment, and exactly who do you get your scientific advice from?
Baroness Neville-Jones: That sounds like my question. Clearly, drawing up the national risk assessment is a team effort. Let me start with the scientific advice, because there is obviously a process. The Cabinet Office takes charge of the regular updating of the national risk assessment and that is done by a team in the Civil Contingencies Secretariat, who have a structured relationship with the scientific advice available to Government through the Government Office for Science and particularly Sir John Beddington. Scientific advice and, indeed, help in the definition of what constitutes the risk, particularly both likelihood and impact, is fed in from the very start. I wouldn't say that there is any stage at which scientific advice is not available or, indeed, not actively involved in the process of consideration.
When it comes to the actual approval of the risk assessment itself, that does go to Ministers, and individual risks, depending on the nature of the risk, can be discussed in detail. It is fair to say that the Ministers do take responsibility for the national risk assessment, the grid on which it is founded, and indeed, in the case of the more sensitive risks, the ones which are more difficult—the high risks, often low likelihood, but not always—get considerable scrutiny and I, personally, give them considerable scrutiny as the Minister who is charge of resilience.

Q384 Chair: Who gives you the scientific advice, though, because Sir John said it's not him?
Baroness Neville-Jones: It will depend on the subject, obviously, because you will have observed that there are a whole series of committees now exist in relation to different sorts of advice that the Government need. The Civil Contingencies Secretariat will be liable to turn to people who have been on those committees or who are able to give advice as to whom they should in turn seek advice from. It won't always be the person who is familiar to Government who will eventually be involved in giving the advice, because they may, in turn, say, "I think you ought to talk to X", and X is somebody who has not previously been involved in giving advice to Government. It is quite an open process.

Q385 Chair: But X could be someone anywhere in the country?
Baroness Neville-Jones: Or internationally, Chair.

Q386 Chair: Indeed. And many of the risks exist in many locations up and down the country. Why is it that the Local Government Association is on record as saying that the National Risk Register is "rarely informed by issues identified at the regional and sub-regional level"?
Baroness Neville-Jones: I had not heard that comment, which I take seriously. **Chair:** I do because I live in a hazard area.
Baroness Neville-Jones: Absolutely. It is the case, however, that there are regional committees, so-called STACs, which do indeed inform the process. The point you are making is probably that structured regional scientific and local advice needs to be fed into the national risk assessment, and particularly the register, when it cascades down to the local level. I take that point. It is perfectly fair and sensible.

Q387 Chair: Who is allowed access to the national risk assessment, and what kind of information is withheld from the register?
Baroness Neville-Jones: From the register? You are right to distinguish between those two because they are, obviously, different and the National Risk Register is an unclassified version of the NRA. One of the things that we want to try and do, if I might just say that, is to put as much into the National Risk Register as we can; that is to say, not to have a big difference between what is in the NRA and what is in the National Risk Register. There are, however, some items in the National Risk Register that are genuinely very sensitive and it is difficult to put it all into the public domain.
The National Risk Register is an open document. It can be seen by people. It is part of the guide to local authorities at the sub-regional and regional level. We want to make that document as useful as possible and, therefore, as full as possible. The classified document is available to those who have the right clearance to see it.

Q388 Chair: I asked Sir David Pepper this exact question last night—
Baroness Neville-Jones: And?
Chair:—about the areas that you and I have been interested in over a number of years in terms of cyber-threats.
Baroness Neville-Jones: Absolutely. Yes.

Q389 Chair: Some of those cyber-threats are significant threats to civilian parts of the nation's structures—banks, utilities and so on. There are great chunks of those areas where people don't have any security clearance.
Baroness Neville-Jones: Correct.

Q390 Chair: How do we manage that difficult relationship?

Baroness Neville-Jones: There is what we do now and there is what we hope to do in the future. If you look at the National Risk Register, you will see that electronic attack is on it. It is one of the things that we need to develop as the result of developing the cyber-security strategy, which is something which is now going to take shape in the next few months, and we hope to publish the strategy in the spring. Therefore, our treatment in the National Risk Register, as it stands, and the assessment, is incomplete. However, that doesn't mean to say that Government isn't active, because there is a serious threat both to Government systems and, as I think is implied in your question, the critical national infrastructure, which is largely in private hands.

There is a close and co-operative relationship between CSOC, which is developing national situational awareness. This has further to go, but it is going to be absolutely key to the development of and building on existing close co-operation between public and private operators, which is what I have described as being both a strategic and an operational partnership with the private sector. What we would like to do is to develop our policies in co-operation with the private sector, given that they are key owners and key operators and are themselves very often suppliers to Government. It makes a very great deal of sense not just for the Government to try on its own to specify what it needs but to conduct a much more co-operative relationship of the kind where you define what the problem is together and you solve it together. Then there needs to be an operational relationship where the situational awareness which Government itself develops, which I would hope the private sector would feed into, will then be available at times of emergency—that is to say, if there is an attack—as a source, first of all, to report into but also, then, to be the base on which decisions are taken about what happens next and what solutions are arrived at. I would see it as being something which is both strategic in character and is there as the underlying framework in which policy is made but also the operating framework for keeping the country secure in cyber.

Q391 Chair: But there is, undoubtedly, this conflict with areas where national security comes in but advice, guidance and expertise reside in the technical parts of the private sector—the supply chain to Government—but there is also a different level of expertise, hugely important, in areas like the banks and so on. This is going to present you with a big challenge, isn't it?

Baroness Neville-Jones: Yes. You can, I think, exaggerate it. Certainly, there is an argument that not everything is going to be readily available. My own view is that a very large number of the problems that we will face, the issues that we will need to try and solve and the ways in which we will need to find solutions to existing problems can be abstracted from the data that is the sensitive issue. Very often, you have a systems problem and you need to try and solve it. You do not need to have access to the data that it carries in order to be able to make a worthwhile contribution to the solution of that problem.

I think you can exaggerate the extent to which it is absolutely necessary for somebody who is outside the Government circle, who may not wish, themselves, to take Government clearance. The Government, on the whole, wants to clear people who can help it, but if that's the case I don't think these people are excluded from giving extraordinarily helpful, worthwhile information.

I would say that one other area that could also be regarded as constituting a problem is reputational risk. Companies are known not to want, quite understandably, to get themselves into trouble with either their competitors or the markets in being shown to have had some kind of cyber-accident, if I can put it that way. But I think there are ways round that too. It does involve developing a trusted circle between Government and both operators and suppliers in which they are willing to talk to each other but in which, equally—I think, in the national interest—the solution is found without there being great damage to the individual reputation of the company.

Q392 Pamela Nash: I would like to ask you, Baroness Neville-Jones, how the Cabinet Office chooses a lead Government Department when a crisis ensues. Is it an active choice or does the Cabinet Office sit back, as it were, and wait for one to emerge?

Baroness Neville-Jones: Normally, it is not difficult to see to which Government Department the lead should fall. Most topics present themselves with an obvious answer. If it doesn't, I can give you an example. I think space weather is one area that covers many Departments and it is not abundantly obvious right from the outset which Government Department should actually lead. In that situation, and particularly if you have something you need to deal with, as we did, then the Cabinet Office will act and it will draw in the Government Departments that are needed to be there in order to handle whatever crisis it is. What we don't intend to do is to end up with the Cabinet Office becoming departmentally responsible. At the moment, particularly in relation to space, where there is yet no decision on which Government Department should actually take the lead responsibility, we are looking at all the factors. There is ongoing work to decide where the bulk of the responsibility should lie. That will depend, to some extent, on the analysis of the factors that go into your assessment of likelihood, impact and, therefore, risk, and the nature of those risks. I think that is the procedural answer to your question.

Q393 Pamela Nash: That's interesting. What I was trying to get to the bottom of is whether a list of departmental responsibilities is enough, and what you have told us is that in very specific issues it is not. So there is work that goes on behind the scenes to prepare.

Baroness Neville-Jones: A decision has to be taken—absolutely. You can't just stop, when the emergency is over, deciding how you will, in future, handle another emergency should it arise. That is an ongoing issue for us and we will, indeed, take a decision on where it should lie.

I might say, and I think it is important to understand this, that the Government is less and less stove-piped in the way it carries out business. A lead Government Department may well be in the chair but other Departments round the table will be absolutely vital to the collective solution that the Government brings to any emergency.

Q394 Pamela Nash: On space weather, which you mentioned, what are your views on the Office of Cyber Security, for instance, on solar and cyber attacks, or the UK Space Agency on space weather actually taking a co-ordinating role if an emergency was to occur between Government Departments?
Baroness Neville-Jones: The Space Agency would need, I think, to be involved. In fact, I would regard the Space Agency as being one of our resources in future for developing the policy that we need to pursue on the risks involved in severe space weather. We have been forewarned, in a sense, that the sunspot cycle is coming to a peak and it looks as though it is going to be a fairly vigorous peak. It, therefore, behoves us to have laid a good ground for that. I would regard the Space Agency as being both a resource nationally for some expertise but also being a connection to international expertise on it as well. Clearly, if you get vigorous space weather and, in particular, you get spikes in the solar cycle, it can clearly affect, in particular, telecommunications, not only power. There are a number of utilities we need to look at under that head.

Q395 Chair: Members of the Committee saw some very interesting presentations yesterday at the British Antarctic Survey, for example.
Baroness Neville-Jones: Absolutely.

Q396 Chair: Mr Willetts, this spills into your bailiwick as well. Do you see the Space Agency having a key role here?
Mr Willetts: Absolutely. I agree with what the Baroness said. We have a double role. There is a role in obtaining information and research evidence and there is also, of course, co-ordinating with the private sector, because things like privately operated satellites are, clearly, vulnerable. So there is a double interest. Indeed, it is something we have already discussed briefly and I hope to put back on the agenda at the Space Leadership Council, which I co-chair.

Q397 Graham Stringer: Do you think the National Grid is at risk? We have had slightly conflicting evidence. The sun is approaching one of its phases when it might be ejecting more stuff. Do you believe that the National Grid is at risk?
Baroness Neville-Jones: The National Grid is itself doing an assessment at the moment because precisely the question you have asked is the one that we need to have more of a fix on than we have at the moment. My feeling is that there must be some risk. Every country, it turns out, is specific in this. There are no generalisations and a lot depends, for instance, on how many overhead lines you've got, how much you have buried underground, and specific vulnerabilities, such as, I'm told, when the power lines come from underwater to on-land. That junction, apparently, is a specific vulnerability. The answer to your question is that we need to do, and this is what the National Grid is doing, a study in specific detail on UK conditions. The answer to your question is that there must be some risk. What we don't yet know, but I think they are reporting in the spring, is how great it is.

Q398 Graham Stringer: Will that be made public?
Baroness Neville-Jones: I would think there is every good reason to suppose that knowledge about it should be in the public domain, yes, absolutely.

Q399 Stephen Mosley: In some of the evidence that we have seen, in particular relating to cyber-security, there has been a suggestion that there are two separate cultures—one intelligence and defence and one the civil side of things—and that information flows only one way, and I think you can guess which way that is. Do you agree with that analysis at all?
Baroness Neville-Jones: I think there have, historically, been two tribes. Yes, I think that is fair comment. One of the things we are trying to do in the cyber-security strategy is, frankly, to break that down. If you learn anything about modern Government it is that stovepipes won't do and that you lose greatly if you don't allow both information and technique to flow both ways. If you look at the sciences that are going to be involved in any security strategy that we have, it's the same for both communities. I do take the view that GCHQ is the right organisation for it, but by having an organisation in Government that crosses those boundaries and services both, in that respect, I personally think we are better placed than the Americans, who have the NSA, which is very distinctly defence. Then it has other less well defined structures in the civilian sphere. I think we have a better chance of bringing our community together on a national basis.

Q400 Chair: Would that be strengthened if there was greater representation of scientists and engineers across the civil service? Isn't part of the underlying problem that the stovepipes are, in a sense, enhanced because of the characteristics of the population?
Baroness Neville-Jones: I think scientists can certainly help us to break down the stovepipes, yes. One of the things this Government is trying to do is to break down the stovepipes. That is one of the reasons why we have the National Security Council, and this sort of issue would go to the National Security Council. So it does help to break down stovepipes at both the departmental consideration and also ministerial consideration. You can't present a paper to a collection of Ministers if it doesn't cover all the ambits and all the facets that it needs to. So I think it does help that.

Q401 Chair: Several witnesses in our inquiry have touched on the absence of a chief scientific officer at the Treasury. What is your view?
Baroness Neville-Jones: I note it is a Department without.
Chair: We will interpret that.

Q402 Stephen Mosley: Still on co-operation but more on international co-operation, we have heard in both space weather and in cyber-security the importance of international co-operation between ourselves, in particular, and people like America and Europe, but also elsewhere. How does the UK resolve the tension between co-ordinating and sharing information with some countries and also doing the opposite in hiding information from others?

Baroness Neville-Jones: I think the answer is that we certainly do have closer partners. This is true of all Governments. All Governments have their close relationships and their less close relationships. In this sort of area, in cyber-security, for instance, one would want fairly close relations. When it comes to something like space weather, the circles within which you would want to consult, spread and share information would be quite broad because, apart from anything else, our state of knowledge generally is not so brilliant that one would want to exclude the possibility of obtaining information from quite far-flung sources.

When it comes to some of the more sensitive forms of activity in which science is involved, of which cyber is one, you have to discriminate a bit between your close partners and others, if only because you do have some adversaries in that game. There is a difference between those fields in which you may be talking more about threat than hazard and those fields in which you are talking about hazard.

Q403 Stephen Metcalfe: Mr Willetts, during our investigation we have seen the value of scientific advice across Government. I am sure the Government appreciates that. There is a small concern, though. As we see departmental spending reduce, how do we make sure that we maintain that scientific capability within individual Departments and that that is not the area that gets squeezed?

Mr Willetts: This is something that is very important and it is why Sir John Beddington and I wrote jointly to Cabinet colleagues during the CSR process reminding them of the importance of continuing with their R&D responsibilities, and inviting them to come to us if they were planning any substantial reduction in departmental R&D. Of course, the position is still being finalised as people work through the detail of their CSR settlements, but, as I reported to this Committee last week, in general, we feel it is working quite well. We have a health budget with a continuing robust commitment to R&D; Defence is doing pretty well on R&D; and DIFD is doing quite well on R&D. But Sir John and I carry on monitoring this. As yet, we have not identified a Department that seems to us to be making a massive reduction in its R&D effort.

Q404 Stephen Metcalfe: That's good to hear. You have touched on the R&D side of things. Taking the research and development issue and applying it to Government advice in emergencies, who should be funding that research? Should it be the individual Departments or should there be some other body?

Mr Willetts: If you take a step back, if you mean the scientific capacity within the nation to understand these challenges, that is something that we finance via research councils and via the QR money that goes to universities. Without being complacent, I think we are fortunate. We are one of the nations that, facing these challenges, probably has a more broadly-based scientific community to draw on than just about anywhere else. If you mean specifically, I know there is an issue that has arisen on these specific exercises about the exact budgetary funding when NERC finds itself providing resource during the volcanic ash episode. During the crisis itself, it's common sense—people just get on with it. It's true to say that now there are some accounting issues that are still being resolved. During these crises individual scientists are very good at coming forward on a pro bono basis and providing their advice and assistance, but I don't think it would be fair if that was the basis on which we always worked, especially if the time commitment becomes substantial. We do need mechanisms to provide, in specific circumstances, proper financial support for people who help out during a crisis.

Q405 Stephen Metcalfe: Where a potential emergency has been identified and it makes it on to the national risk assessment but there isn't any research necessarily being undertaken across the wider scientific community, what role do you think the Government has? Should it direct someone who is already funded to look at that or should it fund that research itself?

Mr Willetts: We do try through the research councils, when a big issue has been identified, to commission research in the area. Cyber-security is a very good example. It is clearly coming up the agenda. We recognise we need to have a strong in-house capacity on that, and work is currently going on as to how we might commission background research in that whole area that can be drawn on. I don't know if the Baroness wants to add to that.

Baroness Neville-Jones: That's right. In the case of cyber, of course, there is specific work that the national research councils might do. There is also a big reservoir in the academic world. What we try to do in Government, therefore, are those things that we can't in the Government's scientific offices—those things that, for whatever reason, are so specific to Government's needs that it is sensible to do the research in Government. Were we only to rely on that, it would be a very impoverished way of looking at our scientific base. Increasingly, what tends to happen is that Government scientific laboratories are in very close contact with people who are in the academic world. There is a very close intellectual relationship and, what's more, the Government's scientific laboratories themselves contract out to the academic world and to the research councils for certain work to be done. It is very hard, in the end, to separate these things from each other. They constitute a mosaic.

Q406 Stephen Metcalfe: You are very happy with the arrangement as it is at the moment—that if an issue does come up there is the ability to fund that research?

Baroness Neville-Jones: We would always like more money.

Q407 Stephen Metcalfe: I realise that. That was a stupid question.
Mr Willetts: I am normally less subtle than that in my ways of putting it.
Baroness Neville-Jones: Resources aside, I think the methodology has been developed, and the degree of contact that takes place between the two. I know some people think that the British Government is still not good at reaching out to the academic and the scientific world, and one does hear that view expressed. All I can say is two things. One is that it is an awful lot better than it used to be. Can it go still further? I've no doubt. What I do think—this is one of the changes I would say between having previously been in government and now—is that people are very much more aware of, in a sense, how little Government knows, and how much others do need to contribute. You don't operate just on the basis of Government information. I think there is a real change in outlook and attitude and that goes from top to bottom, too.

Q408 Stephen Metcalfe: Let me focus, finally, on the cyber-security issue. I think that is something that is rising up the agenda fairly quickly. Do you feel that we need to develop more capacity across Government—across all Departments perhaps—to understand that better and the science of that, and perhaps with specific focus on the social and behavioural sciences? Do you think that that is an area where we are perhaps lacking at the moment?
Baroness Neville-Jones: Yes, I would say that's true because I think Government is a reflection of the nation. That is a national issue. We need much greater awareness and it should take at least two forms. One is that we need to upskill our population. Things like *Get Safe Online* are very important parts of educating the so-called 80%. I think that knowledge and a more sophisticated understanding of this subject also need to penetrate more deeply. Everybody is aware of its importance, but do they really understand it? I suspect there is more to be done there. Can we do that with the development of the security strategy and things? Yes, I think that will be a contribution. Is it going to be something that we need to develop over a period of time? I've no doubt about that. There is the national issue, and what is going to be an important part of this is increasing the profile—David may want to contribute on this—in our universities to the profile given to qualifications in this area and, indeed, the way in which the public sector and universities invest in cyber-skills.
Mr Willetts: The Office of Cyber Security & Information Assurance is actually working now on a cyber-security R&D programme. That will both be involving activity within Government and also will feed into some of the research council commissioning. If I may say so, I very much agreed with your final point that this is not simply a matter of the physical sciences. So many of these policy areas ultimately become matters of human behaviour. The social sciences, even the humanities, have a role here. As we allocate money between the different research councils, we have to remember that no one discipline has all the answers.
Baroness Neville-Jones: The human factor is extraordinarily important. Look at airport security. The human factor is very important.

Q409 Chair: On several occasions you have suggested that there needs to be more openness and more collaboration between the traditional agencies that protect us from electronic attacks and so on, and the private sector. It brought to mind the section in Simon Singh's book, *The Code Book: The Secret History of Codes and Code-breaking*, where he argues that the algorithms that were necessary to create the business RSL were first established in Cheltenham. Do you envisage a change that is so radical that it will have the commercialisation of products, working in partnership with the private sector, or do you still see that traditional barrier occurring?
Baroness Neville-Jones: You are taking me on to ground, Chairman, that we are thinking about. There are many ways of tackling the whole question of whether, for instance, if Cheltenham were to supply a service to the private sector how that might be funded and what the financial relationship might be. If you'll forgive me, I don't terribly want to go very far. There are a number of options. It's a live issue, I would say.

Q410 Chair: If RSL had been created in the UK then you would have a bit more money to spend.
Baroness Neville-Jones: All of the above, yes.

Q411 Chair: In terms of structures, should the Government Office for Science be in the Cabinet Office? Would that create a better relationship?
Mr Willetts: It has been located in various places over the years. I don't think there is any ideal location. All I can say is that we are very comfortable with the current arrangement. The Prime Minister took a very clear view when the coalition Government came into office that he wasn't going to divert his energies into reorganising Whitehall. As we do have within BIS responsibility for the science budget in research councils and universities, there is certainly a very strong logic to having the Government Office based in BIS. Of course, Sir John is not a conventional part of the BIS machine. He is a resource for Government as a whole. He is, I know, in the service of the Cabinet Office machine and No. 10, so he is not there as a conventional BIS official, but it is fair to say that we are all very happy to have that operation based there because it does help, given that we at least have by far the biggest science budget.

Q412 Graham Stringer: Having looked at the swine flu pandemic and the volcanic event earlier this year, is there anything that you have learnt from that that you would apply to emergencies in the future or the application of scientific advice to emergencies in the future?
Mr Willetts: I think there are some lessons actually, and perhaps this Committee's investigation will help us learn the lessons because it is clearly something in process. I mentioned earlier that there is one specific issue, for example, about funding, which we are having to sort out afterwards. The scientific community has been heroic in people just turning up

and providing advice for free, but there comes a point, as an emergency runs on, that you are affecting their ability to do other work and you do need to have some mechanism for reimbursing them. We recognise—this may have been something you were discussing earlier today—that there are a range of uncertainties in science. There is a tension between scientists who give advice across a range, from a best case to a worst case scenario, and we know that it is very easy for the media then to pick up on the worst case and the political process to be driven absolutely by the worst case rather than the range of risks. Communicating the intrinsic uncertainties in scientific advice is something that we probably need to do better.

Chair: We thank you for your attendance this morning. Some of the issues we have discussed are clearly going to be of interest to the House in terms of future inquiries, particularly as some of the thinking unfolds on cyber-security issues, because there are some very important subjects just below the surface there that go beyond the scope of our current inquiry. I am sure we will want to keep in touch with you, Baroness Neville-Jones. Thank you for your attendance. Thank you, again, David Willetts, for your attendance.

Written evidence

Memorandum submitted by the Government Office for Science and the Cabinet Office (SAGE 00)

Letter to the Clerk of the Committee from the Cabinet Office, 14 September 2010

I write in regard to the questions that the House of Commons Science and Technology Committee has set out as part of its inquiry into "Scientific Advice and Evidence in Emergencies".

I attach a memorandum, preparation of which has involved the Department of Health, Department for Transport, Department for the Environment, Food and Rural Affairs, Home Office, Department for Energy and Climate Change, Centre for Protection of National Infrastructure, Department for Business, Innovation and Skills, Ministry of Defence and the Devolved Administrations.

Propriety and Ethics Team
Cabinet Office

MEMORANDUM

Planning for Emergencies

The management of the risks of civil emergencies in the United Kingdom is coordinated by the Cabinet Office. The Civil Contingencies Act 2004, together with its supporting statutory[1] and non-statutory[2] guidance, provide the framework for civil protection activity by local emergency planners and responders around the country. The Cabinet Office works in partnership with other Government departments and the Devolved Administrations.

The Civil Contingencies Act defines the meaning of emergency as an event or situation which threatens serious damage to human welfare, or the environment, in a place in the United Kingdom; or war, or terrorism, which threatens serious damage to the security of the UK. It defines the duties of local emergency responders inter alia to assess the risk of emergencies, to maintain plans, and to maintain arrangements to warn and provide information and advice to the public.

Since 2004 the Government, through the Civil Contingencies Secretariat (CCS) in the Cabinet Office, has maintained a capacity at the national level to provide guidance and support to local emergency responders in these areas, through a National Risk Assessment process, and a national Resilience Capability Programme. Since 2008, a National Risk Register has been published, indicating the main kinds of emergency for which communities and local commercial organisations may wish to prepare themselves. This is in addition to the primary function of the CCS to coordinate the crisis management response to terrorist and other civil emergencies.

The National Risk Assessment and Register, and the crisis management response, are all underpinned by scientific advice coordinated by the Government Office for Science (GO-Science), under the Government Chief Scientific Adviser.[3] The GCSA provides advice directly to Ministers and uses the Scientific Advisory Group for Emergencies (SAGE) mechanism (detailed below) to ensure that the advice given is coherent, robust, identifies key areas of uncertainty and is externally peer reviewed wherever possible.

The National Risk Assessment and Risk Register

The National Risk Assessment process (NRA) is a comprehensive, classified assessment of the most significant emergencies (malicious and non-malicious) that people in the United Kingdom could face over the next five years. This confidential assessment draws on expertise from a wide range of departments and agencies of Government. It is used for planning for emergencies at a Government level, and to provide guidance to local emergency planners and responders on the kinds of risks which they may need to assess and plan for in their local area. The objectives are: to assist in the prioritisation of risks for emergency planning purposes; to enable reasonable quantitative and qualitative estimates to be made of the likely consequences that need to be planned for; and to facilitate risk communication in both these areas (weight and impact) to be communicated to those planning for emergencies, in the public, private and community and volunteer sectors.

The NRA is updated annually. There are three stages to the assessment: the identification of risks; assessment of the likelihood of the risks occurring and their impact; and comparison of the risks. All three

[1] Emergency Preparedness—Guidance on Party 1 of the Civil Contingencies Act 2004, its associated Regulations and non-statutory arrangements
[2] Emergency Response and Recovery
[3] This includes advice on social sciences, engineering and technology.

stages involve consultation of Subject Matter Experts and a standard process is used that is designed to ensure that the assessment of all individual risks is, to the extent possible, on a comparable basis:

- Risks are identified by consulting, through Government departments, a wide range of experts who are able to take an informed view of the seriousness of the risks according to the criteria in the Civil Contingencies Act. After initial scrutiny, most proposals are taken forward into a detailed assessment phase; some may kept under review.
- The assessment is done on the basis of an agreed "reasonable worst case scenario". This concept is designed to exclude theoretically possible scenarios which have so little probability of occurring that planning for them would be likely to lead to disproportionate use of resources. They are not predictions of what will happen or the most likely manifestation of a particular type of hazard.
- Risks are assessed using objective historical, statistical and scientific data where they are available; where possible, the assessment looks forward to take account of known or probable developments over the next five years. In the case of the risks of terrorist or other malicious attacks, the risks are assessed more subjectively. The willingness and motivation of individuals or groups to carry out attacks is assessed and balanced against what is known of their capability and capacity, and the vulnerability of their intended victims or targets.
- Impacts are assessed against five main criteria: the numbers of fatalities that are likely to be directly attributable to the emergency; the extent of human illnesses or injury over a period following the onset of an emergency; social disruption, under ten headings designed to measure significant disruption to people's daily lives; economic damage; and the potential for significant outrage and anxiety to be caused to communities.

Most types of risk are reviewed every year, but some at longer intervals by experts within Government departments most affected. Existing structures within these departments provide independent scientific or technical advice, eg the Pandemic Influenza Preparedness Programme (PIPP) in DH which advises on pandemic flu, which feeds into the assessment process through this inter-departmental working group.

Since 2008, an unclassified version of the National Risk Assessment, The National Risk Register (NRR) has been produced, designed to assist individuals and communities interested in improving their own preparedness for emergencies. The NRR[4] is publicly available and provides an indication of the types of risks the UK faces and an indication of what the Government is doing to prepare for them.[5]

Concept of Operations for the UK Central Government Response to Emergencies

Responding to Emergencies: The UK Central Government Response: Concept of Operations (Conops) guidance[6] also sets out the guiding principles and a framework for emergency management. Wherever possible, preparations, planning, response and recovery are local-led drawing on local expertise and knowledge.[7] But the scale, complexity and/or severity of some emergencies mean that these local resources are overwhelmed and assistance is needed from Government. If an emergency impacts on multiple sectors, as is often the case, collaboration between Government departments is required. This function is fulfilled by the Cabinet Office Briefing Room (COBR) which facilitates collaboration and aims to ensure an effective, efficient response.

When COBR is activated a Lead Government Department (LGD) is appointed to provide leadership. LGD's are appointed using a pre-determined list of department roles and responsibilities. Where the lead is unclear (eg because the emergency affects a number of sectors equally) the default is a Cabinet Office lead.

Where an emergency occurs in Scotland, Wales, or Northern Ireland and falls within the competence of the relevant Devolved Administration, they will lead the response in their territory reporting through the relevant minister to the devolved legislature. In such circumstances there will often be little if any involvement for UK Government departments. Where an emergency occurs in Scotland, Wales, or Northern Ireland but competence is reserved to the UK Government (and therefore the UK Parliament), the relevant UK Government department will lead the response liaising closely with the relevant Devolved Administration(s).

Scientific Advisory Group for Emergencies (SAGE)

One of COBR's key functions is to ensure that there is a common understanding of the evolving situation and that there is a sufficient evidence base for decision making. For many emergencies this will involve the provision of scientific and technical advice. For such occasions the LGD or the Cabinet Office, in consultation with GO-Science, may activate a Scientific Advisory Group for Emergencies (SAGE) which aims to provide timely and coordinated scientific advice by bringing together key experts.

As with COBR, SAGE is designed to be both flexible and scalable. The arrangement is that SAGE provides the lead for commissioning and assessing scientific advice from a range of expert bodies. SAGE is usually chaired by the Government's Chief Scientific Adviser (GCSA) or a departmental CSA as

[4] http://www.cabinetoffice.gov.uk/intelligence-security-resilience/civil-contingencies-uk-resilience/national_risk_register.aspx
[5] The risk assessment process is described at chapter 5 of the NRR.
[6] http://www.cabinetoffice.gov.uk/media/349120/conops-2010.pdf
[7] Responders, as defined by the Civil Contingencies Act (2004) have a statutory duty to prepare for emergencies.

appropriate. Where there is a strong departmental lead a co-chair may be appointed; and the chair and co-chairs may change in the transition from the response phase of an emergency to the recovery phase. Secretariat support is provided by the LGD, the Devolved Administration (DA)—if in their area—or by the Cabinet Office and GO-Science where the LGD is unclear.

The membership of SAGE and any expert groups is specific to each emergency. Pre-existing scientific groups and networks will be utilised, where they exist and have appropriate expertise. Where existing groups do not exist, the GCSA or relevant officials would identify appropriate experts in consultation with National Academies, Learned Societies and other relevant professional organisations and institutions. The precise membership of SAGE may change as emergency develops or as the UK moves into the recovery stage.

The main role of SAGE is to ensure that there is a sufficient evidence base for decision making and to provide timely and coordinated advice. Within this remit the specific focus of SAGE and its sub-groups may evolve during the course of an emergency. It provides strategic scientific advice for the UK and so if devolved issues are involved, due consideration should be given to the DAs.

Scientific and Technical Advice Cells (STAC)

At the local level emergencies are coordinated by Strategic Coordinating Groups (SCGs). These groups may also require science advice in some emergencies. Where SAGE has not been activated, scientific and technical advice is provided to the SCG by local Scientific and Technical Advice Cells (STAC). The decision to set up this group is the responsibility of the local SCG.

In the event of wide-area emergencies where more than one SCG might require scientific advice, consideration would be given to how best to provide local access to specialist scientific advice recognising the limited number of "experts" that might be available nationally and the need to maintain consistency between the UK wide, national, regional and local response.

In some cases, this might best be provided by disseminating widely strategic advice from the SAGE. In others, it might be appropriate to set up a support centre to provide operational advice on request to local areas. Where SAGE has been activated, the strategic advice it provides should, once endorsed be applied in a consistent manner regionally and locally.

Testing and Exercising

A framework is in place to test the central Government response to the wide range of threats and hazards facing the UK. Exercises involving the activation of COBR are delivered up to three times per year and their primary objectives include the provision of science advice in an emergency.

Case Studies

The attached case studies provide further details on the specific emergencies or potential emergencies that the Committee has indicated the inquiry will consider. These are (i) the swine flu pandemic in 2009, (ii) the Icelandic volcanic ash eruptions in 2010, and the potential emergency situations that are (iii) solar storms and (iv) cyber attacks.

Case Study 1: H1N1 (Swine Flu) Pandemic Influenza

Background

The UK has been preparing for an influenza pandemic for some years. In January 2002, the Chief Medical Officer for England published "*Getting ahead of the Curve: A strategy for combating infectious diseases*",[8] which identified a new pandemic as a particular disease threat. When the first National Risk Assessment was produced in 2005, human pandemic influenza was therefore identified as a significant risk; and it has been consistently identified as among the highest risks, when both likelihood and impact are taken into account, during annual reviews of the NRA. This was reflected in the first public National Risk Register (NRR), published in 2008.

The Department of Health (DH) is the lead Government department for the risk of an outbreak of infectious disease, working with the Cabinet Office whose Civil Contingencies Secretariat leads on overall preparedness for emergencies. The Department of Health is responsible for identifying and assessing the risks, and for determining policy in preparing for a pandemic.

Current risk assessment and preparations for emergencies

The current risk assessment identifies as the "reasonable worst case" a flu pandemic caused by the emergence of a new human influenza virus, with a clinical attack rate of 25% to 50% of the population spread over one or more waves, and with a case fatality rate of up to 2.5%. This is assessed to have a medium high likelihood of occurring over the next five years, and is based on scientific assessment of pandemics over the past 100 years and the emerging threats of new viruses such as Highly Pathogenic Avian Influenza (H5N1). More detailed planning assumptions are at Appendix A.

[8] http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4007697

The UK was considered by the World Health Organisation to be among the best prepared countries in the world for an influenza pandemic. The planning framework for preparedness is the joint Department of Health and Cabinet Office publication "*Pandemic flu: A national framework for responding to an influenza pandemic*" published in November 2007 following extensive work at national, regional and local level to consider the risks and impacts, including wider socio-economic impacts, of a pandemic on the case illustrated by the worst case scenario. The framework provides the Government's strategic approach for responding to an influenza pandemic and background information and guidance to public and private organisations developing response plans.

Each of the Devolved Administrations has developed its own pandemic preparedness plan, fully consistent with the UK-wide National Framework, to reflect its own particular circumstance.

This Framework is currently under revision to ensure lessons learned during the 2009 H1N1 pandemic are captured for future pandemics. The current planning assumptions are being reviewed as part of this process to ensure the underpinning science is robust and the "reasonable worst case" assumptions remain valid. The revision is due to be published by March 2011.

Scientific input into preparing for a pandemic

Following the publication of the UK influenza pandemic contingency plan in 2005, a Scientific Advisory Group on Pandemic Influenza (SAG) was set up to advise UK health departments or directorates on the scientific evidence base for health-related pandemic influenza policies.

Under the auspices of the SAG, five scientific papers were developed in 2006, dealing with the risk of a pandemic originating from an H5N1 virus, and clinical countermeasures (antivirals, vaccines, antibiotics and facemasks). These papers underwent significant peer review by national and international scientific reviewers in early 2007. These were then further reviewed at a colloquium, convened by the Secretary of State for Health, of national and international scientific experts in April 2007. The papers were agreed by the SAG as reflecting a comprehensive and state of the art summary as of June 2007. This evidence base is currently being reviewed by the Department of Health. Any revisions to the evidence base will be published alongside the revised National Framework by March 2011.

In 2007, the "*Overarching Government strategy to respond to an Influenza Pandemic—Analysis of the scientific evidence base"*[9] was published by the Cabinet Office. This paper summarised the evidence base, on which the National Framework and the key planning assumptions are based. The paper drew on available scientific papers, modelling, economic assessments, real events, social sciences and international comparisons.

Following the publication of these scientific evidence base papers the role of the SAG was reviewed and membership of the group was expanded to include a wider range of scientific disciplines including traditional infectious diseases-related sciences such as virology and immunology, and also sciences such as risk management, behavioural sciences and diagnostics; an independent chair, Professor Sir Gordon Duff, was appointed. At this point, the group was known as the Scientific Pandemic Influenza Advisory Committee (SPI). The minutes of its meetings are published on the Department of Health website.[10]

Health departments/directorate also receive advice from the Joint Committee on Vaccination and Immunisation (JCVI) and the Advisory Committee on Dangerous Pathogens, and work closely with the Government's Chief Scientific Adviser and the Government Office for Science to ensure that Government is making best use of expert scientific advice in this area.

International scientific input

Coordinating preparedness for emergencies such as pandemic influenza can advance international resilience through development and use of information-sharing networks, by facilitating consistency of operational plans, and by establishing mutual trust. The international institutional architecture, multilateral and bilateral ties enable effective inter-Governmental and inter-agency coordination.

This co-ordination also enabled a series of international conferences of ministers and senior officials focusing on high-level policy, most recently in April 2010 as hosted by the Government of Vietnam. In association with these, the major global inter-governmental agencies hosted a series of specialised technical consultation meetings to address influenza and wider related scientific issues. This has helped to ensure rapid sharing of information across veterinary and human health sectors; enabled progress on policy challenges including new virus sample-sharing arrangements; and stimulated close inter-agency collaboration on emerging zoonotic diseases more generally.

UK scientists play significant roles in many of the international advisory bodies, such as the World Health Organization (WHO) and European Centre for Disease Control and Prevention (ECDC), and have strong connections with key national bodies such as the Centre for Disease Control and Prevention (CDC) in the US.

[9] http://www.cabinetoffice.gov.uk/ukresilience/pandemicflu/evidence.aspx
[10] http://www.dh.gov.uk/ab/SPI/index.htm

Scientific input into responding to the 2009 H1N1 pandemic influenza

The Chief Medical Officer, Sir Liam Donaldson, and Government's Chief Scientific Adviser, Professor Sir John Beddington both attended ministerial meetings during the 2009 pandemic. In order to inform decisions during the 2009 pandemic, Ministers needed advice on:

— The progress of the pandemic.
— The clinical impact of the pandemic.
— Antivirals.
— Vaccination.
— Communication.
— Behavioural responses.

Initially, the Scientific Pandemic Influenza Advisory Committee (SPI) took the lead in providing preliminary advice on these issues, pending the establishment of a Scientific Advisory Group for Emergencies (SAGE) on 5 May 2010.

Scientific Advisory Group for Emergencies (SAGE)—Meetings of SAGE were chaired jointly by the Government's Chief Scientific Adviser and the chair of SPI, Professor Sir Gordon Duff. SAGE oversaw the scientific contribution to the national management of the pandemic. It received updates from the Health Protection Agency (HPA) on case numbers, surveillance, epidemiology and severity throughout England, and received similar updates from the Devolved Administrations and the European Centre for Disease Control and Prevention (ECDC). There were 22 meetings of SAGE between May 2009 and January 2010. Committee members were not remunerated for their work on SAGE and gave up a great deal of time to attend meetings and support the work of the committee despite being under pressure in their day jobs.

A number of key advisory bodies and panels fed advice into SAGE that was used to produce consolidated advice to Ministers on key issues.

The three existing SPI sub-committees on Modelling (SPI Modelling and its Operational sub-group (SPI-M & SPI-M-O)); Behaviour and communications (SPI-B&C) and Clinical Countermeasures (SPI-CC) met throughout the outbreak and gave regular reports into SAGE on their activities. SPI-M-O provided advice to SAGE on the current situation, information on key parameters (case fatality rate, clinical attack rate, hospitalisation) and the implications of these numbers for the purposes of planning assumptions. SPI-B&C also provided advice to Government Departments on behavioural and communication matters relating to the health response to an influenza pandemic. SPI-CC provided advice to SAGE on science and technical matters relating to clinical countermeasures, such as antivirals and antibiotics.

A number of other advisory groups contributed to both DH policy development and SAGE advice including: The Pandemic Influenza Clinical and Operational Advisory Group's Clinical Sub-Group (PICO-CGS), which provided expert clinical advice recommendations to support the health and social care response to an influenza pandemic in the UK; Influenza Clinical Information Network (FLU-CIN) Strategy Group provided advice on the clinical management of patients in hospital with pandemic influenza.

Additional ad hoc advice was also provided through SAGE by the HPA, the Advisory Committee on Dangerous Pathogens (ACDP) and the Advisory Committee on the Safety of Blood, Tissues and Organs (SaBTO). In addition, the Medicines and Healthcare products Regulatory Agency (MHRA) provided ongoing advice to SAGE on the safety of antivirals and vaccines through the enhanced reporting systems it put in place during the pandemic in addition to the yellow card reporting system.

The Joint Committee on Vaccination and Immunisation (JCVI), which is the statutory body on vaccination and immunisation, was also asked to provided advice on matters relating to pandemic vaccination directly to Ministers. Key JCVI advice was scrutinised by SAGE prior to recommendations being made to Ministers. The chair of JCVI was a member of SAGE.

The Devolved Administrations had observers on each committee. Experts on the committees came from across the UK and consisted of Government officials, leading academics, clinicians and other health professionals.

International scientific input

During the H1N1 2009 pandemic, strong bilateral relationships with Australia, Canada and USA facilitated rapid sharing of new epidemiological and clinical data on the A/H1N1 virus as the 2009–10 pandemic developed. Strong links with international organisations such and WHO and ECDC also contributed to SAGE discussions and advice to Officials and Ministers.

Review of the UK response to 2009 H1N1 pandemic influenza

In March 2010, the four UK health ministers commissioned Dame Deirdre Hine to review the UK strategy for responding to the H1N1 pandemic flu. The scope included consideration of cross-cutting issues affecting the strategic decisions, including scientific advice. Dame Deirdre's report[11] was published on 1 July 2010. It contains a chapter on the scientific advice during the response.

[11] http://www.cabinetoffice.gov.uk/media/416533/the2009influenzapandemic-review.pdf

Obstacles to obtaining reliable, timely scientific advice

SAGE and its sub-groups considered all pertinent data from both UK and international sources as soon as it was made available to them. During the first wave of the outbreak, there was significant uncertainly regarding key parameters, such as the clinical attack rate, which made modelling the progress of the pandemic difficult. This was due, in part, to the relative mildness of the disease (a large proportion of those infected showed limited or no signs of the disease) and the level of pre-existing immunity in the population. It was not until a fieldable test to confirm H1N1 could be developed, and a serology baseline performed, that these factors could be confirmed. This information was key to understanding the future development and impact of the outbreak. By the end of the first wave, data became available and these parameters were clearer and modelling provided accurate figures.

A decision on the amount of vaccine to procure needed to be made early in the outbreak, to ensure that the vaccine was produced in time to be useful. This meant that the decision had to be made during a period when there was still significant uncertainty about the nature of the virus. Dame Deirdre Hine recommended in her review that the four Chief Medical Officers commission further work to support key decision-making early in a pandemic by January 2011. The Department of Health is taking forward this work.

Research base

Prior to the pandemic, the Department of Health had developed a prioritised list of research for departmental funding and communication to other funders. These priorities were rapidly reviewed in response to the H1N1 outbreak leading to SAGE identifying its high-priority areas for research on 9 June 2009. The National Institute for Health Research (NIHR) fast-tracked the commissioning of research in these areas. By 19 August 2009, 14 research proposals were funded, at a cost of £2.25 million.

Collaboration between all the main UK funders of research continued during the H1N1 2009 pandemic. The Wellcome Trust maintained a website of all research funded in response to the pandemic.[12]

H1N1 current situation update

The Health Protection Agency (HPA) continue to monitor the ongoing situation regarding pandemic viruses mainly using information reported up to the World Health Organization from affected countries. The headlines from this information, along with the UK situation, are then published in the HPA weekly National influenza report. The HPA also recently convened a flu threat assessment meeting which reviewed the current global situation and implications for the forthcoming winter season.

Case Study 2: Volcanic Ash Disruption (April/May 2010)

Background

On 20 March 2010 the Eyjafjallajökull volcano in Iceland erupted from a side-fissure. Due to the low intensity and location of this initial activity, impacts were at this stage, limited to Iceland. On 14 April 2010, the location of the eruption moved to the central crater and intensified. Unlike the side-fissure this new vent was covered by a glacier which meant there was significant interaction between the magma that was being ejected and water in the form of melted ice. This interaction created an explosive eruption with an eruption column to 11km and highly effective fragmentation of material. These factors together with the unusually unfavourable weather conditions led to significant ash incursions over the UK and Northern Europe between the 15 and 21 April and significant disruption to civil aviation, with commensurate side-effects. On 11 May 2010 volcanic activity at Eyjafjallajökull significantly reduced. A full timeline of geological events at Eyjafjallajökull can be found at: http://www.earthice.hi.is/page/ies_EYJO_compiled.

Risk assessments and monitoring prior to April 2010

In the 1990's, the International Civil Aviation Organization (ICAO), set up an International Airways Volcano Watch (IAVW). This was in response to a number of reports of commercial aircraft experiencing technical difficulties whilst operating in ash plumes, This included the set up of nine Volcanic Ash Advisory Centres (VAAC) located around the world which had the responsibility for coordinating and disseminating information on volcanic ash that might endanger aircraft.

The London VAAC, run by the UK Met Office has responsibility for monitoring Iceland, the UK and the North-East area of the North Atlantic. The Met Office is also one of eight globally located Regional Specialised Meteorological Centres for atmospheric modelling for environmental emergency response that are operated under the auspices of the World Meteorological Organisation. As part of this they developed an atmospheric dispersion model (Numerical Atmospheric-dispersion Modelling Environment or NAME). NAME is a sophisticated and flexible model which can be used for a number of purposes, including the prediction of volcanic ash plume dispersal. The Met Office's world leading modelling capability, along with a close working relationship with the Icelandic Meteorological Office which itself is in close contact with the University of Iceland, enables it to fulfil its VAAC functions. This pre-existing work and expertise was essential to the response to the volcanic ash disruption of April 2010.

[12] http://www.wellcome.ac.uk/About-us/Policy/Spotlight-issues/Influenza/UK-pandemic-H1N1-projects/index.htm

For national emergency planning purposes, the risk of disruption to aviation caused by a natural disaster occurring overseas was kept under review annually for the National Risk Assessment (NRA), from 2005 to 2008. No review was undertaken in 2009.

The provision of scientific advice during the April/May volcanic ash disruption

On 20 March 2010 when Eyjafjallajökull first erupted, in addition to performing their usual VAAC functions, the Met Office notified the Civil Contingencies Secretariat (CCS) of the emerging risk in accordance with established procedure. This notification triggered a Health Protection Agency (HPA) and Scottish Government assessment of the potential health risks of this eruption. The Government Chief Scientific Adviser discussed this issue with the Cabinet Office on 15 April, and it was clear that scientific advice would be needed to deal with the situation, and assess how it was likely to develop in the coming days. On the Saturday (17 April) Sir John Beddington met with officials from CCS to update them on his discussions with the scientific experts and, at the Prime Minister's request, Sir John Beddington went to number 10 on the Sunday evening (18 April) to update him on developments.

In accordance with the Government's approach to the engagement of scientific advice in civil contingencies, the Scientific Advisory Group for Emergencies (SAGE) was activated to support COBR, with the Government Chief Scientific Adviser in the chair. Two lead Government departments (LGD) were identified: the Department for Transport (DfT) for responding to transport disruptions and the Foreign and Commonwealth Office (FCO) for managing the repatriation of UK nationals. To ensure a coordinated cross-Government approach to SAGE GO-Science acted as the lead for this group.

SAGE members included both independent and Government experts, Chief Scientific Advisers from several Government departments and a representative from the Civil Aviation Authority. Initial teleconferences were held with members on the 20 April and the first SAGE meeting was on the 21 April. In total there were four volcanic ash SAGE meetings, all chaired by the GCSA. It is to the credit of SAGE members that effective advice was quickly available in such a short timescale. SAGE provided advice to COBR on the latest behaviour of the volcano and the current weather patterns, and how the situation was likely to develop over the coming days. SAGE also advised on the likely medium to longer term developments such as potential changes in volcanic eruption. SAGE ensured that the geology and meteorology underpinning these assessments was robust, and that any uncertainties were clearly identified.

Sub-groups were created as required to take-forward individual workstreams. Existing science advisory groups and experts were engaged as necessary. Many departments provided assessments of the potential impacts of the volcanic plume to SAGE. For example, the Department for Health and the Health Protection Agency (HPA) worked with other relevant departments and agencies, including the Devolved Administrations, the Met Office and WHO to agree the current health risk (if any) and prepare for any possible changes to this assessment. Examples are provided in Appendix B, which summarises the risks to animal health and the environment (from the Defra Scientific Advisory Group), and Appendix C on MOD monitoring of the volcanic plume. The progress and findings of each sub-group were reported and discussed at SAGE meetings. In addition to the formal sub-groups virtual working and ad-hoc meetings were used to collate and discuss advice.

There was a lot of media interest and public concern at the time. The GCSA and several SAGE members briefed representatives of the airline industry on the science behind this incident at an industry briefing day organised by the CAA.

International engagement, particularly with the Icelandic authorities, formed a key component of SAGE's work. Existing relationships, particularly between the Iceland Meteorological Office,[13] the Institute of Earth Sciences (University of Iceland), the British Geological Survey and the UK Met Office were key to this engagement. A Memorandum of Understanding (MoU) between the UK and Iceland is being drafted to strengthen cooperation in assessing and monitoring volcanic hazards. The UK also provided a significant contribution to the EU's European Volcanic Ash Experts Group, led by the Spanish Presidency through the office of the Department for Transport Chief Scientific Adviser. UK scientists are also heavily involved in a range of activities and workshops across Europe focusing on the impact of eruptive explosions, particularly on aviation.

The use of scientific information during the April/May volcanic ash disruption

The ways in which scientific advice was used during the emergency is summarised below.

Early warning, monitoring and modelling

Icelandic authorities and UK experts from BGS collaborated to use existing monitoring networks in Iceland to gain as much information as possible on the Eyjafjallajökull eruption. These measurements were augmented by additional instruments supplied by the UK to Iceland that increase the density of measurements around Eyjafjallajökull and Katla. This included the use of seismic monitoring and crust deformation measurements which provided some indication of current volcanic behaviour and supported assessment of possible future developments. In addition to monitoring in Iceland, rainwater and herbage

[13] The Icelandic Met. Office have national responsibility for response to volcanic events in Iceland

samples were also collected across the UK and analysed to identify if elevated levels of contaminants were occurring that could cause widespread impacts, such as environmental and health effects. Existing routine monitoring of air quality continued throughout the incident. The Defra science group, worked with the Scottish Environmental Protection Agency, Scottish Government, Welsh Assembly Government and Department of Agriculture and Rural Development (DARD) as well as the Agri-Food and Biosciences Institute (AFBI) in Northern Ireland to ensure that environmental sampling and analysis strategy was consistent in terms of methodology and procedures across the UK.

A range of empirical data was provided by volcanologists and atmospheric scientists (both British and Icelandic), including observations from the ground, satellite imagery and airborne measurements. Where appropriate, additional observations and data were input into the pre-existing NAME model. Maps of ash concentration, at a range of flight levels, were produced from this modelling. Observations of airborne volcanic ash proved challenging, both in the vicinity of the volcano and at a distance, because of the limited number of observation sites. Separate observations from ground based LIDAR,[14] airborne measurements (collected by NERC) and satellite imagery were used to validate the outputs of the model. This indicated that the outputs were good and within an order of magnitude, though it should be noted that even this level of accuracy presents challenges when outputs are to be used to define flight zones. NAME was used to provide 24 hour forecasts with air traffic control and COBR. As CAA, in discussion with the airlines and international aviation partners, developed modified procedures for safe flight operation in ash plumes, the outputs of the NAME model were adapted to provide additional information as required. The creation of flight zones determined by ash concentrations, rather than based on the presence or absence of ash as required by ICAO, increased the demands on the modelling. The Met Office continued to improve the outputs of NAME to produce maps showing concentrations for each respective flight zone.

Assessing the emerging risk

As with all emergencies the evolving risk and future prognosis was assessed to help inform decision making through-out the volcanic ash disruption of April 2010. This included the assessment of for instance the immediate risks posed by an eruption of neighbouring volcano, Katla, which historical records indicate could accompany or follow an eruption at Eyjafjallajökull.

Scientific experts (led by relevant experts from SAGE) were asked to identify the key factors that would influence whether Icelandic volcanic eruptions could have consequences in the UK and the extent, scale and nature of these disruptions.

SAGE used this information to develop a range of plausible indicative scenarios, and to identify knowledge gaps to attempt to reduce the uncertainty in these scenarios. Ad hoc groups were set up to explore:

- — the potential link between Eyjafjallajökull and Katla eruptions to determine the probability of a Katla eruption following closely on activity at Eyjafjallajökull;
- — historical and geological records to determine the most likely duration and intensity of Eyjafjallajökull (and possible Katla) eruptions; and
- — climatic records, to determine the likelihood of unfavourable weather conditions (predominantly NW flow) coinciding with Icelandic volcanic eruptions.

Understanding aircraft engine ash tolerances

Until May 2010 ICAO international guidance advised that aircraft avoid ash. Until the Eyjafjallajökull eruption these guidelines had been considered sufficient as aircraft had been able to re-route around ash incursions which were generally localised. The ash incursion generated by the 2010 Eyjafjallajökull eruption covered one of the most congested airspace regions in the world over Europe and the trans-Atlantic routes between Europe and North America, making re-routing virtually impossible.

As engine ash tolerances were unknown, the Civil Aviations Authority (CAA) took the lead in incrementally improving the understanding of aircraft operations in ash. In doing this they engaged with aircraft and engine manufactures and other European and International regulators. As understanding increased, the DfT Chief Scientific Adviser peer reviewed this emerging advice through a DfT science group, and reported to SAGE. Further details on the work of CAA and the DfT science group can be found in appendix D.

Assessing the risk of volcanic hazards more generally

SAGE has initiated work to assess the longer-term risks posed by volcanic hazards of this kind, as part of the review of these risks in the National Risk Assessment. This review has examined the main categories of risk (explosive eruptions like Eyjafjallajökull that eject mainly ash; and effusive eruptions which eject mainly lava and gas). It has assessed what is the reasonable worst case for an explosive eruption, and for an effusive eruption. Given the historical precedent of the 1783–84 effusive eruption of Laki, it has also considered what the likely sulphur dioxide levels from a modern Laki-type eruption might be. In accordance

[14] Light Detection and Ranging.

with the usual risk assessment process, the relative, and indicative, probabilities attaching to the main scenarios are being calculated; and an assessment being made of the main impacts of each in terms of public health and social welfare, and economic activity. When complete, the results will be included as appropriate in the National Risk Assessment and public Risk Register.

Case Study 3: Severe Space Weather

Background

Space weather includes a variety of solar phenomena that disturb the upper atmosphere and near-space environment of the Earth and damage space and ground-based technologies.

The largest recorded space weather episode is known as the Carrington event that happened in 1859. Since then, a number of similar but smaller solar events have occurred, the most recent in 2003, which had impacts upon power networks, airline flights and spacecraft operations.

Indications that the severity of future space weather events may be much greater than those experienced in 1921, 1989, and 2003, led to this being identified as a risk to be assessed during preparation of NRA 2010. When complete, this new assessment will enable appropriate planning for the impacts of this hazard, which are likely to affect the electricity transmission sector, satellite and other telecommunications sectors.

Current NRA risk assessment

The reasonable worst case scenario (a plausible yet challenging manifestation of this phenomenon) has been agreed with the cross-Government Risk Assessment Group, which has drawn on the expertise of the Science and Technologies Facilities Council, through the Rutherford-Appleton Laboratory. The British Geological Survey, which first highlighted the potentially growing risk, was also involved in the assessment.

The "reasonable worst case scenario" in the next five years was assessed to be more severe than previously expected. Work is continuing with space scientists, the satellite industry, representatives from the National Grid, Government departments and other agencies to understand fully the potential impact. This includes both the direct impact on infrastructure and technologies vulnerable to different space weather phenomena and also the secondary effects on sectors reliant upon these technologies

Involvement of scientific advice in assessing impacts of severe space weather

Early work to assess impacts has centred upon the National Grid system and hence the assessment for this sector is further advanced than for other sectors. Initial discussions with space scientists, Government departments and the National Grid have focused on identifying elements of the electricity transmission hardware that could be vulnerable to solar-generated geomagnetic storms of a significantly greater severity than those experienced in recent decades. Experts from the British Geological Survey, the Rutherford-Appleton Laboratory, Oxford and the Electric Infrastructure Security council have also been part of consultations examining National Grid geomagnetic forecasting and monitoring capabilities and the contingency measures the network have in place in the event of severe space weather. DECC's Chief Scientific Adviser has also asked DECC's Scientific Advisory Group to advise on the risks to the electricity distribution network.

Solar winds and radiation storms can temporarily disrupt and/or permanently damage satellites and spacecraft that support key applications including communication, position, location and timing systems such as GPS, and Earth observation, including meteorology and security surveillance applications. Work to assess the impacts in this sector in the Cabinet Office has involved central Departments, Defence Science and Technology Laboratories and the Centre for the Protection of National Infrastructure (CPNI) and the UK space industry. CPNI are currently undertaking an investigation looking specifically at dependencies of UK infrastructure upon satellite technology. The findings of both these studies will inform wider discussions between space scientists, the national infrastructure and satellite industries about resilience to space weather hazards.

The UK Space Agency supports several spacecraft currently observing the Sun. Data from these observations assist in assessing the risks to the Earth's technologies and infrastructure.

International co-ordination

Relevant Government departments have been in discussions with US members of the EIS council who have provided a perspective of the risk to US-based power network infrastructure. There has also been engagement with counterparts in USA, Sweden and EU raising awareness of the need to prepare for geomagnetic storms collaboratively. HMG continues to explore potential ways to enhance international coordination in circumstances such as these.

Future work

Once an agreed cross-Government understanding of the main impacts of severe space weather is achieved, a full risk description and assessment will be added to the National Risk Assessment.

The assessment will also inform 2011 Sector Resilience Plans, which are produced annually, by each lead department, as part of an ongoing assessment to increase Government's understanding of the level of resilience of the UK's critical infrastructure to natural hazards. Plans are developed for the nine infrastructure sectors: Water, Energy, Transport, Communications, Health, Emergency Services, Finance, Food and Government. The Plan should alert Ministers to any perceived vulnerabilities and set out a programme of measures (an action plan) to improve resilience where necessary.

Case Study 4: Cyber Attacks

Background

As the UK and our critical national infrastructure become increasingly dependent on cyber activity, we also become more exposed to the rapidly evolving range of threats and risks.

The Government has been taking action to secure cyber space for several years. CESG, the Information Assurance arm of Government Communications Headquarters (GCHQ), uses its expertise in this fast moving arena of cyber security to provide help and support to Government in dealing with these risks. The Centre for the Protection of National Infrastructure (CPNI) provides advice on protective security measures and direct technical support to organisations within the national infrastructure. Individual Government departments are currently responsible for the protection of their own systems and infrastructure.

The UK's Cyber Security Strategy was published in June 2009. The key aims of the strategy are to: reduce risks from the UK's use of cyber space; exploit opportunities in cyber space; and improve cyber knowledge, capabilities and decision-making. In the wake of this, the Office of Cyber Security (OCS) situated in Cabinet Office, and Cyber Security Operations Centre (CSOC) were set up to provide strategic leadership in the cyber domain, monitor developments in cyber space, analyse trends and improve the collective response to cyber incidents.

Current Risk Assessment

Since 2005 cyber threat risks have been extensively covered in the National Risk Assessment (NRA). In the 2010 NRA there are nine separate cyber risks which, broadly, fall into two categories: cyber attacks on confidential or sensitive data; and cyber attacks on infrastructure. To prepare and mitigate the threat of attacks on infrastructure CPNI provides advice on good practice on protective security and on communications resilience using industry expertise and good practice network design principles. CPNI has also established a broad network of information exchanges to ensure effective engagement with critical infrastructure providers, including the exchange of threat and vulnerability information.

As part of the annual refresh of the NRA, each cyber risk is re-evaluated in terms of its likelihood and impact and any changes are reflected in the NRA and associated planning assumptions documents. As is standard for risk of malicious damage in the NRA, the assessment of likelihood will take into account an objective assessment of the capacity of those intent on causing harm through cyber attacks and the vulnerability of their intended targets. In Autumn 2010 the Civil Contingencies Secretariat (CCS) will be facilitating a full review of the cyber risks in the NRA to ensure that the NRA continues accurately to reflect the latest assessments across Government of the range of plausible cyber threats to the UK. In doing so the CCS will draw on scientific advice including scenario planning, horizon scanning and technology watch activities undertaken by OCS and by other departments and agencies.

Individual departments consider cyber threats as part of their own information assurance and business continuity planning activities. For example, the Ministry of Defence has assessed the impact of cyber attack in a wide range of scenarios to inform ongoing work on the Strategic Defence and Security Review. In doing so MOD has drawn extensively on scientific advice on the nature of the current and future threat, alongside operational analysis and scenario planning techniques.

Response to Cyber Incidents

A variety of mechanisms exist in the UK, both within HMG and the private sector, to identify and respond to cyber-related emergencies. Relationships between the primary emergency response teams covering the Government infrastructure (GOVCERTUK and MODCERT), critical national infrastructure (CSIRT and many private sector CERTS) and central Government departments are strong. Government departments responsible for sectors of the critical national infrastructure have established links to infrastructure providers which allows information to be exchanged and action to be taken. CSOC has defined and shared an incident management process that enables CSOC to coordinate stakeholder activity in the event of a serious incident, with OCS (and relevant lead Government department/s) attending COBR as necessary

The identification and response process to cyber incidents requires the use of techniques from computer science (software instrumentation, code analysis) and the use of scientific method to draw conclusions about the probable cause of the incident and the nature of the most effective mitigation. CSOC is able to draw on scientific advice across Government including expertise within GCHQ and the Defence Science and

Technology Laboratory (Dstl). CSOC has developed and continues to develop relationships across the UK cyber community in order to support this activity with common situational awareness. Exercise White Noise (conducted by BIS in November 2009) highlighted the benefits of technical contributions at a high level. However further work needs to be done to develop mechanisms to identify scientific and technical experts in industry and academia.

Individual departments have made arrangements to respond to cyber attacks on their own systems and infrastructure. For example, the Ministry of Defence Global Operations and Security Control Centre (GOSCC) provides a focus for the monitoring of attacks against defence systems, and the co-ordination of MOD response actions. The GOSCC works closely with the CSOC to ensure a consistent and effective national response. The MOD is able to draw on specialist scientific advice from the Cyber and Influence science and technology centre within Dstl, as well as from a broader network of strategic partnerships with information infrastructure and system providers

These mechanisms have been tested in several genuine cyber incidents of limited scale. A number of cyber-specific exercises are being coordinated by CSOC, including UK play in the US-led CyberStorm III international exercise later in 2010. Activity will test existing response mechanisms in CSOC, the CERTs, HMG, law enforcement, and aspects of the UK critical national infrastructure provided by the private sector. A second exercise involving the UK telecoms sector will also take place later this year, and further exercises are planned for 2011.

Strategic Co-ordination

OCS leads the co-ordination of the UKs cyber security strategy, as part of this OCS is developing a private sector engagement strategy and associated science and technology plan. OCS also work with the Research Councils, Technology Strategy Board and individual departments (such as MOD and GCHQ) to ensure a co-ordinated approach to research and development in this area.

International Coordination

OCS lead international engagement on Cyber issues with other nations and have established strong links with the US, Australia and European Allies on Cyber matters. GCHQ, CPNI and the Ministry of Defence also maintain close liaison links with their international colleagues.

The geographic independence of cyber attacks makes international cooperation and coordination vital. CSOC has started to develop relationships with a variety of international partners and intends to participate in further international exercises and knowledge exchanges.

APPENDIX A

PANDEMIC INFLUENZA—REASONABLE WORST CASE NATIONAL PLANNING SCENARIO

The reasonable worst case is a concept developed for emergency planning in the UK. This concept is designed to exclude theoretically possible scenarios, which have so little probability of occurring that planning for them would lead to a disproportionate use of resources. They are not predictions of what will happen but of the worst that might realistically happen, and therefore we would expect most pandemics to be less severe and less widespread than the reasonable worst case. By planning for the reasonable worst case planners are assured that they have a high probability of meeting the demands posed by the hazard should it occur.

— Up to 50% of the population ill (with infection attack rates up to 80–85%) (Department of Health 2006c).

— Of which, from 10% up to 25% are expected to have complications, half of these bacteriological. (With possibly as little as a 35% overlap between the "at risk groups" and those who actually get complications (Meier et al. 2000).)

— Peak illness rates of around 10–12% (measured in new clinical cases per week as a proportion of the population) in each of the weeks in the peak fortnight (Department of Health 2005).

— Absences rates for illness reach 15–20% in the peak weeks (at a 50% overall clinical attack rate, assuming an average seven working day absence for those without complications, 10 for those with, and some allowance for those at home caring for children (Department of Health 2006b)).

— Case hospitalisation demand rates up to 4% with an average six day length of stay.

— but, of which 25% could, if the capacity existed, require intensive care for 10 days.

— Case fatality ratios up to 2.5%.

APPENDIX B

VOLCANIC ASH—THE WORK OF THE DEFRA SAG

Professor Bob Watson (CSA, Defra) and Dr Miles Parker (Deputy CSA, Defra) convened an advisory network of approximately 40 experts, from an extensive range of disciplines, and held the first of a series of daily teleconferences on the 16 April. At the initial teleconference the hazards and environmental media at risk were identified. Fluorine was identified as the main substance of concern in the ash. At an elevated level fluorine is hazardous to human and livestock health. Fluorosis (a condition relating to the increase in levels of fluoride) is a recognised cause of mortality of livestock in other volcanic eruptions. In response DEFRA and colleagues from the Devolved Administrations, put in place a UK wide sampling and analysis strategy of environmental samples including rainwater and herbage samples. Existing routine monitoring of air quality continued throughout the incident.

Sulphur dioxide was identified as a substance of concern but low risk in this case. An increase in the atmospheric levels of sulphur would have been picked up by the routine acid rain monitoring programme and hourly ambient air sampling for SO_2. If these parameters had increased, herbage samples would have been analysed for sulphur.

The DEFRA Science Advisory group provided regular updates on the key issues (air quality, drinking water quality, environmental water and grazing land) to SAGE members. Analysis of environmental samples returned no significant levels of SO_2 or fluorine or increased PM_10 values.

If significant ash deposition did occur DEFRA would need to consider if other chemical elements were an issue. This would be based on information of ash analysis from Iceland as well as ash deposited in the UK. Whilst we do not currently know what determinants we would need to test for and whether or not the UK has the analytical capabilities for these, likely determinants would be sulphur and heavy metals. Identified capabilities already exist for these.

Regarding air quality, alerts would be raised with the Health Protection Agency (HPA) if hourly PM_10 (particulate matter below 10 micrometers in diameter) values exceed 500 $\mu g/m^3$ and there is confirmatory evidence in neighboring sites showing similar increases and/or there is evidence of SO_2 exceeding 1,000 $\mu g/m^3$ over 15 mins.

APPENDIX C

VOLCANIC ASH—THE WORK OF THE MINISTRY OF DEFENCE

The hazards to the MOD from the volcanic ash cloud revolved around the potential impact of flying military aircraft (including fast jets, heavy lift aircraft and helicopters) through the clouds and this entailed sampling the clouds to determine their composition. In also entailed establishing an accurate method of determining in real time where the dangerous particles were at dangerous levels of concentration within the clouds. The identification of these hazards was based on known previous incidents of aircraft experiencing engine problems during or shortly after flight through clouds of volcanic ash.

The Ministry of Defence provided information on the contents of the ash cloud through samples taken of the cloud using a coherent swabbing regime designed to rigorous scientific standards by the Defence Science and Technology Laboratory (Dstl) and the Materials Integrity Group (MIG), part of 1710 Naval Air Squadron.

MOD's primary conduit for relaying scientific advice to wider Government in an emergency such as the volcanic ash cloud is the MOD Chief Scientific Adviser's (CSA) presence on the SAGE. In addition, in this emergency, the MOD's CSA took on responsibility for co-ordinating MOD's S&T response to the ash cloud and for feeding that in to wider Government scientific advice SAGE.

The Ministry of Defence's own ad-hoc coordination measures, such as the MOD's Chief Scientific Adviser's (CSA) seminar, also facilitated the sharing of knowledge and ideas, and to establish contact between involved parties. Links with private-sector organisations worked well. The MOD CSA hosted a seminar day attended by representatives of DSTL, the Met Office, the RAF and Joint Helicopter Command, Rolls Royce, Academia, the Materials Integrity Group and MOD Defence Science and Technology (DST) to enhance knowledge transfer.

In addition, representatives of MOD DST attended meeting of the Civil Contingencies Committee (Officials) (CCC(O)) to relay details of Government response back to the relevant sections of the scientific community.

MOD is therefore now better prepared for a similar situation in the following respects:

1. The initially developed rapid pragmatic fit for purpose method for identifying volcanic ash contamination is currently being further developed as a more scientifically rigorous process as the contaminating ash composition and distribution becomes better understood.
2. Dstl are familiar with the nature of the measuring equipment required and able to provide it at short notice.
3. The contacts within the network of those who would be involved in any future similar incident are better-established.

APPENDIX D

VOLCANIC ASH—THE WORK OF THE DFT SCIENCE GROUP AND THE CAA

Aircraft and engine manufacturers are responsible for determining what level of ash their products can safely tolerate. Urgent confirmation was needed on whether such a zero tolerance of volcanic ash was necessary to maintain flight safety. From the outset of the crisis, the CAA took the lead in coordinating international efforts with aircraft and engine manufacturers as well as airlines and other regulators to develop new measures to reduce airspace closures caused by volcanic ash. This led to the establishment of a wider area in which it is safe to fly, consistent with the framework agreed by EU Transport Ministers on 19 April—this area being ash concentrations between 200 microgrammes/m^3 and 2,000 microgrammes/m^3, commonly referred to as the "Enhanced Procedures Zone" (EPZ). Manufacturers issued guidance to the operators of their products on the enhanced procedures applicable to their products and operators then submitted safety cases to the CAA to support flight operations in the EPZ.

By 17 May, subsequent work had established a further new area of operations—the "Time Limited Zone"—for operations for a limited time at higher ash densities between 2,000 microgrammes/m^3 and 4,000 microgrammes/m^3. Again, to operate in this zone, airlines need to present the CAA with a safety case that includes the agreement of their aircraft and engine manufacturers. These tolerable limits were agreed by the aircraft and engine manufacturers on the basis of new research and analysis based on evidence gained from this and previous ash encounters. The no-fly zone (concentrations above 4,000 microgrammes/m^3) is under constant review based on scientifically reliable data available to CAA, industry and other regulatory agencies.

CAA, the UK's independent aviation regulator, attended SAGE and kept the group informed of key developments, including evidence-based cases for zoning arrangements. The DfT's CSA established an aviation sub-group, involving aviation, meteorology, volcanologist, geology and engineering experts to peer review the evidence processes to establish threshold for safe flying in volcanic ash. The subgroup reported outputs and recommendations to SAGE.

In addition, the CAA established a "Blue Skies Group" bringing together a range of experts, including SAGE representatives, in aviation, meteorology, geology and volcanology to consider the long term opportunities for improved management of the impact on aviation of ash contamination. The group reached a range of conclusions on managing safety using visible ash, ash accumulation rates and average ash density contours, and recommended further work on improving the methodology for modelling eruptive strength and increasing the usability to the aviation community of forecasting dispersion products. The recommendations of the Blue Skies Group are being addressed by the CAA, Met Office and engine manufacturers in a range of follow-up initiatives to maximise the volume of airspace that may remain open to airlines in the event of further Icelandic volcanic eruptions. These initiatives, in broad terms, seek to establish levels of ash in the atmosphere, the effect of such levels of ash on aircraft and the means to manage the risk.

The CAA is also taking a leading role in the work of the ICAO Volcanic Ash Task Force (IVATF), which has followed work at the ICAO Regional level to refine contingency plans for the ICAO Europe/North Atlantic Region, which is also working to develop means to safely manage flights in the vicinity of ash and minimise flight disruption.

Government Office for Science and the Cabinet Office

14 September 2010

Supplementary memorandum submitted by the Government Office for Science and the Cabinet Office (SAGE 00a)

RESPONSE TO 11 NOVEMBER HOUSE OF COMMONS SCIENCE AND TECHNOLOGY COMMITTEE REQUEST FOR FURTHER INFORMATION ON THE INQUIRY ON "SCIENTIFIC ADVICE AND EVIDENCE IN EMERGENCIES".

1. *The Committee requests that the Government provide it with a full list of SAGE sub-groups and sub-group members set up during the volcanic ash emergency in April 2010 (as mentioned on page 14 of the Government's original written submission).*

The list of SAGE sub-groups and its members is attached at Annex A.

2. *Following yesterday's evidence session on the volcanic ash emergency, it emerged from Professor Brian Collins' oral evidence that some SAGE members were required to sign non-disclosure agreements. The Committee requests an example of the non-disclosure agreement that SAGE members signed with a note on who was required to sign it and why.*

The "Code of Conduct" document signed by SAGE members is attached at Annex B. Also attached at Annex C is a document entitled "Guidance on dealing with the media" which was also circulated to SAGE members.

All non-government members of SAGE were expected to sign the code of conduct in order to ensure conflicts of interest were declared, and clarifying the confidentiality of the group because of its role in providing advice in formulation of government policy.

3. *Minutes of SAGE meetings have not been published and the Committee is seeking insight into the advice that SAGE gave to Government. Therefore it requests that the Government provide a list of documents prepared by SAGE for the Civil Contingencies Committee (CCC), including (i) dates of when they were circulated to and discussed by the CCC and (ii) a short summary of what types of scientific advice each document included.*

Sir John Beddington, acting as Chair of SAGE, attended all CCC meetings on volcanic ash. Sir John provided oral updates from SAGE at each of these meetings, providing an overview of advice on issues such as volcanic activity, meteorology and planning assumptions/scenarios, and answering any specific questions from Ministers. In addition to these oral updates CCC were provided with two papers from SAGE on volcanic ash in April on the following subjects;

— Planning Assumptions paper

  — Paper outlined advice on best case, reasonable worst case, and most probable scenarios taking into consideration what was known about Eyjafjallaj¦¶kull volcanic activity (and other associated volcanoes) and meteorology at that time.

— Volcanic Ash; Indicative scenarios paper

  — Paper outlined the various types of scenarios possible taking into account potential geological and meteorological scenarios.

4. *Lastly, the Committee would be grateful if the Government could provide a timetable concerning the publication of SAGE minutes.*

In light of lessons learned from the use of scientific advice and evidence, and the establishment of SAGE in the swine flu and volcanic ash responses, Government is currently developing guidance for coordinating scientific and technical advice to support UK cross-government decision making during emergencies. The publication of the volcanic ash SAGE minutes is being considered in this light, and the intention is to publish the SAGE minutes, subject to the application of FOI principles, by the end of the calendar year.

Annex A

SAGE SUB-GROUPS AND MEMBERS

METEROLOGY SUBGROUP

Chair:	Professor	Slingo	Julia	CSA, Met Office
Members:	Dr	Thompson	David	Met Office
	Professor	Mobbs	Stephen	NERC NCAS, Leeds
	Professor	Coe	Hugh	University of Manchester
	Professor	Simmons	Adrian	European Centre for Medium-Range Weather Forecasts (ECMWF)

GEOLOGY SUBGROUP

Chair:	Dr	Loughlin	Sue	British Geological Survey
Members:	Dr	Kerridge	David	British Geological Survey
	Professor	Sparks	Steve	University of Bristol
	Dr	Aspinall	Willy	University of Bristol
	Professor	Halliday	Alex	University of Oxford
	Dr	Gilbert	Jennie	University of Lancaster
	Professor	Wilson	Marge	University of Leeds
	Professor	McGuire	Bill	University College London

AVIATION SUBGROUP

Chair:	Professor	Collins	Brian	DfT
Members:	Dr	Aspinall	Willy	Bristol University
	Mr	Elgy	Ray	CAA
	Mr	Evans	Phil	Met Office
	Dr	Haselbach	Frank	Rolls Royce
	Captain	Jones	Bob	CAA
	Mr	Lambourne	David	Rolls Royce
	Mr	McColl	John	CAA
	Mr	Nicholls	Duncan	DfT
	Professor	Pilidis	Pericles	Cranfield University
	Professor	Savill	Mark	Cranfield University

	Dr	Thomson	David	Met Office
	Dr	Walker	Alan	Royal Academy of Engineering
	Dr	Watson	Matt	Bristol University

VOLCANIC HAZARDS ASSESSMENT SUBGROUP

Chair:	Professor	Aspinall	Willy	University of Bristol (BRISK)
Members:	Dr	Jenkins	Susanna	Cambridge Architectural Research
	Dr	Loughlin	Sue	British Geological Survey
	Professor	Sparks	Steve	University of Bristol (BRISK)
	Professor	Spiegelhalter	David	University of Cambridge
	Dr	Thordarson	Thor	University of Edinburgh
	Dr	Larsen	Gudrun	University of Iceland

Annex B

SAGE CODE OF CONDUCT

Scientific Advisory Group for Emergencies (SAGE) Icelandic Volcanic Eruption

CODE OF CONDUCT

1. SAGE members, and respective sub-group members or invited experts, should conduct themselves with integrity and honesty. They should not deceive or knowingly mislead Parliament or the public. They should not misuse their official position or information acquired in the course of their official duties to further their private interests or the private interests of others. They should not receive benefits of any kind which others might reasonably see as compromising their personal judgement or integrity. They should not, without authority, disclose official information which has been communicated in confidence in government or received in confidence from others. Discussions and advice provided by SAGE will remain confidential whilst SAGE is operational. However, information may be released later under the government's principles of freedom of information.

2. Members or invited experts are expected to adhere to the core public service values of integrity, honesty, objectivity and impartiality. This means:

- "integrity" is putting the obligations of public service above your own personal interests;
- "honesty" is being truthful and open;
- "objectivity" is basing your advice and decisions on rigorous analysis of the evidence; and
- "Impartiality" is acting solely according to the merits of the case and serving equally well Governments of different political persuasions.

3. In practice this means:

You must:

- set out the facts and relevant issues truthfully, and correct any errors as soon as possible; and
- use resources only for the authorised public purposes for which they are provided.
- provide information and advice, including advice to Ministers, on the basis of the evidence, and accurately present the options and facts;
- take decisions on the merits of the case;
- take due account of expert and professional advice.
- inform the Chair(s) of all contacts with the media.

4. SAGE and respective sub-groups members or invited experts should inform the SAGE Secretariat in writing of any potential conflicts of interest such as any personal interests relating to these duties, and should inform the Secretariat if any others arise during their work on SAGE. The SAGE secretariat can give advice on what could constitute a potential conflict of interest.

I have read and understood the above code of conduct.

I have declared my conflicts of interest below/I am currently unaware of any conflicts of interest (please delete as applicable).

SIGNED .....

SURNAME (BLOCK LETTERS) .....

FORENAME(S) (BLOCK LETTERS) .....

DATE .....

Annex C

SAGE GUIDANCE ON DEALING WITH THE MEDIA

Scientific Advisory Group for Emergencies (SAGE)

Guidance on dealing with the media

We have received a few enquiries from SAGE members regarding their dealings with the media.

Responsibilities

I would draw your attention to the section in the Code of Conduct which states that members "should not, without authority, disclose official information which has been communicated in confidence in government or received in confidence from others. Discussions and advice provided by SAGE will remain confidential whilst SAGE is operational."

However, you are of course entitled to talk to the media as an expert in your own right. The only restrictions on this are:

- You must not claim to represent SAGE in any way, or allow that impression to be created.
- You must not divulge details of discussions that happened in SAGE, or the outcomes of those discussions.
- You must not pass on any information which you would not have had, had you not been a member of SAGE.

Talking about your own work, or the situation more generally, is not restricted by your membership of SAGE.

Making Statements to the Media

You are not required to have any statements of the media "checked" by us prior to publication. However, if you are unsure whether what you have said violates the Code of Conduct, we will be very happy to check it for you if you would like.

We would also appreciate if you could flag up any statements, interviews etc. to us.

Membership of SAGE

While you are not permitted to discuss SAGE meetings, you are entitled to confirm that you are a member, and publish it on departmental websites etc. as you wish.

However, please be aware that if you publicise the fact that you are a member of SAGE, you may invite increased questioning from the media.

Media Training

We are sure most of you have plenty of experience with handling the media. However, if any of you feel you may need some training on this issue, it may be something we can discuss in the future.

Government Office for Science and the Cabinet Office

16 November 2010

Further supplementary memorandum submitted by the Government Office for Science and the Cabinet Office (SAGE 00b)

RECORD OF THE SEVERE SPACE WEATHER WORKSHOP

Meeting held in Room 35 Great Smith Street, London on 21 September 2010 at 1000.

Representation from Government: Cabinet Office, Ministry of Defence, Her Majesty's Treasury, Department for Transport, Department of Energy and Climate Change, Centre for the Protection of National Infrastructure, Government Office for Science, Department of Health.

Representation from the science community: The Rutherford Appleton Laboratory, The British Geological Survey, The Electrical Infrastructure Security Council, The Meteorological Office.

Representation from the Energy, Communication and Transport Sectors.

(1) Introducing the meeting, the Chair said that the purpose of the meeting was to hold an initial exchange of views on the likelihood of severe space weather and possible impacts. The discussion would contribute to the process Government uses to understand risks in this area.

THE REASONABLE WORST CASE SCENARIO

(2) The selection of the Carrington Event as the basis for a reasonable worse case solar scenario was discussed. Although much work has been done on the scaling of this event compared to other historical events, the data on which this has been based are limited. A full analysis and use of the Carrington event as a reasonable worst case scenario requires the use of "extreme value statistics" and the currently available data allow only rough and preliminary estimates using this technique. Discussion also centred on different scaling factors used between the UK and the US, because of differences in magnetic latitude. Given these uncertainties, the view of most was that the duration and magnitude of a Carrington event scenario cannot at present be used with high levels of confidence.

(3) It was reported that there was a 1% chance of a Carrington-like event occurring during a solar maxima year. The Carrington Event was 150 years ago but the intervening years contain about 30 strong geomagnetic storms of a similar but slightly lower intensity, notably the 1921 storm which damaged telephone networks in Sweden. It was also reported that large geomagnetic storms can be caused by a rapid succession of flare/Coronal Mass Ejections and this has been the case in several important storms. Discussions were held on the increase or decrease in the probability of a severe event in relation to solar maxima and minima years respectively. It was reported that strong solar events can happen at any time, including minima years (eg the 1986 storm), however there is 20 fold increase in likelihood of an event happening during maxima years. Discussions also centred on the robustness of 1% likelihood of a Carrington-like event and whether this was a sufficiently reliable statistic on which to base investment in more resilient technologies.

(4) Concerns were raised about the amount of credible data available which could be used to make predictions about future solar events. It was reported that, while UK Flood risk assessment exploits decades of data from similar streams in different catchment areas to construct long statistical datasets (hundreds of years of data), accurate solar data has only been available for the past 40yrs, and with only one source; the Sun within the Solar System. Around 500 years of good recorded data would be needed to estimate 1/100 year events with high degrees of confidence. Ice core readings containing trapped nitrates have provided data which may be used as a proxy of solar radiation storms over the past 400 years, but no proxy yet exists for geomagnetic storms. It was noted that there has been a very strong scientific focus on the Carrington Event in recent years and that other storms should also be considered to construct a reasonable worst case scenario.

(5) The direction of solar events was discussed. The impact of a Coronal Mass Ejection (CME) of Carrington magnitude is dependent upon the direction of the ejection and the orientation of its magnetic field, relative to that of the earth. In November 2003, a large CME plumed on the west side of the Sun as seen from the Earth. The effects were far less severe than would be expected had the ejection pointed towards the Earth. If the earth were impacted by a severe solar event, disruption would likely be global. The effects would first be directed to the northern and southern Polar Regions by the geomagnetic field but would rapidly extend to lower latitudes through changes in the upper atmosphere. While a direct event passes earth quickly, magnetosphere instability would last for many days.

(6) Impacts on the Communications, Transport and Energy Sectors. There were informal presentations from representatives from the Communication, Transport and Energy sectors on the possible impact on assets in their sectors.

(7) International Co-operation. The Meteorological Office is working with the US NOAA (National Oceanic and Atmospheric Administration) Space Weather Prediction Centre to collect space weather information.

Memorandum submitted by the Royal Astronomical Society (SAGE 04)

1. With more than 3,500 Fellows, the Royal Astronomical Society (RAS) is the leading UK body representing the interests of astronomers, space scientists and geophysicists (including specialists in solar-terrestrial physics).

2. As such, the Society is very much interested in two aspects of this inquiry, namely the Icelandic volcanic ash eruptions in 2010 and the potential emergency situations that could arise from future solar storms.

3. The submission on the Icelandic volcanic ash eruptions will be submitted separately by the British Geophysical Association, the Joint Association of the RAS and the Geological Society.

EXECUTIVE SUMMARY

4. Solar storms or space weather events originate from Coronal Mass Ejections (CMEs), where a large amount of material is ejected from the outer atmosphere of the Sun, and phenomena associated with them. When CME material reaches the Earth, it creates fluctuations in the terrestrial magnetic field and affects a number of natural and artificial systems.

5. Space weather events are relatively common, with their frequency increasing at times of higher solar activity such the forthcoming solar maximum expected between 2012 and 2014. The majority of these events are minor, but larger scale events occur, such as those in 1989 and 2003. The events of 1859 and 1921 were larger still and similar sized storms are anticipated to occur at some point in the future.

6. The RAS notes that space weather events can have a great impact on many areas of civil and military life, including satellites, navigation systems, communications, IT infrastructure including both computer chips and Wi-Fi systems and electrical power grids. In the most severe cases power distribution systems can be seriously damaged at great cost to a national and even the global economy.

7. The RAS further notes that the preparedness of the UK Government for such events remains uncoordinated although progress has been made in recent years by a number of public sector departments and agencies. The Society recommends that these efforts continue and that Government departments are made aware of the impact that a space weather event could have on their "core business." On an international level, the UK should invest more heavily in the European Space Agency (ESA) Space Situational Awareness (SSA) programme which considers this at a European level.

Solar storms: What are the potential hazards and risks and how were they identified?

8. The section of the RAS submission sets out the nature and potential impact of solar storms.

9. "Solar storms" are a popular name for what is generally now called "space weather". This describes severe disturbances of the upper atmosphere and near-space environments, most of which are caused by violent events on the Sun.

10. The most important events in this context are coronal mass ejections (CMEs) which are large bodies of ionized matter (plasma) ejected into interplanetary space when magnetic structures in the outer solar atmosphere (the corona) become unstable.

11. If CMEs encounter the Earth they can greatly enhance the electric currents that naturally flow in space around our planet and thereby create fluctuations in the Earth's magnetic field (magnetic storms).

12. These fluctuations induce electric fields below the surface of the Earth, driving additional current into power grids and affecting their operation. There is significant scientific evidence that the performance of power grids around the world varies with space weather conditions.

13. This is mostly a minor problem, but the strongest CMEs can trigger violent magnetic storms that can damage power grids as happened in March 1989 (when Quebec suffered a power blackout) and in October 2003 (when Sweden was affected in the same way). The 1989 event also damaged UK power systems and the level of space weather protection on the National Grid was raised.

14. The last decade has seen major advances in this area, with the threat from inclement space weather now understood to be global rather than just confined to high latitudes. There is also strong evidence that two severe space weather events in September 1859 and May 1921 would have been much more dangerous to modern power grids (had they existed) than the storms of 1989 and 2003.

15. The magnetic storms created by CMEs also generate profound changes in the density, temperature, composition and wind systems of the upper atmosphere (here defined as more than 100 km above the surface of the Earth). These changes affect radio waves passing through the upper atmosphere—a process used by many civil and military technologies including satellite communications, satellite navigation (GPS), high frequency radio communications, over-the-horizon radars, space-based radars used for earth observation and security surveillance and ground-based radars used to track space objects.

16. In normal conditions these systems mitigate the impact of space weather through choice of radio frequency or by applying correction factors. During a space weather event it becomes much more difficult to determine these—at worst the radio signals can become unstable and the technology can fail. For example, GPS is vulnerable, as demonstrated by problems experienced in the US during the October 2003 space weather event.

17. The other major solar source of severe space weather is "solar energetic particle events", sometimes called solar radiation storms. These are intense bursts of charged particles produced by events in the solar atmosphere, especially the shock waves generated by CMEs. This particle radiation can damage electronics and power systems in spacecraft. The energetic particles can pass through computer chips, changing their digital state, thereby corrupting data and on-board software. This can disrupt the operation of the spacecraft, something that may take several days of work by ground controllers to put right.

18. A severe space weather event can then disrupt the space-based infrastructure (eg communications, navigation) that many activities in society depend on. If spacecraft are permanently disabled, restoring them requires the construction and launch of replacements. Many everyday activities will be disrupted by the lack of satellite capacity and consequent increases in the market costs for space-based services.

19. Energetic particles from the Sun can also enter the Earth's atmosphere, where they collide with the nuclei of atoms to produce neutrons. Some of these neutrons can reach the Earth's surface and raise radiation levels.

20. Like the impact on satellites, this enhanced radiation can disrupt digital systems in aircraft and on the ground. It is important that electronics systems on aircraft are robust against such events, eg through the use of at least triply redundant systems.

21. Similar considerations apply to electronic systems used in critical activities on the ground. For example, safety-critical systems must be robust against single event effects where radiation disrupts computer chips (as vendors will advise).

22. In the most severe space weather events the flux of space radiation entering the atmosphere will increase dramatically (eg on 23 February 1956 UK scientists observed a 50-fold increase at ground level). In these circumstances there is the possibility that the number of single event effects will be too large to be contained by normal mitigation measures.

23. There is also the prospect of widespread failures in non-critical ground systems. Given the widespread use of computer chips to control all manner of devices, it could cause very significant economic and societal disruption.

24. Another potentially disruptive class of solar events are solar radio bursts. These are intense bursts of natural radio noise produced by events in the solar atmosphere, such as CME launches. They are strong enough to interfere with the low power wireless radio technologies that have been widely adopted over the past decade—including mobile telephones, wireless internet, GPS receivers and short range device control systems. Many scientists are interested to see how much these new technologies are disrupted by the strong radio bursts expected during the forthcoming solar maximum (2012–14), with some concern that there is the potential to trigger widespread and highly disruptive simultaneous failures.

25. There are many other solar events that produce space weather effects at Earth, most notably the spectacular explosions termed solar flares. However, these events produce only modest effects at Earth. The Society stresses that these are important for understanding average space weather but less so in respect of the severe conditions that will lead to emergencies that are the aim of the Committee's inquiry.

Solar storms: how does the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

26. Until recently this issue has been addressed separately by different departments and by groups within departments. As a result the RAS believes that the Government's preparedness has become very patchy. Indeed, some Government changes, such as the replacement of the Radio Communications Agency by Ofcom, have inadvertently reduced, and perhaps lost, the technical capability and coordination that underpins preparedness (eg the widespread disruption of radio communications that could arise during a severe space weather event).

27. This situation has been very frustrating for members of the solar-terrestrial physics community who wish to transfer relevant knowledge to potential users in government and industry. The situation in the UK has been very unsatisfactory compared to other countries such as Belgium, France, Germany, Spain and the US.

28. The Society acknowledges positive steps taken over the past few years. These include:

- UK membership of the ESA Space Situational Awareness programme, established in 2009, which focuses European efforts on space hazards and works with the parallel US programme.
- Establishment of the UK Space Agency in April 2010, which should provide better leadership in space activities.
- Work to prepare a National Space Security policy, including protection of assets at risk from space weather.
- Discussions about including space weather hazards in the National Risk Register.
- Recognition of the need for international exchange of space weather data by MOD in its 2006 Defence Technology Strategy.
- Development of the e-LORAN navigation system by the General Lighthouse Authorities. This recognises the need for a navigation system that uses a different technology to GPS and thus provides redundancy in the case that GPS is degraded by natural or human interference (including that from space weather).

29. Thus the RAS welcomes the Government move towards a position where it is much better prepared to address emergencies caused by space weather. It is a work in progress with much to do, but the first steps have been taken. An important aspect of this progress is the opening up of communications between the scientific and policy making communities. This is crucial—the scientific community needs to become more aware of what information is needed by the policy community and vice versa, policy makers need to become aware of the relevant scientific capabilities that exist in the UK. These capabilities are intellectual, physical and computational and are set out in the "List of potential UK space weather assets" of Rutherford Appleton Laboratory's Professor Mike Hapgood. They include work taking place at universities, public sector research facilities and private sector companies.

30. The recent transfer of Earth-Orientated Solar-Terrestrial Physics (EO-STP) from STFC to NERC is a valuable step towards this goal since the scope of EO-STP includes many aspects of space weather. In particular, EO-STP addresses the effects of space weather that have greatest economic impact, namely those that affect the Earth's surface and upper atmosphere. NERC is experienced in building links between science and the policy community, eg through its natural hazards programme. Thus it is well-placed to promote such links for space weather and, indeed, is already working with the scientific community to see how space weather might fit into the natural hazards programme.

31. Some responsibility for space weather science lies with other bodies:

— STFC—UK research into the solar sources of space weather and their propagation to Earth.

— UK Space Agency—operations of space-based science instruments such as the UK-led Heliospheric Imager on the NASA STEREO mission.

— EPSRC—research on specialist aspects of space weather, eg advanced tools for analysis of solar images, modelling space weather impact on the National Grid.

— MOD—measurement and research programmes linked to specialist interests.

32. The major obstacle to provision of reliable, timely scientific advice and evidence has been the fragmentary nature of governmental activity in this area. Indeed, the past experience of the expert community has been that of "pass the parcel", ie when a particular body is asked, the responsibility always lies elsewhere. It is timely to establish a more coordinated approach to space weather as has been done in other countries, notably the US with its National Space Weather Programme, but also our European partners such as Belgium, France and Germany. In all these countries, space weather activities are spread over a number of bodies, including the military but national coordination allows them to work together to deliver effective scientific advice.

33. Another barrier to the provision of scientific advice has been the attitude in some bodies that potentially useful space weather research should be immediately transitioned to end user funding without any consideration (or funding) of processes to mediate that transition. This has discouraged many scientists from exploring how to apply their research, including as advice to government and industry. Recent developments suggest that this attitude is passing, which is very welcome but it is important that funding mechanisms provide positive encouragement for scientists looking to apply space weather knowledge.

34. The Society recommends the establishment of a process to coordinate UK space weather research activities, perhaps building on and formalizing existing community efforts. NERC and the UK Space Agency should both be major players in this process, but it should operate at RCUK level to ensure that other Research Councils are engaged. It should also build links with public and private sector bodies that are potential users of space weather research outputs.

35. Finally the RAS notes that a crucial aspect of the scientific evidence on space weather is the data produced by scientific instruments monitoring space weather—some based in space and many based on ground. As in meteorology such measurements are an international enterprise with countries making an appropriate contribution but having access to the global set of data.

36. The proposed national coordination on space weather should include the coordination of UK space weather monitoring activities and especially the need to develop funding mechanisms that strike a balance between research needs and user needs for space weather data. It should raise awareness in other government bodies (eg MOD, CAA, DECC and DfT), and perhaps industry, of where space weather monitoring is relevant to their core business.

International Coordination

37. Space weather is a global phenomenon. A severe space weather event will affect the whole planet; indeed it will affect the whole of our solar system. The severe event of October 2003, already mentioned above, had profound effects on several deep space missions. The radiation storm within this event blinded navigation sensors on ESA's Mars Express spacecraft, then en route to Mars and destroyed a radiation sensor on NASA's Mars Odyssey spacecraft which was already orbiting the red planet. There is no safe hiding place from a very severe space weather event.

38. It is therefore widely recognised that space weather is a natural topic for international cooperation. Much of this cooperation is now being focused as a major element of Space Situational Awareness (SSA) or knowledge of conditions in space that are relevant to human activities.

39. Both ESA and NASA have established SSA programmes and are looking to space weather as the key area for cooperation but the UK is only weakly linked into this activity. Britain has joined the ESA programme but only at a minimum subscription level. This means that the UK only plays a minor role in and cannot lead the SSA space weather activities, with limited influence on the evolution of the programme. If this continues, it is likely that other member states will develop capabilities that outstrip those currently available in the UK.

40. For example, ESA recently announced an opportunity to develop a solar imaging instrument for the SSA programme. This would have been a good opportunity to build on UK capabilities, such as those used on the recently launched NASA Solar Dynamics Observatory mission. However, the UK was not able to

propose this because of our limited engagement in the relevant ESA programmes. Other opportunities are likely to emerge in the future, but UK experts will be excluded whilst the current funding arrangements continue.

41. It is worth noting that Finland, another country with good space weather skills, has recently (June 2010) joined the SSA programme. Finland had stayed out of the programme at its launch in January 2009, but changed policy when it became clear that the programme offered opportunities to develop their space weather capabilities.

42. The RAS therefore strongly recommends that the UK subscription to the ESA SSA programme should be reviewed and increased as soon as financial conditions allow. We note that the SSA programme operates under the ESA juste-retour rule so that UK expenditure on this programme will feed back to the UK as contracts to UK bodies. Membership would thus help those bodies to expand their space weather skills and thus provide better inputs to government. It would also enable the development of UK-based space weather services that would become part of the growing space export market.

Royal Astronomical Society

2 September 2010

Supplementary memorandum submitted by the Royal Astronomical Society (SAGE 04a)

SPACE WEATHER EFFECTS ON THE GALILEO SATELLITE NAVIGATION SYSTEM

1. The memorandum is submitted in response to a Committee request for further comments on the resilience of Galileo to space weather.

2. The European satellite navigation system, Galileo, is being developed to complement the Global Positioning System (GPS), which is owned and operated by the US Department of Defence. Galileo is one of a number of non-US systems satellite navigation systems; others include the GLONASS system operated by Russia and Compass or Beidou-2 system being developed by China.

3. All these satellite navigation systems, including Galileo, exploit the same scientific principles—namely the reception of suitable radio signals from a network of spacecraft can be used to determine the location of the satnav device and give a precise measure of the current time. Any satnav device must receive signals from a minimum of four spacecraft to obtain a precise location and time.

4. The Galileo programme is applying lessons learned from GPS to develop its system so that it will deliver more accurate location data than is provided by the existing GPS service. This includes increased resilience against the day-to-day effects of space weather, eg by incorporating more sophisticated models of those effects.

5. The existence of complementary systems, such as Galileo and GPS, will provide a level of redundancy against random failures of any one system, eg through the use of satnav devices that can simultaneously use the complementary systems. However, it does not provide redundancy against extreme space weather events because those events are global phenomenon—and thus have the potential to induce many simultaneous failures across all these systems.

6. This potential for simultaneous failures arises because these systems operate on the same scientific principles. Thus they are all vulnerable to the same space weather effects:

— Damage to satellite sub-systems by radiation or electrical charging.

— Solar radio bursts interfering with the satnav signal.

— Disruption of the satnav signal as it passes through Earth's upper atmosphere.

7. Space weather damage to these satellites is treated very seriously. The GPS satellites are military systems and thus are thought to incorporate a high level of protection against both hostile human interference and space weather. The Galileo programme also aims to build its operational spacecraft so they incorporate good protection against space weather. The two Galileo test spacecraft now in orbit carry a number of radiation monitors, several of which are UK-built. The data from these monitors are now available to researchers via agreements with the Galileo programme. This will help to build up UK and other European understanding of the radiation and charging environment that Galileo will face. The EU FP7 programme has just funded several research projects in this area and these include significant UK participation and leadership.

8. Solar radio interference with satnav systems was well demonstrated by an intense solar event at around 19:30 UTC on 6 December 2006. This caused widespread temporary failure of GPS receivers across North and South America. Fortunately, the event occurred well after sunset in the UK, so no effects were recorded here. Future solar events, occurring during UK daytime, could disrupt the reception of the weak signals from both GPS and Galileo. The direct impact would be a brief (10 mins) loss of satnav signals, but we do not yet understand the wider economic and societal impact from simultaneous loss of many satnav systems.

9. The radio signals from GPS and Galileo are very slightly delayed (compared to travel at the speed of light) as they cross Earth's upper atmosphere. Satnav receivers must correct for this delay to give a precise position. During severe space weather events the corrections may be become inaccurate, so it is important (a) to warn satnav users of this inaccuracy via the "integrity flags" included in signals sent to satnav receivers and (b) for users to then switch to backup navigation systems.

10. The radio signals from GPS and Galileo are also subject to scintillation due to turbulence in Earth's upper atmosphere (this is the radio equivalent of the twinkling of stars due to turbulence in the lower atmosphere). Severe scintillation can cause receivers to lose satnav signals—and thus loss of position and time data. However, these bad conditions are usually confined to polar regions and to equatorial regions (the latter especially around dusk). During severe space weather events the aurora borealis (Northern Lights) may expand from the polar regions and cover the UK. In those circumstances, we should expect severe scintillation and loss of satnav signals over the UK.

11. The risk of losing satnav signals (both GPS and Galileo) to natural interference (solar radio bursts and scintillation) is very dependent on receiver design. There is considerable scope for engineering mitigation of these effects by good design. It is important to raise and maintain market awareness of this so that vendors are encouraged to provide high quality equipment and users recognise the need to buy such equipment when they have critical requirements for accuracy.

12. It is important to complement with satnav with other navigation systems that have different response to space weather. An excellent UK example is the e-LORAN system being developed by Babcock (formerly VT Communications) under contract to the General Lighthouse Authorities. This uses a ground-based radio system operating at very different frequencies to GPS and Galileo.

Mike Hapgood
Royal Astronomical Society

24 November 2010

Memorandum submitted by the Royal Aeronautical Society (SAGE 10)

Executive Summary

The eruption of the Eyjafjallajokull volcano had a big impact on the Air Transport industry, causing considerable disruption and economic cost. There are recognised international procedures for avoiding flight in ash clouds, which were followed by UK and European regulators. Monitoring and evaluating the progress, extent and danger of the cloud often entailed taking decisions with partial data and imperfect models. The UK professional agencies in the main responded appropriately and well; some of the UK governmental structures responded less well. However, the UK in general was able to lead Europe in coping with the crisis.

An intense period of solar storms is likely, and will have the potential to cause considerable disruption to space-based hardware and especially communications on which many key terrestrial services have come to depend. The ability of the UK and Europe to assess and to respond to the resultant crisis is currently limited. However, steps are being taken to increase understanding of solar storm risks and to establish appropriate procedures.

Introduction

1. The Royal Aeronautical Society (RAeS) is the world's only professional body dedicated to the entire aerospace community. Established in 1866, the Society has 17,000 members in over 100 countries (including 3,500 classified as young members), and is a leader and provider of foresight within the aerospace community. The work of the Society is supported by a number of specialist groups including a Flight Operations Group and a Space Group. The Society's response focuses on two of the case studies—the impact of volcanic ash on air transport and solar storms.

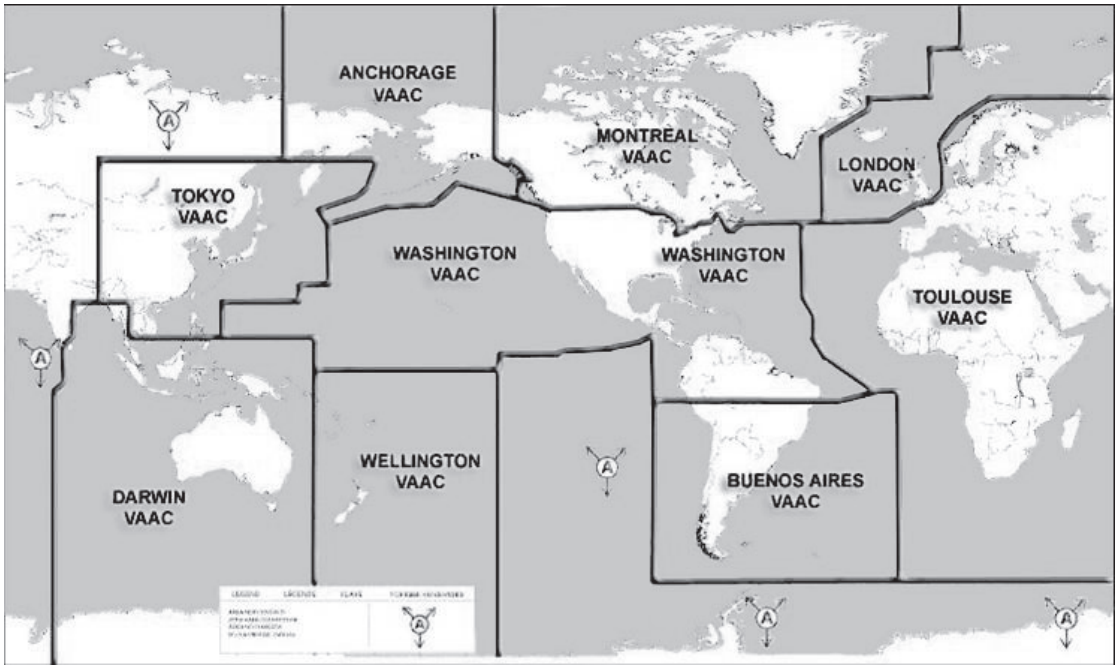
Volcanic Ash

2. The affects of volcanic ash clouds on civil aircraft have been recognised for some time. These primarily relate to the dangers of material ingested into jet engines leading to immediate loss of power, or a cumulative effect on engine performance and durability as a result of chemical bonding on fan and turbine blades and blockage of inlets. In at least one well known incident, a BA Boeing 747 lost power from all four engines over Indonesia, but recovered after an emergency restart to make an emergency landing.

Detection and monitoring of the eruption

3. Detecting and monitoring of the eruption including quantitative information on the size, composition and other physical features of the ash cloud, plus forecasting the movement of the ash and gas clouds into the future.

4. The first step (detection, monitoring and forecasting) is coordinated under the auspices of the International Civil Aviation Organisation (ICAO). Nine Volcanic Ash Advisory Centres (VAACs) are located around the world, each responsible for providing the information on eruptions in a defined geographical region—see map. Approximately 60 volcanic eruptions occur each year many close to well travelled air routes, for example across the North Pacific and in South-East Asia, the Caribbean and South America. For the Eyjafjallajokull eruption, the UK Met Office was the responsible VAAC. Data from a mix of ground, air and space platforms was used by the UK Met Office together with its Numerical Atmospheric-dispersion Modelling Environment (NAME) computer model.



5. On 26–27 May 2010, following the eruption, a workshop in Frascati Italy took stock of Europe's remote sensing capabilities to address the impact of the Eyjafjallajokull eruption.[15] The recommendations of the Frascati and an earlier meeting prior to the Icelandic eruption in Chile, provide an authoritative and up-to-the-minute view of what actions can and should be taken to improve the detection and monitoring of eruptions as concerns our ability to cope with the consequences of future events for air transport.

6. The Chilean workshop noted that instrumentation on the European Meteosat Second Generation (MSG) weather satellite offers superior spectral, spatial, and temporal capabilities compared to the other geostationary instruments currently in orbit. MSG covers Europe, Africa, and the Atlantic as far as the Lesser Antilles, which means that significant improvement in satellite ash detection for Europe and Africa is already in place that will not be available in the Americas for example until after 2015 when the GOES-R satellite is due to be launched.

7. The Frascati workshop concluded that "the London VAAC did an excellent job on the monitoring and forecasting of the movement of the volcanic ash during the Eyjafjallajokull eruption" and noted that "the collection of remote sensing data, acquired over the period of the eruption of Eyjafjallajokull l, presents a remarkably rich source of information for studying this event".

8. The workshop summarised the two major lessons learned from the experience:

— One of the largest uncertainties was information on the eruption source parameters for model initialisation which leads to discrepancies in model outputs. Action is needed to ensure that accurate and timely data are available from volcano observatories or monitoring stations situated near volcanoes. In addition to monitoring the eruptions as they progress, satellites are recognised as able to provide early warning, ie: advance notice, of volcanic eruptions by detecting hot spots or sulphur dioxide emissions.

— The second big uncertainty was obtaining information on ash cloud concentrations. There is pressing need for further development and application of techniques for incorporating satellite data in forecast models in order to provide quantified ash cloud advisory information including height.

[15] ESA/Eumetsat workshop on Volcanic Ash Monitoring, 26–27 May 2010 at ESA/ESRIN in Frascati (Italy) involving 53 invited scientists from Universities, Meteorological Offices, Research Laboratories, national and international Agencies (eg DLR, EC, ECMWF, NASA, USGS) from Europe and the United States; the draft report is available at: http://earth.eo.esa.int/workshops/Volcano/files/STM_280_ash100801_2v.pdf and is provided as part of this evidence.

9. The space community is already responding to the recommendations of the Frascati workshop, with studies to be made of potential new satellites and instruments dedicated to monitoring volcanic ash plumes and eruptions. The European Space Agency has already adjusted an ongoing study on a class of sensors called lidars to address this question.[16]

The hazard and standard procedures

10. There are established procedures to cope with eruptions. ICAO rules are clear: any flight in known volcanic ash is to be prohibited.[17] This ruling was followed in the case of the Eyjafjallajokull eruption defaulting to the safe condition of grounding of most flights over the United Kingdom and Northern Europe. This was at some cost to the European transport industry, estimated to be in the order of £100–£200 million (US$150–300 million) per day (with doubtless greater losses to the rest of the economy).[18] The Eyjafjallajokull eruption was especially disruptive due to unseasonable weather conditions and the fact that this eruption covered a particularly intense part of the global air transport network.

11. The hazards presented by the 2010 Eyjafjallajokull (E15) eruption were the potential damage that volcanic residues (ash and chemical aerosol) could cause to flying aircraft, in particular jet aircraft carrying passengers. The presence of this hazard was identified by the United Kingdom VAAC operated on behalf of the International Civil Aviation Organisation (ICAO) by the Met Office (a trading fund of the Ministry of Defence). These hazards were identified from local reports of volcanic eruptions, then forecast models run at Met Office's headquarters in Exeter. This information was then supplied to the UK's Civil Aviation Authority (CAA) and National Air Traffic Services (NATS).

Government preparations for the emergency and use of scientific advice

12. Some parts of UK government handled this emergency extremely well, others less so. It must also be recognised that the lack of elected leadership through this crisis was particularly unfortunate, coinciding as it did with the general election campaign. Senior participants were aware in the early part of the crisis of the considerable intellectual leadership of Lord Andrew Adonis as both transport and science minister; but once the election campaign was under way this leadership was not apparently replaced by a single either elected or appointed official or by a defined group. The main agencies involved were:

Civil Aviation Authority (CAA)

13. The CAA initially closed UK airspace, appropriately and promptly, in accordance with ICAO procedures. There was an expectation that leadership in these issues would be taken by the European Aviation Safety Agency (EASA); once this was not forthcoming from EASA, the CAA through its Head of Airworthiness rapidly created a working conference of all available national and international experts which subsequently steered UK (and through example, Europe) to timely solutions.

Met Office

14. The Met Office, acting as an agency of the MoD, has a role in providing support to the UK in cases of civil contingency. In this case, it was the UK VAAC and provided regularly updated information to CAA on the status of the ash cloud.

15. The Met Office rapidly redirected the available scientific resources to develop an under standing of the problems and to provide advice to central government. However in the early stages of the crisis there appears to have been a deterioration in communications, which led other organisations to question the Met Office's role and competence. Later in the crisis, the Met Office more effectively took on a scientific leadership role.

Department for Transport (DfT)

16. A few days into the crisis, the DfT attempted to assume a leadership role. However, this largely confused issues rather than helping, tending to interfere with the work of the CAA and other scientific actors who by that time already had a better appreciation of the situation and scientific competence and were far better placed to lead the response.

The Natural Environment Research Council (NERC)

17. The Natural Environment Research Council (NERC) is operator of the Dornier 228 Airborne Research and Surveying Facility (ARSF), and 50% owner with the Met Office of the Facility for Airborne Atmospheric Measurements (FAAM), operating the BAe-146-301 large Atmospheric Research Aircraft (ARA).

[16] Lidar: loosely derived from "Light Detection And Ranging"
[17] ICAO, *Volcanic Ash Contingency Plan: EUR Region,* 2nd Edition September 2009 (available at http://www.skybrary.aero/bookshelf/books/357.pdf)
[18] http://www.telegraph.co.uk/finance/newsbysector/transport/7641020/Volcanic-ash-cloud-cost-air-industry-2bn.html [accessed 13 August 2010]

18. NERC reconfigured ARSF using instruments from FAAM and was obtaining airborne data to supply CAA and the Met Office within 11 hours of the initial airspace closure. Once it was realised that this emergency was not short term, NERC worked with the Met Office to make the ARA available within six days of the initial airspace closure. NERC's National Centre for Atmospheric Sciences (NCAS) and British Geological Survey (BGS) took an immediate national lead in providing expert advice as required on the non-engineering scientific issues that became live. Subsequently, NERC's British Atmospheric Data Centre (BADC) took the European lead in collating all data that was collected by various means.

National Air Traffic Services (NATS)

19. National Air Traffic Services (NATS) ensured timely closure of airspace once volcanic ash was known to be present, subsequently taking instruction from the CAA.

Ministry of Defence (MoD)

20. MoD was heavily affected, primarily as a large operator of aeroplanes. It was able rapidly to take appropriate advice and decided that flying would only be authorised for lifesaving purposes, whilst keeping the situation under review. Appropriate MoD laboratories were also rapidly redirected to investigating necessary airworthiness issues. There was to some extent a failure on the part of MoD to ensure adequate coordination with the airworthiness efforts centre on the CAA. Better coordination between MoD and CAA would have been beneficial.

Cabinet Office Civil Contingency Office

21. The Cabinet Office's Civil Contingency Office co-ordinated with the Department for Transport and others, but like DfT, it came relatively late to the event and failed to recognise the leadership already assumed by other actors, particular by the CAA, Met Office and NERC.

The Government Chief Scientist

22. The Government Chief Scientist formed a Scientific Advisory Group for Emergencies (SAGE), which brought together a wide group of appropriate scientists—albeit under some secrecy. SAGE appears to have acted as a useful co-ordination medium for those senior scientists, but the lack of visibility of its existence and membership perhaps degraded its usefulness, since other players within the emergency could otherwise have perhaps been able to contact individual members with requests that SAGE acted as a co-ordinator for other critical communications.

Government agencies' understanding of the crisis—a summary

23. There were clear differences between government organisations in the degree of scientific and situational understanding of the crisis. The CAA, with the Met Office and NERC close behind had the clearest understanding of a difficult and complex problem where data and scientific modelling were often uncertain. The MoD had good scientific appreciation but did not heavily engage with the civil efforts. The DfT and the Cabinet Office had a poor scientific understanding for much of the time; this weakened their situational appreciation, rendering their attempts to adopt leadership roles often ill-judged. SAGE clearly had good scientific literacy, but the relative secrecy of its operation was an obvious weakness.

Obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies

24. However, it is clear that, despite some problems, the UK agencies worked very well together—certainly far more coherently than any other country in Europe. Decision makers had access very rapidly to high quality scientific advice, which was freely given.

25. There were occasions where this advice was not adequately used; the most obvious of these being that considerable resources were expended on the problem of flying research aircraft into the core of the ash plume. Scientific advice was that this was both unnecessary to achieve a good understanding of the situation, and endangered vital national assets. For example, the USA withdrew an offer to lend aircraft because they, like the UK aircraft operators, were unprepared to fly into the core of the ash plume—indeed a NASA DC8 did so in 2000 and suffered US3.2 million of damage. Despite these strong caveats from expert bodies, senior management in several organisations pursued this course of action, distracting them from more important issues.

Government powers and resources

26. In most cases, the Government had sufficient power resources to get to grips with the problem. The largest obstacle was financial commitment—the DfT were particularly very reluctant to underwrite the cost of damage to, or to pay for the use of airborne resources committed by NERC and the Met Office. The DfT still has not done so, with the risk that these resources will not be available be in a future emergency.

The adequacy and timeliness of scientific evidence informing policy decisions

27. Scientific evidence was available from various sources—universities, NERC and the Met Office worked together to provide geological and atmospheric science advice freely available as and when required by decision makers. The CAA worked with aircraft and engine manufacturers to ensure a high level of understanding of the engineering science problems and thus the airworthiness implications.

Strategic coordination

28. Strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies was less effective Preparation for this emergency was essentially non-existent and almost all coordination occurred *ad-hoc*. Nonetheless, the quality of this *ad-hoc* decision making structure turned out to be very good, and served the UK very well.

29. It could be argued that a scientifically and managerial competent "national emergency co-ordinating body" could have provided better leadership—although in this instance this might have been doubtful given the special circumstances surrounding this crisis. However, it was clear that the required leadership ultimately came down to a small number of key individuals who might not be present in a comparable emergency in the future.

International coordination

30. International coordination was necessary on two levels; sharing of information and the coordination of resources.

31. The sharing of information worked extremely well; aeronautical engineering data exchange was coordinated through the CAA's airworthiness/volcanic ash teleconferences and supporting communication. Such sharing was probably unprecedented in the history of aeronautics.

32. International (as opposed to British national) coordination of resources was often very poor. US Government offers of resources were wasted through lack of understanding in the senior ranks of HMG organisations. The Spanish government requested a one-day "hire" of the ARA to try and unlock Spanish airspace, which was refused by HMG in order to hold the aircraft in reserve when it was clear that it was not going to be required at the time.

Solar Storms

33. The volcanic ash crisis was an unusually disruptive event but in all probability volcanic eruptions will occur again in the European area. Solar storms are also regular natural phenomena, but we have yet to experience a major event that has the potential to have a disruptive global impact on satellite-based or dependent services. There have been a number of serious local disruptive events.

34. In the USA, the National Oceanic and Atmospheric Administration (NOAA) is mandated to provide space weather information. In the same way that NOAA supplies information freely about earth-bound weather, anyone interested in the subject of space weather can obtain it from the NOAA Space Weather Prediction Centre (SWPC).[19] There is no equivalent arrangement or organisation in the UK, although there has been some discussion about the Met Office setting up a UK Natural Hazards centre to cover all aspects of natural hazards including space weather.

35. In 2009, the European Space Agency began a Space Weather activity within its broader Space Situational Awareness (SSA) programme. During the first three years, that is until 2011, ESA is consolidating the requirements for SSA information, and performing architectural design studies of the complete SSA system. SSA is an optional ESA programme[20] and the UK has opted not to fund any activity in the space weather area.

Effects of Solar Storms

36. Space weather is driven by the sun which experiences outbursts (solar storms) from time to time. The consequences of severe solar storms can be significant. Anecdotal evidence mentioned in a US National Research Council (NRC) report[21] and the recent POST leaflet includes:

— the collapse within 90 seconds of north-eastern Canada's Hydro-Quebec power grid during the geomagnetic storm of March 1989 affecting several million people for nine hours;

— the outage in January 1994 of two Canadian satellites during a period of enhanced energetic electron flux; recovery of the 2nd satellite took six months and cost $50–70 million;

[19] http://www.swpc.noaa.gov/

[20] Each Member State chooses how much to subscribe to the programme and in which of three broad areas: space weather, space debris and Near Earth Objects (asteroids)

[21] *Severe Space Weather Events—Understanding Societal and Economic Impacts; a workshop report*; National Research Council, 2008. Summary: http://www.nap.edu/nap-cgi/report.cgi?record_id = 12507&type = pdfxsum

— the diversion of 26 scheduled airline flights to less-than-optimum routes during disturbed space weather in January 2005 resulting in increased costs and journey times and disrupted flight connections;

— disabling of part of the US Federal Aviation Administration's air traffic management infrastructure for 30 hours during severe space weather in October-November 2003; and

— an hour-long power outage in Sweden and permanent disabling of a $640 million Japanese satellite during those same autumn 2003 solar storms.

37. The historical record contains descriptions of solar storms much more severe than anything experienced in the past 30 years. By several measures, the most severe space weather event recorded was the so-called Carrington event of 1859 which disrupted telegraph services and produced spectacular aurora displays. Another extreme event occurred in 1921. The impact of an event similar to the 1859 or 1921 events today is likely to be much greater due to our increased reliance on electricity-based technology. The NRC report mentions "an estimate of $1–2 trillion during the first year alone for the societal and economic impact of a severe geomagnetic storm scenario with recovery times of four to 10 years".

Information sources

38. Information about solar storms comes from ground-based and space-based sensors. Two examples illustrate the importance of spacecraft in this context:

— STEREO: NASA's two STEREO spacecraft, each carrying a UK-built Heliospheric Imager, are giving us the first 3-D view of solar storms, allowing us for the first time to track solar outbursts while they are in transit to Earth.[22]

— ACE: NASA's ACE spacecraft is located 1.5 million km closer to the sun than Earth, and is thus the only means of measuring material ejected by the sun before it reaches the Earth.[23]

UK Initiatives and Research

39. The UK Centre for the Protection of National Infrastructure (CPNI) "provides integrated security advice (combining information, personnel and physical) to the businesses and organisations which make up the national infrastructure. Through the delivery of this advice, CPNI protects national security by helping to reduce the vulnerability of the national infrastructure to terrorism and other threats."[24] The CPNI has also placed a contract with Logica to study reliance on satellite technology in a number of key sectors of the UK economy. While the affects of solar storms are not explicitly identified as one of the threats, they will be considered. The study is due to be published early in 2011.

40. The Royal Astronomical Society sponsors an initiative called MIST to coordinate the science community "with interests in physical processes within the Sun-Earth system and other planets".[25] Research into solar weather was until recently funded primarily by the Science and Technology Facilities Council (STFC), but parts of that responsibility have now been given to the Natural Environment Research Council (NERC) and the new UK Space Agency. It is too soon to say what effects this change will have.

41. A particularly interesting initiative is that by the University of Strathclyde in defining a highly innovative concept to place a space probe even closer to the sun than the ACE spacecraft mentioned above.[26] The result would be a tripling of the warning time afforded by ACE and much of the key technology underpinning the concept was developed in UK industry.

Conclusion

42. Solar storms of the severity of those experienced in 1921 and 1859 could cause severe economic damage. The degree to which such an event will impact on the UK is not clear, but future studies may provide better understanding of the scope and potential costs.

Final Words

43. The Icelandic eruption caused considerable disruption to European air transport, with significant economic cost and inconvenience to a large number of people. Severe solar storms may have the capacity to inflict even more disruption to services on which global society has come to depend. In the case of the latter, it is imperative that the UK government uses scientific expertise early to anticipate the likely effects on the UK and to propose ameliorative strategies.

[22] http://www.nasa.gov/mission_pages/stereo/main/index.html
[23] http://www.srl.caltech.edu/ACE/ACE is located close to the L1 Lagrange point where sun and Earth gravity cancel each other out.
[24] http://www.cpni.gov.uk/aboutcpni188.aspx
[25] www.mist.ac.uk
[26] McKay, R J, et al (2009) Non-Keplerian orbits using low thrust, high ISP propulsion systems. In: 60th International Astronautical Congress, 12–16 October 2009, Daejeon, Korea; available from: http://strathprints.strath.ac.uk/12919/

44. A volcanic incident on the scale of the Eyjafjallajokull eruption is likely to reoccur somewhere else in Europe, and a repeat event is predicted for Iceland. In the latter case, the UK will again be in the forefront of any response. While on balance the system worked reasonably well under a severe test—particularly the agencies tasked to evaluate and assess the situation as it evolved—it is to be hoped that the appropriate lessons will have been learned from recent events. This applies particularly in the way in which central government institutions might work better to use the scientific advice that was available. However, the Society does commend the political leadership of Lord Adonis for resisting pressure from commercial interests to open airspace without confirmation by evidence.

Royal Aeronautical Society

September 2010

Memorandum submitted by the Research Councils UK (SAGE 22)

EXECUTIVE SUMMARY

1. This response makes a number of general introductory points about the wider role of the Research Councils in providing scientific advice and evidence in emergencies, and responds to case study questions relating to swine flu, the Icelandic volcanic ash eruptions and solar storms.

2. The 2009 H1N1 pandemic potentially posed a major challenge to public health. RCUK considers that the Government was well prepared for the emergence of H1N1 in terms of planning for vaccine development and provision and an established antiviral stockpile. Research funders and the research community responded jointly and swiftly to the emergency. However, securing necessary approvals for clinical studies and staff recruitment in academic institutions presented challenges.

3. UK research particularly that supported by national capability was central to assessing the threats posed by volcanic ash, including that to airspace. UK scientists provided crucial evidence to inform policy decisions, necessary liaison with Icelandic authorities, and continue to work with aviation authorities globally. Whilst the UK was able to dispatch aircraft to carry out investigative flights in the immediate aftermath of the eruptions, a better coordinated approach to such flights at a domestic and international level is recommended.

4. Advisory structures, such as the Scientific Advisory Group for Emergencies (SAGE), which was initially established during the H1N1 pandemic, played an important role in the response to both of these emergencies. Effective information sharing and additional subgroups to consider the consequences of specific threats would further enhance this capability.

5. Space weather events today would have far greater implications on society, due to our greater reliance on technology, than past events. The UK Research Councils are the significant funders of relevant research and investment programmes. Unlike international partners, the UK lacks national coordination on space weather, although the flow of advice from the solar-terrestrial physics community to Government is growing. The establishment of the UK Space Agency could have significant bearing over the direction of the UK's strategic investment in space weather preparedness and related areas.

INTRODUCTION

6. Research Councils UK (RCUK) is a strategic partnership set up to champion the research supported by the seven UK Research Councils. RCUK was established in 2002 to enable the Councils to work together more effectively to enhance the overall impact and effectiveness of their research, training and innovation activities, contributing to the delivery of the Government's objectives for science and innovation. Further details are available at www.rcuk.ac.uk.

7. This evidence is submitted by RCUK on behalf of the Research Councils listed below and represents their independent views. It does not include or necessarily reflect the views of the Science and Research Group in the Department for Business, Innovation and Skills. The submission is made on behalf of the following Councils:

- Biotechnology and Biological Sciences Research Council (BBSRC).
- Engineering and Physical Sciences Research Council (EPSRC).
- Economic and Social Research Council (ESRC).
- Medical Research Council (MRC).
- Natural Environment Research Council (NERC).
- Science and Technology Facilities Council (STFC).

8. The Research Councils play a key role in ensuring the long-term health of inter-related but distinct disciplines over long timescales. By building national capability RCUK ensures that the UK is equipped to respond to and research both known, developing and unknown challenges and potential threats.

9. The importance of maintaining a publicly-funded research base and ensuring a suitable structure through which policymakers can elicit and assess evidence drawn from academic research cannot be underestimated, both in terms of advance warning of potential emergencies and in times of crisis. Applicants for Research Council funding are required to indicate how their research may be relevant to others and how they plan to help those others to be aware of this.

10. Mechanisms for dialogue already exist between Research Councils and Government departments and agencies, such as regular concordat meetings to discuss arrangements for liaison and collaboration. RCUK-funded researchers have given expert scientific advice to advisory groups, such as the Scientific Advisory Groups for Emergencies (SAGE), which ensure that the UK has on-going consortia of experts providing reliable, timely scientific advice to inform policy decisions and identify research priorities. Effective information sharing and additional subgroups to consider the consequences of specific threats would further enhance this capability.

11. RCUK considers that there is a need to examine how research in priority areas with small research bases can be activated in response to new or emerging threats. Furthermore, it is important to ensure that sufficient resources are identified and available to Research Councils to continue to be able to rapidly fund high quality research during emergencies to inform policy decisions.

12. In times of crisis the processes used to develop scientific advice should be made clear, as should the policymakers' assessment of the robustness of the available evidence. To the extent that those policy decisions remain in place beyond the crisis, steps should be taken to re-visit and revise the evidence and scientific advice, and to make adjustments to the policy if appropriate. Principles of quality, engagement and transparency should still be followed as far as is practicable.

13. The importance of transparent and accountable scientific advice without compromising conflicts of interest needs to be recognised so that interactions between co-operating bodies do not suffer problems with real or perceived conflicts of interest.

14. RCUK recognises the tensions which can arise between implementing measured scientific and operational activities and the pressure that governments are under to appear to respond immediately to emergencies.[27] However, it remains vital that relevant scientific advice and evidence should be sought and acted upon as appropriate with clear lines of communication open between policymakers and Government and that the strengths and limitations of any evidence or models are fully understood. Research Council-funded knowledge exchange has led to the publication in May 2009 of evidence-based guidance for policymakers on the communication of risk taking into account available evidence and acknowledged public perspectives.[28]

15. RCUK welcomes the publication in July 2010 of the Government Chief Scientific Adviser's *Guidelines on the Use of Scientific and Engineering Advice in Policy Making*,[29] in particular the statement that: "Departmental guidance should consider how advice is provided in an emergency, including clear designation of responsibility, the processes to be employed and the sources of advice".

16. Many of the threats faced today cross national borders and so international coordination and collaboration is essential for an appropriate response to emerging threats. For known and developing threats, RCUK considers it advisable to improve current international dialogue in order to establish better operational mechanisms to deal with future events.

Case Study (i): Swine Flu Pandemic in 2009

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

17. Influenza pandemics of the 20th century have resulted in global fatalities of over 53 million people. As the question of severity is one that cannot be gauged ahead of an actual outbreak the 2009 H1N1 pandemic potentially posed a major challenge to public health. However, the outbreak was not as severe as previous pandemics as the virus did not evolve into a more transmissible or more virulent virus, or gain resistance to antiviral drugs, and resulted in only in an estimated 450 deaths in the UK and around 20,000 world-wide.

18. The risks were identified by normal public health procedures, enhanced for the pandemic. These measures were able to confirm cases and monitor sensitivity of virus isolates to antiviral compounds. Normal capability was enhanced through increased genetic analysis of viruses isolated in UK based on pre-pandemic research initiatives designed to be used during a pandemic.

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[27] See also Hutter, Bridget M. (2009) "The Role of Risk Regulation in Mitigating Natural Disasters" in *Learning from Catastrophes: Strategies for Reaction and Response*, Wharton School Publishing

[28] ESRC Placement Fellowship in partnership with the Risk and Regulation Advisory Council and the Government Office for Science: *A practical guide to public risk communication: the five essentials of good practice, http://www.bis.gov.uk/files/file51458.pdf*

[29] http://www.bis.gov.uk/assets/biscore/goscience/docs/g/10-669-gcsa-guidelines-scientific-engineering-advice-policy-making.pdf

19. The perceived threat from avian influenza, particularly the highly pathogenic H5N1 virus, over the last decade resulted in enhanced preparedness plans and a good level of public awareness. The Government was both well briefed and well prepared for the emergence of H1N1 in 2009 and plans included vaccine development and the purchase of large supplies of antiviral drugs.

20. A number of Research Council initiatives, some undertaken jointly with other funders supported government planning in anticipation of a possible pandemic and increased capacity and infrastructure. Notable amongst these were MRC FluWatch;[30] increased infrastructure at the MRC National Institute for Medical Research (also home to one of the WHO World Collaborating Centres on Influenza (WHO CC)); the establishment of the MRC Centre for Outbreak Analysis and Modelling;[31] BBSRC's Combating Avian Influenza Initiative;[32] and the NERC PREPARE initiative, funded in 2008 to examine issues posed by widespread use of antiviral drugs during a pandemic which included the risks of environmental pollution caused by the release of biologically-active forms of the drugs into sewage works and rivers, and increased risk of antiviral resistance and genetic exchange between influenza viruses in wildfowl. BBSRC has been planning new avian facilities at the Institute of Animal Health, Pirbright (although the scale of development depends on support from the Large Facilities Capital Fund).

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

21. The options for controlling a pandemic considered by the Government as part of preparedness planning were based on advice from advisory groups such as SAGE (and its predecessors) and the Joint Committee on Vaccination and Immunisation, Government agencies, the Research Councils and other bodies. These included isolation, social distancing, restriction of movement, availability of antivirals and the development and roll-out of vaccines.

22. Two main areas where scientific advice was crucial to planning were the composition of the antiviral stockpile and the choice of vaccine. These were also topics highlighted in a Royal Society/Academy of Medical Sciences report on pandemic influenza[33] and following its publication Government subsequently enhanced its antiviral stockpile adding a second antiviral drug, zanamivir, in addition to oseltamivir. Initial planning on the choice of vaccine was not as transparent as some might have wished due to issues of commercial confidentiality.

23. Mathematical modelling of outbreaks had been a major feature of the pre-pandemic planning and continued to play a role as the pandemic emerged, providing advice on numbers of cases, transmission parameters and efficacy of antiviral treatments. It is important for the future that strengths and limitations of modelling are fully understood, and that changes in human behaviour are understood so as to be factored into models.[34]

3. *What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? For case studies (i) and (ii) was there sufficient and timely scientific evidence to inform policy decisions?*

24. The potential for a virus to evolve during its global spread presents particular difficulties during the emergence of an influenza pandemic. Reliable data on early cases and their contacts is essential to understand the transmission dynamics and disease severity. The low virulence of the H1N1 virus was not fully recognised as information first emerged from cases in Mexico, and the age profile of those infected and those suffering more severe infection could only be reliably deduced as cases increased.

25. Government should plan for early and later phases of a pandemic concurrently including the following influenza season, and recognise key parameters such as the proportion of the population still at risk. These data are routinely reported by HPA and with mathematical modelling can inform policy.

26. Increasing, or changing, research resources can also provide more detailed information as pandemics emerge. In 2009 £4.8 million was awarded to two collaborative research initiatives established rapidly by the MRC, Wellcome Trust and the National Institute for Health Research: MOSAIC, a study of hospitalised patients with severe infection which examined factors contributing to severity; and an extension of the existing MRC FluWatch surveillance programme which provided monthly estimates of population infection rates in different subgroups throughout the pandemic. A further £1.7 million initiative funded by BBRSC, MRC, Wellcome Trust and Defra, the Combating Swine Influenza, aimed to develop an understanding of how the virus behaves in the pig population and how interaction with farm workers may help it evolve and spread in both pig herds and the human population which will help to develop strategies to combat future outbreaks.

[30] http://www.mrc.ac.uk/Newspublications/News/MRC006480
[31] http://www1.imperial.ac.uk/medicine/about/institutes/outbreaks/
[32] http://www.bbsrc.ac.uk/funding/opportunities/2006/avian-influenza.aspx
[33] http://royalsociety.org/Pandemic-influenza-science-to-policy
[34] Modelled Encounters with Public Health Risks: How Do We Predict the "Unpredictable"? Erika Mansnerus, CARR Discussion Paper 56. http://www.lse.ac.uk/collections/CARR/pdf/DPs/Disspaper56.pdf

27. The calls for proposals were launched rapidly, but the recruitment of patients to the clinical studies was delayed, due to in part the requirements of setting up necessary ethical approvals and a delay in academic institutions recruiting the necessary staff for the studies. In the case of future pandemics, mechanisms that ensure necessary approvals are agreed swiftly, and studies are fully staffed, should be considered.

4. *How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?*

28. During the pandemic the advisory function was effective with the Chief Scientist and others in direct contact with SAGE presenting advice to Ministers. However, it is not clear that SAGE's composition and internal structures covered all aspects and key questions most effectively as the pandemic emerged. For instance the international perspective might be enhanced by including representation from the WHO CCs, in addition to the European Centre for Disease Control.

29. Key interactions between Government and private bodies appeared to be on the composition of the antiviral stockpile and the timely procurement and supply of vaccine. While vaccine supply is constrained by the nature and time-lines of production, it was available for those at risk during the autumn phase of the pandemic. Should the pandemic have been more serious the inevitable delay in vaccine availability would have been a challenge to Government.

5. *How important is international coordination and how could it be strengthened?*

30. International collaboration is essential for the timely delivery of scientific advice on the risk of influenza, monitoring the evolution of the virus as it spreads around the globe and the development of a vaccine. The pandemic vaccine was produced to the anticipated time-lines through a highly effective international collaboration involving the WHO CCs with statutory National Control Laboratories in UK (National Institute for Biological Standards and Control), USA and Australia. All parties combined their information, viruses and reagents to enable vaccine production as soon as possible. Over the period of the pandemic the London WHO CC received clinical samples and virus isolates from over 50 countries including the UK, creating an integrated picture of the virus evolution worldwide. It also assisted countries with less capability with virus characterization, sharing protocols and providing training, and by examining viruses from numerous countries for changes in antigenicity, virulence and drug resistance. In addition, the European ERA-NET on Emerging and Major Infectious Diseases of Livestock and GLOBAL-NET—Global Strategic Alliance for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses provide ideal platforms to promote coordination and cooperation of research programmes to combat global infectious diseases at the European and international level respectively.

31. The Global Influenza Surveillance Network (GISN) also plays an important role in supporting international coordination in identifying newly emerging strains of influenza virus and monitoring human infections caused by animal influenza viruses, the emergence of new strains of human influenza viruses that necessitate a new vaccine, the emergence of drug resistant strains of virus and to survey the general threat of influenza to global public health. The network is coordinated by WHO and currently comprises 134 laboratories in 104 countries.

Case Study (ii): Icelandic Volcanic Ash Eruptions in 2010

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

32. Particles in volcanic ash are highly abrasive to aircraft moving parts and windows, with glass shards potentially fusing to engine-interiors causing engine failure. The London Volcanic Ash Advisory Centre (UK Met Office) identified the hazard and the decision to stop air traffic was taken, based on international regulations. A NERC research aircraft—a Dornier 228[35]—was diverted from planned science work and converted at three hours notice on 15 April to provide interim sampling capability, flying daily until 21 April to assess the location and nature of the emissions. A NERC-Met Office BAe146[36], which due to maintenance work was not flown until the morning of 20 April, mapped the cloud from above and observed the plume from within. The Dornier 228 was the only aircraft permitted to operate in UK airspace above 2500ft until 20 April.

33. NERC's British Geological Survey (BGS) supplied information about the volcano and interpretation of Icelandic Met Office geophysical monitoring data to the Civil Contingency Secretariat from 15 April.

34. NERC's National Centre for Atmospheric Science (NCAS) led the analysis of the airborne sampling of the volcanic plume (ash, gases and aerosols, including sulphuric acid which is potentially highly hazardous to airframes). Aircraft provide the only means of determining the ash properties, which vary between different volcanoes. Without accurate constraints on these properties, more comprehensive satellite

[35] http://arsf.nerc.ac.uk/aircraft/
[36] operated by the joint NERC—Met Office Facility for Airborne Atmospheric Measurements

and ground-based remote sensing data cannot be interpreted. Dispersion modelling of the ash plume, carried out by NCAS in collaboration with the Met Office, enabled the Civil Aviation Authority (CAA) to introduce new regulations, based on Met Office forecasts, for flying in volcanic ash.

35. NCAS and STFC's Chilbolton Observatory supplied the Met Office with LIDAR[37] and sun photometer measurements revealing when the volcanic ash layers were above each of the instrumented sites, the altitude of those layers, and their depth. The measurements also provided an estimate of ash particle size.[38]

36. To identify the risk to the UK from sulphur, chlorine, fluorine and other elements entering the atmosphere, terrestrial freshwater and marine environments, the NERC Centre for Ecology and Hydrology (CEH) increased[39] sampling rates at its long-term monitoring programme sites.[40] Research cruises involving staff from the NERC National Oceanography Centre continue to investigate longer-term effects of the ash on marine ecosystems.

37. NERC funded five urgency research grant applications relating to the volcanic eruption.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

38. BGS and NCAS secondees to the Chief Scientist's Scientific Advisory Group in Emergencies (SAGE) group provided crucial scientific advice for policy decisions concerning the aviation industry. BGS and NCAS led liaison with Icelandic authorities.

39. BGS scientists assisted with daily briefings of the Civil Contingencies Committee (Officials) and with colleagues in SAGE and developed scenarios and the case for including volcanic eruptions in the UK National Risk Register.

40. Data collected by NERC-supported aircraft informed the civil aviation industry's decision to resume air traffic in UK airspace on 19 April and helped the CAA and Department for Transport (DfT) assess aviation hazards and manage civil airspace.

41. Members of NCAS, the Facility for Airborne Atmospheric Measurements (FAAM)[41] and the Met Office contributed daily during the emergency to the CAA's International Teleconferences on Volcanic Ash, alongside representatives of the aircraft manufacturers and airlines. These meetings identified how to resume flight operations after six days of the emergency.

42. The Airborne Research and Survey Facility (ARSF)[42] is working closely with aviation authorities globally and engine and airframe manufacturers to assess damage caused by flights, to ascertain safe levels of exposure for civil aircraft. This is the first time aerosol and gas measurements can be directly related to the condition of aircraft components. The Royal Air Force, Fleet Air Arm, British Airways, Virgin Atlantic, BMI and Iceland Air contacted NERC (via ARSF) for advice on operating conditions and safety.

43. CEH, BGS and NERC provided scientists and data to inform Defra, by participating in Defra's Volcanic Ash Network[43] and providing scientific advice regarding health and environmental impacts.

3. *What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? For case studies (i) and (ii) was there sufficient and timely scientific evidence to inform policy decisions?*

44. The CAA's International Teleconferences on Volcanic Ash were a particularly effective means to develop new regulations for flying in volcanic ash during the first six days of the emergency.

45. Early Dornier 228 flights were limited by the emergency nature of the reconfiguration and installation of un-calibrated instruments. Nevertheless, qualitative data verified there was significant contamination risk, provided validation for Met Office dispersion forecasts and demonstrated catastrophic engine failure was not inevitable.

46. A reduction in vital public data and information flowing from the Icelandic Met Office and University of Iceland, occurring when Icelandic scientists feared misuse of data, was partially rectified by a reassurance visit by BGS and NCAS. BGS and NCAS assisted in drafting an MoU between Iceland and UK at Government level.

47. Detailed and timely data and observations of the source of a volcanic plume are essential in real time. During an eruption, scientists in Iceland will have significant local hazards to deal with so UK must ensure it has ready access to data. To ensure such information is available in future eruptions, investment in observation and monitoring equipment would be required.

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[37] Light Detection And Ranging is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target.
[38] http://www.metoffice.gov.uk/corporate/pressoffice/2010/volcano/verification/
[39] http://www.ceh.ac.uk/news/news_archive/2010_news_item_12.html
[40] http://www.ceh.ac.uk/science/EnvironmentalMonitoring.html
[41] http://www.faam.ac.uk/
[42] http://arsf.nerc.ac.uk/
[43] http://www.uk-pollutantdeposition.ceh.ac.uk/monitoring_deposition_eyjafjallaj%C3%B6kull_volcano

4. *How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?*

48. BGS is well-linked to UK Higher Education Institutes and individuals specialising in volcanology and was able to put relevant experts in contact with each other and Government throughout the crisis (eg Met Office and volcanic plume modellers).

49. The Met Office has lead agency status on airborne Civil Contingency (CC) operations using the BAe146, with NERC providing technical and scientific staff. Scenarios qualifying deployment of the BAe146 in a CC role had been agreed informally by the Met Office with the Cabinet Office, though volcanic eruptions were not covered by this.

50. Flights of the BAe146 nullified insurance cover held by the operators of the aircraft (Direct flight Ltd), and contractual obligations of the owners (BAESYSTEMS) to NERC and Met Office. It was difficult to persuade DfT to provide appropriate indemnification, causing delays and preventing some flights.

51. Planning of Dornier 228 flights was sometimes compromised by conflicting views of their purpose by CAA, DfT, and at times the Met Office resulting in some sub-optimal missions. Although commitment to use assets such as aircraft during the emergency existed, it was sometimes unclear where responsibility—especially financial—lay.

52. Met Office, NERC, and BAES have agreed a clearer and more robust mechanism for assessing future CC work and establishing a firm basis for committing to such tasks, including payment arrangements, for approval by the Cabinet Office.

53. NERC expects costs of flights to date (approximately £500K), anticipated cost of repairs to the Dornier engines (estimated £300K) and consequential losses (approximately £450K, from a 12 month delay to committed overseas scientific programmes displaced during the emergency) to be refunded, and is awaiting confirmation.

5. *How important is international coordination and how could it be strengthened?*

54. International co-ordination is very important as ash plumes nearly always have a cross-border impact and infrastructure and capability is not held by all nations. Such co-ordination is being strengthened in numerous ways.

55. Most European countries capable of operating suitable research aircraft were not as well prepared as the UK with sorties not flown until several days had elapsed. Most European aircraft operators belong to the EC FP7 funded initiative "European fleet for Airborne Research (EUFAR)". EUFAR initiated dialogue between research teams, implemented a database (hosted by NERC) for archiving ash data (although no data was loaded by the aircraft operators) and held regular teleconferences to exchange information. The international civil aviation authorities are working towards better management of future volcanic events via EUFAR, which could be achieved by *i)* a more coordinated approach to investigative flights *ii)* agreeing on instrument deployment *iii)* speedy exchange of flight results and analyses.

56. Representatives of ARSF, FAAM and NCAS continue to contribute to the International Airworthiness Task Force (Volcanic Ash), chaired by the UK CAA, which is working towards developing and implementing a mechanism for better managing UK and European airspace in the event of another volcanic eruption.

57. BGS prompted a Memo from Iceland Met Office to SAGE identifying areas (including equipment and expertise) where UK could potentially support their volcano monitoring. A Memorandum of Understanding formalised co-operation between the Icelandic Met Office, BGS, NCAS and the UK Met Office on 26 May 2010. BGS has since provided six new seismic stations to supplement the Icelandic Met Office's seismic network and NCAS has supplied a LIDAR and radiosonde station. This addresses the IUGG statement[44] published in June 2010 urging international scientific communities to support volcano monitoring.

58. BGS staff are on the organising committee of the WMO-sponsored "Ash dispersal forecast and civil aviation" workshop in Geneva (October 2010). BGS are members of the IAVCEI working group on Ash Fall Impacts. International coordination and collaboration of volcanologists and atmospheric scientists is critical both in provision of advice to VAACs and plume dispersion modelling. Volcanic ash plumes nearly always have a cross-border impact.

Case Study (iii): Solar Storms

We note that the term "Space Weather" is used to describe the conditions in space that impact on the Earth. Solar storms are the source of Space weather disturbances and the two terms can be taken to refer to the same phenomena for the purposes of this submission. A description of the nature and effects of space weather can be found in the POSTnote 261 (July 2010) "Space Weather".[45] An important form of "solar storms" are coronal mass ejections (CMEs) which can cause bursts of intense radiation and geomagnetic storms.

[44] http://www.iugg.org/publications/ejournals/IUGGej1006.pdf
[45] http://www.parliament.uk/documents/post/postpn361-space-weather.pdf

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

59. Space weather is a natural occurrence. Its primary impact is its effects on the technological systems upon which society is increasingly reliant. Major events have been recorded in the past (eg 1859 and 1921) but had relatively minor impact, disrupting telegraph and telephone communications. An equivalent event today could be dangerous due to our greater reliance on technology.

60. Examples of the hazards and risks associated with Space Weather include:

(a) Damage to Space-based infrastructure (satellites) by energetic particles and radiation.

(b) Disturbance of the ionosphere degrading communication and navigation signals (including GPS) with particular impacts on aviation and shipping.

(c) Electricity distribution grids extending over long distances experiencing geomagnetically induced currents (GICs) which can cause blackouts and damage.

We have never experienced a 1-in-100 year space weather event to test the vulnerability of space technology and the susceptibility of electricity power systems. There is growing evidence that such events pose a major threat to economies around the world, as shown by the June 2010 report of the North American Reliability Corporation.[46]

61. The UK has over 100 years' leadership in the science underpinning our understanding of space weather. This continues today with the UK Research Councils, NERC and STFC, as the significant funders of relevant research programmes.[47]

62. Research Council commitment to researching the effects of solar activity is split between ground-based studies (eg using the EISCAT radars) and space-based (eg using STEREO, SoHo, Hinode, SDO and other missions). There are many inter-relationships between the various areas of research. UK scientists are world leaders at combining data from ground—and space-based studies.

63. Annex 1[48] provides an audit of potential UK based space weather assets, prepared recently (November 2009) as an input to ESA's Space Situational Awareness programme.[49] It can be seen as one measure of the UK's "preparedness" to predict, monitor and analyse the effects of space weather, or more loosely the UK's "National Capability" in respect to space weather and solar storms.

64. The UK currently has no single funding stream to provide a National Capability (measurement and predictive systems) that can respond to a space weather emergency. No single scientific community, group, individual or institute is equipped to address all of the challenges in isolation, and nor does any single body have exclusive interest in any single aspect. For example:

(a) understanding the effects of space weather on technical equipment and hardware;

(b) studying the behaviour of the Sun and the impacts of its variation on the Earth;

(c) requirements from and provision of early warning systems;

can all involve an array of national and international collaborators including academia, standards authorities, funding agencies, industry, individual eminent scientists and others.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

65. The Government has recently started to develop better links with the UK space weather science community, eg through work on the National Risk Register. This involves expertise from both NERC and STFC as well as universities.

3. *What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? For case studies (i) and (ii) was there sufficient and timely scientific evidence to inform policy decisions?*

66. Until recently space weather was not recognised as an issue for which the Government needed scientific advice. This is now changing and should be facilitated by the transfer of responsibility for earth-orientated solar-terrestrial physics (STP) to NERC. NERC experience will facilitate the flow of advice from the STP community to Government.

[46] http://www.nerc.com/files/HILF.pdf

[47] From 2008 responsibility for ground based research transferred from STFC to NERC and amounted to approximately £2.7 million per annum. The space-based research programme funded by STFC currently amounts to approximately £1 million per annum, but is difficult to accurately define given the many crossovers. These figures do not include spend on post-launch support or new mission development (eg ESA's Cosmic Vision Solar Orbiter mission) and this aspect is now managed by the UK Space Agency.

[48] Annex 1: UK space weather assets as published by ESA in tender 2010 (pdf). Not published.

[49] ibid

67. The UK lacks any national coordination on space weather unlike our international partners. A coordination mechanism will help government access scientific resources (both people and instruments) and also enable the scientific community to understand what government needs. This coordination should also to assess what financial support is needed to ensure resources remain available to Government when needed.

4. *How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?*

68. This is a developing area and it is too soon for definitive comment. However, we suggest that the proposed national coordination is a key factor in achieving this goal.

5. *How important is international coordination and how could it be strengthened?*

69. Space weather is a global problem so international coordination is critical. This is increasingly focused through Space Situational Awareness programmes in Europe and the US. The UK needs to make the most of its membership of the ESA SSA programme. The UK contributions to the global networks that monitor space weather (eg the magnetic observatories operated by NERC) are a key input to international coordination, including the SSA programmes.

70. EU FP7 recently allocated approximately EU22 million to space hazards including Space Weather, and the UK is involved in projects funded under this line. Discussions about bidding for FP8 programme content are starting and UK scientists are leading efforts to lobby for space weather studies in economically important areas.

71. The establishment of the UK Space Agency could have significant bearing over the direction of the UK's strategic investment in space weather preparedness and related areas through its leadership role and by potentially bringing together the themes and capabilities at hand (eg by providing a single voice at the ESA negotiating table).

Research Councils UK

14 September 2010

Memorandum submitted by Professor Peter Sommer (SAGE 23)

1. I am a Visiting Professor at the London School of Economics and a Visiting Reader at the Open University. I attach, as Appendix I, a CV.

2. I believe I may be able to assist the Committee in two ways. Between July 2003 and March 2009 I was a member of the Scientific Advisory Panel on Emergency Response (SAPER) run by the Government's Chief Scientific Advisor and can comment on the experience. I have had interactions with parts of government in relation to cybersecurity since 1995. Together with Dr Ian Brown of the Oxford Internet Institute I am the author of a forthcoming OECD study entitled *Systemic Cyber Security Risk* which is part of their *Future Global Shocks* programme.

SAPER

3. If the Committee has not already had submissions on the existence and work of the Scientific Advisory Panel on Emergency Response (SAPER), then it will do well to make inquiries of the Government Chief Scientific Advisor. I will confine my comments to my own experiences

4. SAPER was set up by Professor David King when he has GCSA to support his role in COBRA. As I understand it, the decision was partly informed by the then developing "civil contingencies" agenda which included the Civil Contingencies legislation. The essential idea was that the GCSA needed to have a wide variety of sources to inform his advice. A number of scientists from the ministries, agencies and wider academia would be briefed about government plans for addressing emergencies both in terms of structure for decision-making and underlying analyses. As I understand it, the role of the non-government academics was twofold: to provide additional and fresh perspective on the issues but more importantly to provide networks by which other academics could be identified on an as-needed basis in specific circumstances.

5. The non-government academics were drawn from a wide range of disciplines which included engineering, the social sciences and finance/economics.

6. Regular briefings were provided on the development of government policy (we had an early presentation on CONTEST from David Omand), government structure for decision-making, horizon-scanning assessments from the Cabinet Office Civil Contingencies Secretariat and, as the counter-terrorism agenda became more important, from the Joint Terrorism Analysis Centre (JTAC). We were given previews of how a pandemic would be assessed and then specifically managed. There were also presentations on a number of actual and potential counter-terrorism technologies given by a variety of specialist scientists. These were all accompanied by discussions.

7. SAPER also undertook various projects. At one stage there were brain-storming sessions on the problems and features of "kitchen-sink bomb making". There was a review of the availability and practical use of computer models/simulations during the management of disasters; potential models included the spread of infectious diseases, the behaviour of plumes of noxious substances and the dispersal of irradiated contaminated material in a dirty bomb. There were also studies carried out by sub-groups: one looked at the behaviour of crowds during emergencies and with particular reference to London Underground.

8. Discussions were always on a multi-disciplinary basis. That is to say, although most of us had been recruited on the basis of specialist knowledge (in my case, of social science disciplines and cybersecurity), we were encouraged to contribute freely across the entire agenda.

9. Towards the end of its existence there emerged concern that there might be too many semi-duplicating and uncoordinated initiatives in ministries addressing aspects of the Counter-Terrorism agenda. There was an attempt by SAPER to collect data on these and then use regular academic skills in project funding assessment (as used by grant-awarding bodies) to identify good and not-so-good projects in terms of clarity of objectives, soundness of methods, and requirements for funding. I do not know what became of this exercise.

10. The current GCSA (who was on SAPER as CSA for the Ministry of Agriculture) should be able to explain how far SAPER has been replaced.

11. It is difficult for me, who have never been in direct full-time government employment, to assess the value of SAPER's work. As a participant I found the activities extremely interesting. As an academic I had had some interest in the generic issues of government response to emergencies from such books as *Beneath the City Streets* by Peter Laurie and Peter Hennessy's *The Secret State*. The officials from CCS, JTAC, the security agencies and bodies like HSE all stated that there were benefits to them. However in the nature of things it is quite difficult for me to track specific SAPER activity in terms of real policy outcomes.

12. A further problem in terms of the use of non-government service academics is that they are relatively unlikely to have been through developed vetting but be simply security cleared. The dilemma is this: the external academic may bring fresh insights, but cannot necessarily be shown a full picture—and that might include seeing how advice is converted into policy. Of course some academics may feel that they do not wish to go through any form of vetting.

Cybersecurity

13. Although the Cybersecurity agenda is wider than this, possible events which seem to relate to the need for future emergency activity are:

- Loss, as a result of accident or bug, of computer services critical to central and/or local government activity.
- Loss or compromise of large quantities of critical government data, including data about citizens which should be held confidential.
- Loss, as a result of accident or bug, of computer services owned in the private sector but part of the Critical National Infrastructure.
- Deliberate attacks on computer services critical to central and/or local government activity.
- Deliberate attacks on computer services owned in the private sector but part of the Critical National Infrastructure.

It should be noted that "cyber attack" is only one set of scenarios that might trigger an emergency affecting the public.

14. The Committee should, if it is not doing so already, obtain an update on coalition plans for cybersecurity.

15. The wider cybersecurity agenda also includes the need to protect critical central government, intelligence agency, military and police data and systems. But there are many events here which, though important, do not amount to emergencies immediately affecting the public as a whole.

16. "Cybersecurity" at government level has several components and in assessing the role of scientific advice the Committee needs to be aware of the various elements:

- Security Technologies: there is a substantial technical element within a "computer sciences" domain. It includes: engineering requirements analysis, access control/identity management, the development of safe databases, the deployment of encryption, the use and development of Intrusion Detection Systems, malware research, tracing/attribution.
- Risk Analysis and Management is an essential element.

— Dependency Analysis studies the ways in which, in this highly-inter-connected world, dependencies can be mapped and modelled.

— Human factors: a great deal of security planning and engineering relies on an understanding of how individuals by themselves and as members of a group behave—how do they react to the interfaces to the security technologies and to security policies, for example?

— Criminology of Cybercrime Taxonomies of criminals, Motivations.

— Political Analysis In terms of cyber-attacks, an understanding of the motivations of likely actors is at least as important as appreciating the technologies they may be able to deploy.

— Management Science, among other things, to help develop a relationship with the private sector aspects of the CNI.

— Contingency Planning Preventative and Detective measures are insufficient to guarantee an absence of cybersercurity problems. Considerable attention to methods of rapid recovery after an incident is an essential component.

17. Much research work in all of these sectors is openly available and published, not the least because many of the problems , albeit in slightly different forms, also apply to large and not-so-large businesses. As a result security officials may not need much in the way of specialist research.

18. There are a number of research programmes available for academics through which to channel and fund their activities in these areas. The include:

— Under the European Commission Framework Programme 7: http://ec.europa.eu/research/fp7/index_en.cfm?pg=security

— Under current ESRC plans, the Environment, Energy and Resilience, Security, Conflict and Justice themes: http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/strategicplan/challenges/environmentandenergy.aspx and http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/strategicplan/challenges/securityandconflict.aspx

— I also draw attention to the Cybersecurity KTN: http://www.innovationuk.org/news/innovation-uk-vol4-1/0101-cyber-security-ktn.html

19. My experience is that officials from CPNI, CESG and CCS all attend specialist academic workshops, seminars and conferences without necessarily drawing attention to their actual employers.

20. Officials also participate in think-tank workshops held under "Chatham House" rules. (Chatham House has a current cyber security project, but so do some other think tanks). There are also a number of industry-funded membership-by-invitation organisations within the computer and security industries who host off-the-record workshops.

21. The linked Office of CyberSecurity (OCS) and CyberSecurity Operations Centre (CSOC) have attended and participated in a number of events. They have also arranged for external academics to attend horizon-scanning sessions.

22. In addition security officials build up informal relationships with individual researchers of interest. My own experience of this is in the form of discussions of broad trends and clarification of research. The flow of information has been largely towards the security officials. I am aware that other researchers may from time to time have a more formal relationship and be commissioned to carry out specific work.

23. Many non-government academics are wary of obtaining commissions direct from the security agencies. The reasons include: ideology (a feeling that science should always be open) and restrictions on publication (which is one very important measure of academic excellence and key to further promotion).

I would be happy to expand on any of these issues.

Professor Peter Sommer

14 September 2010

Memorandum submitted by the Foundation for Information Policy Research (SAGE 26)

The Foundation for Information Policy Research (FIPR) is an independent body that studies the interaction between information technology and society. Its goal is to identify technical developments with significant social impact, commission and undertake research into public policy alternatives, and promote public understanding and dialogue between technologists and policy-makers in the UK and Europe.

FIPR's relevant expertise lies in cyber security and security economics, so we will confine our remarks to these fields.

1. The risks of cyber-attacks on national infrastructure by state opponents are currently being hyped vigorously, especially in the USA, where the NSA is pushing for budget and control aided by lobbying from a number of vendors. The risks may be smaller than these enthusiasts would have them—but they are not zero and they will increase over time. As for targets, it is often said that electric power would be a target. It may become a target eventually (especially if we all get smart meters with a remote off-switch), but at present our generation, transmission and distribution assets use such a diversity of old systems that a capable motivated opponent would be better off doing what the IRA tried to do in 1996 (blow up three Supergrid substations). As it happens there is some UK research on control system security; see for example "Who Controls the Off Switch?".[50]

2. The government's Chief Scientific Advisor John Beddington FRS has recently run a "Blackett Review" of cyber security, by an ad-hoc committee. This is supposed to feed in to national security strategy.

3. Scientific research on cyber-security is a vigorous field with a competitive research community whose results are widely disseminated. It would be helpful if researchers had access to more data; for example, very few EU member states publish bank fraud statistics. (The UK is one of the exceptions.)

4. The many problems facing government defensive efforts in cyberspace include (a) almost all critical national infrastructure assets are in private hands (b) the UK is a small player in a globalised world (c) the UK public sector is not very competent at IT and (d) departments and agencies pay little attention to research, getting their advice second-hand or third-hand through consultancies or CESG. Coordination with industry is poor; it is hampered both by tensions between ISPs and government departments (over issues from file-sharing to interception modernisation) and by the fact that the two agencies principally involved in defence (CPNI and CESG) are part of the intelligence community. Many of the real experts in academia and industry refuse to get a security clearance, because of the toxic effects on international collaboration, academic publication and the free exchange of information. The UK badly needs a cyber-security capability outside the world of defence and intelligence, as NIST provides in the USA. Two members of FIPR's Advisory Council (Richard Clayton and Ross Anderson) are involved in an EPSRC-funded project to try to establish such a capability at NPL. (This is really just re-establishing a capability that existed there in the 1980s and early 1990s.)

5. Better international cooperation is critical. We wrote a report about this for the European Network and Information Security Agency: "Security Economics and the Internal Market"[51] which we commend to the Committee. The cooperation has to start with cybercrime. This now probably accounts for the majority of acquisitive crime by number of incidents reported by victims (over two million a year versus about one million for burglaries and thefts of and from vehicles, if you believe the British Crime Survey). The police mostly consider it "too hard" to tackle high-volume low-value international offences. But so long as that swamp continues to grow, it will continue to attract national intelligence agencies. The cyber underworld provides hacking tools, proxies, botnets and other wicked services that enable targeted attacks to be carried out on key companies and individuals. Intelligence agencies can either use hacker gangs as mercenaries to carry out such attacks, thus providing some deniability, or can simply use criminal tools and methods. This is not fundamentally new; an intelligence agent wishing to bug a target's house could either engage a burglar to do the job, or pretend to be a common burglar if caught. However, the lack of effective police action against cyber-criminals makes things much easier for hostile nation states and substate groups. We made some suggestions in our report as to how police cooperation could be improved. But the intel/defence tension always remains: if it's convenient for GCHQ's offensive operations for the Internet to remain a swamp, and convenient for the defensive operations of CESG and CPNI that it should be drained, who will prevail?

We hope that the Committee will find these remarks helpful.

Professor Ross Anderson FRS FREng
Chairman
Foundation for Information Policy Research

14 September 2010

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[50] RJ Anderson, S Fuloria "Who Controls the Off Switch?"IEEE SmartGridComm 2010, at http://www.cl.cam.ac.uk/~rja14/Papers/meters-offswitch.pdf

[51] http://www.cl.cam.ac.uk/~rja14/Papers/enisa-short.pdf

Memorandum submitted by the Health Protection Agency (SAGE 28)

INTRODUCTION

The Health Protection Agency was established with a prime duty "to protect the community (or any part of the community) against infectious diseases and other dangers to health" (Health Protection Agency Act 2004). In carrying out its prime duty the agency is organised to provide a wide range of services and public health actions that in turn deliver the following key strategic health outcomes:

(a) Reduce key infections.

(b) Minimise the health impact from environmental hazards, including radiation, chemicals and poisons.

(c) Promote safe and effective biological medicines.

These health outcomes are achieved through the detection and monitoring of threats, the provision of appropriate, independent and expert scientific advice and effective public health actions at local, national and international level. The agency generates scientific knowledge through primary and applied research, health surveillance and the analysis of information; it undertakes commercial activity on an international scale that generates knowledge, enhances UK capacity and produces income in support of the agency's functions; and it converts that knowledge into expert advice and action at the right level to improve public health—from individuals making choices about their own actions to government developing policy.

Of the four incidents in which the Committee has expressed interest, the agency has so far only had practical experience of two and so we have only commented in detail on these. However we are aware of the general thinking coordinated by CCS in the recent past on all of these issues, and we suggest that in the light of the proposed changes to the machinery of government, a review should be undertaken to ensure the robustness of scientific advisory arrangements.

1. THE SWINE FLU PANDEMIC IN 2009

The four UK administrations conducted a review of the 2009 Influenza Pandemic led by the Cabinet Office, to which the HPA contributed. This review culminated in the publication of the Hine Report[1].

The agency has a major role in supporting the UK preparations for and response to an influenza pandemic. The agency provides independent scientific and public health advice and operational support to the Department of Health, Strategic Health Authorities, the National Health Service, and other organisations whose formal responsibilities include responding to an influenza pandemic.

The agency has specific responsibilities within England and Wales (the latter, in conjunction with Public Health Wales) and cooperates closely with its sister agencies in Scotland and Northern Ireland. The agency has been collaborating with all UK Devolved Administrations and their health protection services to optimise the UK's preparedness and response to pandemic influenza. In the event of a pandemic the agency collates UK surveillance data for the purpose of providing regular updates to DH and the Civil Contingencies Committee (CCC).

(i) *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

The independent review of the UK response to the 2009 influenza pandemic (Hine Report) concluded that "overall, the UK response was highly satisfactory". The planning for a pandemic was well developed; the personnel involved were fully prepared.

For many years prior to 2009, the agency has been aware of the threat to public health posed by pandemic influenza including the rapid spread of illness affecting a large proportion of the population, with severe disease in some, pressures on the health service and societal, logistic and economic impacts. Assessment of the likely impact of a pandemic was carried out using experience and data from previous seasonal and pandemic influenza periods, review of the scientific literature and mathematical modelling of the potential range of impact on the population. The agency drew up and exercised contingency plans with partners, helped prepare clinical and public health systems to identify and manage cases, contacts, outbreaks, infection control and all the attendant challenges to ensure continuity of health care and other business critical activities in the UK. Parts of the agency, especially the National Institute of Biological Standards and Controls (NIBSC) have had significant input into the development of both seasonal and in this response the H1N1 pandemic influenza vaccine.

Scientific and clinical advisory committees were integral to the provision of risk assessments and scientific advice. Experts from the agency including epidemiologists, virologists and modellers, contributed to these committees which included:

> *Scientific Pandemic Influenza Advisory Committee (SPI)*—Between 28 April 2009 and 1 May 2009, two emergency meetings of SPI were held to review the ongoing situation. This committee was stood down on 5 May 2009 following the activation of SAGE. The committee were involved in the preparedness work for possible influenza pandemics and reviewed and interpreted some of the agency work referred to earlier, to inform policy development.

Scientific Advisory Group for Emergencies (SAGE)—SAGE members were drawn from SPI with other independent experts and operated under the joint chair of the Government's Chief Scientific Advisor, Professor Sir John Beddington and the chair of SPI, Professor Sir Gordon Duff. SAGE met 22 times from the 5 May 2009 to 11 January 2010 to discuss the H1N1 pandemic influenza. Meetings of SAGE covered the progress of the pandemic, with updates from the agency on case numbers, surveillance, epidemiology and severity throughout England, and similar updates from the devolved administrations and the European Centre for Disease Prevention and Control (ECDC). This information was then synthesised by the agency to produce evidence for policy development during the pandemic, such as whether to close ports, targeting use of anti-virals and vaccines and school closure.

SPI Modelling and its Operational sub-group (SPI-M & SPI-M-O)

SPI-M was established to provide advice to SPI on all matters relating to the modelling of anticipated aspects of an influenza pandemic and the potential implications for policy decisions. During the H1N1 2009 pandemic, a reduced membership version of SPI-M, called SPI-M-O was formed according to pre-existing plans. SPI-M-O provided advice to SAGE on the current situation, information on key parameters (case fatality rate, clinical attack rate, hospitalisations) and the implications of these numbers for the purposes of planning assumptions.

SPI-M-O played a key role in anticipating and assessing the evolving risk and epidemiologists from the HPA were members of this committee. One of SPI-M-O's key functions during the epidemic was to produce a Consensus Statement (CS) and Interpretive Statement (IS) each week. The aim of the CS was to convey the SPI-M-O committee's current evidence base and its latest consensus on the reasonable worst case and anticipated ranges for key epidemiological parameters. The aim of the IS was to review the latest available indicators in order to interpret how the epidemic was progressing. These documents, alongside current situation figures from the agency the Devolved Administrations and the international situation, were briefed into SAGE, and then on to meetings in COBR.

The agency continues to monitor the ongoing situation regarding pandemic viruses using information reported up to the World Health Organization from affected countries and the agency's involvement in the WHO Global Influenza Surveillance Network. The headlines from this information, along with the UK situation, are then published in the agency weekly national influenza report. Following the H1N1 pandemic the agency also convened a flu threat assessment meeting which reviewed the current global situation and implications for the 2009–10 winter season.

Plans in the health sector were developed over a long time scale and had been considered and tested, and this showed in the response. The preparedness was driven by "worst case" scenario modelling, modelling of vaccine efficacy and of the effects of port and school closure. The agency played a key role in the development and delivery of exercises to test response mechanisms prior to the pandemic and this was very valuable. The lessons gained from the multi agency response) to avian influenza outbreaks were invaluable in the pandemic response. These helped identify the gaps in our evidence and stimulated work to close these gaps. We also played a key role in the non-health sectors with provision of tailored risk assessments and infection control advice, expert input into Regional and Local Resilience Forums, extensive planning with prisons, ports etc.

(ii) *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

The Government is critically dependent on expert scientific advice to identify threats and mount an emergency response. In the public health field, the agency has multiple mechanisms for "horizon scanning" emerging threats which can be infectious (eg novel infectious diseases) or non-infectious (eg climate change, new chemicals). The methods include continuous monitoring of scientific literature, "grey literature" and media reports on the internet using software tools, surveillance activity including international co-operation and direct research on emerging disease in developing countries. This information is used to look at preparedness activity to ensure plans take into account likely future hazards. SAGE was the key mechanism in providing scientific advice to Government during the H1N1 pandemic and this was the first SAGE to be convened by the Government in response to a civil contingencies emergency. Overall this group worked well and permitted Government policy to be as informed by up-to-date scientific evidence as possible in a rapidly developing situation. The agency was represented on this group as an organisation in addition to other agency staff who were members of the group for their independent scientific expertise. It should be noted that to operate SAGE needs to have high quality surveillance data, real-time research and modelling, and reliable reporting of the impacts at a local level from clinical and public health workers, to characterise the public health effects of an emergency. The agency played an important role in developing much of the primary scientific data, including virological, serological and epidemiological data, which informed decision making and underpinned assumptions in modelling.

(iii) *What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? Was there sufficient and timely scientific evidence to inform policy decisions?*

The agency worked with the SAGE review team which debriefed after the 2009 swine flu pandemic and identified constraints/areas of weakness in providing reliable, timely scientific advice. Addressing the issues listed below[(2)] will improve the effectiveness of scientific advice in a future emergency including a pandemic:

(a) There should be closer links between SAGE and the Chief Medical Officer and his office;

(b) There should be better co-ordination between SAGE and the Pandemic Influenza Clinical and Operational Advisory Group (PICO) and further consideration given to clarifying relationships with other key scientific committees involved in the response;

(c) A briefing should be prepared on the limits of science and in particular of epidemiological modelling to manage expectations about what can meaningfully be delivered in what timescales; at the start of a new pandemic, this briefing should be fully explained to Ministers and to the Cabinet Office and CCC attendees and/or other government departments;

(d) SAGE should give greater attention to identifying key scientific messages that should be promoted in media handling and public communications;

(e) Improvement is needed in the ability rapidly to implement research necessary to the management of a pandemic. Key research questions should be pre-agreed and mechanisms put in place, for example centres of excellence pre-identified to carry out the work and rapid initiation of the research. Pre-agreed research questions of a generic nature will need to be rapidly reviewed, and refined if necessary, in the light of the prevailing circumstances of a specific emergency;

(f) Communications between the media and individual SAGE members needs to be governed by a clear code of practice;

(g) It is recommended that the Government process for issuing planning assumptions and revisions of assumptions should be considerably speeded up.

The key issues for a pandemic of greater severity are that decisions may need to be made very quickly on the basis of limited information on which interpretation may legitimately differ; there needs to be a clear process for recording disagreements by SAGE group members when advice is given in such circumstances, and consensus cannot be reached.

(iv) *How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?*

The Hine report found that the outbreak had demonstrated that the four UK governments could work together effectively to meet such an emergency and that overall, the UK response was "proportionate and effective".

The Hine report also concluded that scientific staff acted rapidly to provide expert virological surveillance, modelling and epidemiological information on which to base the response, initially and throughout the course of the pandemic.

The following were seen as key strengths of SAGE[(2)]:

(a) It worked well with the Government's Chief Scientific Adviser (co-) chairing SAGE. This should be retained, particularly where a departmental CSA is not in a position to chair, and where the emergency is pan-government in the need for response;

(b) The capacity to analyse emerging scientific information rapidly and advise Government quickly is a key strength;

(c) Where possible, an independent co-chair with specialist expertise (in this case the Chair of the Scientific Pandemic Influenza Advisory Committee) strengthens the leadership and work of the Group, ensuring continuity from the planning phase as well as enhancing credibility and communication within the scientific community;

(d) A wide range of expertise was, and needs to be, represented on the Group, whilst keeping the Group a manageable size;

(e) The facility to invite additional experts to specific meetings to obtain highly specialist advice;

(f) A dedicated secretariat with appropriate scientific expertise.

(v) *How important is international coordination and how could it be strengthened?*

International coordination is essential in an incident that affects more than the UK, both to share information, and likely future actions, and to ensure co-ordinated public messages. The agency contributed substantially to the effectiveness of international coordination and, in consequence, to the effectiveness of

the actions taken within the UK, through a range of activities with international partners. These included intelligence gathering in collaboration with other countries and international organisations and the posting of staff, when appropriate, to other countries to obtain information; participation in international teleconferences with WHO, ECDC and other major national health protection bodies, on epidemiological, virological and other clinical and public health aspects of the pandemic; contribution of UK national experts to international advisory committees.

2. The Icelandic Volcanic Ash Eruptions in 2010

The agency established an emergency operations centre to facilitate the coordination of the UK public health response and to support the Department of Health, Civil Contingencies Secretariat and Devolved Administrations. The aim was to ensure that any potential public health hazards from the volcanic eruption were identified and suitable measures were adopted to protect the health of the public.

(i) *What were the potential hazards and risks and how were they identified? How prepared was the Government for the emergency?*

The public health risks and hazards for volcanic ash were identified very early eg possible health and aircraft damage by small particles and health concerns regarding the chemical composition of the particles. This was based on the past experience from the Montserrat Volcano, however, more clarity is needed with regard to the mechanism for accessing archived advice, expertise, evidence and reports and sharing this information between responder organisations.

(ii) *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

The Government is critically dependent on expert scientific advice to mount an emergency response. Whilst generic emergency preparedness and response mechanisms are crucial they need to be amended in the light of novel threats. In addition risk registers need to be updated based on expert scientific advice. (Also please see 1ii re identify and prepare.)

(iii) *What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? Was there sufficient and timely scientific evidence to inform policy decisions?*

The key constraint is resources. It is often the case that Government expertise is located within Departments or Agencies which provide coordination or response to an emergency and often the same individuals are required during an emergency both to act as experts advising Government and to carry out research to develop the required risk assessments. These assessments often need to be carried out quickly with limited data and refined as further data becomes available.

From a public health perspective the agency was able to provide timely scientific advice in this event. However, the Government should consider undertaking a review as to whether the resource available in particular specialist fields is sufficient.

(iv) *How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?*

The strategic coordination of this response worked well. However it would be helpful to clarify further the processes for identifying, obtaining and disseminating scientific information—for example, SAGE identified a need for better data on the composition of the particles reaching the UK, but did not have the resources to ensure this information was obtained quickly.

(v) *How important is international coordination and how could it be strengthened?*

International co-operation is vital in an incident that affects multiple countries, both to share information and likely future actions, and to ensure a co-ordinated public message. However, during "volcanic ash" much of this co-operation and co-ordination was conducted informally, via personal contacts, for example colleagues in WHO Euro and their Health Action in Crisis Group and WHO European Centre for Environment and Health, Bonn, Germany Air Quality Group. As a result of these contacts WHO/Europe set up an Expert Group where the agency was invited to participate. This included keeping the governments of the European Member States informed through established procedures and making recommendations on effective ways to address the situation from a public health perspective. WHO also coordinated its advice with partner agencies, including the European Union's Directorate-General for Health and Consumers, the European Centre for Disease Prevention and Control, and the European Food Safety Authority. Once the expert group had been set up, coordination worked well, but prior to this, there were problems of diverging public health messages being circulated in Europe.

International coordination can be strengthened through enhanced sharing and learning opportunities and regular collaboration during "peace time". This builds the trust and networks required to respond in an emergency more effectively. It is not clear whether it is possible or practicable to try to set up additional formal structures internationally.

Prepared by Dr John Simpson, Health Protection Agency

September 2010

References:

(1) The 2009 influenza pandemic, July 2010 (Hine report)

(2) Lessons learned consensus document, SAGE OC 01

Supplementary memorandum submitted by the Health Protection Agency (SAGE 28a)

ADDITIONAL WRITTEN SUBMISSION TO THE COMMONS SCIENCE AND TECHNOLOGY COMMITTEE FROM THE HEALTH PROTECTION AGENCY

Following its oral evidence session on 20 October the committee has asked the Health Protection Agency (HPA) to submit written evidence in answer to the question:

> "As the government plans for the Health Protection Agency (HPA) to be abolished and its functions transferred to the Department of Health (DH) under a new Public Health Service (PHS), how do you see the HPA's role as a source of independent scientific advice being preserved?"

1. The HPA has welcomed the Government's proposal to improve the focus on public health through the creation of an integrated national Public Health Service (PHS) and is looking forward to playing an important role within it.

2. HPA is currently working with colleagues in the Department of Health to advise on how the Secretary of State's objectives can best be met while protecting the key strengths of the HPA in respect of its independent expert advice and the integrated delivery of its health protection functions.

3. HPA is pleased that the Government has been explicit in its intention to incorporate all of HPA's health protection remit within the new PHS as the benefits of an integrated health protection service have been repeatedly demonstrated—for example during the response to the Polonium 210 poisoning in London, several flood events, and during the H1N1 flu pandemic.

4. It is not yet clear how independence of expert evidence based advice will be preserved and accommodated within the PHS. This is critical in terms of retaining credibility and the trust and confidence of the public, health professionals and others working in the field of health protection—locally, nationally and internationally. Clearly if the integrity of advice provision were to be eroded, or perceived to be so, then the impact on our ability to influence, protect and improve public health could be seriously affected (in the absence of a recognisably independent expert source, the public could turn to other, potentially poorly evidence based and unreliable sources of information).

5. Scientific advisory committees (soon to become Expert Committees of the Department, on which devolved Administrations may only have Observer status) can address some, though not all, of the aspects of independence of advice. These committees are an excellent way of ensuring that the evidence base being used to inform policy on recognised issues is well founded and balanced.

6. However, such committees are not an appropriate means either of ensuring that expert professional advice is available in real time in response to typical incidents (HPA responds to 1000s of these each year—many of which are local rather than national), and nor are they a suitable mechanism to ensure that the right topics are researched (eg when evidence of a new problem starts to emerge). Their ability to respond rapidly and flexibly is necessarily limited, and they do not have a budget to direct research.

7. In addition to the need for independence in formulating evidence based expert advice there is an important need for this advice *to be seen to be* independent. The catastrophic loss of public confidence and trust in the advice of "government scientists" following the BSE incident was partly because they were seen to be part of the establishment and "not independent". This was one of the drivers behind the establishment of the independent HPA, and its value has been demonstrated for example by the public trust in the Agency's response to the use of Polonium 210 radioactive poison in a public place in London in 2006.

8. At local level our independence from Government and local authorities has encouraged the public to trust in our expertise on a range of environmental issues ranging from power lines to contaminated land. For example, at present HPA is providing health protection advice regarding the remediation of a former chemical site in the constituency of the Secretary of State for health. Regardless of the reality, it would be harder to convince people of the independence of HPA's advice if we were seen to be indistinguishable from his departmental policy advisors.

9. HPA's independence in the provision of Healthcare Associated Infection (HCAI) surveillance outputs has been critical in securing public confidence in Government claims relating to trends in HCAIs—because they are based on our independent evidence. We have also been advising Government on the health impacts of the proposals for new nuclear power stations at various sites around the country. In such circumstances the importance of there being a clear distinction between the independent advice given by the HPA and those responsible for developing Government policy becomes obvious.

10. When the HPA's functions and staff are transferred to the new PHS, within the Department of (Public) Health, there is a risk that its advice will no longer be seen to be independent of Government unless steps are taken to preserve its independence.

11. To credibly fulfil the role of provision of independent expert advice, particularly to the public, PHS needs to be seen to have both a separate identity and an independent voice, and to be able to initiate work in areas it deems of importance to health protection. The high approval ratings enjoyed by the equivalent organisation in the USA, the Centers for Disease Control and Prevention (CDC) demonstrate how such a model can be made to work within Government.

12. It must also be able to formulate and disseminate advice promptly in emergencies, and its staff (including Directors of Public Health) must be free to give the timely local advice which is essential in the management of outbreaks and incidents where the perception of independence is equally important.

Health Protection Agency

28 October 2010

Memorandum submitted by the Royal Statistical Society (SAGE 30)

The Inquiry by the Science & Technology Committee (STC) has selected four case-studies, the first of which (the swine flu pandemic in 2009) the Royal Statistical Society took a close interest in. The President, Professor David Hand FBA, wrote to the-then Chief Medical Officer, Sir Liam Donaldson, on 30 July 2009 because the Royal Statistical Society had identified a number of issues related to reporting standards and broad epidemics that weekly updates on the pandemic needed to address. The correspondence is at Annex A.[52] The Royal Statistical Society noted that improvements were subsequently made which we attribute to Sir Liam's intervention.

The Royal Statistical Society wishes to make some general observations before addressing STC's specific questions in relation to H1N1 (2009).

We are aware that the Government's Chief Scientist, Professor Sir John Beddington FRS, has commissioned a review, which includes statistical matters, of the Government's risk register, what have come to be known as "reasonable worst case planning assumptions" (vide infra), and their calculation. We expect that the Royal Academy of Engineering will address the STC on cyber attacks and the vulnerabilities that arise if much of a country's critical infrastructure is in private hands or if a government does not have significant information-technology expertise.

SWINE-FLU EPIDEMIC IN 2009

A. *General tenets*

1. Attention must focus on quantifying the actual impact of events, which may be quite different from the impact that was planned for. The 2009 pandemic, instead of being a highly lethal variant of H5N1, was low lethality H1N1.

2. Even if it is reasonable to plan for a "worst-case scenario", which is strongly disputable, planners (and public) should be have an operational understanding of the "reasonable worst-case scenario": for intensive care unit (ICU) admissions, say. The reasonable worst case scenarios might carry meaning as follows: there is a 10% chance that actual ICU admissions during the pandemic will exceed the I10 planning level, a 1% chance that actual ICU admissions will exceed the I100 planning threshold, and 1 chance in 1,000 that actual ICU admissions will exceed the I1000 threshold. Governments have to decide what operational meaning, affordably, to attach to "reasonable worst-case scenario".

3. Even if it were reasonable to plan for the I100 "worst-case scenario", this scenario should not be computed by taking all contributing parameters (H1N1 clinical attack rate * hospitalisation rate of clinically affected H1N1 cases * ICU-admission rate for hospitalised H1N1 cases) at their "worst-cases"! From the standpoint of statistical science, this could be argued to have been poor risk analysis, even without the benefit of hindsight.

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[52] Not published.

4. If the Government's prior pandemic assumption was a 1% case fatality rate, and there have been 4,000 confirmed cases to date with only 10 deaths (versus the 40 deaths expected if the prior assumption had held true), then these few deaths constitute compelling evidence that UK's actual case fatality rate is substantially below 1%. Thus, low numbers of deaths can be highly informative for rejecting a prior judgment about a relatively high case fatality rate.

5. The Royal Statistical Society regrets that, in the first pandemic of the 21st century, England's Chief Medical Officer was obliged to make extraordinary personal effort to establish the number of H1N1-related deaths because of a lacuna in England's registration system. In England, unlike in Scotland, there is no obligation for the fact, and date, of death to be registered within so many days of a death having been ascertained if the death is referred to coroners. This loop-hole needs to be closed for there to be effective monitoring of the lethality of epidemics—whether H1N1, heroin, cocaine or mephedrone.

6. The term "excess deaths", as used by statisticians, is unhelpful when it comes to public understanding of epidemics. Rightly, the public appreciates that if a new virus, such as H1N1, causes deaths then these are "excess" deaths in the sense that, but for H1N1, they would not have occurred. Confusingly, statisticians use the term "excess deaths" to refer to the difference between the actual number of deaths (say, in week 40 of 2009) and the number that, by comparison with the past decade (say), would have been expected in week 40. Whether the weekly deviations between actual and historically-expected deaths were consistent with year-to-year random fluctuation or sufficiently extreme to alert to impact from the pandemic (for example, deviant more than 1.6 standard deviations) was an aspect of pandemic monitoring that the Royal Statistical Society had expected to see conducted by age-group and in the public domain. The above lacuna in the registration of deaths in England was, of course, a complication but lack of transparency about age-specific monitoring of deaths was both puzzling and disquieting.

7. For H1N1, the Scientific Advisory Group in Emergencies (SAGE) in England had access to three modelling teams within the Department of Health, the Health Protection Agency, and the Medical Research Council/Imperial College; and in Scotland to the modelling team within Health Protection Scotland/ University of Strathclyde. The four teams contained deep expertise at an international level. However, data, methods and communications of these groups were kept very tightly under control to an extent that was undermining of them as apparently conflicting with expectations on independent scientific advice. Future epidemic analysis for a SAGE could be opened up to more external scientific scrutiny (see also: Dame Deirdre's report), and particularly so when SAGE has taken over from an independent scientific advisory committee (Scientific Pandemic Influenza Advisory Committee).

8. The membership of SAGE is, of course, itself constituted to offer scientific challenge. In particular, statistical challenge to epidemic modelling requires transparency about the extent—or paucity—of empirical data or expert judgments which are used as inputs to infectious disease models. In particular, it is never sufficient to be told a percentage (eg 11%) without also knowing either the numerator/denominator from which it was derived (eg 1/9 or 110/1,000) or the standard error that qualifies the estimate. Only by being told explicitly about data limitations can SAGE take action to remedy any deficiencies in surveillance designs or other data capture.

9. In addition to adherence to robust statistical reporting standards, the Royal Statistical Society commends to the attention of STC the benefits of:

> *representative sampling:* i) to reduce burden, for example if a laboratory can test only 200 samples per day, but 1,000 are referred in, then a suitable random sampling scheme is needed by which to select 200 for testing; ii) for surveillance, for example to estimate unbiasedly the weekly age-group-specific proportion of patients who contact their doctor about an influenza-like-illness who have H1N1.
>
> *sample size that is fit-for-purpose:* precision in estimation depends on sample size and, in general, to increase precision by a factor of two, sample size has to increase by a factor of four.
>
> *randomization:* i) for fair allocation of scare resources (if two, equally-eligible patients need the last available ICU bed, determine the admission by randomization); ii) for like-with-like comparison to learn efficiently and defendably which of several possible treatments of a novel disease is the best choice.

10. The Royal Statistical Society considers that fast-track refereeing of research protocols, fast-track licensing for pandemic vaccines, and fast-track ethical clearance for pandemic research studies were excellent initiatives, to which fast-tracked administrative clearances might be added in future to minimize delays in initiating studies that had research and ethical clearances. Although the European Medicines Authority heightened its licensing barrier when the pandemic virus turned out not to be a highly lethal variant of H5N1, uptake of H1N1 vaccines by healthcare professionals and the general public was limited. Did expedition in licensing on the basis of size-limited randomized controlled trials of immune-reaction inadvertently undermine trust in the vaccines' safety when individuals came to make their own risk-benefit assessments?

B. *Answers to specific questions by Science and Technology Committee*

Q1a Potential hazards and risks and how were they identified? The UK experienced three pandemics in the 20th century, and so one or more pandemic influenzas in the 21st century were to be expected. Worse, highly lethal H5N1(A) influenza had been transmitted from birds to humans. Its human-to-human transmissibility was low but that could change by mutation, or if H5N1 assorted with a highly transmissible influenza virus in birds, pigs or man. In fact, the pandemic arose from H1N1 not H5N1, and in the West (Mexico) not the East, and had low, not high, lethality. Characterisation of influenza—prior immunity, transmissibility (Ro initially and consequent on social distancing/prophylaxis/treatment), age-specific hospitalisation and death rates per 100 clinical cases and prior risk factors for infection or hospitalisation had been addressed. With hindsight, too little attention had been paid to the apparently "known" risks to pregnant women—yet international variation in whether seasonal influenza vaccine is advocated for pregnant women suggests conflicted prior beliefs.

Q1b How prepared was the Government for the emergency? By international judgement, the UK's preparedness was highly acclaimed, and looked to. The UK's preparedness in scientific, vaccine, clinical, and infectious disease modelling terms was indeed very well done: provision had been made to ensure that the UK would not be short of antivirals, antibiotics, or vaccine. Provision was made that capacity for intensive care unit admissions could be doubled and, by introduction of the National Pandemic Flu Service, that general practitioners could concentrate on the more seriously ill of their patients. Provision was made for cancellation of elective surgery and modelling studies, notably by the team at the Medical Research Council/Imperial College, had about exhausted what could be learned from historical pandemics and had investigated the impact of routine (that is: pre-planned) school closures on influenza transmission in France.

The extent of the UK government's preparedness for high impact pandemic may mean that the Government seemed to react rather slowly to the more mild profile of H1N1, of which its cleaving overlong to reasonable worst case planning assumptions rather than evolving projections (with uncertainty) of the H1N1 epidemic seemed symptomatic.

Q2. How did the Government use scientific advice and evidence to identify, prepare for and react to the emergency? Please see answer to Q1b. In addition, the UK had an independent Scientific Pandemic Influenza Advisory Committee (SPI) and a predecessor committee, and research funders (notably: Medical Research Council, Wellcome, and NIHR) had given strategic priority to pandemic-related research. Unusually, however, the SPI was, in effect, stood down on 4 May 2009 and did not meet thereafter until 10 September 2010. Formerly SPI subcommittees worked to SAGE but their remit as a subcommittee of an independent scientific advisory committee was, in effect, in abeyance.

In terms of statistical science, some key surveillance designs (such as the FF100 cases and contacts by which initial Ro was to be determined) were not subject to independent peer-review ahead of H1N1; other surveillances were scientifically reviewed but sample sizes remained inadequate for their national purpose despite review; and there was inconsistency across hospitals in England about the virological testing of patients who were hospitalised for suspect H1N1. Monitoring of mortality by week and age-group (one to four years and five to 14 years) in 2009 against historical expectations was not brought into public view until June 2010.

Q3a What were the obstacles to obtaining reliable, timely, scientific advice and evidence to inform policy decisions? Please see answer to Q2 and General Tenets above.

Q3b Has the government sufficient powers and resources to overcome the obstacles? Please see General Tenets.

Q3c Was there sufficient and timely scientific evidence to inform policy decisions? The Royal Statistical Society is unsighted on SAGE's decision-making. However, Dame Deirdre's review suggests that key decisions re H1N1 had to be taken in June 2009 on the basis of judgment rather than data.

Q4 How effective was strategic co-ordination? Please see General Tenets. Timely steps were not taken to improve representativeness of samples (and their number) in England on which weekly estimates were based of age-group-specific H1N1 proportion among those who consulted doctors about an influenza-like-illness.

Q5 How important was international co-ordination? Statistical reporting standards needed to be improved internationally to include when each nation ceased routine testing for H1N1. However, the excellent documentation by intensive care specialists of the impact on admissions to intensive care units in Australia and New Zealand of their first winter wave of pre-vaccination H1N1 was crucial for calibrating the UK's expectations of its second wave of H1N1.

Royal Statistical Society

14 September 2010

Supplementary memorandum submitted by the Royal Statistical Society (SAGE 30a)

TRANSCRIPT OF EVIDENCE—20 OCTOBER 2010

Q24 *Alok Sharma*: Can I just turn to the question of how well the Government communicated scientific advice both to the public and also to the responders? I will read you a small extract from the BMA, who stated the following. I don't know, Dr Holden, whether you actually wrote this. They said: "Doctors felt overwhelmed by the volume of information about the H1N1 pandemic issued by various bodies, including Government. Key advice was lost within the large quantity of emails received which often duplicated information." Could I turn to you, first, Professor Ferguson, and just ask you, as a member of SAGE, did you actually feel comfortable in communicating openly with the media about the swine flu pandemic?

Professor Neil Ferguson: Absolutely. There were no restrictions put on me. I was asked to inform the Department of Health if I was doing so. I was so busy, frankly, that I actually did relatively little of it. It is very easy in such circumstances as an independent scientist to become a regular on media programmes. As you all know, even a five-minute slot on the Today programme takes nearly two hours out of your day to do. So I did it very infrequently. Overall, and I did talk informally to journalists on the phone quite a lot, I was quite impressed with the media coverage. There were some outliers but, generally, I thought the way the risk was presented was not inflammatory or exaggerated. It represented an uncertainty and it communicated policy decisions fairly well. What I am not privy to, and I had no sight of, was the torrent of emails that, I am sure, were going to GPs and clinicians in the NHS. I really just saw the public face of communication. I had a few concerns about the weekly CMO's briefings, **similar to the Royal Statistical Society**, in what they focused on and the presentation of certain numbers as if this was the number of cases in the country. I don't want to go into the technical details. I think those lessons have been learned, but you do need to have a consistent face for the media, and I was satisfied with the CMO being that role.

The Royal Statistical Society was concerned about how the above clinical case estimates were derived and their public reporting by Health Protection Agency, from which they emanated. The President wrote to Sir Liam Donaldson, himself a recipient of the estimates and, by background, a public health doctor, to seek his assistance in resolution of this and other epidemic-monitoring issues.

Professor Sheila M Bird
Royal Statistical Society

25 October 2010

Memorandum submitted by the British Medical Association (SAGE 32)

EXECUTIVE SUMMARY

— The UK had been preparing for pandemic flu for several years prior to the H1N1 pandemic in 2009. Although the UK is one of the best prepared countries for a pandemic, the H1N1 flu pandemic highlighted a number of challenges such as ensuring consistent service-wide demand management; the maintenance of adequate staffing levels; and effective engagement of all areas of the National Health Service (NHS). The UK's preparations were beneficial in the event of the H1N1 pandemic, but it must be emphasised that the H1N1 virus was a "mild" flu virus, and planning for future pandemic scenarios should be based on the worst case possibilities.

— During the containment phase of the H1N1 pandemic, a shortage of staffing capacity amongst public health doctors, general practice and in laboratories providing analysis of swabs taken from suspected H1N1 carriers meant that the pandemic surveillance efforts stretched these bodies to the limit, hampering their ordinary work and slowing down analysis of the pandemic spread. Demands for epidemiological information should be streamlined and coordinated in the event of a future pandemic.

— The provision of certain scientific information and evidence to the frontline medical staff dealing with the pandemic response was subject to delay, causing confusion amongst doctors. Doctors felt overwhelmed by the sheer volume of scientific (and operational) information with which they were presented, and a clearer, more coordinated system of cascading information to ordinary doctors should be developed.

— The Government's use of scientific information in devising the pandemic flu response plan was beneficial but the provision of more information on the scientific evidence underpinning the decision to widely distribute antiviral medication would have been appreciated by doctors. Publication of scientific evidence regarding the safety of the H1N1 vaccine with regards to pregnant women and their unborn babies should have been distributed to midwives at an earlier stage. Clear information on the side effects of antivirals would have calmed the anxiety of patients suffering from their side effects.

— Organisational cooperation on local, national and international levels helped to assess the capacity of organisations to deal with the H1N1 flu pandemic. It facilitated both the relay of information for the monitoring of the pandemic and the dissemination of scientific information amongst relevant bodies. The 2009 pandemic helped to develop links between organisations in practice, and enabled identification of the most relevant body to provide information on different matters.

About the BMA

1. The British Medical Association (BMA) is an independent trade union and voluntary professional association which represents doctors and medical students from all branches of medicine all over the UK. With a membership of over 143,000 worldwide, the BMA promotes the medical and allied sciences, seek to maintain the honour and interests of the medical profession and promote the achievement of high quality healthcare.

Introduction

2. The UK has been preparing for a pandemic flu outbreak for a number of years and a very wide range of guidance has been developed through joint working between the Department of Health (DH) and the devolved administrations, the Health Protection Agency (HPA), the BMA, the Royal College of GPs (RCGP) the College of Emergency Medicine and the Royal College of Nursing, amongst others.

3. Although the UK is one of the best prepared countries for a pandemic, the H1N1 flu pandemic highlighted a number of challenges such as ensuring consistent service-wide demand management; the maintenance of adequate staffing levels; and effective engagement of all areas of the National Health Service (NHS).

With regards to scientific advice and evidence, what are the potential hazards and risks and how were they identified?

Morbidity and mortality directly related to infection with H1N1 flu

4. Early indications from experience of H1N1 flu infections in Mexico suggested a very high mortality rate (above that modelled pre-pandemic), but this was not borne out by UK and global experience.[1] Some mortality was seen in healthy adult groups, and thus the impact of the pandemic measured in years of life lost was much greater than many commentators have suggested based on the predominantly mild symptoms experienced by most people.[2] It became clear by the end of the summer 2009 that this was not as severe as had been planned for.

Insufficient health service resources

5. The first ten weeks of the pandemic—the containment phase—were used to allow the NHS time to set up its pandemic response. This phase was characterised by evolving epidemiology, and attempts to contain all cases of H1N1 infection. This period was particularly difficult for HPA doctors and GPs, in terms of the complexity of management, lack of (human) resources, and the requirements for the collection of information to inform rapidly changing health policy.

6. It has been estimated that undertaking containment delayed the pandemic in the UK by several weeks compared to countries that did not do this, and this was valuable in giving the NHS time to prepare for the treatment phase.[3] It would not have been possible to sustain containment for a longer period of time with the available resources, as both public health doctors and GPs began to suffer exhaustion and burnout.

7. Public health doctors in the HPA and in PCOs were heavily involved in planning for pandemic flu and the response to it. Public health doctors and frontline medical staff worked extremely long hours in difficult circumstances for protracted periods, often with insufficient rest time.

8. Setting up for the treatment phase was extremely labour intensive. On a local basis, preparation for the treatment phase relied heavily on individual public health doctors working in PCOs, who had to also simultaneously ensure that the rest of their remit was delivered as normal.

9. Modelling of the effects of pandemic flu relied on accurate estimates of the available healthcare workforce. Double counting occurred with regards to some GPs who worked during the day and undertook Out of Hours (OOH) work in a different role. The volume of calls to GP surgeries and OOH services, as well as NHS Direct, meant that there was a high risk that patients suffering from serious-non flu illnesses would experience a delay in diagnosis, which could severely affect their prognosis.

Information demands

10. In response to demands for information from the Cabinet Office and Chief Medical Officer (CMO), the HPA requested a range of information from public health doctors, and PCOs requested information from GPs. The number and nature of organisational and governmental information demands led to a huge workload and this diverted healthcare staff away from the frontline planning and delivery of services.

11. Public health doctors were required to submit information on the number of local H1N1 cases, the number of contacts per case, the clinical outcome per case and the duration of symptoms, which was essential to monitor the spread and severity of the disease spread. Information which was far less pertinent to the clinical monitoring of the pandemic was also requested from doctors, such as on the number of hours spent on H1N1 work by grade of employment and the names of family contacts of clinical staff.

12. Some PCOs requested that GPs complete detailed pandemic influenza investigation forms for every suspected case of H1N1 infection that they encountered. Such requests were uncoordinated and disruptive to doctors' work during a period of high demand for their services. Due to the demands placed on public health doctors, GPs had to carry out most of the swabbing of patients with suspected H1N1 infection, using up further staff time during the busy period of pandemic flu response.

13. In the containment phase, healthcare workers were required to swab patients and patients' contacts suspected to have contracted the H1N1 virus. Contact tracing of symptomatic patients was also required, in order to provide information on the spread of the disease to the HPA. These activities took up a further proportion of health professionals' time in a period of high demand for their services.

14. As a consequence of the difficulties encountered in terms of information demands, the BMA recommends for the future that organisational and governmental information demands on public health and frontline healthcare staff are streamlined in future contingency situations.

Maintaining normal service for other services

15. Maintaining the response to swine flu took up so much public health, GP, OOH GP services and intensive care resources that it was not possible or very difficult to properly maintain other services. The impact of this has not been quantified.

16. During the first three months of the pandemic, public health doctors were unable to carry out their normal business continuity work, as there was insufficient staffing to also carry out the more urgent pandemic related tasks—provision of advice on how to respond to the flu at a public level, contact tracing and reporting activities. Public health staff were also requested to travel, with very little notice, to pandemic "hotspots" in London and Birmingham in order to contribute to the flu response efforts in these cities.

17. During the containment phase of the pandemic, GPs had to swab all patients with suspected H1N1 infection, carry out home visits to patients with suspected flu, submit detailed information on H1N1 cases and provide much advice and reassurance to patients anxious about the pandemic. In "hotspot" areas of H1N1 infection, GP practices had to suspend non-urgent activities such as medicines use reviews and elements of work connected with the Quality and Outcomes Framework (following negotiation between the NHS Employers and the BMA's General Practitioners Committee to ensure that this did not impact adversely upon practice incomes).

18. The analysis of the swabs of suspected H1N1 patients was slow, due to the intense demands on public health laboratories. In some cases, swab samples were sent by couriers to distant laboratories, further slowing down the communication of the results of the analysis, heightening patient anxiety.

19. OOH GP services were severely stretched by responding to the pandemic flu. In many areas, OOH doctors carried out home visits to swab suspected H1N1 victims. The volume of calls to OOH services in the flu "hotspots" of London, Birmingham and Glasgow was extremely high at the peak of the pandemic, resulting in delays of several hours in responding to less urgent cases.

20. In intensive care units (ICUs), patients suffering from complications related to contraction of the H1N1 virus took up beds, eliminating extra capacity for further patients. There were only a very low number of specialist paediatric ICU places available, and measures had to be taken to adapt adult ICU facilities for children. Extracorporeal membrane oxygenation (ECMO) facilities were also taken up by patients suffering from H1N1-related complications, and the number of available facilities had to be increased during the pandemic.

Issues with the provision of scientific advice to frontline healthcare staff

21. Pandemic flu guidance for use in periods of an extreme surge in demand for medical services—*Pandemic flu Managing Demand and Capacity in Health Care Organisations. (Surge)*—was published in April 2009.[4] It was noted in the surge guidance that the DH was in the process of working with Clinical Reference Groups to develop outcome tools to support clinicians in their decision making in a surge situation. The tools took several weeks to produce, during a period in which the H1N1 pandemic was developing rapidly. Doctors required these tools in order to be fully prepared for a surge situation, and raised concerns that the assessment tools were not available.

22. During the initial stages of the pandemic, GPs required information on how to minimise transmission of the H1N1 virus. The BMA's General Practitioners Committee received many queries from GPs on the use of face marks, overalls, goggle, gloves and respirators (personal protective equipment—PPE), and the type of equipment to use. Doctors were unsure when to use PPE (for example, when visiting people suspected to have contracted the H1N1 virus, or when carrying out certain medical procedures on any patients), and which items to use. Definitive information on the use of PPE from the HPA was not provided for several weeks.

23. GPs were given confused messages about the prescription of antiviral medication in a prophylactic capacity. For example, in cases where people contracted H1N1 and had close contacts who were at risk from developing serious complications if they contracted the virus, it was advised by the CMO that prophylactic antivirals be administered to the vulnerable contacts, whereas local specialists (such as microbiologists) advised that antivirals were not to be used in a prophylactic capacity. Such contradictory messages were reinforced by the antiviral voucher system. Antiviral vouchers enabled symptomatic patients to obtain antivirals for treatment purposes only, with no provision for prophylactic purposes possible. Doctors were unable to prescribe antivirals (for prophylactic or treatment purposes) due to the regulations surrounding the system of antiviral voucher provision.

24. There were delays in the provision of information on the administration and storage of the H1N1 vaccines, which was required by GPs in order to effectively plan for vaccination clinics. The development of an H1N1 vaccine by the major pharmaceutical companies (the Baxter *Celvapan* and Glaxosmithkline's *Pandemrix*) took time, and it was therefore not possible for full information on the vaccine storage tolerances and detailed logistics to be disseminated prior to its final development. Final vaccine distribution and storage logistical information could not be issued until the conclusion of Government negotiations regarding the supply contract of H1N1 vaccines. It is unlikely that fuller information on the vaccines could have been supplied to doctors at an earlier stage of the planning process.

25. Doctors felt overwhelmed by the volume of information about the H1N1 pandemic issued by various bodies, such as the HPA, RCGP, BMA, DH, PCOs and Local Medical Committees (LMCs). Key advice was lost within the large quantity of emails received, which often duplicated information already disseminated by other organisations. The specific highlighting of any changes to advice and evidence, and provision of information at the top of the email body, would have aided doctors in assimilating changes to information.

26. The BMA believes that in future, essential scientific information should be clearly marked and consistent. Organisations disseminating such information should coordinate their releases to minimise repetition.

27. Sessional GPs were heavily involved in responding to the H1N1 pandemic.[5] They were not always party to the latest scientific advice and evidence (and operational information) from the CMO due to ineffective information distribution by PCOs. This problem was brought to the attention of the DH via the GP Flu Operations Group (GP FLOG)[6]. The DH then communicated with Strategic Health Authorities (SHAs) and PCOs in order to eliminate this problem.

28. The scientific evidence upon which the English policy of distributing antiviral medication was devised should have been made readily available to clinicians. In the professional clinical opinion of many doctors, there was no reason for healthy adults with no underlying health problems to take antivirals, and the H1N1 virus was a mild strain of flu. The policy of wide scale distribution of antivirals to all symptomatic patients undermined the clinical judgement of such doctors. Doctors do not tend to prescribe antivirals to symptomatic but otherwise healthy patients for seasonal flu. It is also notable that antiviral medication was not distributed to all symptomatic patients in Northern Ireland, Scotland and Wales on the same scale as it was in England during the H1N1 pandemic, and that this did not lead to higher morbidity and mortality rates from H1N1 in these countries. Doctors feared that the policy of distributing large quantities of antiviral medication was based on economic, rather than scientific reasoning.

29. GPs reported cases in which midwives advised pregnant women against receiving H1N1 vaccination, claiming that it had not been fully tested and could harm their baby. Pregnant women were at risk of developing complications in the case of contracting H1N1. Immunisation would reduce such a risk. Clear and direct communications to midwives of scientific evidence regarding the safety of the H1N1 vaccination could have helped to overcome this issue. Additionally, it was not beneficial for pregnant women to receive messages from their doctors (urging H1N1 vaccination) and midwives (advising against vaccination).

Identification of risks and hazards associated with a flu pandemic

30. Since 2008, the BMA's General Practitioners Committee has been involved in working with representatives of the DH and the RCGP in order to develop guidance for use by GPs in the case of a flu pandemic. This guidance, *Pandemic influenza Guidance for GP practices,* was first published in January 2009.[7] Liaison between the BMA, RCGP and the DH ensured that doctors' representatives could directly voice their concerns to DH representatives, helping to identify the potential risks and hazards involved in a pandemic situation which could then be passed onto governmental planning agencies.

31. In 2006, the BMA provided evidence to the House of Lords Science and Technology Committee regarding the response to a flu pandemic, helping to highlight the potential problems which had to be considered in devising the healthcare response to a flu pandemic.[8]

How prepared is/was the Government for the emergency?

32. The UK was well prepared for the H1N1 pandemic flu emergency, especially in comparison with the response readiness of other developed countries.[9] The most unexpected factor was that the H1N1 pandemic was a less severe pandemic than had been planned for.

33. The BMA maintains that the experience of the healthcare response to the H1N1 pandemic must not lead to complacency or undermine plans to deal with future pandemics. The BMA also believes that pandemic planning must continue along a "plan for the worst case and hope for the best case" basis.

34. Following the H1N1 pandemic in 2009, the links between the organisations—DH, HPA, PCTs, SHAs, LMCs, Royal Colleges of Medicine, BMA and public health dealing with and providing information on pandemic flu have been strengthened, improving the preparedness of the UK to deal with future pandemics.

How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

35. The Government utilised information derived from the previous pandemics of 1918–19, 1957–58 and 1968–69 to plan well for future ones[10]. The projected adverse impact of the 2009 H1N1 pandemic on the healthcare pandemic response were greater than the actual impacts, but it must not be assumed that future pandemics will be so mild.

36. The UK's involvement in the World Health Organisation Global Influenza Surveillance Network, providing international disease tracking and epidemiology, helped to identify the emergent threat from the H1N1 virus in good time.

37. The epidemiology undertaken during the containment phase was properly used to develop and refine clinical algorithms as the pandemic progressed. The number and frequency of these refinements meant it was difficult to ensure all clinical staff that needed to know were always up to date with the most recent advice.

38. In the response to the H1N1 pandemic, the clinical algorithms used by non-clinically trained call handlers at the Flu Line were effective for the provision of advice to callers with mild symptoms of the H1N1 virus, but did not result in the correct advice being provided to callers who had more complex or severe symptoms, or who were at greater risk from complications from the flu virus. The National Patient Safety Agency was notified of many incidents relating to delayed or missed diagnosis of "other" conditions mistakenly labelled initially as "flu" by call handlers.

39. The CMO's monitoring and weekly announcement of key indicators was found to be useful by healthcare staff and helped to fine tune the healthcare response to the pandemic. The weekly information from the CMO allowed the public to understand at least part of how the pandemic was progressing. However, the public information/advice on what to do and what not to do was overly simplistic and the message was not amended as the pandemic progressed. This should have been addressed at the time.

40. Widespread information on the potential side effects of Tamiflu, disseminated to the public and provided at an earlier stage of the pandemic response would have ensured that people were fully informed and less likely to contact health services after suffering side effects from the drug.

What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? Was there sufficient and timely scientific evidence to inform policy decisions?

Information gathering

41. Gathering epidemiological data on an emerging pandemic is labour intensive. The HPA did not have sufficient resources to undertake all of the information gathering that could have been carried out.

42. A lack of pre-prepared systems for information gathering resulted in frequent demands for different types of information related to the effects of the pandemic and the healthcare response. Frontline healthcare staff were thus overburdened and the BMA believes that this resulted in a reduction in the efficiency of the containment policy.

43. In many instances during the containment phase of the pandemic response, GP practices ran out of HPA-approved swabbing equipment, hampering the provision to the HPA of information on the progress of the spread of the virus.

The use of information to decide policy and clinical algorithms

44. Policy and clinical algorithms were decided using available information streams on the H1N1 pandemic. Had additional resources been available to the bodies gathering information, it would have been reasonable for additional information to have been collected by those deciding policy and developing clinical algorithms. Such extra information could have led to the avoidance of other difficulties.

Dissemination of information to those that need to implement pandemic response policy

45. The advice provided to central Government for the purposes of informing policy was timely and useful. It was difficult to disseminate advice to clinicians in the field—particularly GPs—in a timely fashion. Advice was also subject to overtly frequent change, with often daily minor incremental change to the advice.

46. There were problems in providing clinical backup advice to GPs facing complex problems as a result of the H1N1 pandemic. Routine and basic advice and assistance was provided by administrative staff working from clinical algorithms, but it remained difficult to provide expert back up advice from clinical public health staff due to mismatch of the volume of demand and the small numbers of consultant staff. Consultants in communicable disease control, who were the group best qualified to give this advice, were mostly engaged in containment or epidemiological work and could not be spared to give clinical backup to GPs until late in the containment phase. The BMA would be happy to offer frequent updates to all doctors through its, and the BMJ's, websites to contribute to ensuring rapidly updated, single and consistent messaging during any future epidemic/pandemic.

47. The BMA recommends that the Government must ensure that relevant organisations liaise with each other, and that the appropriate personnel are in contact with each other, so that in the event of an emergency, communications can be made quickly and effectively. In order to make certain that staffing levels are optimal to provide a response to a pandemic, the Government should agree the arrangements for resourcing the public health departments and frontline healthcare providers in emergency situations. In the 2009 H1N1 pandemic, many GPs were concerned by the lack of an emergency Statement of Financial Entitlements, arrangements for death in service benefits for locum GPs and payment arrangements for providing H1N1 vaccination.

48. The BMA also believes that contingency plans should be developed in order to cope with excessive demand on services providing scientific advice and monitoring to overcome problems associated with high demand. Measures should also be taken to ensure that the scientific advice given to health professionals and the public is consistent in an emergency scenario.

How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?

49. Engagement between key public stakeholders—including in regional and local pandemic resilience fora was key to mounting an effective, joined up response to the H1N1 pandemic.[11] Such local coordination enabled resilience planners to fully understand the extent of their capacity to deal with the effects of a pandemic. The roles of other organisations and the extent to which they could extend their remit in a time of crisis were clearly defined. The fora also enabled the issuing of advice to other organisations and the public. The coordination between the organisations ensured that there was a clear path for the distribution of communications from the Government and organisations concerned with providing advice on the national healthcare response in a pandemic.

50. Pandemic resilience fora failed to engage private bodies in the pandemic preparation phase and during the emergency itself, despite efforts to do so. Private sector representatives could not recognise direct benefit to their organisations in participating in the fora.

51. Frontline clinician representatives were not always included in PCO H1N1 response meetings. The involvement of clinicians was essential in order to ensure that the H1N1 response plans were achievable and realistic, and that any potential problems identified by clinicians could be highlighted.

52. Many PCOs had not prioritised the development of technological solutions to enable GPs to gain secure, remote access to GP clinical systems, hampering the flexibility of GPs to work at different sites when the demand for their services was very high. GPs with remote access reported that they were able to complete work away from their surgeries, which aided their response to the demands of the pandemic.

53. The BMA suggests that PCOs should ensure that technology is enabled to allow secure remote access to GP clinical systems in times of emergency.

How important is international coordination and how could it be strengthened?

54. Coordination at any level of organisation (local, national or international) helps to improve the overall response to emergency situations. A united, UK-wide response to the flu pandemic, backed up by evidence and the same scientific strategy across all four UK administrations would have aided the emergency response to the pandemic.

55. The UK's pandemic response planning was greatly aided by its involvement in international disease tracking and epidemiology, via the World Health Organisation Global Influenza Surveillance Network.

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[5] Sessional GPs are fully qualified GPs who are either have a contract to provide for contractor or a PCO, providing GP cover for a specified period or working on a freelance basis; or are employed by a practice, PCO or alternative provider of medical services.

[6] The GP Flu Operations Group consisted of representatives of the GPC, RCGP, NHSE and DH, with the remit to resolve operational problems, meeting on a weekly basis in the latter half of 2009.

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[11] Pandemic resilience fora consisted of police leads, category 1 responders ("blue light" services, the NHS, local authorities, HPA, Health and Safety Executive, etc.) plus more lower key category 2 responders (representatives from other public organisations, etc).

British Medical Association

14 September 2010

Supplementary memorandum submitted by the British Medical Association (SAGE 32a)

Many thanks for the opportunity to appear as a witness on 20 October 2010, I hope that the Committee found the evidence session helpful.

In response to your question about the potential shift to practitioner-led commissioning and the impact on a future pandemic response, it would be premature to respond to this question fully until the publication of the Government's Public Health White Paper. The White Paper, which the Government states is due to be published at the end of the year, will establish a Public Health Service that will encompass existing health improvement and protection bodies and responsibilities. We believe that local authorities will have a public health role in coordinating the response locally but we feel that consortia should be a focal point of the organisation of local practices. As they will be led by GPs, they will well understand the issues and level of response which can be expected from practices. Whatever structural changes are made, it will be essential for the Government to ensure that there are robust arrangements in place to ensure efficient coordination between the Departments of Health and local areas in responding to a national emergency.

The implications of the National Commissioning Board's role in centrally commissioning pharmacy will need to be clarified, as pharmacies were used during the pandemic for Tamiflu distribution at the direction of primary care organisations. The role of central coordination in an otherwise devolved health service will need to be clearly understood by everyone from the Cabinet downwards. The structures that worked well in the last pandemic did so because a small number of representatives and experts agreed what had to be done on behalf of all the professionals and organisations that had to contribute to the pandemic effort. This should not be devolved away in the future.

I hope that you find this useful.

Dr Peter Holden
BMA General Practitioners Committee

10 November 2010

Memorandum submitted by The Royal Academy of Engineering (SAGE 33)

Introduction

The Academy welcomes the inquiry into *Scientific advice and evidence in emergencies* and has previously responded to the Government Chief Scientific Officer's consultation on *Guidelines on scientific advice in policy making* in February 2010.[53]

In the *Guidelines on scientific advice in policy making* response, the Academy made the point that while it is important that the scientific and engineering advice used by government should be independent, at the height of a crisis, the level of independence could be less of a priority as expert knowledge becomes more important. To take the example of BSE, at the inception of the crisis, it would have been unhelpful not to use the expertise of stakeholders such as farmers and vets directly involved, despite their having a direct interest in the issues. Later, as the issues become clearer, a broader group of experts with fewer direct interests would be appropriate to advise on mitigation and recovery.

In this response, we have tackled two of the four case studies the Committee has chosen to cover: solar events and cyber security. These differ in important aspects: space weather is a natural phenomenon, whereas an attack on cyber infrastructure is likely to be a deliberate act. The emphasis in terms of space weather events is therefore resilience and recovery where as the emphasis for cyber attacks is prevention ahead of resilience and recovery.

Solar Storms

1. *What are the potential hazards and risks and how would they be identified? How prepared is the Government for the emergency?*

Extreme solar storms can knock out space craft and affect passengers' health on transpolar air flights through the effects of high energy particles and radiation. They can also cause long lasting problems if physical damage or data corruption occurs in space to ground radio communication, radio navigation or radio surveillance systems. Furthermore, such storms can damage electrical transformers and thus cause outages on the electricity network. These extreme events, sometimes known as Carrington Events (after British astronomer Richard Carrington), probably occur once every century or two.

Many critical infrastructure systems rely on timing signals derived from the GPS system to manage date transfers over networks and synchronisation. In the event of the loss of that timing signal, for what ever reason, most systems can "free wheel" with marginally reduced efficiency for a number of hours or days on less accurate internal clocks. Alternatively, highly accurate timing signals could be derived from ground based navigation systems such as eLORAN which would be significantly more robust to space weather events than the GPS satellite constellation. In the event of the loss of external timing signals, new innovations such as chip scale atomic clocks (CSACs) will reduce this vulnerability further. It is expected that such systems would be able to "free wheel" for the duration of any space weather event, re-synchronising their clocks when timing signals from the GPS system become available again.

Very much less extreme solar storms occur much more frequently and mitigation is largely provided through good engineering practice; for example by designing well protected spacecraft and using suitably rated transformers on the electricity network. Through strong engineering in place already, the UK infrastructure is generally well protected with long lasting problems being most unusual. Somewhat more problematical is dealing with the variability of signals caused by day-to-day space weather. For such radio systems, the national need is generally focused on defence systems which require higher signal integrity rather than civilian applications.

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[53] http://www.raeng.org.uk/societygov/policy/responses/pdf/Scientific_Analysis_in_Policy_Making.pdf

2. *How does the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

There are three types of space weather effects that need to be considered, each with differing warning periods from observation and duration. Because of the topology of the earth's magnetic field, the effects of radiation and geomagnetic storms are felt more acutely near the poles.

- Electromagnetic radiation:
  - Arrival: eight minutes.
  - Duration: one to two hours.
  - Effects: Dayside high frequency (HF) radio blackout, radio noise bursts causing interference on some satcom, navigation and radar systems.
- High-energy charged particles—direct effects:
  - Arrival: 15 minutes to days.
  - Duration: hours to days.
  - Effects: Satellite anomalies, passenger radiation exposure, avionic glitches.
- High-energy charged particles—indirect effects:
  - Arrival: one to four days.
  - Duration: hours to days.
  - Effects: Severe HF radio blackout in polar regions (including polar HF communications to aircraft), suppression of HF capability at all latitudes, GPS/Galileo accuracy degradation, potential for power grid problems.

The quantification of the risk associated with major storm events is not a simple matter and can only be achieved through the combined study of both engineers and space scientists. Many studies of this type have been conducted by various agencies, but the majority fail to consider both the engineering and scientific solutions. In principle, it is best, where possible, to engineer out the risk at the design stage if this can be achieved at acceptable cost.

There have been no extreme solar storm events in the UK since the start of the space era, but lesser storms have caused problems on European Space Agency (ESA) satellites and on HF communication systems amongst others. Lesser storms have also caused minor perturbations to the electricity network in the UK.

Scientific and engineering advice on space weather effects has been used and applied by operators to safeguard the services they provide and ensure a certain level of system resilience. Space weather events are transient and most effects are transient as well. Where there are longer term effects and where risks have not been successfully engineered out of systems, the recovery and resilience of affected systems are, to a large extent, independent of the cause of the failure. Where it is applicable, Government should use scientific and engineering advice to ensure the resilience or quick recovery of critical systems in the event of a serious space weather event.

3. *What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies?*

The UK has no central coordinating agency for these events. One clear candidate is the Centre for the Protection of National Infrastructure (CPNI). Another is Defence Intelligence (DI) Intelligence Collection Strategy and Plans (ICSP) in the MOD. This Department has responsibility for the Defence Meteorological Programme and the MOD embryonic Space Weather programme. Wherever in Government this capability is located, it should have the ability to deal with classified material.

4. *How effective is the strategic coordination between Government departments, public bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies.*

There have been no major storm events since the start of the space era but in the context of lesser storm events there is little indication of any coordination across government. However, the MOD recognised some years ago that the response to impact of space weather on radio systems must be unified. Consequently, it contracted QinetiQ to develop a space-weather mitigation model with real-time capability which can be used operationally to support radio systems, where engineering mitigation is not possible.

How important is international coordination and how could it be strengthened?

International coordination is critical. Space weather sensors and predictions are an international endeavour; moreover the impact of extreme solar storms will be global. Realistically, the US will be a focus for space weather monitoring and notification as US society and defence are highly reliant on space assets. The US electricity network is also located at a higher geomagnetic latitude than the UK system making it more susceptible to such events. The European Space Agency (ESA) has the remit to provide the civilian

focus for solar storm monitoring and space weather in Europe and will develop high level links into the US programme. In the UK and in the defence domain, linkages have been developed between MOD and DoD, resulting in a series of US-UK MOU Project Arrangements in this topic area.

Cyber Attacks

1. *What are the potential hazards and risks surrounding cyber attacks and how are they identified? How prepared is the Government for an emergency in this area? What kind of systems are the most likely targets and what would the impact be?*

The risk of serious cyber attack is perhaps somewhat hyped in the media, and in reality it is small; there is no known looming threat of an "internet 9/11". However, the risk is not zero and is likely to be increasing. Nation states have developed and will develop a cyber warfare capability—the attacks on Estonia in 2007 are evidence of this.

There is no single scenario to prepare for—different individuals, organisations or countries will attack different targets for their particular reasons. Cyber attacks can be used by criminals to make money or gain information; be undertaken purely as an exercise in hubris or with malign intent by hackers; or by nations to cripple another's critical national infrastructure.

It will not always be clear who the attacker is and what their motives are. For example, a cyber attack apparently by a hacker working alone might, in fact, be a politically motivated attack. It is also possible to disguise which country an attack originates from, as perpetrators working in one country can bounce information they send from a server in another country. This makes it very difficult to mobilise the appropriate response swiftly. In the time it takes to ascertain whether an attack should be met with a military, diplomatic or criminal agency response, the attack could have occurred and perpetrators will have moved on.

Large-scale organised cyber crime is a significant threat, with growing markets for selling and acquiring cyber attack capabilities. There is a flourishing and fast evolving market in the trading of botnet code that can insert itself into computers that then launch denial of service attacks under central or distributed direction.

Cyber attacks can have real physical effects, especially if they are targeted at critical infrastructure. An attack aimed at the control systems in a power plant could interrupt generation and potentially damage the plant. If smart meters are introduced, cyber attacks could turn large numbers of them off remotely. However, in reality more damage is likely to be done to the electricity infrastructure through physical attacks on substations. Conversely, nation states could also attack cyber-infrastructure using other means, such as an Electromagnetic Pulse (EMP), though to effect large scale damage to the cyber-infrastructure would require a pulse of the magnitude caused by a nuclear explosion.

2. *How does the Government use scientific advice and evidence to identify, prepare for and react to a cyber attack?*

The Office of Cyber Security (OCS) and other agencies have established ad-hoc networks seeking academic and industry support, but this is still formative. The role of the OCS needs clarification, particularly in terms of its ability to coordinate existing expertise.

The network of CSAs is, as always, important in providing Government with a capability to use scientific advice and evidence, and can work with the learned societies and professional bodies to do so. The GCSA John Beddington's recent review of cyber security, run by an ad hoc committee of experts in the area, should feed into national security strategy.

The Serious Organised Crime Agency (SOCA) appears to have had a good understanding of how the criminal world is developing cyber attack capabilities. It cooperated and coordinated with other law enforcement agencies but there is undoubtedly much more to be done here and more support will be required by any agency planned to replace SOCA. In general, there is little expertise within the public sector, and the Government relies on experts in the private sector working together on common issues.

Ensuring availability of evidence and advice is a challenge. There is science and engineering research devoted to encryption and the hardening of the software running our systems. But there is too little research on the systemic way in which the Web is changing and evolving and new applications can arise faster than our ability to appreciate their significance. The newly emerging discipline of Web Science is an attempt to anticipate how the evolving cyber capabilities present new vulnerabilities and new opportunities and it could be exploited further by Government.

3. *What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles?*

There is a lack of coherent leadership within Government, with no central conduit for advice on this area. The process of obtaining advice needs to be better resourced & made coherent with alerting through CPNI and SOCA or its replacement.

Academics working in this area rarely have the level of security clearance required to engage with Government and help to plan for cyber attacks, putting potentially useful advice is out of reach. Government also needs to work with experts in the commercial sector, but some of these may work in businesses which lack the structure to engage with Government.

The fact that almost all critical infrastructure assets are in private hands is a potential obstacle, as is the fact that the UK is a small player in a globalised world.

4. *How effective is the strategic coordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to a cyber attack?*

Coordination is likely to be limited because:

— some of these areas are highly sensitive and the agencies involved find it difficult to share insights;

— key aspects of the cyber estate are in the control of private companies;

— many of the public bodies that need to play a role lack the required competences; and

— research on the Web as a critical ecosystem is fragmented.

At present, there is no one place in Government where responsibility lies, and different departments ask the same of advice of the same people. The role and resourcing of OCS needs to be resolved, clarifying whether OCS is merely raising awareness of this issue, or whether it will be setting out and enacting a cyber security strategy.

5. *How important is international coordination and how could it be strengthened?*

Organised cyber crime is not an issue that can be resolved at a national level and urgently needs international diplomatic effort to agree behavioural norms, including a UN cyber crime treaty. Mutual Legal Assistance Treaty processes are not fit for purpose in this domain as they take too long: attacks are over and perpetrators have moved on before any kind of agreement can be reached. There must be better international police cooperation in order to deal with the high levels of acquisitive cyber crime.

Submitted by:

Mr P Greenish CBE
Chief Executive
The Royal Academy of Engineering

Prepared by:

Katherine MacGregor
Policy Advisor

14 September 2010

Supplementary memorandum submitted by The Royal Academy of Engineering (SAGE 33a)

VULNERABILITY OF THE GALILEO SATELLITES TO EXTREME SPACE WEATHER EVENTS

You recently invited The Royal Academy of Engineering to give evidence to the House of Commons Science and Technology Committee inquiry on extreme space weather events along with the impact of solar storms on the mobile telephone network. Professor Paul Cannon FREng appeared as our witness: his additional comments on both issues are set out below.

GALILEO

You asked for additional information regarding the vulnerability of the Galileo satellites (as opposed to the GPS satellites) to extreme space weather events.

Both satellite constellations are/will be in medium earth orbit (MEO) and as such they are exposed to high energy electrons and very high energy solar particle events, both of which can have a deleterious impact on satellites. The GPS satellites are of military origin and we can expect that they have been "hardened". The Galileo constellation is, however, a civilian system and so is being designed in accordance with usual space engineering practice. That means that the satellites will be designed, with some margin, to operate over their design lifetime while subjected to a standard model of the high energy particle environment. This environmental specification is based upon measurements conducted since the start of the space era, rather

than a major Carrington event. The detailed design requirements will be held by the European Space Agency (ESA). As part of the government's assessment of the vulnerability of national infrastructure to major solar storms, it may be appropriate for these specifications to be reviewed by expert authority.

Both the GPS system and Galileo systems operate at similar frequencies and consequently the impact of the solar storm on the radio signals will be very similar. It is very possible that combined GPS and Galileo receivers will be somewhat more resilient to these propagation impairments by virtue of the special separation of the signal paths from the satellites to the ground.

Impact of Loss of GPS/Galileo Signals on Mobile Phone Networks

Timing

It is our understanding that neither the GSM standard (2G) nor the wideband code division multiple access (CDMA) standard (3G) as implemented in the UK are dependent on GPS timing for their operation. Base stations operate asynchronously and timing in the backhaul network is distributed through the communications protocols.

The situation is very different in the USA, where, GPS timing is deeply integrated into the US (CDMA) standard known as IS95. Again, there is no GSM (2G) GPS dependency. The Academy also understands that GPS timing is employed to deliver against FCC requirements on 911 (emergency) localisation of mobile users.

In conclusion, the US mobile network appears to be vulnerable to the loss of GPS timing, and the UK network seems to be resilient—but we would expect the Government to check these understandings given the importance of the mobile network to the UK infrastructure.

Solar Radio Bursts

There is documented evidence that Solar Radio Bursts (SRBs) can detrimentally affect GPS systems for a period of $\sim$20 minutes. We have already indicated that the mobile telecommunications system in the UK is not dependent on GPS.

It has been suggested, however, that SRBs can affect the performance of mobile phone networks by increasing the noise floor in the system and causing an increase in the dropped call rate. The effect should be most evident if the base station antenna is pointing at the sun (ie antennas pointing to the east and west and when an SRB occurs at sunrise or sunset respectively).

The effect is probably small—it has not been possible to find any reports of wide scale effects resulting from the Dec 2006 SRB (the largest on record).

Should you require further information, please do not hesitate to contact the policy team at The Royal Academy of Engineering.

Philip Greenish
The Royal Academy of Engineering

23 November 2010

Memorandum submitted by the Met Office (SAGE 34)

Introduction

1. The last three major emergencies which involved UK Government response were weather related: Cumbria floods in 2009; winter salt shortages in 2010 and volcanic ash in 2010. Weather is undoubtedly the single risk that could be said to cut across all emergency situations. Even when not the initial cause, weather may be the direct driver of secondary factors that act to intensify the impacts, hamper emergency response or slow recovery.

2. All Met Office operational services, and the meteorological advice Government relies on in emergency situations, are underpinned by a strong and dynamic science base. Our proven 24/7 operational capability ensures delivery to the right people fast—through a resilient and secure infrastructure that routinely carries classified information.

3. The Met Office is globally unique in our capability to pull emerging meteorological and climate science directly from research—either our own or in collaboration with academia—to fully operational and targeted applications.

Using Met Office Expertise in Identifying and Quantifying Emergencies

4. Weather is frequently either the direct or a secondary driver in emergencies. The Met Office feeds directly into the annual process for assessing risk to the UK from natural hazards and is frequently an expert member of the Science Advice Group in Emergency (SAGE) convened and led by the Government's Chief Scientific Advisor. During the recent volcanic ash emergency the Met Office Chief Scientist was part of the SAGE core team (working alongside an expert from the British Geological Survey (BGS)).

5. The Met Office has long established links directly into the Cabinet Office Civil Contingencies Secretariat, COBR and its counterparts in the devolved administrations. We update both Official and Ministerial meetings with real-time evidence, situational analysis and impartial advice based on robust predictions enabling Government to make immediate but considered decisions.

6. Risks arising from natural hazards have previously, and correctly, been based largely on historical and statistical data and evidence. However, the world's climate is changing and the science community agree that the frequency of damaging weather-related events is increasing. A robust underpinning science base, delivering impartial results, is therefore vital to ensure a measured yet realistic assessment of changing risk is maintained.

7. An emerging issue is also the need to be better prepared for the impacts of concurrent hazards and to increase the resilience of the UK's critical infrastructure; recognising that the functionality of one critical service (eg water) is interdependent on others (power). Although infrastructure and users may be resilient to a number of hazards experienced individually, they may experience a different level and type of risk when they are combined eg the recent incident in New Zealand which saw the strongest earthquake since 1931 hit Christchurch causing widespread damage and power outages, followed by winds of up to 80 miles per hour and heavy rain which hampered the recovery efforts and caused further evacuations due to risk of flooding.

8. Horizon scanning is an important aspect of the Government's risk assessment process. In addition to the changing probability of weather related incidents, the UK's vulnerability is changing: the recent volcanic eruption in Iceland highlighted the vulnerability of airline operations with respect to ash plumes and the relatively recent and rapidly growing global reliance on technology, for example, has catapulted the risks from space weather to life, the economy and infrastructure to the fore bringing concern about the ability of UK infrastructure to withstand major space weather events.

Risks Presented by Space Weather

9. The term space weather encompasses the conditions on the sun, the solar wind, the magnetosphere, the ionosphere, and the neutral atmosphere that can influence the performance and reliability of space-borne and ground-based technological systems.

10. Extreme space weather events typically occur at the solar maximum, which itself follows a roughly 11 year cycle. The next solar maximum is expected around 2012–13—potentially coinciding with the London Olympic Games.

11. Ionospheric storms disrupt global navigation satellite systems and high frequency communications, magnetic storms induce damaging currents in power lines and can weaken pipelines, and radiation storms affect the health and safety of passengers and aircrews. Prediction of space weather conditions can help to reduce, or avoid, the impact of space weather on our lives.

12. An event of the scale of the 1859 Carrington event, the most powerful in recorded history, could result in national grid failure causing power loss across significant areas of the UK for up to 12 hours, and up to several weeks if many transformers were damaged, due to the long manufacture lead times for these components.

13. A storm of the severity of the Carrington event could cause the permanent loss of 30% of satellites, leading to disruption of communication satellites, Earth Observation facilities and Position Navigation and Timing services, including GPS. This would have a severe impact upon global and UK monetary systems which are primarily composed of electronic accounts and assets and rely on accurate timings from GPS to synchronise trades.

14. A US National Academy of Sciences paper estimated that if the Carrington event were repeated today, the economic and societal costs to the USA could reach US$1-2 trillion in the first year, with full recovery taking four to 10 years.

Using Met Office Expertise to Prepare for and React to Emergencies

15. The Met Office operates the London Volcanic Ash Advisory Centre, one of nine such centres worldwide, and has responsibility for predicting and monitoring the spread of ash plumes arising from eruptions in the Northeast Atlantic, including Iceland. We also host and operate the Radioactive Incident Monitoring Network (RIMNET) on behalf of DECC which records and analyses radioactive levels across the UK. The Flood Forecasting Centre harnesses meteorological and hydrological expertise jointly from the Met Office and the Environment Agency and provides flood warnings across England and Wales. We operate the National Severe Weather Warning System that ensured the UK, and emergency responders in particular, were sufficiently prepared during the severe cold and snow events of last winter.

16. Those responsible for directing and taking action during an emergency do so in real time, relying on skilled interpretation and clear communication of often complex information. The Met Office, as the UK's National Meteorological Service and as the preferred supplier of meteorological information under the Civil Contingencies Act, is at the forefront of providing the impartial advice and supporting evidence required to enable Government to make the best decisions possible in real time during emergencies. The emergency response community, the public, and industry and commerce also look directly to us for the authoritative information and advice upon which to base their actions.

17. Users of science advice must be confident in its veracity, its relevance and be assured of an organisation's capability to continue to deliver to a wide range of stakeholders. Policy makers plan and prepare according to the best advice and forward-looking analysis that science can provide. It is vital that decisions are based on the best science to ensure risk mitigation and preparedness is appropriate, cost effective and provides true value for money.

18. Confidence in policy and action comes from the knowledge that expert advice, and therefore the underpinning science, is robust. The UK is assured of the quality of Met Office science, operations and advice through continual benchmarking against international scientific institutes and the close monitoring by the Public Weather Service Customer Group. The Met Office is one of only two World Aviation Forecast Centres (the other being in Washington, US), and is the accredited aviation forecast provider to the CAA under the EU Single European Sky legislation.

19. Although the Met Office's reputation as a world leading science institute is perhaps more commonly associated with terrestrial weather, the breadth and depth of our capability, our science expertise and our role as a facilitator of academic research, is enabling a developing involvement and expertise in space weather prediction.

20. We already know that the military, and therefore security, is heavily dependent on space weather information. Organisations such as QinetiQ and some US departments are developing basic decision making tools but they still require an interpreter trained in space weather to make best use of the information for each customer community. The Met Office has been delivering training in space weather to our own forecast staff and to Royal Navy forecasters since 2006.

21. The focus of current Met Office work is to bridge the gap in the user's understanding between the scientific output in the space weather products and what this means for the user's system. For example, current space weather outputs might say, "a Coronal Mass Ejection has just occurred'; we are translating this into actionable and relevant advice such as "this has a, b and c operational implications for system X", rather than leaving the user with the difficult (and unwanted) task of interpreting the space weather information.

22. The Met Office is collaborating with NOAA to mirror their space weather predictions on an operational basis and to push forward with science developments. Our research into space weather has to date focussed on exploiting our existing strengths in troposphere/stratosphere/mesosphere modelling and data assimilation and we have utilised these in collaborative projects with University College London to test existing models.

23. We are actively engaged with space weather experts in BGS and the Science and Technology Facilities Council as well as collaborating with Bath University on an Engineering and Physical Sciences Research Council Doctorate studentship entitled "Design and Development of a Space Weather Forecast System". This runs from 2009 to 2013 with the student based full time at the Met Office from autumn 2010.

Obstacles to Obtaining Reliable and Timely Scientific Advice and Evidence

24. When multiple hazards are experienced, Government and the wider user community may find themselves taking advice and information on each parameter separately and sometimes from conflicting perspectives. In addition to central Government departments, local authorities and civil contingency responders, over 20 agencies can be involved in providing data, intelligence and advice to decision makers.

25. These agencies, including the Met Office, sit within different departments, have different responsibilities and perspectives, issue warnings for different specific hazards and are developing new capabilities—both individually and in collaboration. Without a clear set of priorities or the best level of overall agency-wide and academic coordination there is potential for duplication of effort and, more critically, capability gaps may not be readily identifiable.

26. In real-time decision making terms, multiple sources of rapidly updating information and advice may cause delays as time is taken to assimilate and analyse data. In extreme cases, particularly where the full picture is not known to all, advice could be ambiguous, confusing or even in direct conflict. More information does not necessarily mean better advice and clarity.

27. There is increasing recognition of the need for cross-departmental coordination to ensure adequate mechanisms are in place to develop or enhance warning services focussed on critical areas—especially when we consider that although infrastructure may have sufficient tolerance for single hazard events, a combination of hazards may affect the total resilience of any part of the infrastructure.

28. Other countries, most notably the US and China, are moving towards a more integrated one-stop-shop approach to realise efficiencies across infrastructure and warning systems through the adoption of a multi hazard approach.

29. The Met Office already plays a unique and critical role in hazard management and in providing science advice and evidence. We frequently act as a hub for many strands of environmental information and there is an opportunity for this central role to be further enhanced by closer collaboration with existing partners and by exploiting the security and resilience of our physical infrastructure and technical expertise.

CASE STUDY (II)—WAS THERE SUFFICIENT & TIMELY ADVICE IN ASH?

30. The Met Office was formally appointed as one of nine International Civil Aviation Organization (ICAO) Volcanic Ash Advisory Centres (VAAC) in 1987. Policy and operational procedures of a VAAC is set by ICAO. As a VAAC, the Met Office is responsible for issuing volcanic ash advisories of the forecast trajectory of ash from any erupting volcanoes within its designated area which includes Iceland and the Canary Islands. Six-monthly exercises are undertaken to test the ICAO European and North Atlantic contingency plan for volcanic eruptions and ensure the relevant parties are familiar with the procedures. The last exercise prior to the eruption of Eyjafjallajökull took place on 25 February 2010.

31. The weather forecast model which underpins the Met Office's NAME dispersion model has been subject to continuous research and development. Comparisons of the accuracy of the Met Office weather forecast model predictions with those from other weather forecasting centres consistently show the Met Office's forecasts to be within the top three in the world. The dispersion model itself has also been continuously developed and tested against other models for a range of environmental hazards since it was introduced in 1986. Indeed, this is an advantage of using a common dispersion model for multiple purposes: funding, research and expertise can be used to deliver benefit for multiple emergency scenarios.

32. NAME has been used to support a number of incidents including:

(a) pollution resulting from the Kuwaiti oil fires (First Gulf War);

(b) the 2005 Buncefield oil storage depot incident;

(c) the 2001 and 2007 Foot and Mouth disease outbreaks;

(d) the 2008 Bluetongue outbreak in northern Europe; and

(e) the Icelandic volcanic eruption in 2010.

It is also used more routinely to support smaller, potentially hazardous incidents such as tanker vehicle fires and to provide air quality forecasts. There are numerous papers in the peer reviewed literature which compare the performance of NAME to similar models and, where possible, observed data. The most relevant is a comparison of the London, Darwin, Washington, Montreal and Toulouse VAAC models undertaken following the Grimsvotn eruption in 2004. The comparison of ash dispersion predictions from all five VAAC models showed good agreement, despite the different model details and meteorology used.

33. The Eyjafjallajökull volcano in Iceland erupted in March 2010, though the specific location of the fissure, the intensity of the eruption and the prevailing weather conditions meant that the impacts were largely confined to Iceland. On 14 April 2010 however, a much more intense and sustained eruption took place towards the centre of the crater under a glacier. The resultant ejection was more explosive with a high concentration of solid particulates.

34. The Met Office's Environment Monitoring and Response Centre (EMARC) was notified by the Icelandic Meteorological Office (IMO) of the eruption and instigated standard procedures in line with ICAO guidance. The NAME dispersion model was run twice a day to provide forecasts of the location of the ash. These predictions were used in conjunction with any available observations of the ash to generate the VAAC Advisory graphics and associated text messages. It is standard weather forecasting process that a trained forecaster combines forecast model information with observational data to provide a prediction. This same interpretation of the model output also formed the basis of advice the Met Office provided to the relevant parties. Whenever the Met Office was notified of a significant change in the volcano's behaviour by IMO, either in terms of the amount of material emitted or the height to which it was emitted, the dispersion model was re-run. VAAC forecasts were issued at 0, 6, 12 and 18:00 hours GMT every day.

35. During the course of this event the Met Office was in contact through telephone conferences and email with the following organisations:

(a) CAA;

(b) NATS and through them the airlines and airports in teleconferences;

(c) the Department for Transport and other Government departments;

(d) Eurocontrol and through them other air traffic control organisations;

(e) European aviation met services and through them other national regulators;

(f) European Met Watch Offices;

(g) Other VAACs, in particular VAAC Toulouse who would have been responsible for providing predictions should the Met Office's system have failed;

(h) ICAO (European office and Montreal Office);

(i) World Meteorological Organization; and

(j) NERC for the provision of airspace and surface monitoring facilities.

The Met Office was in regular contact with each of these bodies, in most cases several times a day. Guidance was provided to the RAF through our Defence forecasters as part of our standard briefing process. We also participated in, and provided briefings to, COBR and its Scottish equivalent, SAGE, the Health Protection Agency and Defra.

36. As is normal practise the Met Office established an Incident Management Team to oversee all aspects of its involvement in the incident.

37. Paragraph 3.4.8 of the ICAO Manual[54] makes clear that there were no agreed values of ash concentration which constitute a hazard to jet aircraft engine. The recommended procedure was therefore to avoid flying through any concentration of volcanic ash. The Met Office was asked to provide its forecasting and advisory services to the CAA on this basis. The model threshold used as the basis for delineating areas of ash in London VAAC guidance was based on the data in a table used in the Volcanic Ash Forecast Transport and Dispersion (VAFTAD—a model used in the USA).

38. In response to VAAC London advice that the "ash cloud" would cover much of Europe, many European nations' aviation authorities closed airspace during the period 15–23 April 2010. The unprecedented scale and impact of the Icelandic volcanic eruption prompted airlines and aircraft manufacturers to agree between themselves a safe level of atmospheric ash concentration which the CAA promptly endorsed. Once these new standards were agreed, the Met Office was asked to modify its advice to provide differing sets of analysis depending on the concentration of ash in the atmosphere. These products were issued as supplementary guidance to the official VAAC advisory graphics.

39. Throughout the incident work was ongoing to extend the capability of NAME to represent more fully the specific nature of the Eyjafjallajökull eruption[55] and develop additional products to help Cabinet Office, the civil aviation industry, MOD and Defra to manage the incident. Development occurred at pace, but always in such a way as to ensure resilience of the production capability, with many more staff than normal working shift patterns and being on call to ensure we could respond promptly to changes in volcanic activity or customer needs.

40. In parallel with providing forecasts of the ash trajectory it was necessary to obtain observations of the ash cloud, the size, location and concentration of the particles. These were needed to:

(a) determine the height to which the volcano was erupting and how much material was being emitted;

(b) manually adjust the extent of the ash cloud before issuance of the VAAC product;

(c) assist regulators in tactical decisions about opening/closing airports;

(d) provide data to assist engine and airframe manufacturers in determining safe limits; and

(e) help convince the public, media and airline industry the threat was real.

41. Three sources of observational data exist: satellite data, *in-situ* data taken from an aircraft and remotely sensed ground based observations. All three sources of observation have limitations and concentration and particle size estimates have significant error bars associated with them. Whilst it is possible to provide ash/no ash observations relatively quickly and initial estimates of concentration ranges, these observations need time-consuming and lengthy analysis before concentration and particle size data estimates can be quoted with confidence.

42. The Met Office has access to large amounts of satellite derived products; some are fully operational others are still in development. These were routinely used, particularly to help assess the height to which the volcano was erupting and the extent of the ash. However satellite derived products have a number of limitations, particularly in cloudy conditions, often prevalent in northern latitudes, or when the ash particles become coated in ice.

[54] The ICAO Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds states: *"Unfortunately, at present there are no agreed values of ash concentration which constitute a hazard to jet aircraft engines. This matter is discussed in detail in Chapter 4, but it is worth noting at this stage that the exposure time of the engines to the ash and the thrust settings at the time of the encounter both have a direct bearing on the threshold value of ash concentration that constitutes a hazard. In view of this, the recommended procedure in the case of volcanic ash is exactly the same as with low-level wind shear, regardless of ash concentration: AVOID AVOID AVOID"*

[55] No two volcanic eruptions, or indeed natural hazard events, will be the same. As the event unfolds and more observational data becomes available it is possible to refine the modelling to provide more specific advice.

43. Ground based observation assets are limited, but inventive use of the assets did help to observe the plume. The Met Office contacted colleagues in academia and using both Met Office, NERC and academic instruments it was possible to obtain data for up to six fixed locations within the UK from 15 April 2010. These data were supplemented by information from the Met Office's standard network of cloud observing equipment.

44. The Facility for Airborne Atmospheric Measurements (FAAM) BAe 146 aircraft (jointly leased by NERC and the Met Office to perform atmospheric research) was unavailable at the start of the eruption as it was stripped down for essential maintenance. Instruments were transferred from it to the Natural Environment Research Council (NERC) Dornier 228 aircraft which flew four flights until it suffered engine damage on 19 April 2010 which was later found to be consistent with sulphuric acid. The BAe146 was re-equipped and flew 11 missions between 20 April 2010 and 18 May 2010. The Met Office played a key role in planning these flights and provided scientists to help staff the flights and analyse the data.

45. The Met Office also contacted its European and North American counterparts to ask for assistance in providing observational data of the "ash cloud". This provided access (not necessarily in real time) to additional ground based observations and satellite products which were under development. Of particular value however was the assistance provided by the German Aerospace Centre (DLR) in conjunction with the German Met Service (DWD). They provided intelligence from their research aircraft which undertook flights in both UK and European airspace, complementing the flights undertaken by the BAe 146 and Dornier.

46. The Met Office also explored options with MOD and its supply chain for the provision of additional UK assets (including Unmanned Airborne Vehicles) which would be suitable to provide additional data. When all suitable assets were found to be deployed on operations joint Met Office and FCO diplomatic communications with the US were started. One member of Met Office staff was transferred to the UK Embassy in Washington to help negotiations and provide briefings on the situation.

Importance of Coordination and how it could be Strengthened

47. Weather systems and other natural hazards do not respect international boundaries and hence international cooperation is often essential in the management of weather related hazards. This is particularly true if the event involves the transport of material (volcanic ash, chemical, biological or nuclear agent) which has been emitted into the atmosphere and is thus able to be carried long distances by the wind.

48. Nor do they respect the delineation between Government Department and research body responsibilities. Better coordination of expertise and developing capability has already proven successful in the Flood Forecasting Centre. This partnership between the Met Office and the Environment Agency provided much clearer and longer lead times for warnings during last year's Cumbrian floods and there is scope, through further partnerships, to expand this concept to encompass other natural hazards in a single warning and monitoring centre.

49. An example of international partnering to the benefit of all participating countries is in space weather where the UK has the data assimilation skills lacking in the US and the US has the satellite, solar modelling and predictive capability. Partnerships like this, whether where UK national and international concerns coincide or in drawing cross-Government capability together in the UK, would undoubtedly result in a more cost effective final solution and on a time scale much increased than each partner alone would otherwise achieve.

The Met Office

The Met Office is a Trading Fund Agency owned by MOD. We are a world leading scientific organisation, both in the field of weather forecasting and climate prediction. An independent review of the Met Office Hadley Centre published in 2007[56] acknowledged the pioneering nature of our work and our position at the "pinnacle of global climate science".

The Met Office is globally unique. We offer prediction across all timescales (weather and climate) using a single, highly sophisticated computer forecasting model and drawing from an extensive, shared observations network.

The Met Office operates the Public Weather Service (PWS), which is funded by Government through MOD, providing operational forecasts to the public—including the Severe Weather Warning System—and fulfilling international commitments on behalf of the UK Government.

Weather forecasting has improved rapidly in the last 10 years and the latest figures from the World Meteorological Organization (a UN agency) show definitively that the Met Office is the most accurate operational weather forecaster in the world. These improvements are bringing real and genuine value to the economy: an independent report from 2007 concluded that for every £1.40 of public money invested in our Public Weather Service alone, the Met Office returned over £10 of savings to the UK taxpayer. The report

[56] *Hadley Centre Review 2006 Final Report; a report for DEFRA/MOD*—Risk Solutions March 2007

also acknowledged how investment in the PWS enabled the development of the science that underpins the UK's response to incidents as diverse as Buncefield, Volcanic Ash and outbreaks of bluetongue among UK livestock.

Although the Met Office has no statutory responsibility it is identified as the preferred supplier of meteorological information and services under the Civil Contingencies Act.

Met Office

16 September 2010

Supplementary memorandum submitted by the Met Office (SAGE 34a)

SUPPLEMENTARY NOTE ON INTERNATIONAL COLLABORATION IN SPACE WEATHER PREDICTION

In our written evidence, we highlighted the work the Met Office is involved in with relation to space weather prediction and mentioned that we are collaborating with NOAA (the US National Oceanic and Atmospheric Administration) to mirror their space weather predictions on an operational basis and to push forward with science developments, utilising our expertise in advising on the impact and risk of natural hazards on a 24*7*365 basis.

Further to this, the Committee may wish to note that a Letter of Intent has now been signed which expresses the intent of the UK Met Office and the NOAA Space Weather Prediction Center (SWPC) to explore future cooperation in space weather prediction research and applications projects. The desire to explore such cooperation is motivated by the respective efforts of both organizations to understand and to predict changes in Earth's environment, and to mitigate the economic and security risks associated with space weather.

Objectives for the envisioned cooperation are to increase staff interactions, to exchange data, and to identify possible operational and scientific collaboration between the Met Office and SWPC. The Met Office and SWPC intend to enhance this cooperative relationship through regular exchange of information about plans and priorities, coordination of research, and identification and implementation of collaborative projects. The benefits of this cooperative framework are expected to enable both organisations to advance the science more rapidly, to accelerate the development of improved models and space weather prediction systems, and to make more effective use of space weather data. In this context, our current activities in coordinating the research and knowledge of space weather across the UK's research institutes will ensure the best transfer and sharing of the science internationally. We will now work towards the development and agreement of a full Memorandum of Understanding with NOAA on behalf of the UK Government.

This latest step towards increasing international collaboration complements the UK's existing scientific and operational input on volcanic ash and space weather matters through the Met Office's membership, on behalf of the UK, of the World Meteorological Organization (WMO). Within the WMO the Met Office is represented on the two Commissions responsible for space weather, these being: the Commission for Aeronautical Meteorology and the Commission for Basic Systems. The Met office is also represented on the International Airways Volcanic Watch which is the body responsible for space weather within the International Civil Aviation Organisation (ICAO).

Met Office

14 October 2010

Memorandum submitted by British Airways Plc (SAGE 37)

INTRODUCTION

British Airways welcomes the opportunity to submit evidence to the House of Commons Science & Technology Select Committee's inquiry into 'Scientific advice and evidence in emergencies'. It comes at a time when the aviation industry has experienced two challenging and different emergency situations where scientific advice was key to its daily global operation.

British Airways is one of the world's largest international airlines, carrying almost 32 million passengers worldwide on almost 750 daily flights in the financial year to 31 March 2010. The airline employs 40,000 people, the vast majority of these at its sites throughout the UK.

The airline's two main operating bases are London's Heathrow and Gatwick airports, with a smaller base at London City airport serving New York and European business destinations. From these, British Airways flies 238 aircraft to 155 destinations in 70 countries. In addition to passengers, the airline also transported 760,000 tonnes of cargo around the globe.

The evidence provided below refers to the two emergencies of which we have direct experience—the swine flu pandemic in 2009 and the volcanic ash eruptions in 2010.

Case Study 1. Swine Flu Pandemic 2009

Question 1. *What are the potential hazards and how were they identified? How prepared was the Government for the emergency?*

1.1.1 The potential hazards and risks of a swine flu pandemic have been well-documented and discussed by the medical and emergency planning communities. British Airways considers that the Government was well prepared for the emergency. The planning at all levels and within the National Health Service was good.

Question 2. *How did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

1.2.1 The Government and its agencies used the experience gained in the SARS outbreak of 2003 as the basis for its response in 2009. The agencies carried out an extensive review following the 2003 outbreak and lessons were learned. New procedures were introduced and processes and advice were improved.

1.2.2 During the SARS emergency, communications from Government were inconsistent and erratic, although the advice provided by the international aviation governmental body, ICAO, was good. Post SARS, ICAO established a global working group to co-ordinate action.

1.2.3 There was co-ordinated action by the NHS, the Health Protection Agency (HPA), International Air Transport Association (IATA) and UK airlines. The main benefit was the extensive sharing of information with involved parties.

Question 3. *What are the obstacles to obtaining reliable and timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? Was there sufficient and timely scientific evidence to inform policy decisions?*

1.3.1 For the swine flu pandemic, the main obstacle was that it was a new situation. There was limited experience and knowledge of how such an emergency might develop, but this was common among many Governments. In the UK, this was countered by the development of contingency plans at all levels where possible, building on the experience of 2003. However, there will always be 'known unknowns'.

1.3.2 In 2003, the speed and scope of the spread of SARS, and aviation's role within this most recent modern global epidemic, could only be estimated. In 2009, Governments worldwide were far better prepared—and connected—to deal with the swine flu outbreak.

1.3.3 With regard to powers available to the Government, British Airways believes the UK appeared to have sufficient powers and resources.

Question 4. *How effective is the strategic co-ordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?*

1.4.1 The co-ordination by all organisations involved in the swine flu pandemic emergency was very good in our experience.

1.4.2 The Cabinet Office had well-developed contingency plans and airlines were included in both the domestic and global contexts. The Foreign & Commonwealth Office was in regular contact with British Airways regarding repatriation of UK citizens from overseas at the same time as recognising the risk to the airline's staff and the difficulties in dealing with infected citizens overseas. The sharing of information was co-ordinated.

1.4.3 Advice from the HPA was excellent, and the creation of a single point of contact for British Airways was very useful. This allowed a strong working relationship with an HPA adviser who knew the specific concerns of our business and was fully abreast of the developments within the industry. We could contact the liaison manager at any time without having to explain our issues from scratch, and be confident that the advice was consistent.

1.4.4. Post SARS, generic advice and guidelines were tailored to suit the industry, for example for cabin and flight crew, engineers, cleaning and airport check-in staff. This enabled us to provide a consistent message to our customers and staff based on the knowledge and expertise of the HPA specialists.

1.4.5 There was inter-agency co-operation in the UK and further co-ordination on a worldwide level. Co-operation was successful, led by a small group of specialists. The aviation and international perspective was particularly well understood and the UK authorities are to be praised for its efforts and achievements. A notable example was the scientific advice for passengers presenting with symptoms are check-in.

1.4.6 CAA was very quick to issues advice on passenger and crew fitness to fly and the medications required. It was not expected to provide specific aviation medical advice but it did fill in the gaps left by the general medical advice for the airline industry that were consequently identified. There is no criticism of its actions.

Question 5. *How important is international co-ordination and how could it be strengthened?*

1.5.1 For the swine flu pandemic, international co-ordination was and remains vital. Aviation is a global transport industry and it is essential that issues affecting it are dealt with in a co-ordinated and coherent manner.

1.5.2 Development of a universal landing card would have been of benefit. Many States required passengers to complete landing cards detailing contact information and medical symptoms, and many States required specific announcements to be made on arrival. Compliance with such a variety of similar, but different, requirements is difficult.

Case Study 2. Icelandic Volcanic Ash Eruption 2010

Question 1. *What are the potential hazards and how were they identified? How prepared was the Government for the emergency?*

2.1.1 The risks of flying in an ash plume are well known. ICAO has published procedures in this situation and established Nine Volcanic Ash Advisory Centres (VAACs) worldwide.

2.1.2 The UK is responsible for the London VAAC that covers parts of Northern Europe including Iceland . The London VAAC is part of the Meteorological Office and reports to the Ministry of Defence, and is thus under Government control. The output of the London VAAC is then published as a —Notice to Airmen— (NOTAM) by NATS, a public/private company.

2.1.3 The LVAAC model is dependent upon accurate estimation of volcanic output and it is evident that the actual output of Jake was very different from the estimates being input into the LVAAC computer model.

2.1.4 NATS had a contingency plan but it appears that it had not been run through to the end in a mock practice session ie if a volcano erupts, what do we, the UK, do—would there be airspace closures? There had been no contact with UK aviation operators prior to the live situation in April.

Question 2. *How did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

2.2.1 The Government used the VAAC model to plan and to react to the emergency situation. It appears the Met Office was more intent on proving the accuracy of the model and justifying its decisions that accepting that the data input was inaccurate. The Met Office was either not willing or unable to review the data, resulting in the unnecessary closure of airspace over much of Western and Northern Europe for six days.

2.2.2 ICAO guidance to aircraft operators is clear and unambivalent—avoid visible ash at all times. The areas of predicted contamination produced by the VAAC model were vastly over-conservative: the Met Office has since admitted this. Blue skies prevailed over much of the predicted area of contamination for the majority of the time that the volcano was erupting but this evidence was not taken into account by government agencies. They contradicted ICAO guidance and imposed unreasonable restrictions upon operators against established protocols.

2.2.3 The arrangements for utilisation of aircraft fitted with scientific sensing equipment are inadequate. There is no system in place to utilise such aircraft in a co-ordinated manner or indeed, to use the data provided by such aircraft to improve the fidelity of the theoretical model.

Question 3. *What are the obstacles to obtaining reliable and timely scientific advice and evidence to inform policy decisions in emergencies? Has the Government sufficient powers and resources to overcome the obstacles? Was there sufficient and timely scientific evidence to inform policy decisions?*

2.3.1 There was insufficient and untimely scientific evidence. The collection and assessment of data was poor, there was a lack of understanding and interpretation of the modelling and data output, and a reluctance by the regulatory community to admit that an incorrect assessment had been made.

2.3.2 There was an inability to measure ash output from Eyjafjallajokull which is now a cost issue. Five months after the eruption, on behalf of the EU, ICAO is working on installing the correct equipment to measure the ash concentrations. This will cost approximately only £2 million, and although now approved, the granting of funding was an obstacle for EU governments.

2.3.3 To work effectively, the London VAAC relies on accurate input data. On this occasion, the VAAC insisted on standing by its evidence, rather than considering other available scientific evidence, which would have opened EU airspace sooner. Worldwide ICAO standards require satellite imagery at all other global VAAC, but this was not used in London. The London VAAC position creates a problem, in that there is inconsistency in the VAAC modelling for the industry.

2.3.4 A further obstacle was the decision by NATS and the CAA to remove responsibility for ash avoidance from the operators and to reduce the flow rate to zero (effectively to close the airspace). This was contrary to worldwide practice, which is a proven and safe way for aviation operations through volcanic eruptions. There has been no loss of aircraft or life incurred through the worldwide system where responsibility for operational decision rests with airlines, based on the available VAAC data.

2.3.5 In contrast, the CAA International division, which includes the Montserrat volcano in its remit, follows a different process to the London VAAC. It adheres to ICAO guidance and publishes information on the ash concentrations and other hazards. The decision on how and when to operate is then left to the airline operators. In 2008 and earlier in 2010, British Airways reviewed the evidence presented in the NOTAM and took the decision to cancel flights that would operate close to the Montserrat ash concentrations.

2.3.6 The airline did so because it believed the risk was unacceptable; it was not instructed to do so by the UK CAA International. This is the basis upon which all operators (including UK operators) act anywhere else in the world.

2.3.7 Government has the power and resources to override the London VAAC evidence but did not to do so. British Airways believes it did not have sufficient or timely scientific evidence. The evidence presented by test flights and by commercial airlines, many of which are well experienced in volcanic ash situations and procedures elsewhere in the world, was not given due or timely consideration.

2.3.8 Instead, a—no-risk—model was applied, ie no risk was acceptable. In reality, all airlines operate on a known-risk basis, for example aircraft are allowed to depart with Allowable Aircraft Defects on the basis that the remaining redundancy is sufficient to ensure the safety of flight. We are not aware of any flight safety issues with clear skies anywhere in the world.

Question 4. *How effective is the strategic co-ordination between Government departments, public bodies, private bodies, sources of scientific advice and the research base in preparing for and reacting to emergencies?*

2.4.1 The strategic co-ordination between Government departments, public bodies, private bodies and sources of scientific advice was not effective. The aviation industry had to press the Government and its agencies for review and action—the Government did not approach the industry experts, the engine manufacturers or the airlines who have extensive experience of flight operations in such conditions.

2.4.2 Both the engine manufacturers and airlines are united in the requirement to avoid flying in visible ash. However, the Government is calling for the engine manufacturers to determine the safe levels of ash for operations despite there being no method of measuring it at the levels expected for the proposed limit. Avoiding visible ash is the safest way forward, as it is throughout the rest of the world, but this is not recognised in the UK.

2.4.3 The process for night-time flying is similar but necessarily stricter. Aircraft operators review the visible ash in daylight and build safe margins into night operations. The Montserrat situation mentioned above is one such example.

Question 5. *How important is international co-ordination and how could it be strengthened?*

2.5.1 International co-ordination for the global aviation industry is vital. There must be a worldwide system and standards for worldwide operators. British Airways urges the Committee to press Government to ensure it works towards implementing the internationally-agreed standard for air operations in volcanic ash situations.

2.5.2 The solution should be based on management of overall operational risk and not solely an airworthiness solution based on the redefinition of tolerance levels.

Summary

British Airways has worked closely with the Government and its agencies during the two recent emergencies reviewed by the Committee. We have had a markedly different experience on each occasion. We would hope and expect that a major review of the handling of the volcanic ash emergency will be held as a matter of urgency to ensure that lessons are learned and the difficulties encountered in April 2010 will not be repeated.

British Airways Government Affairs

September 2010

Supplementary written evidence submitted by Professor Ross Anderson (SAGE 41)

After testifying to the committee, I recalled another matter that I'd like to bring to members' attention. Our system of classifications and clearances is essentially American: its origin is an executive order of President Roosevelt in 1940. A recent report by the Mitre Corporation (the US equivalent of Qinetiq) sets out its history and analyses what's wrong with it. The report concludes that the system is breaking down, and needs to be replaced. This report is starting to drive some interesting research in security engineering in the USA. I see little evidence of attention being paid here though:

http://www.fas.org/irp/agency/dod/jason/classpol.pdf

Professor Ross Anderson

18 November 2010

Supplementary written evidence submitted by the Civil Aviation Authority (SAGE 42)

Thank you for your letter of 11 November 2010 in which you seek additional information for the Committee's review of volcanic ash.

I am pleased to be able to provide the information that you have requested as follows.

Firstly, with regard to the relationship between SAGE and the CAA expert group(s) (Ref Q67 of the oral evidence), I can confirm that there was no formal relationship between SAGE and the group of experts that had been assembled by the CAA. The CAA, on Friday 16 April, marshalled together specialists from around the globe to work together to find a solution that would help to open up airspace in Northern Europe that was affected by ash. This group comprised representatives from regulators (eg the American Federal Aviation Administration, Transport Canada, and EASA), engine and aircraft manufacturers (including Airbus, Boeing, General Electric and Rolls-Royce), airlines (including British Airways), air traffic service providers, meteorologists, vulcanologists, and geologists. In all, approximately 100 people from over 60 organisations participated in the work, conducted by a series of telephone conference calls and e-mail, that resulted in a new tolerance threshold being scientifically established for the operation of aircraft in ash. This enabled large parts of airspace to be made available to flights on 20 April 2010.

Whilst a number of the UK experts in the "CAA Group" also participated in the subsequent meetings of SAGE, the timing of the meetings of this "CAA Group" and the later SAGE meetings meant that there was no formal link between the two.

I will now address your question about how SAGE validated the CAA's work and how advice to Government was coordinated. The SAGE meetings identified the problems causing the flight restrictions, and considered what options were available to address them. SAGE came to the view that the issues broadly fell into two areas:

1. How much ash was in the atmosphere and where exactly was it?, and

2. How much ash could aircraft and engines safely tolerate?

In focussing on these two areas and the ways in which these issues could be tackled, SAGE confirmed that the work that the CAA had already set in train was targeting the right issues and objectives, thus effectively validating the approach taken by the CAA.

On the final point regarding the coordination of advice to Government, the CAA was only one source of such advice. The CAA appointed a programme manager for ash to coordinate all related activity within the CAA, and to ensure that all our advice and guidance was coordinated before being provided to Government—principally the Secretary of State for Transport and his Department—other agencies and industry. In addition, the CAA contributed advice through its participation in SAGE and was also in regular contact with the Scottish Government.

Thank you for affording the CAA the opportunity to contribute to this important review.

Ray Elgy
Head of Licensing & Training Standards
Civil Aviation Authority

22 November 2010

Memorandum submitted by Sir Liam Donaldson (SAGE 44)

You asked me to write to elaborate my comments, made during evidence to the Committee, that modelling data were of less value in guiding the response than they had been in the advance planning phase.

During the pandemic, a team of clinical advisors under my direct supervision, carefully investigated and documented every death attributable to swine 'flu. This was vital work. It allowed me to present accurate information to the public and media. It helped show that we had a good grasp on the evolving pandemic in the UK. The work has subsequently been published in the Lancet and the British Medical Journal.

Combining our emerging data with case estimates, produced by the Health Protection Agency, allowed my team to estimate a case fatality rate (the percentage of people who develop swine 'flu and subsequently go on to die). From an early stage in the UK pandemic it was apparent that the case fatality rate was much lower than we had feared.

The first planning assumptions, released on 16 July 2009 from scientific modelling work, suggested a much higher case fatality rate than our own emerging data. At that time our data indicated a case fatality rate of around 0.05%, compared with the published figure of 0.1–0.35%. Extrapolating our figures to the UK population, using SPI's assumptions around attack rates, would have led to a "best" estimate of 9,000 deaths, and a "worst case" scenario of 25,000 deaths (see attached table). Such estimates made intuitive sense. The virus was being described as "mild", and the past two pandemics, prior to recent advances in intensive care medicine, had seen around 30,000 to 35,000 deaths in the UK.

It was important to make the right judgement on a sensible upper case fatality rate. It was also important not to give too much weight to the Mexico experience, with uncertainties about their data and a different healthcare system.

Modelling scientists will always quite properly say that their estimates depend on the nature and quality of the input data. Thus, they become more refined as time goes on and more real data accumulate. The problem is that the public and media perception is different. They take estimates at face value so that even with the caveats expressed, the failure of early estimates to match with later actual figures leads to criticism and sometimes ridicule of those communicating the data. In the pandemic I found the deaths data I gathered, used to provide insights into the behaviour of the pandemic, on a rule of thumb basis, was giving me a fairer idea about severity from quite early on. The very high deaths scenarios seemed to me implausible. Such deaths data would not normally be available since ONS works in arrears and death certificates are not reliable on their own so the approach was novel. Understandably the modelling methods that had been carefully worked out over many years in the preparatory phase held scientific sway.

None of this is a criticism of the distinguished modellers who did the work just something that I feel needs to be reflected on. That is why before I left as CMO I established a Statistical Legacy Group whose report might be available soon.

Sir Liam Donaldson
Chairman
National Patient Safety Agency

23 November 2010

APPENDIX

COMPARING THE CMO'S TEAM'S EMERGING DATA WITH SPI ESTIMATES OF MORTALITY.

Predictions of overall mortality for the UK have been estimated by applying the SPI attack rate and the case fatality estimated from the CMO dataset to the UK population. These are shown in table 1.

The case fatality rate (CFR) for the CMO data set has been calculated from the "best data" available at the time. The total deaths in England as published in the CMO media brief on the Thursdays of 16 July 2009, 3 September 2009 and 22 October 2009 were used. These data were combined with the Health Protection Agency cumulative case estimates for the previous week, to produce case fatality estimates. The mid—and low—case estimates give a best and worst case estimate for overall mortality respectively. These calculations are shown in table 2.

The attack rates taken from the SPI documents to produce overall population mortality estimates are shown in table 3.

Table 1

COMPARISON OF THE PREDICTED OVERALL MORTALITY BASED ON THE CASE FATALITY RATE FROM THE CMO DATA SET WITH THE PREDICTIONS PUBLISHED BY SPI

	Worst Case		*Best Estimate*	
	SPI	*CMO*	*SPI*	*CMO*
16 July	65,000	25,000	23,000	9,000
3 September	20,000	9,000	5,000	2,000
22 October*	1,000	3,500	80–500	800

* 22 October estimates refer to the second wave only

Table 2

CALCULATION OF CASE FATALITY RATE FROM CMO DATASET

	Cases			*Case Fatality Rate*	
	Deaths	*Low*	*Mid*	*Worst*	*Best*
16 July	26	50,000	20,000	0.13	0.05
3 September	61	280,000	120,000	0.05	0.02
22 October	93	435,000	195,000	0.04	0.02

Table 3

ATTACK RATES ESTIMATED BY SPI

	Attack Rate	
	Worst Case	*Best Estimate*
16 July	30%	25% (20–30%)
3 September	30%	15% (10–20%)
22 October*	12%	6% (less than 12%)

* 22 October estimates refer to the second wave only

Memorandum submitted by MRC Centre for Outbreak Analysis and Modelling, Imperial College London (SAGE 46)

Apologies for the delay in responding to your letter of 28 October. My responses to the two follow-up questions follow:

1. *You mentioned in your oral evidence (Q29 of transcript) that there were difficulties in sharing raw data between countries. Could you please provide your views on why this occurred?*

There is little tradition of real-time sharing of epidemiological data by public health agencies across the world. In my view this has a number of causes: (a) concern about data protection (inadvertent release of data on individuals); (b) limited resources to document data to a level which makes sharing useful—the often quoted (and somewhat justified) fear is that raw data is complex to interpret and misinterpretation might cause confusion; (c) fears of organisational or individual reputational damage should errors or limitations of data be highlighted; (d) a desire by organisations to lead on publications in the scientific and/or medical literature which might be compromised by early release of raw data. Together these factors tend to mean that raw data is only shared with trusted collaborators under strict data access agreements. This tends to preclude the more routine sharing of data at an institutional level (eg between HPA and CDC). I would suggest that if this is to be a priority for future crises then effort needs to be put into building inter-agency links now—not just at the level of high level agreements, but at the level of staff exchanges and other long-term confidence building measures. Where high-level agreements might be useful is in allowing high-level briefing documents (eg SitReps) to be shared between HPA/DH and CDC in Atlanta (and perhaps other key EU counterparts).

2. *We would also welcome your views on Sir Liam Donaldson's comments (Q33 of transcript) that there were some problems with the use of modelling data—do you have any insight into why this was the case?*

It is unclear what is being referred to here. My best guess is the confusion over the "65,000" deaths figure which was issued as a reasonable worst case for NHS planning in July. These were often reported as predictions:

http://www.guardian.co.uk/world/2009/jul/16/swine-flu-pandemic-warning-helpline

http://www.timesonline.co.uk/tol/life_and_style/health/article6716477.ece

http://news.bbc.co.uk/1/hi/8154419.stm

The release of these reasonable worst case figures unfortunately coincided with my group publishing a paper on challenges in estimating severity in a pandemic. While this paper was accurately reported by the BBC (http://news.bbc.co.uk/1/hi/uk/8150952.stm), other reports focussed on the fact that Sir Liam's official mortality figures (29 deaths up to that week in July) were likely to be an underestimate (eg http://www.heraldscotland.com/deaths-from-swine-flu-could-be-higher-than-reported-1.914626). This certainly caused a degree of confusion and perhaps embarrassment within DH. But overall I don't think any of this really reflected a problem with modelling—the uncertainty around eventual mortality was very large at that time. However, it did reflect the less than optimal coordination between the SAGE group (and its SPI-M subgroup) and the CMO's office. Had the CMO attended SAGE meetings (and been represented at SPI-M) then I suspect the 65,000 figure might have been presented differently and less emphasis might have been placed by the CMO on reporting weekly cases and deaths as precise numbers. I understand that Sir Liam rejected sitting on SAGE for fear that it would compromise his "independence". I have to say that I fail to understand this argument—I suspect that the academic scientists and clinicians on SAGE are perceived as rather more independent than the CMO, and the entire purpose of SAGE was to give the best possible independent scientific advice to government. As one of the key consumers of such advice, it would have been preferable that the CMO was an ex-officio member (or indeed, co-chair). While Sir Liam was briefed on SAGE deliberations and saw resulting documents, this would not have informed him of the nuances of the scientific discussions that took place—such as the issues surrounding estimation and presentation of data on pandemic severity.

Regarding the actual "best guess" and "reasonable worst case" estimates of severity produced at different times during the pandemic by SPI-M, I believe Dr Peter Grove at DH has compiled a chronology of these. The committee may wish to request these from Prof David Harper.

I hope this addresses the committee's queries. If I can assist with anything else, please get in touch.

Professor Neil M Ferguson
Director

29 November 2010

Further supplementary memorandum submitted by the Department of Health (SAGE 00c)

Thank you for your letter of 20 January regarding the Committee's inquiry into Scientific Advice and Evidence in Emergencies. You asked for information relating to the swine flu (H1N1) pandemic of 2009–10—in particular, why the seasonal flu vaccination programme's strategy regarding vaccination of healthy children in 2010–11 differs to that adopted during the pandemic.

It is important to be clear about the differences between seasonal flu and pandemic flu. Seasonal flu occurs every winter and there is some level of pre-existing immunity to the flu strains that circulate from exposure to these or similar strains in previous winters. In contrast, pandemic flu is a rare occurrence when a new influenza virus emerges for which people have little or no immunity and as a result we have limited understanding of its clinical pattern. This allows it to spread widely, easily and to potentially cause more serious illness.

The aim of the seasonal flu vaccination programme is to offer protection to those who are most at risk of serious illness or death should they develop seasonal flu. The groups that receive seasonal flu vaccine have been identified by the independent scientific expert advice by the Joint Committee on Vaccination and Immunisations (JCVI).

The JCVI considers all the evidence and gives advice which includes consideration of cost effectiveness. The groups include all those aged 65 years and older and all those aged six months to under 65 years in groups with medical conditions that are considered to put them at greater risk from flu (seasonal flu clinical risks groups). Healthy children have never been included in the seasonal flu vaccination programme. Evidence on the effectiveness of seasonal flu vaccine in young children is limited.

When the pandemic flu virus emerged in 2009, pandemic preparedness plans were triggered. One element of these plans was the vaccination of groups of the population that would be identified based upon the epidemiology of the pandemic flu strain. Advice on the priority groups to receive pandemic vaccine was provided by JCVI in August[57] and October 2009[58] following consideration of the available data on the epidemiology of influenza A (H1N1v) and from clinical trials on the safety and immunogenicity of H1N1v vaccines. The committee confirmed that the primary objective of the pandemic vaccination programme would be to reduce mortality and morbidity and advised that the following groups should be prioritised to receive vaccine:

— Individuals aged between six months and up to 65 years in the current seasonal flu vaccine clinical at-risk groups.

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[57] JCVI statement of August 2009.
http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@ab/documents/digitalasset/dh_104372.pdf

[58] Minute of JCVI meeting on 8 October 2009.
http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@ab/documents/digitalasset/dh_108833.pdf

— All pregnant women.

— Household contacts of immunocompromised individuals.

— People aged 65 and over in the current seasonal flu vaccine clinical at-risk groups.

At that time JCVI considered that "the available epidemiological evidence does not indicate that any one age group of the healthy population should be offered vaccine preferentially once all those in the priority groups had received vaccine."

In November 2009, following further consideration of emerging data on the epidemiology of influenza A (H1N1v) and on the safety and immunogenicity of H1N1v vaccines, particularly in children, JCVI provided additional scientific advice:[59]

> "The committee still did not consider that the epidemiological picture indicated any particular age group as being the next priority for vaccination. … The committee considered that the use of mass vaccination campaigns, including school based programmes, were not indicated and noted that school based programmes would incur significant opportunity costs for other public health interventions in schools and the wider community. Since operationally the offer of vaccination to anyone who requested it in the remaining population might best be done in a phased manner the committee considered that it was reasonable to commence this by making the Pandemrix vaccine available on request to healthy children aged six months and over to under five years of age as proposed by the Department of Health. The committee also noted that the epidemic may be waning and that this could obviate the need for further vaccination if it continues to decline."

Following this advice all children aged between six months and below five years were offered pandemic vaccine. This advice was specific to the 2009–10 pandemic vaccination programme.

Following the pandemic, JCVI provided scientific advice on seasonal flu vaccinations during the 2010–11 seasonal flu vaccination programme in light of the experience of the pandemic and the expectation that the influenza A (H1N1v) would be the predominating flu strain this winter.[60] It did not recommend the continued vaccination of healthy children.

This was because H1N1v infection resulted in predominantly mild illness for healthy people and it was considered that a substantial proportion of children were likely to have been exposed to H1N1v during the pandemic and developed immunity to H1N1v.

In light of the emerging epidemiology of flu this winter, JCVI met on 30 December to review the latest evidence and to consider specifically the vaccination of healthy children. The committee issued a statement:

> "JCVI was presented with data on the current seasonal influenza epidemiology, seroepidemological data collected during the 2009–10 pandemic, modelling of the impact of vaccination strategies during the pandemic, data on the effectiveness of influenza vaccines in the young and vaccine uptake and safety data.
>
> JCVI noted that a large proportion of those individuals with severe disease are in recognised risk groups for influenza but unfortunately were not vaccinated. It strongly re-iterated its previous advice that all individuals in risk groups should be vaccinated as soon as possible, particularly those aged less than 65 years.
>
> The committee considered the issue of offering vaccination to healthy children either 0–4 years and/or 5–15 years of age. However, although there is a high incidence of influenza-like illness currently in these age groups, a significant proportion of this is due to other viruses such as Respiratory Syncytial Virus (RSV). In addition, only a very small proportion of those with severe disease are in these age groups. Based on previous seasonal influenza epidemiology it would be hoped that influenza circulation will have subsided within a month. We do not believe that seasonal or pandemic vaccine should be used for these or other healthy person groups. The greatest gain will be achieved in increasing vaccine uptake in the clinical risk groups. These are:
>
> — Chronic respiratory disease, including asthma.
>
> — Chronic neurological disease.
>
> — Chronic heart disease.
>
> — Chronic kidney disease.
>
> — Chronic liver disease.
>
> — Diabetes.
>
> — Immunosuppression.
>
> — Pregnancy.

[59] JCVI statement of November 2009. http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@ab/documents/digitalasset/dh_108832.pdf

[60] JCVI statement February 2010 (updated in March and July) http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@ab/documents/digitalasset/dh_118093.pdf

JCVI hopes that stakeholder groups such as Scope and the Neurological Alliance will emphasise the importance of vaccination to their constituencies."[61]

The draft minute of that meeting has yet to be finalised by the committee (it will be finalised when the committee meets on 2 February 2011) but is appended in draft form to provide you with further background to the above advice.[62] However, I would be grateful if you could refer to the finalised minute in any public statement that the Science and Technology Committee may make. I have also attached a table showing estimated mortality rates influenza by age-group, September 2010 to 19 January 2011, UK.

As with all vaccination programmes, JCVI as an independent scientific advisory committee will keep this matter under review. During 2011 they will consider a study that is underway to assess the impact and cost effectiveness of seasonal flu vaccination programme and possible extensions to it and any other new relevant data.

I hope that the Committee finds this response helpful in understanding the Government's policy on seasonal flu vaccination.

Rt Hon Andrew Lansley CBE MP
Secretary of State for Health

27 January 2011

POPULATION MORTALITY RATES FOR INFLUENZA BY AGE-GROUP, SEPTEMBER 2010 TO 19 JANUARY 2011, UK

Age-group	*Number of fatal cases*	*Rate per 100,000 population*
0–4	7	0.19
5–14	11	0.16
15–44	59	0.23
45–64	78	0.50
65 and over	55	0.54

Source: HPA

[61] http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@ab/documents/digitalasset/dh_123209.pdf
[62] Not printed.

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