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Science and Technology
Committee

Scientific advice and evidence in emergencies

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Volume II

Additional written evidence

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The Science and Technology Committee

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Written evidence

Memorandum submitted by Ian M Jones (SAGE 01)

I am responding in my capacity as a spokesperson during the influenza flu pandemic of 2009. I am Professor of Virology at the University of Reading and am a frequent commentator for the press on virus outbreaks as and when they occur. My comments are sought and covered by the regional press, particularly BBC radio Oxford, BBC radio Berkshire, and BBC Three Counties radio. I also respond to national press enquiries as required be they from radio, television or the newspapers. In addition I have provided expert briefings for both national and international information sources. I am registered at the Science Media Centre and about half of the enquiries I deal with are routed from there. The remainder come directly or via the press office at the University of Reading.

1. What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?

The threat of an influenza pandemic, indeed the threat of any biological agent outbreak, falls into the difficult class of threats that are certain in the long term but uncertain in the short to medium term. In addition, the question of severity is one that cannot be gauged ahead of an actual outbreak. As a result of the certainty there is almost always a preparedness plan but there are questions around how up to date, robust, responsive and adaptable the plan is once set in motion. In the case of influenza, the last major pandemic occurred in 1968 so a substantial proportion of the population has never encountered a pandemic before. In addition the public's perception of risk today is very different from what it was 40 years ago. A plan dating from that time would undoubtedly have been found wanting had it been the only response available. However, the perceived threat from avian influenza, particularly the highly pathogenic H5N1 virus, over the last decade has resulted in updated plans and a good level of public awareness. This acted in support of the response to the 2009 swine flu outbreak when it occurred and the Government was both well briefed and well prepared when the new strain of influenza emerged in the early part of that year. A significant downside however was the fact that having prepared for a very severe virus infection the response to the swine flu outbreak has subsequently been criticised for being unduly alarmist. This is unfair but it does add fuel to the flames of those who are sceptical of the government's ability to correctly judge, and appropriately respond to, a significant biological threat.

2. How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

As noted, the Government, through its agencies and with advice from the relevant research councils and other medical bodies, had conducted an in-depth review of the threat of an influenza pandemic following the re-emergence of H5N1 avian influenza from 2001 onwards. The options for the control of epidemic disease; isolation, social distancing, restriction of movement, availability of antivirals and the development and roll-out of a vaccine were therefore all considered and rejected or put in place as appropriate. A genuine difficulty is the question of scale (and/or severity) which is almost impossible to judge, and the upfront engagement of the pharmaceutical industry whose cooperation is essential if the roll-out of any treatment, preventative or palliative, is to be assured. There is much to be said for the benefits of an active and competitive pharmaceutical industry but the fact that it has completely displaced older notions of state serum institutes, which at one time would have enabled a certain amount of government controlled manufacture, means that both drugs and vaccines are provided entirely by the commercial sector where the guarantee of a market is the foremost drive for the commitment to manufacture. Truly comprehensive preparedness will always be limited by this point. What the Government SHOULD do was a question frequently asked of me. But what the Government is ABLE to do would have been a more useful query. More general information that clarified the role of Government in the eye of the public would have been useful in this respect.

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?

The general preparations for an influenza pandemic have already been noted above. In the swine flu outbreak a significant problem early on was the unreliability of the data relating to the very first cases. The virus emerged from the swine population in Mexico and early reports suggested a very virulent virus capable of causing high mortality in young adults. This was reminiscent of the 1918 influenza outbreak whose imagery had been much used in the discussion surrounding the preparations for an outbreak of avian influenza. In a sense therefore, the public had been primed with the worst possible scenarios and it was difficult to source reliable information which argued against this early in the pandemic. The government clearly has an overseas presence in many countries but it is difficult to judge whether or not those bodies were able to source reliable information from the local government or were simply passing on alarmist press

reports prior to their general release via the Internet. A review of the reliability of overseas sources of information particularly relating to infectious disease might therefore be a useful exercise (note: the current alarm and confusion over the “NDM superbug” would be another case in point).

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?*

I judge this to have been fairly good in the case of the 2009 influenza pandemic. Bodies such as the Wellcome Trust, the Medical Research Council and the Health Protection Agency worked together well to ensure a relatively unified front. The role of the Science Media Centre is worthy of particular note as it worked quickly to counter the more alarmist elements of the press. In terms of reacting to the emergency I would reiterate my point about the essential role of the commercial sector as there was some concern by the summer of 2009 over the availability of the vaccine for the coming winter. In the event the vaccine became available but there was certainly uncertainty over whether a vaccine would be made, how much vaccine would be made, who would be the primary recipients of a vaccine and whether or not a vaccine was safe.

5. *How important is international coordination and how could it be strengthened?*

This is of paramount importance to the question of emerging infectious disease. The volume, extent and variable routes of overseas travel is such that any notion of restricting an epidemic outbreak to one country or another (for example by stopping incoming flights) is essentially pointless. An accurate risk assessment of an emerging situation can therefore only be made by gauging the validity of the reports available in the country of emergence and by continual and timely updates. At the same time the availability and shipping of possible treatments, which may be held abroad, is something which needs to be investigated at the earliest possible moment. This is as much to prevent an early alarmist overreaction to an emerging situation as it is to be comprehensively prepared for a situation that will eventually reach the UK. Timely reviews of reporting networks and the action plans that depend on them is therefore an important part of a constantly improving process.

Ian Jones

School of Biological Sciences
University of Reading

14 August 2010

Memorandum submitted by the Food and Drink Federation (SAGE 02)

This submission is made by the Food and Drink Federation (FDF), the trade association for food and drink manufacturing. Food and drink is the largest manufacturing sector in the UK, directly employing some 440,000 people in companies of all sizes with annual turnover of around £72 billion. FDF is very actively involved in the prevention of incidents and in the development of strategies to minimise risk along the food supply chain. We have extensive expertise in risk assessment, risk management and risk communication and take food safety and consumer trust in food manufacturing very seriously.

FDF welcome the inquiry by the Science and Technology Committee on scientific advice and evidence in emergencies as we strongly believe that timely advice based on sound scientific evidence is crucial in the management of incidents and in the development of proportionate and effective responses. We recognise that the contribution that we are able to make to this inquiry is quite limited but we welcome the opportunity to support the need for tested science and evidence based approaches to incident management and prevention.

CASE STUDY II—THE ICELANDIC VOLCANIC ASH ERUPTIONS IN 2010

Timeline of events

14/4 volcano erupted.

19/4 FDF contacted FSA asking about food safety implications. In the absence of direct information from FSA we surveyed available literature on potential risks from volcanic eruptions. The composition of the ash, which varies from eruption to eruption, is critical but was not known at that time.

20/4 FDF researched the supply chain and distribution aspects of the potential crisis to quantify potential disruptions to food supplies.

Some coverage started to appear in the trade press.

22/4 The European Commission asked EFSA for an urgent assessment.

FSA and DEFRA were reported by the trade press as saying that there was “no food safety issue at present” and “no immediate concern for animal health or crop production”.

26/4 EFSA statement was issued and was circulated by FDF to members. The statement indicated that, based on available information, the potential risk to human and animal health arising from fall-out of Icelandic volcanic ash was considered to be negligible, but that information on the composition of ash and the distribution of fall out over the EU were both limited at that time and the risks should be re-evaluated as and when more information became available.

30/4 FSA Ireland issued a statement confirming no food safety or supply chain issues for Ireland and giving first limited information on the composition of the ash.

The information that we provided to members was based on limited data about the composition of the ash that was depositing on UK soil and on the official statements from EFSA and FSA Ireland.

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

Potential contamination of UK agricultural soil and water. The risk to health from UK crops would not have been immediate due to the time of year.

FSA is responsible for conducting chemical analysis of potential contaminants when required and for issuing advice accordingly.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

No official statements were issued by the UK FSA, probably because no questions were asked as the incident response focussed quite rightly on other aspects.

A risk assessment, although based on limited data, was issued by the European Food Safety Authority 12 days after the eruption.

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?*

There was uncertainty on the composition of the ash that prevented national and European authorities from conducting a risk assessment very quickly.

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?*

We were satisfied with the statement from EFSA and FSA Ireland and understood from the trade press that FSA was in agreement with the conclusions by EFSA.

5. *How important is international coordination and how could it be strengthened?*

As the spread of the volcanic ash affected a very large part of Europe, the European Commission and the European Food Safety Authority became involved in the very early stages of this emergency and pre-empted what the UK FSA would have done had the UK been the only affected country.

Food and Drink Federation

24 August 2010

Memorandum submitted by the National Physical Laboratory (SAGE 03)

**Input to the Science and Technology Committee Inquiry on:
*Science advice and evidence in emergencies***

INTRODUCTION

The National Physical Laboratory welcomes the opportunity to make an input to the Science and Technology Committee inquiry on *Scientific advice and evidence in emergencies*. We respond to just one of the Inquiry questions, question 4 about strategic coordination.

NATIONAL PHYSICAL LABORATORY

The National Physical Laboratory (NPL) is the UK’s national measurement institute (NMI) and sits at the intersection between scientific discovery and real world application. Its expertise and original research have underpinned quality of life, innovation and competitiveness for UK citizens and business for more than a century.

- NPL develops and maintains the nation’s primary measurement standards, supporting an infrastructure of traceable measurement throughout the UK and the world to ensure accuracy and consistency—a necessary foundation for a technologically advanced economy.
- NPL provides companies with access to world leading support and technical expertise, inspiring the absolute measurement confidence required to realise competitive advantage from new materials, techniques and technologies.
- NPL has a GOCO structure—Government owned, contractor operated.

It is estimated by government economists that the UK’s National Measurement System, of which NPL is the main provider, generates benefits of up to £2 billion p.a. to UK GDP.

On the strength of its NMI capabilities, NPL also plays a broader national role, supporting the policy objectives of BIS and other government departments with leading edge science. For example it is a partner in more than 30 Technology Strategy Board collaborative R&D projects and manages two of the national Knowledge Transfer Networks, supporting the Technology Strategy Board’s aim to make the UK a global leader in innovation. It also provides Defra with a suite of scientific services concerned with air quality.

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?

At present BIS and other government departments make relatively little use of NPL except for its core purpose of delivering the NMS. This is a missed opportunity, not matched by our competitors in Europe and the USA. For example:

- In the USA our sister laboratory, the National Institute of Standards and Technology, supports the US government well beyond measurement, including policy development where there is a strong science and technology component. It is located within the Department of Commerce but is funded directly by other US government departments who exploit its capabilities for their own purposes. For example it led studies that investigated the cause of the collapse of the World Trade Centre in New York after the terrorist attack on 9/11.

NPL is just one of about 160 UK Public Sector Research Establishments (PSREs) that provide expert and independent advice to government. These PSREs provide an under-utilised and strategically poorly-coordinated source for expert scientific advice for government, which could be organised to provide essential advice to government in times of emergency. However, currently the body of PSREs is poorly coordinated so that it is difficult for government to identify quickly from where appropriate advice can be obtained. The PSREs are generally associated with a particular government department, hindering the access of advice that in emergencies often needs to cross-departmental boundaries.

Our view is that a core group of these PSREs should be developed as *National Laboratories* becoming an effective network enabling pan-government solutions to strategic, economic, social and environmental problems of vital national and international importance, including providing expert scientific advice for national emergencies.

National Physical Laboratory

26 August 2010

Memorandum submitted by Professor Clive Dyer (SAGE 05)

Please find enclosed my submission concerning solar storms concentrating on radiation hazards to spacecraft and aircraft.

I am writing to you in my private capacity and not as a member of any particular company or body and the views expressed are mine and not necessarily that of any company with which I have been associated. However I believe that these views are well founded and backed up by peer-reviewed research publications in the open literature. I am happy to provide further advice and papers if required. I trust that the following summary biography illustrates my credentials in this area.

Following degrees at Christ’s College Cambridge and Imperial College London I have spent some 40 years in the aerospace industry mainly researching radiation environments and their effects on electronics and personnel. After positions with NASA Goddard Space Flight Center, USA and the Royal Naval College Greenwich I spent most of my career at Farnborough where the Royal Aircraft Establishment has evolved to become QinetiQ. There I founded and developed a research team to study radiation environments, effects and hardening and became Senior Fellow and Chief Scientist(Space). The initial emphasis was on Space Systems but in the late 1980s I was one of the first to identify potential problems for avionics and this aspect has steadily grown. I am co-author of several standards including the IEC TS62396 standard for SEE in avionics. I have published some 167 papers in the open literature including 35 on aircraft radiation environments and effects. I retired from full-time employment at QinetiQ in 2008 but continue to supply consultancy in my areas of expertise. In July 2010 I was honoured with “The Radiation Effects Award” of the IEEE Nuclear and Plasma Sciences Society.

I hope that this submission is useful to the committee.

Clive Dyer

Professor Clive Dyer, MA (Cantab.), PhD (Lond.), DIC.

INQUIRY INTO SCIENTIFIC ADVICE AND EVIDENCE IN EMERGENCIES: (III) SOLAR STORMS

SUBMISSION ON RADIATION HAZARDS TO SPACECRAFT AND AIRCRAFT

1. INTRODUCTION

Solar storms comprise bulk emissions of high speed ionised gas (coronal mass ejections), which take a day or two to reach earth where they disturb the earth's magnetic field, and/or acceleration of particles to high energies which take a matter of minutes to arrive at earth leading to a radiation hazard and ionisation of the upper atmosphere. These storms can produce a range of effects on technological systems and could in extreme situations lead to an emergency situation. Such effects include:

- (i) Disruption of the National Grid from geomagnetic storms;
- (ii) Disruption of communications due to ionospheric disturbances;
- (iii) Disruption of global positioning signals from satellites due to ionospheric disturbances;
- (iv) Damage or down time of key satellites caused by enhanced levels of ionising radiation;
- (v) Dose to air crew and passengers and disruption to avionics due to enhanced ionising radiation from solar particle events.

Of course a sinister synergy of all the above would lead to the most severe emergency and this could indeed occur from a sequence of solar storms over several days. However, in this submission I will concentrate in items iv and v as they are my major area of expertise and in the case of v, in my opinion, the least appreciated and understood.

2. RADIATION EFFECTS ON SPACECRAFT

During certain solar storms energetic protons and heavier ions are accelerated and arrive at earth within about 10 minutes with the enhanced levels lasting from hours to days. In addition major geomagnetic storms can lead to enhanced levels of trapped electrons in the radiation belts. Both types of environment enhancement are significant at key orbits such as geosynchronous orbit, used by communication and broadcast satellites, and at orbits used by global positioning systems.

The effects of such radiation on spacecraft range from cumulative dose and damage, such as solar array degradation, to more immediate problems from electrostatic discharge or single particle induced upsets in on-board computers and memories.

Although the experience of the space industry is extensive, engineering mistakes are still made and losses and outages still occur in extreme events. Most systems are specified to the worst radiation levels measured since the beginning of the space age. However this experience is limited and more severe events have occurred historically, such as the Carrington event of 1 September 1859. In addition modern microelectronics is becoming increasingly susceptible to individual particles of radiation (single event effects-SEE) due to their higher density and performance requirements.

In general there is good international communication on understanding environments and effects. However commercial operators will always limit the degree of hardening to that which they consider to be cost-effective. For critical systems there is a need for greater communication and understanding to safeguard the infrastructure. At present initiatives tend to be bottom-up from concerned scientists.

3. RADIATION EFFECTS ON AIRCRAFT AND AIR CREW

Solar storms can disrupt communications and navigation signals to aircraft due to the disturbed ionosphere. In addition certain events can lead to enhanced levels of ionising radiation at aircraft altitudes. Again synergy of such effects in conjunction with ground level problems is a recipe for an emergency.

The earth's atmosphere in conjunction with the geomagnetic field provides considerable protection against both cosmic rays and solar particle events. However the protective layer of the atmosphere is reduced to about one third at normal subsonic cruising altitudes and to one tenth at supersonic altitudes leading to background radiation levels that are 300 to 1,000 times higher than at sea level. As a result air crew are the most highly exposed occupation with long haul crew receiving typically 4 to 6 milliSieverts (mSv) per year [1], the upper level being limited by guidelines accompanying the current legislation [2]. The milliSievert is a measure of effective radiation dose which is used to assess the probability of long term effects such as cancer. By comparison the average sea level dose is 2 to 3 mSv per year (from both rocks and cosmic rays) while medical diagnostic doses range from 0.004 mSv for a dental X-ray to 0.06 mSv for a chest X-ray.

A small but very important subset of solar particle events can generate particles of sufficient energy to enhance radiation levels at aircraft altitudes [3]. Because they are also detectable by ground level monitors (in general large area neutron monitors) these are frequently referred to as ground level events (GLEs). While

increases at ground level can be up to a factor 50 (as measured at Leeds on 23 February 1956), increases at flight altitudes can be 1000-fold leading to effective dose rates of several mSv/hr, hence exceeding annual flight limits in one flight if no avoiding action is taken [4]. In this regard it should be noted that in Europe the general public and pregnant air crew are restricted to 1 mSv per year and 1 mSv per term of pregnancy respectively. FAA guidelines further limit exposure in pregnancy to no more than 0.5 mSv in a month. If the geomagnetic field is not disturbed there is a steep gradient of dose with respect to magnetic latitude and such problems occur only with high latitude flights. However this includes flights on some of the most densely populated routes, such as from UK and Europe to North America and Japan. Fortunately such large GLEs are rare and it is estimated that about six events since 1942 (the start of ground level monitoring) would have exceeded the 1 mSv legal limit for an example flight from London to Los Angeles at 39,000 feet [5]. Indirect evidence of solar particle radiation from ice core samples shows that the 1859 event could have been four times worse than any of these [6]. If the geomagnetic field is highly disturbed when the particles arrive, then much lower latitudes can be exposed. Indeed the 1859 event could have given significant exposure down to the tropics. Fortunately the growth of civil aviation has been accompanied by a quieter sun. However there was a wake-up call on 20 January 2005 when a major GLE gave a factor 50 increase in the Antarctic region corresponding to effective dose rates of 3 mSv/hr at cruising altitudes. Fortunately for aviation this was very short lived and localised, northern hemisphere rates being an order of magnitude lower.

Another problem that has become increasingly evident since about 1990 is the effect of radiation on avionics via the single event effects mechanism mentioned above. There is now a considerable body of evidence of upsets in flight systems and hard failures in certain electronics [7]. These have been shown to correlate with cosmic ray fluxes [8] but fortunately during this time no very large ground level events have occurred. For such events significant numbers of upsets could occur in a single flight leading to possible flight hazards [9]. For example an autopilot system was found to upset on average every 200 flight hours and return control to the pilot. If a major GLE had occurred before this problem was eventually fixed such an upset could have occurred every hour making safe flight very difficult. Upsets from cosmic rays are now starting to be considered in accident investigations [10]. Technical specifications to account for and limit radiation hazards in avionics have been available since 2006 [11, 12] but it is not clear that they are universally applied and there is plenty of pre-2006 equipment in flight.

At present there are no viable methods for predicting GLEs and the exposure of aircraft. Ground level monitors are diminishing in number and by the time such information reached aircraft it would be too late as maximum rates are reached in a matter of 10 minutes or so. Attempts are made to estimate the dose received after the event but even here the accuracy is limited by the lack of information, typically to about a factor 2. Concorde (and supposedly all aircraft operating above 49,000 feet) was compelled to carry a radiation warning monitor [2]. However this has not been extended to other aircraft despite the fact that subsonic routes at high latitude are in fact more exposed than Concorde due to the latitude effect exceeding the influence of the higher altitude [4].

Many pilots would like to carry monitors to measure their radiation environment and warn of enhancements and this is reflected in a recent letter (25 September 2009) to the European Commission from the European Cockpit Association (ECA), which represents more than 38,000 commercial pilots. They make a number of recommendations on controlling exposure to air flights of which the following are relevant to solar particle events:

Sample ECA Recommendations:

8. Every flight of an aircraft should be considered as a planned exposure situation (ICRP 103).
9. Solar energetic particle events and other sudden increases in radiation should be classified as emergency exposure situations (ICRP 103). Accordingly, an action plan (“Emergency Response Plan”) should be established, using reference values (“Dose Constraints”) and measures in the case of current or anticipated radiation increases.
10. All aircraft with a maximum operating altitude of more than 10,000 m (approx. 33,000 ft) shall be equipped with a warning device to detect sudden increases in dose rate. During flight, the cockpit crew shall have the display of the warning function plainly visible.
11. Flight crews shall be provided with regular information of actual and forecasted solar activity.

At present there appears to have been no movement by government bodies to accommodate these recommendations.

There are currently solar particle event warnings from US NOAA and FAA but these are based on satellite measurements of much lower energy particles. It is not clear what notice is taken of them and if it is there is likely to be over-reaction and unnecessary grounding of flights as there are many more low energy events affecting spacecraft than there are high energy events affecting aircraft (about 10:1).

There is clear need for government action and international agreement to protect aircraft and crew. The situation is somewhat analogous to the recent “volcanic ash” emergency, where there was apparently a lack of monitoring and a lack of agreed fly/no-fly criteria. Only with further action will there be a balance between safety on the one hand and unnecessary economic chaos from the widespread grounding of flights on the other. The aviation industry has been fortunate since 1956 but the Sun’s history will one day repeat itself.

4. GOVERNMENT ADVICE AND PREPAREDNESS

In relation to the five questions posed by the Committee my opinions with respect to the above hazards are as follows:

1. The hazards and risks are as above and have largely been identified by basic research. Sometimes the relevant industry will admit to problems following probing by scientists and allow sufficient flight data to prove their cause. However often there is a cloak of commercial sensitivity. In my opinion the Government is totally unprepared for such an emergency.
2. Use of advice in this area is extremely limited. A Cosmic Ray Advisory Group was once established (by DfT and CAA) to consider the implementation of air crew dose legislation. However this appears to have been abandoned without any ongoing methodology for dealing with solar particle events.
3. Major obstacles arise from fragmentation of knowledge across a wide variety of bodies. Government needs to ensure joined-up thinking and coordination. There appears to be very little power to enforce anything. There are too many vested commercial and departmental interests. The situation has not been helped by the commercialisation of research activity over the last decade with consequent lack of objective advice to government.
4. There appears to be no strategic coordination at all.
5. International coordination is extremely important. Scientists communicate well at the research level but this does not appear to be reflected in coordination between legislative bodies. There is a lack of UK support for ESA Space Weather activities which limits UK influence.

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5 September 2010

Supplementary memorandum submitted by Professor Clive Dyer (SAGE 05a)

**INQUIRY INTO SCIENTIFIC ADVICE AND EVIDENCE IN EMERGENCIES:
(III) SOLAR STORMS**

**ADDITIONAL INFORMATION ON RADIATION HAZARDS TO
SPACECRAFT AND AIRCRAFT**

1. INTRODUCTION

Further to my submission prior to the oral session on 10 November, and having listened to most of the session, I offer the following clarifying information.

2. RADIATION EFFECTS ON SATELLITES USED IN THE GLOBAL NAVIGATION SYSTEM

The orbits used by both the US GPS and the planned European Galileo satellites are Medium Earth Orbits (MEO) which pass through the heart of the outer radiation belt where they experience intense fluxes of energetic electrons. These electron fluxes show large time variations which are driven by geomagnetic storms. The largest storms are caused by coronal mass ejections which arrive at earth within about a day of being observed to leave the Sun. The electrons lead to cumulative effects from dose and damage but also to more immediate spacecraft charging and discharging within hours to days.

In addition, such orbits are almost fully exposed to solar particle events (energetic protons and heavier ions) which start to arrive at the same time that the flare event is observed (ie they travel at close to the speed of light). However due to scattering in the interplanetary medium the enhancement is usually spread over a day or two. These particles also contribute to dose and damage but can also greatly enhance the rates of single event effects in microelectronics.

These spacecraft must be carefully engineered on the basis of environment specifications which embody the totality of knowledge since space measurements were commenced in the late 1950's. Margins are then applied to ensure that the system will survive. Confidence levels are applied to the environment to ensure low probabilities that the specification will be exceeded.

The question that needs to be posed is whether the confidence levels and margins are adequate to cope with a Carrington size event. Clearly the US GPS system has a good track record to date, although it is believed that a few anomalies do occur and of course there has not been exposure to a Carrington size event. The specifications are not widely published but possibly include a military specification to cover artificial enhancements; this would aid in providing resilience to natural events. It is noteworthy that the system carries radiation monitors to improve knowledge of the environment and warn of enhancements. Knowledge of the environment enables rapid reaction to make the system safe.

The European Galileo system is currently in the early stages of construction. The question should be asked of this and other critical systems as to whether the environment specification confidence levels and the margins applied are able to cope with a Carrington size event. In addition warning monitors should be carried.

In general spacecraft projects are well aware of radiation effects and spacecraft are engineered accordingly. Prospects for survival should be good but the above questions should be posed to the design authorities.

3. RADIATION EFFECTS ON AIRCRAFT AND AIRCREW

As stated before, radiation hazards to both people and electronics on aircraft are less widely appreciated despite being very significant. Some of the key points are re-emphasised below:

- (1) For high latitude routes at conventional altitudes (33,000 to 39,000 feet) a Carrington size event could deliver a dose to aircrew and passengers 10 to 20 times the annual limit for the general public and pregnant aircrew. Such routes are not confined to transpolar but also include London to USA and Japan. If the particles arrive while a previous geomagnetic storm is in progress the hazard can extend into the tropics.
- (2) At the same time electronics in avionics could show very large upset rates and possible failures and these could compromise flight control systems and safety. For example a Gigabyte of modern memory could show an upset every second during a Carrington size event. It is virtually impossible for aircraft to be manufactured using the very limited range and quantity of radiation-hardened parts that are produced for certain military systems. Hence commercial off-the-shelf (COTS) electronics are employed and are susceptible to single event effects so that system level solutions are required to ensure reliability.
- (3) The energetic particles arrive at close to the speed of light and events are often over within a few hours making prediction nearly impossible.

- (4) At present radiation monitors are **not** routinely flown on aircraft. There are attempts by a few research groups to keep some in the air to possibly capture a solar particle event but these are not used operationally to give a real-time warning and response system. Concorde was compelled to carry a warning monitor but this has not been extended to subsonic flights despite the fact that they are used on routes that experience more radiation than Concorde; this is due to the length of travel and higher latitudes flown by certain subsonic flights exceeding the influence of the higher altitudes used by the supersonic Concorde. Many pilots would welcome such warning monitors (notably the European Cockpit Association) but it would appear that the airline industry and the aviation authorities are currently not taking account of this hazard and its possible mitigation. Widespread use of monitors would have the additional advantage of ensuring that the hazards from background cosmic rays are genuinely monitored (ie measured), as opposed to reliance on calculations, which are currently employed for “monitoring” crew dose.

Professor Clive Dyer

21 November 2010

**Memorandum submitted by Dr Christopher Verity, Ms Lesley Stellitano, and Ms Anne Marie Winstone
(SAGE 06)**

Response from team performing two UK-wide health surveillance studies via the British Paediatric Surveillance Unit (BPSU).

We are a team of three working at Addenbrookes Hospital in Cambridge—a paediatric neurologist, a research nurse and a study co-ordinator. We are carrying out two studies in UK children via the monthly surveillance card that is distributed to all UK Consultant Paediatricians by the British Paediatric Surveillance Unit, which is based in the Royal College of Paediatrics and Child Health. Both of our studies are funded by the English Department of Health. They are:

1. The study of progressive intellectual and neurological deterioration (PIND) that started in 1997 to detect any children in the UK with variant CJD and is scheduled to continue until 2013.
2. The study of Guillain-Barre/Fisher syndrome that started in September 2009. This is the study that is relevant to the Science and Technology Select Committee at present.

The Guillain-Barre/Fisher syndrome (GBS/FS) study.

This study was set up to identify all UK children developing GBS/FS, a possible complication of swine “flu” disease and of swine “flu” vaccination. There had been concern about the association between GBS and swine “flu” vaccination in the USA in 1976, to the extent that the swine “flu” vaccine was then withdrawn.

In the context of the H1N1 pandemic and the need to vaccinate those at high risk in the population the Department of Health funded the surveillance. This was discussed in a meeting of the Joint Committee on Vaccination and Immunisation when all four UK Chief Medical Officers were present and was strongly supported. The study is being performed jointly with Professor Elizabeth Miller of the Health Protection Agency (HPA). It is necessary for us to obtain identifying information about the children that are reported to us so that we can share this with Professor Miller’s team at the HPA and thus obtain accurate information about any vaccines administered to these children.

In view of the public health urgency of this study it went through a “fast-track process” in order to get it under way. We started this process at the end of July 2009. The process was complex and whilst some of the steps were taken quickly others were much slower and more time consuming. This can be summarised below:

1. We thought that the British Paediatric Surveillance Unit (BPSU) process was quick and efficient. We were not slowed up at all by that.
2. Even though we were already experienced in obtaining ethics consent and PIAG consent the IRAS (Integrated Research Application System) form presented a major challenge in terms of time and complexity. We were at it almost full time for a couple of weeks.
3. The REC (Research Ethics Committee) consent process was good—there was a recognised fast track for getting our application into the first available REC slot (in Derby on 03/09/09) and the chairman took action to ensure that we got approval in time for the distribution of the BPSU monthly notification card in September 2009. It helped that the PIND team had the time to go to the REC meeting in person and the committee gave verbal approval immediately—because we asked for it in the meeting! REC approval is OK for all of the UK. *This is the only part of the process that has been streamlined and centralised for the whole UK.*
4. Initially quick NIGB (National Information Governance Board) approval looked as if it might be a problem because they did not have a committee meeting before the September deadline. However after a few phone calls we clarified that we would use the NIGB/BPSU application form rather than the IRAS NIGB form and they did take it forward quickly, (19/08/09: NIGB/BPSU meeting gave 1st approval pending REC approval, final NIGB approval given 08/09/09).

5. R&D (Research and Development) approval is not that straightforward—our local R&D office led on this—as is generally the case. There is no central R&D mechanism. The local R&D office was happy to support the study when REC approval had been obtained. However they took advice from the DH and were told that they had to inform all R&D offices in England. R&D approval is different for Wales and our R&D dept led on this, but Northern Ireland and Scotland were different (see below). We were still getting a trickle of queries from English R&D offices in May 2010. Annual monitoring forms continue to arrive from all the R&D offices.
6. R&D approval and NIGB approval are not covered by Northern Ireland and Scotland. Whilst the Chief Medical Officers for both were supportive there is no central mechanism for these in either country. We had to approach all four Trusts in Northern Ireland and 14 health board Caldicott guardians in Scotland to obtain consent to share identifying data without parental approval and to get R&D consent. Different people dealt with these things in different sites and in different ways (sometimes several different forms had to be filled in for the same health board!). In Scotland we also had to go to the CHI (Community Health Index) committee for approval after obtaining consent from all the health boards. We obtained the final approvals from Scotland in February 2010 (five months after England and Wales).

These are our conclusions, based on our experience of setting up and running these two studies. Whilst some processes are more streamlined than they were, particularly in England, the bureaucracy involved in getting consent for a health surveillance study of national importance means that it was not possible to establish our UK-wide surveillance in a timely manner. Even though we were already experienced in obtaining the relevant approvals it took us seven months before we obtained consent to carry out the study in the whole of the UK.

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6 September 2010

**Memorandum submitted by the WHO Collaborating Centre for Reference and Research on Influenza,
MRC National Institute for Medical Research (SAGE 07)**

This response comes from the WHO Collaborating Centre for Reference and Research on Influenza supported by the Medical Research Council and is based at the MRC National Institute for Medical Research at Mill Hill, London.

The WHO Collaborating Centre has contributed to the reply submitted by the Medical Research Council on the questions about the H1N1 Influenza pandemic of 2009–10 but this reply provides further views from the international perspective and addresses the question: How important is international coordination and how could it be strengthened?

SUMMARY

International collaboration was essential to monitor the evolution of the pandemic H1N1 virus as it spread around the globe. The World Health Organisation coordinates a Global Influenza Surveillance Network (GISN) with virology laboratories in over 130 countries throughout the world; the activities of the laboratories in GISN are integrated by five WHO Collaborating Centres on Influenza (WHO CC), one of which is based at the Medical Research Council National Institute for Medical Research (NIMR). The WHO CCs provide advice, through WHO, on the most appropriate virus strain to be used in vaccines, about the emergence of variant viruses and on the prevalence of drug resistant viruses. It was critical that a soundly established surveillance network was in existence to identify rapidly the new pandemic and provide advice as the pandemic developed.

The WHO CC at NIMR works closely with laboratories throughout Western and Eastern Europe, the Middle East, North Africa, West Africa and the Far East. Within the UK the WHO CC works closely with laboratories within the Health Protection Agency, notably the National Institute for Biological Standards and Control and the Centre for Infections in Colindale, as well as with the Wellcome Trust Sanger Institute. Being based at a medical research institute the WHO CC at NIMR is able to apply state-of-the-art research techniques to any new viruses resulting in an increased understanding of any changes to the virus that might be observed during the course of the pandemic. As part of the WHO network, these results can be rapidly shared with the international community.

It is important to recognise that UK has played, and continues to play, a key role in the global efforts to counter influenza and in the preparedness for new pandemics and new epidemics of influenza. It is essential that UK retains its global role in influenza surveillance, research and development.

THE GLOBAL INFLUENZA SURVEILLANCE NETWORK (GISN)

Pandemic influenza is, by definition, an international problem, and international coordination and collaboration are essential for an appropriate response to the threat posed by an emerging influenza virus. The WHO coordinates a Global Influenza Surveillance Network (GISN) which was initially developed from an MRC project initiated in the late 1940's. The National Institute for Medical Research (NIMR) thus became the first WHO Collaborating Centre for Influenza when WHO formally set up GISN. GISN has laboratories designated as National Influenza Centres (NICs) throughout the world and is currently composed of 134 NICs in 104 countries and continues to expand. The activities of the NICs within GISN are integrated by the WHO Collaborating Centres (WHO CC) on Influenza which have now expanded in number to a total of five: in addition to the WHO CC at NIMR, there are collaborating centres based at Atlanta USA, Tokyo Japan, Melbourne Australia, and a WHO CC on the ecology of animal influenza viruses in Memphis USA. The role of the network is to identify newly emerging strains of influenza virus, to monitor human infections caused by animal influenza viruses (such as H5N1 viruses), to assess any emergence of new strains of human influenza viruses that necessitate a new vaccine, to monitor the emergence of drug resistant strains of virus and to survey the general threat of influenza to global public health. The WHO CCs recommend suitable strains for development into vaccines. In the context of the emergence of the H1N1 viruses international collaboration through GISN was critical to the response to the emerging pandemic.

Funding for the network is complex. The NICs are funded through the Departments of Health of national governments; support for the WHO CCs is from a relevant supporting body. There are WHO NICs responsible for England and Wales, Scotland, and Northern Ireland and they are funded by the Department of Health. In UK the WHO CC is funded as a part of the Medical Research Council programme of research conducted at NIMR and is not funded by the Department of Health.

THE EMERGENCE OF THE H1N1 PANDEMIC

The new H1N1 pandemic influenza virus was first recognised at the WHO CC in Atlanta, USA. Two cases of unusual influenza in California were investigated by the Atlanta scientists who identified the new virus. This information was made public and all the information at hand about the viruses was made freely available. There was immediate recognition that the virus was not confined to California but many cases of influenza in Mexico were likely to have been caused by this new virus.

The first detection of the virus was carried out by the Atlanta WHO CC but all WHO CCs have the capacity and the expertise to carry out detailed analysis of any newly emerging influenza virus. It is the WHO CC that is most likely to carry out the initial characterisation of any new pandemic influenza virus. Each WHO CC will report any findings to the NIC of the country from which a virus has been submitted, as well as alerting WHO headquarters in Geneva of unusual viruses emerging. Thus WHO and the country are able to implement plans for the containment of, and response to, a new threat to health.

INTERNATIONAL SHARING OF GENETIC DATA

Most current diagnostic methods for influenza viruses are based on the molecular characteristics of the virus genome and use the quantitative Polymerase Chain Reaction (qPCR) technique. These methods can be developed to give exquisite specificity but rely on knowledge of the nucleotide sequence of the genome of the virus. The scientists of the WHO CC in Atlanta shared their nucleotide sequence results freely through the public database dedicated to influenza viruses, GISAID.

From these shared data from the WHO CC, National Laboratories were able to identify viruses emerging in the first few days of the pandemic directly from their nucleotide sequence identity with the California prototype H1N1 viruses. Subsequently the genome sequences were used to generate the reagents for the molecular diagnostic reagents. Many countries developed their own diagnostic reagents for validating their tests. The WHO CC laboratories also developed PCR protocols and reagents and these were shared freely through WHO.

The key to the rapid detection of virus as it spread in the first few days of the pandemic and the speedy development of rapid and sensitive tests were both dependent on the timely sharing of results by the WHO CC who first identified the new virus.

INTERNATIONAL SHARING OF VIRUSES

Many questions needed to be urgently answered through laboratory studies of the newly emerged H1N1 virus. These include how pathogenic the virus might be, whether the virus was susceptible to the available antiviral medicines, and whether those vaccinated against seasonal influenza viruses might be protected from infection by the newly emerged virus.

The WHO CC network has the capability to try to answer all these questions. In the case of the H1N1 2009–10 pandemic virus the WHO CCs were all able to examine the prototype virus within a very short time and provide answers to the questions that were posed. The answers to these questions were freely shared with the relevant authorities to assist planning for the pandemic.

Vaccine development and monitoring antigenic drift

International collaboration is essential to the development of influenza vaccine. The pandemic vaccine was produced to the anticipated time-lines through a highly effective international collaboration involving the WHO CCs alongside 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 by the manufacturers to get underway as soon as possible.

When the vaccine was under development and in use an important role of the WHO CCs within GISN was to monitor virus as it circulated all over the world for the emergence of antigenic variants against which vaccine might be less effective. This is a key activity for the WHO CCs for seasonal influenza vaccines and was enhanced for the emerging pandemic virus. To date, very little evidence of antigenic variation has been detected for within the H1N1 pandemic virus but antigenic analysis of all viruses provided by the National Influenza Centres is continuing within each WHO CC.

Monitoring antiviral resistance

The 2009–10 influenza pandemic was the first in which antiviral medicines were widely available. Resistance to antiviral medicines is common amongst influenza viruses with the previously circulating seasonal H1N1 having acquired resistance to oseltamivir in recent years, and both the pandemic H1N1 virus and seasonal H3N2 viruses being resistant to another class of anti-influenza drugs, the adamantanes. It was therefore a priority to monitor on a global level antiviral resistance of the pandemic virus. The WHO CCs examined viruses shared by the NICs in GISN for resistance to both oseltamivir and zanamivir, the neuraminidase inhibitors. This international cooperation through the WHO CCs resulted in a comprehensive and up-to-date recognition of viruses resistant to the main drug of choice—oseltamivir. Throughout the pandemic resistance was only detected rarely and almost invariably was associated with use of oseltamivir.

NICs with the appropriate expertise can carry out national surveillance for drug resistant strains of virus and the first virus that was suspected in Europe as being resistant to oseltamivir was thus detected at the NIC in Denmark. This virus was then shared with the WHO CC at NIMR to determine its precise antiviral profile and this information was immediately shared with the Danish authorities and WHO Headquarters. Subsequently the London WHO CC confirmed that resistant viruses emerged in Israel, France, Belgium, Portugal and Spain.

Monitoring changes in virulence and pathogenicity

As the pandemic of 2009–10 emerged, it became apparent that the infection resulted, generally but not exclusively, in mild illness. Regardless, it was critical to determine whether virus from severe cases represented evolution of the virulence of the virus or was associated with other underlying causes. Many countries suffering severe infections were not able to carry out the detailed analysis required to analyse the viruses circulating in their country. Samples collected from patients with particularly severe illness were sent to WHO CCs for detailed analysis. This allowed the WHO CCs to assemble data on the virulence of viruses from all around the world and disseminate it freely. At the WHO CC at NIMR samples from cases with increased virulence were obtained from many countries but notably samples from Eastern Europe, the former Russian states and several countries in Africa made up the majority of the analyses of samples collected from patients with severe illness.

The results of these analysis indicated that a possible hallmark of many variant viruses associated with increased virulence was detected but the circulation of these variants was not generally sustained.

The WHO CC at NIMR has the ability to carry out such detailed analyses; within the research environment of NIMR the WHO CC is in a position to apply state-of-the-art research techniques in a timely fashion to any newly-emerging influenza virus. At NIMR expertise in physical biochemistry, molecular structure determination, mathematical biology, immunology as well as virology can be harnessed together and lead to an increased understanding of the significance of changes that might be observed in the virus during the pandemic. As part of GISN, the WHO CC can therefore rapidly provide these results of thorough scientific research to the international community through communication with governments and with WHO.

ENHANCING THE CAPACITY OF NATIONAL INFLUENZA CENTRES

Whilst many NICs have sufficient expertise and capability to carry out detailed analysis of viruses in their countries (for example the HPA laboratories at Colindale) many had only limited capacity to handle samples and many did not have laboratories with sufficient containment propagate virus or to handle propagated virus. It is one of the roles of the WHO CCs to give as much assistance as possible to these laboratories. The WHO CC at NIMR received samples for analysis from many countries around the world to assist with the

characterisation of the viruses in the samples. Examples included Ukraine, Moldova, Georgia, Romania, Kosovo, Ghana, Algeria, Morocco, Malta, Oman, Tajikistan, Nepal and many others. In addition a large number of countries shared their first samples taken during the pandemic for the WHO CC to confirm their first sets of results.

Enhanced training for National Influenza Centres

In addition to acting as a WHO CC, the NIMR laboratory at Mill Hill, in partnership with the HPA Colindale and RIVM Netherlands, acts as part of the European Community Reference Laboratory for the European Centres for Disease Control. Both WHO and the ECDC have programmes for international training. These training programmes have been held as short courses, for example one held for ECDC in London for antigenic analysis; in addition specialist training for individuals or pairs of scientists has been provided at the WHO CC at NIMR for periods of two weeks to a month or longer for advanced training. These specialist training periods are focussed in improving molecular analysis or virological analysis of samples allowing the trainees to return to their NIC to enhance their national capability.

At the WHO CC at NIMR we have hosted over the last 12 months visiting training fellows for advanced analysis of virus from Iraq, Senegal, Algeria, Georgia, Malaysia, Romania and Ghana; this training programme continues.

EXTENT AND SUPPORT OF ACTIVITIES RELATED TO THE WHO COLLABORATING CENTRE

Over the period of the 2009–10 pandemic the London WHO CC received clinical samples and virus isolates from over 50 countries including UK. As described above, the samples from some countries were either clinical samples for primary analysis or alternatively viruses already isolated in the country of origin. Over 2,000 samples were received during the 2009–10 pandemic. For all viruses that were propagated antigenic analysis was carried out and anti-neuraminidase drug sensitivity assays were carried out on all viruses that could be propagated to sufficient titre. A proportion of the samples were subjected to sequence analysis of the HA and NA genes (in the order of 20%) and a smaller set analysed by full genome analysis.

MRC supported the WHO CC at NIMR during the pandemic, notably by supporting capital funding for replacing “at risk” high cost equipment and having supported expansion of its high containment laboratory facility. The expansion of this facility resulted in being ready and able within 72 hours of the first recognition of the new pandemic virus to handle and process any samples that might be received. Both the extended laboratory facility and new equipment were essential to fulfilling the international role of the WHO CC at NIMR. As expected staff resources were stretched to the limit throughout the period of the pandemic from April 2009 until June 2010.

The UK has contributed to full genome analysis of a number of UK samples and samples from other countries. The ability to carry out this work had been markedly enhanced by previous funding from the Wellcome Trust to develop an influenza virus sequencing pipeline. This pipeline was further developed during the early stages of the pandemic and has made considerable progress. The first full genome sequence of a UK virus was determined jointly by the WHO CC at Mill Hill and the HPA in Colindale, and subsequently many of the analyses were carried out in collaboration with the newly established Virus Genomics group at the Sanger Institute and scientists from Universities of Oxford and Edinburgh.

INTERNATIONAL ADVICE TO UK GOVERNMENT

The international perspective of the pandemic was provided to UK Government in part by setting up a Scientific Advisory Group for Emergencies (SAGE) focussed on the emerging pandemic. It is striking that advice relating to the international activities was provided not by members of the WHO CC staff at NIMR but by the European Centre for Disease Control (ECDC) in Stockholm. ECDC is not involved directly in WHO GISN and the global surveillance of influenza; hence it was surprising that SAGE had not included a WHO CC representative to provide advice from the widest international viewpoint.

STRENGTHENING INTERNATIONAL COLLABORATION

GISN has been built up over more than 60 years and yet there remain some weaknesses. Some areas of the world have only a small number of National Influenza Centres, although the emergence of the influenza pandemic in 2009–10 has resulted in the WHO recognition of several new NICs. One region that still needs greater coverage is sub-Saharan Africa. International support for the laboratories in many of the countries without the capacity to carry out influenza surveillance would be highly beneficial and increased support for training of members of staff of the new laboratories is important. Currently WHO provide some funds for support, the USA Centers for Disease Control and Prevention also supports laboratory training but, on the whole, increased funding for training is needed.

Recent advances in technology are likely to change the way in which influenza virus surveillance is carried out. Currently viruses are characterised after isolation but modern techniques make it possible to determine the full genome sequence of a virus without it being isolated. In the future it is likely that determination of the virus genome sequence directly on clinical samples will be the first level of virus characterisation, subsequently virus isolation will be carried out on a sub-set of samples that show significant genetic change. This will reverse the present situation with virus isolation preceding selection of strains for nucleotide

sequencing. Whilst sequencing is becoming cheaper, it is still expensive to set up and sustain and it is still far from cost-effective to use sequencing as the primary screen. However, it is very likely that international hubs will be set up to carry out this work. The UK's expertise in sequencing should not be overlooked and the support of the Wellcome Trust Sanger Institute to the influenza work over the period of the pandemic needs to be sustained and expanded. A sustained international focus to sequence influenza virus samples from around the world needs to be encouraged. This focus would be developed hand-in-hand with experts in influenza virology as well as bio-informatics, to combine their expertise to choose and study samples for further analysis.

The timely availability of the vaccine for the 2009 pandemic virus needs to be recognised but it also needs to be noted that this availability was not inevitable. Traditional influenza vaccines have a long history of success but the vaccine totally depends on our ability to culture the virus itself to high titre sufficient for effective vaccine production. Although the H1N1 2009 virus was not easily propagated, the manufacturers were able to adapt the virus adequately for vaccine production; next time we might be less fortunate. To circumvent this, vaccines that do not rely on the propagation of the virus *per se* might offer a feasible alternative. International co-operation should be set up to investigate a small number of new types of influenza vaccines that could be able to go into production over a five to 10 year period. These new vaccines would have to be chosen not only on their likely efficacy but also on their cost effectiveness, since if the vaccine is too expensive then it will not be widely used.

The effectiveness of antiviral drugs in the control of the 2009–10 pandemic has yet to be fully evaluated. It is striking that during the pandemic treatment and prophylaxis was limited to one class of compounds the neuraminidase inhibitors, of which Oseltamivir was the most widely used. International collaborations need to be set up to promote companies to develop new influenza anti-viral compounds that can be used to supplement the neuraminidase inhibitors.

CONCLUSION

UK played an important role during the 2009–10 H1N1 influenza pandemic. Within UK the response nationally was from led by the Health Protection Agency Centre for Infection. Internationally the Health Protection Agency National Institute for Biological Standards and Control played a critical role in the development and assessment of the pandemic vaccine. The WHO Collaborating Centre for Influenza at the Medical Research Council National Institute for Medical Research played an international role by integrating results from around the world with other WHO CCs, by assisting countries with less capability by carrying out virus isolation and characterization, sharing protocols and providing training, and by examining viruses from numerous countries in Europe, Africa, the Middle East and Asia for changes in antigenicity, virulence and drug resistance. It is important that UK continues to play an international role in the international response to influenza.

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6 September 2010

Memorandum submitted by the Royal Society of Chemistry (SAGE 08)

The Royal Society of Chemistry (RSC) welcomes the opportunity to respond to the Science and Technology Committee's consultation on scientific advice and evidence in emergencies.

The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a network of 46,000 members worldwide and an internationally acclaimed publishing business, its activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public.

This document represents the views of the RSC. The RSC has a duty under its Royal Charter "to serve the public interest" by acting in an independent advisory capacity, and it is in this spirit that this submission is made.

Royal Society of Chemistry

September 2010

The Royal Society of Chemistry's response addresses only those questions which fall within its area of concern.

The four case studies:

- (i) the swine flu pandemic in 2009;
- (ii) the Icelandic volcanic ash eruptions in 2010;

- (iii) the potential emergency situations that solar storms could cause; and
- (iv) the potential emergency situations that cyber attacks could cause.

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

The case studies cover a wide range of possible hazards, some of which are better understood than others. In most cases the *hazards* were immediately apparent, but there were conflicting views on the actual *risks* that the hazards posed. The causal agents in case studies (i)–(iii) are all natural phenomena, although life-styles and human activities can affect the consequences to a greater or lesser degree. Case study (iv), emergencies arising from cyber attacks, is a consequence of human activity and the deliberate misuse of technology.

In case study (i), the swine flu pandemic, the hazards were principally to human health, but there was also a significant economic impact. The likelihood of a flu pandemic had been predicted for some time and the mutation of the virus in this case was detected relatively quickly because there is an international system in place to do this. For case study (ii) the hazards relating to the eruption of the Icelandic volcano were principally to air transport with consequences for economic activity eg tourism. The *hazard* was immediately apparent, but there were conflicting views on the *risks* because the possible effect of the ash on aircraft engines was not well understood. 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 be¹.

Emergencies arising from toxicological and chemical disasters would be more within the scope of the RSC's interest and where it could call on its members' expertise. Plant failures can be a source of a major disaster, for example the escape of dioxins from an industrial plant in Seveso, Italy in 1976, or the release of methyl isocyanate at Bhopal, India in 1984. The Seveso incident was a major factor leading to the EU legislation concerning the control of major industrial accident hazards. The Bhopal incident demonstrates the need for relevant toxicological data being available; at the time of the incident there was just one substantial study available. Contamination of food and drink can lead to an emergency. For example the pollution of drinking water in North Cornwall in 1988, or the outbreak of jaundice following the contamination of food during storage in Epping, London in 1965. A useful classification of different types of disaster involving toxic agents, and more examples and discussion can be found in the book *General and Applied Toxicology*¹.

Assessment of potential hazards and risks will differ according to the type of disaster and the ability to move (or minimise) the population at risk. It depends on a source (knowledge of the size and duration of emission), a dispersion pattern (obtained from knowledge of eg meteorological conditions, river flows or food distribution systems) and an end-effect. In the case of toxic hazards, one needs to examine the likely toxicity of the materials involved, including the prediction of the amounts of toxic materials likely to cause these effects. There needs to be planning for the prevention, mitigating the consequences, and preparedness for the emergency response. In addition planning for post-event recovery should be in place.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

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?*

In an emergency it is acknowledged that the gathering of sound scientific advice in order to make informed decisions will depend upon the time available and the pre-existing knowledge base. In many cases we can identify and anticipate an emergency and plan accordingly. In the event that an anticipated emergency occurs, scientific advice and evidence should already be in place. The issues which need scientific and engineering advice need to be identified early so that a wide range of expert advice sources can be drawn upon. The Government does have established processes through the Chief Scientific Advisor network, scientific advisory committees and councils, and the RSC supports the recently updated and published *Government Chief Scientific Adviser's Guidelines on the Use of Scientific and Engineering Advice in Policy Making*, and the *Principles of Scientific Advice to Government*. The RSC further welcomes the key messages in the guidelines that an open and transparent approach should be adopted to the scientific advisory process and that the reasons for policy decisions should be explained publicly, particularly when the decision appears to be inconsistent with scientific advice.

For case study (i), the swine flu pandemic, there was time to plan and the knowledge base was extensive. In an independent review of the UK response to the pandemic,² the review comments that there were high levels of uncertainty regarding the nature of the virus, which meant that ministers were heavily reliant on scientific advice in order to understand the level of risk. The review recommends that key ministers and senior officials should be trained to understand the strengths and limitations of likely available scientific advice. The RSC supports this view and would go further to recommend³ that the presence of civil servants with a scientific background, not just subsequently-trained civil servants, is essential to allow speedy and informed decision making. Scientific training must be accompanied by experience and proven ability in

interpreting scientific data. This would raise the scientific capacity of departments to identify issues quickly. The *Government Chief Scientific Adviser's Guidelines* recommends that departments should ensure that they have the capacity and capability to recognise where there is a need for scientific advice and the RSC endorses this view. There will always be emergencies that are unforeseen, and pertinent scientific information and advice, and the interpretation by decision makers of that advice, will need to be carried out over a short time frame. It is, therefore, all the more important that the scientific capacity of departments is raised from the present levels, so that scientific advice can be interpreted and decisions made quickly.

For case study (ii), the Icelandic volcanic ash eruptions, the time for decision making was short and the knowledge base was incomplete. This specific case is an example of an emergency that was not anticipated, (although the general case had been anticipated). In hindsight, it could be argued that those responsible for air safety should have ensured that information on the possible effects of volcanic dust on aero engines was available; that is, that a pre-existing knowledge base should have been available to draw upon. Indeed later action took account of information on weather patterns and of monitoring effects on aero-engines.

In an unanticipated emergency situation, it is not clear whether the provision of scientific advice has been adequately thought about. Although difficult to maintain, one might expect the relevant government committee to have a database of experts in relevant scientific areas. It would appear that in an unanticipated emergency situation there is a tendency to assume the worse-case scenario and respond accordingly. Precaution takes over from science in determining a first response. An alternative approach would be to take immediate scientific advice on the most likely outcome, while closely monitoring events and changing the response if necessary. Decision makers should be advised appropriately and be able to make a conscious choice as to which approach to follow. It is not clear whether this choice was available during the volcanic ash eruptions and precaution dominated.

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?*

Although the RSC is unable to comment on the *past* effectiveness of coordination between the various bodies, the RSC understands that strategic coordination is currently command led. The RSC believes that with such a “hub and spokes” model there is a danger that the “spokes” may have little understanding of where else information is being sought. It is not currently transparent whether there is a disseminated understanding of who is talking to whom. If the system is to be command led, then a better understanding of the mechanism and the identity of the “spokes” might help each individual spoke to identify interconnections and missing connections. During the volcanic ash emergency for example, it is not clear who was contacted for advice. Who were the “spokes” and how was information gathered and co-ordinated? The “spokes” need to be clear about how, and by whom, the information is to be processed, and who will make decisions based on the processed information. All scientific advice should be coordinated by the Chief Scientific Advisor.

5. *How important is international coordination and how could it be strengthened?*

International coordination is important, both for national and transnational emergencies. In the case of national emergencies, there is likely to be expertise elsewhere to call upon, and the best possible scientific advice should be sought irrespective of national boundaries. Transnational emergencies require coordination at the very least. All four case studies affected/would affect other countries than the UK. The call by John Beddington for more “brutal” scientific advice for European Commissioners and MEPs suggests that the current infrastructure within Europe is not effective at integrating science and engineering into policy making. The Commission draws on the Joint Research Centre when establishing scientific panels and experts working groups to deal with specific issues. However, there is currently no mechanism in place for more proactive scientific advice. The appointment of a Chief Scientific Advisor to the Commission will begin to address this issue, and help to overcome the current fragmented system. This needs to be supported by a wider network of scientific advisors that are aligned with EU structure. Similarly to the UK, this must be backed up by improved literacy amongst civil servants. The RSC welcomes measures designed to strengthen the network of scientific advice throughout Europe and internationally.

REFERENCES

- ¹ See Chapter on Toxicology and Disasters, *General and Applied Toxicology* 2009, 5, pp 3043–3076. H. P. A. Illing.
- ² The 2009 Influenza Pandemic. An independent review of the UK response to the 2009 influenza pandemic. D Hine, July 2010.
- ³ RSC response to the BIS inquiry on scientific analysis in policy making. February 2010.

Dr Susan Weatherby, MRSC
Programme Manager, Physical Sciences
Royal Society of Chemistry

Memorandum submitted by NATS (SAGE 09)

1. INTRODUCTION

1.1 NATS is the UK's leading provider of air traffic management services and we are regarded as a world leader in our industry.

1.2 NATS was established as a PPP in 2001 and is owned 49% by the UK Government, which also maintains a Special Share; 42% by The Airline Group, a consortium of UK airlines; 5% by its employees, and 4% by BAA.

1.3 NATS comprises two businesses. NATS (En Route) plc (NERL) is the monopoly provider of en-route air traffic services in the UK and the north east quadrant of the North Atlantic, provided under licence from, and regulated by, the Civil Aviation Authority (CAA); NATS (Services) Ltd (NSL) is NATS' non-regulated business providing air traffic services at many UK airports and is NATS' interface with the wider UK and global ATM markets.

1.4 The terms of NERL's licence from the CAA require the company to be capable of meeting on a continuous basis any reasonable level of overall demand. NERL is charged under its licence with permitting access to airspace on the part of all users, safely whilst making the most efficient overall use of airspace.

1.5 In other words, NATS' job is to meet the air traffic service requirements of airlines and others using UK airspace, including the Military, and to control traffic safely and efficiently. NATS does not establish airspace policy, which is the responsibility of the Directorate of Airspace Policy (DAP) at the CAA.

1.6 NATS welcomes the Committee's inquiry, and this opportunity to contribute answers to your questions as part of your inquiry.

2. SUMMARY

2.1. NATS' submission to the Committee responds to the questions posed and we would be happy to provide further explanation should the Committee find that helpful. In summary, our responses make the following points:

- The crisis was treated initially as a regulatory and ATM safety issue. As the industry and Government started to gain greater clarity on the risk it became clear that the risk was an airworthiness issue.
- During the crisis the industry and scientific community faced a dichotomy between science and research wishing for more evidence over a prolonged period of time and industry needing immediate and innovative solutions to the issue of safe ash concentrations in which flights could operate.
- UK coordination was generally good but constrained by the international nature of the industry. Management of any risk in the aviation industry calls for a pragmatic international approach given the cross-border nature of our business.

2.2 In addition, we note the Committee's interest in other potential risks including solar flares. We refer briefly to the impact of solar flares which may have an impact on aviation although the risk is still being assessed.

3. ERUPTION OF EYJAFJALLAJOKULL

3.1 On the afternoon of Wednesday 14 April, NATS received an ash report from the Volcanic Ash Advisory Centre (VAAC) of the Met Office. NATS operational staff liaised with the Met Office, airlines and neighbouring ANSPs. It became clear that this would be an unprecedented and significant event.

3.2 NATS established that the application of international guidance material as contained in the ICAO Regional Volcanic Ash contingency plan, was appropriate although it had the potential to have a widespread and significant effect in UK airspace.

3.3 In line with emerging international consensus, and following consultation with UK national authorities, NATS issued Notices to Airmen (NOTAMs) restricting Instrument Flight Rules (IFR) clearances in controlled airspace in areas shown by the VAAC maps to be contaminated. (The Met Office provides these maps).

3.4 The effect of the NOTAMs was that no IFR clearances could be offered in UK controlled airspace. These actions satisfied NATS' obligation to manage the air traffic network safely.

3.5 Overnight, the VAAC chart update showed that the hazardous areas would effectively cover the whole of the UK during the following day.

3.6 On the morning of Thursday 15 April, following discussion and review with the CAA as the Regulator, it reinforced NATS' actions by issuing its own NOTAM, also prohibiting IFR flights in controlled airspace and advising caution with Visual Flight Rules (VFR) flights.

3.7 From that point, NATS continued to assist and consult with airport and airline customers and national authorities to ensure we could restart the national network as safely and efficiently as possible, as soon as new guidelines were issued by the CAA. We initiated regular teleconferences with all these stakeholders, plus Eurocontrol, the VAAC and other European ATM companies,

3.8 The responses from each European State were inconsistent, some following the international guidance and others applying different procedures based on their own supplementary analysis.

3.9 On Tuesday 20 April the CAA issued guidance to airlines permitting IFR clearances over the ash, subject to specific conditions eg flights had to guarantee they were able to land clear of the ash (refer to CAA for more detail).

3.10 Later that day we had indications from the national authorities that fresh guidelines were likely to be issued with respect to flight in contaminated airspace. We intensified our co-ordination with customers, airports and national authorities and with European ANSPs to prepare for a co-ordinated, safe and efficient restart of operations.

3.11 On Friday 23 April at 1,300 local, the ash contamination moved away completely from UK airspace and consequently no restrictions were imposed and there has not yet been a recurrence.

3.12 The eruption caused the largest disruption to commercial aviation in Europe since the Second World War. As the en-route service provider in the airspace adjacent to the disruption, NATS was under intense scrutiny in the way we contributed to the management of the crisis. We continue to be closely engaged with the whole industry to develop new policies and safety rationales to cope with future disruptions.

3.13 Throughout the crisis, NATS was heavily engaged with airlines, regulators and engine manufacturers, seeking improved operational procedures to allow flights to operate safely.

4. THE COMMITTEE'S QUESTIONS.

4.1 *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency*

4.1.1 As part of our routine risk management in 2009, NATS ensured that communications with the UK Met Office and the Regional Volcanic Ash Communication Cell (VACC) were fit for purpose. In addition our units were aware of the risk.

4.1.2 Whilst the ICAO contingency plan was developed with most stakeholders it was not explicit in identifying where the risk lies and who should therefore manage mitigation of the risk. ICAO documentation concentrated on ensuring that information on contamination flowed to the operator in the most expeditious means possible.

4.1.3 We believe that in balancing risk against probability, the industry had looked at the history of aviation encounters with ash and taken the view that the probability of disruption from Eyjafjalla erupting was very low level. This may help explain why there had not been a significant investment by operators or manufacturers to develop the policy with reference to volcanic eruptions beyond the generic "do not fly in visible ash" advice.

4.1.4 The crisis was managed initially as a regulatory and ATM safety issue. As the industry and government gained greater clarity on the risk it became clear that the risk was an airworthiness issue. The owner of the risk should be the aircraft operator community and it is for them to seek mitigation with their manufacturers and to present their safety rationale to the appropriate regulator. The ATM role is then to handle permitted flights safely.

4.1.5 We believe that any risk would benefit from analysis outside the pressures of crisis. The owner of the risk should be unambiguously identified and then empowered to manage the development of mitigation. In many respects the management of Swine Flu seems to have identified the Department of Health as the risk owner and then the population was clear about who owned the problem and was accountable for the procurement of solutions.

4.1.6 Turning to the solar flare risk, we would be keen for the Committee to ensure that the owner of any solar flare risk on Aviation is clearly identified now so that the risk can be clarified and appropriate risk based mitigations developed.

4.2 *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

NATS has no information to aid the Committee on this question.

4.3 *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? Was there sufficient and timely scientific evidence to inform policy decisions?*

4.3.1 It seems little more than luck that the UK had not experienced such levels of aviation disruption before, given that an Icelandic volcano erupts every five to seven years on average.

4.3.2 During the ash crisis it became apparent that whilst the existing dispersion model operated by the UK Met Office was competent, the quality and fidelity of the output was dependant on the accuracy of the inputs to the model. For this event the type of ejection being produced was critical to modelling accurately the dispersal of the ash cloud. 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.

4.3.3 There was a continuing need during the crisis for sampling of the atmospheric to validate the model particularly around critical margins, for instance where a contamination line transits an airport or vital piece of airspace.

4.3.4 NATS supports the review of atmospheric sampling and monitoring in order to improve the accuracy of ash maps; we believe the costs of doing this would be heavily outweighed by the financial impact on the industry of unnecessary disruption. The Committee may wish to consider the costs and benefits of a standing monitoring capability either at a UK or European level and how that might be financed.

4.3.5 During the crisis the industry and scientific community faced a dichotomy between science and research wishing for more evidence over a prolonged period of time and industry needing immediate and innovative solutions to how safe the ash concentrations were to fly in. Over time the scientific community became more engaged in providing real time advice rather than the traditional preference to gather data for further future detailed analysis.

4.3.6 Engine manufacturer advice was—and still is—generic with little momentum for it to be detailed and risk based, though this incident has escalated awareness of the need for a tailored solution for operators.

4.3.7 Different engines may have different tolerances, operators may have different risk appetite and route structure and particular operations may have different exposure times. The Eyjafjalla eruption graphically demonstrated that operators cannot tolerate a “one size fits all” approach to regulation of risk management of this type.

4.3.8 Operators can influence their manufacturers and suppliers to provide appropriate mitigations and tolerances for them to fly and to satisfy any conditions from the appropriate safety regulator. The cost of mitigation would therefore benefit from a cost benefit analysis by the part of the industry that owns the risk and would have to fund mitigation.

4.4 *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?*

4.4.1 Coordination was executed through the National Airspace Crisis Management Executive which is chaired by the CAA with participation of DfT, NATS and MoD. This group had been developed over the previous 18 months to two years under the banner of Joint and Integrated ATM in the UK. It was formed to manage crises in airspace, for instance the airspace implications of a major interruption to Air Traffic Control. The DfT then acted as a conduit to the wider Government community.

4.4.2 Whilst we were fortunate to have the body, this group had difficulty at times influencing the necessary scientific and international regulatory response. This crisis demonstrated that the UK cannot determine such policy in isolation as aviation is global and inconsistencies in regulatory application inevitably cause confusion to the public and imbalances in the route network. The reaction to a crisis in aviation immediately impacts on the wider international network, private organisations will become frustrated by inconsistencies and thus feed public dissatisfaction with the response.

4.4.3 Prior to the crisis the role of the scientific community, principally through the UK Met Office and VACC, was to identify the areas of contamination and to ensure that airspace users were aware of the areas through regular notices and updates. This crisis has broadened the demand on these experts to place greater emphasis on forecasting and dispersion models. In addition manufacturers have had to develop their policy beyond the simple “do not fly in visible ash” to include advice on tolerance to ranges of contamination.

4.4.4 In short, the UK coordination was good but constrained by the international nature of the industry.

4.5 *How important is international coordination and how could it be strengthened?*

4.5.1 We believe that the high level owner of any risk should manage the development of any mitigation with other stakeholders, whether they are regulatory or service provision bodies. The role of the regulator is to listen to the industry and the risk owners and to understand, and if necessary approve, the mitigation proposed.

4.5.2 Management of any risk in the aviation industry calls for a pragmatic international approach given the international nature of our business.

4.5.3 In the specific case of volcanoes it is vital to achieve consistent international airworthiness criteria for flight in ash clouds. To do otherwise will result in airspace complexity where operators fly in accordance with an inconsistent regulatory approach creating inequality across frontiers and greater stresses on regional transport infrastructures.

4.5.4 The ash crisis became deeply political at a European level. We believe the UK response was proportionate, but there was an issue with some of the operational decisions made in other parts of Europe.

4.5.5 We believe that the industry would benefit from stronger central direction/regulation in Europe which is geared to practical well prepared solutions rather than political expedience. In Europe, this is the role of the European Commission, working through Eurocontrol and EASA, the new EU safety regulator. However, solutions must be orchestrated at a practical level internationally and across the industry, not on a political basis. In so doing, effective coordination must be extended beyond the EU to the ICAO European and North Atlantic regions. That in turn would feed into the global ICAO mechanism for development of global guidance and procedures.

NATS

September 2010

Memorandum submitted by Prospect (SAGE 11)

INTRODUCTION

1. Prospect is a trade union representing 122,000 scientific, technical, managerial and specialist staff in the Civil Service and related bodies and major companies. Our members are professionals, managers and specialists across a diverse range of areas, including agriculture, defence, energy, environment, communications, heritage, justice and transport.

2. We welcome the opportunity to submit evidence to this inquiry. Many of Prospect's members work in areas of public science that are often unrecognised except in times of emergency. So, whilst it is interesting and useful to highlight case studies, we would also point out that such contributions are drawn in practice from a wider base of scientific expertise. This is often located in institutes that have also been subject to detrimental decision-making, for example about site closures, transfer of functions and significant cuts in funding streams—with no central knowledge by government of the location, functions or specialist expertise it employs. Hence there is no clarity of what capability is being lost or whether retained capability will be sufficient to cope with future demands.

3. We would draw the Select Committee's attention to our submission in the previous Parliamentary Session on "The impact of spending cuts on science and scientific research". A hard copy of this submission is enclosed with this evidence, but it can also be accessed at <http://library.prospect.org.uk/id/2010/00137>. The issues raised in this submission remain valid and, in the run up to October's Spending Review, needed to be addressed with added urgency.

4. Further, in any assessment of resilience to provide timely scientific advice and evidence we would urge the Select Committee to give high priority to the need attract the best and brightest graduate talent. The case of one Prospect member provides a stark illustration of the challenge faced by the Government in delivering this objective. The member concerned is a physicist involved in the design of particle accelerators, including the New Light Source accelerator and the new Swedish light source. He is also involved in commissioning the UK's only test accelerator suite. This member has degrees from Edinburgh and Durham and has worked at postdoctoral level in the USA, but is still paying off a student loan at a rate of £125 per month for the undergraduate degree he started in 1995. His partner is on maternity leave currently and, taking account of eligibility for additional benefit payments and mortgage interest relief, when his partner's Statutory Maternity Pay ends they would actually be better off if he was out of work and on Jobseekers Allowance until she returns to work. This contravenes Ministerial statements recognising the importance of STEM skills to the UK economy and is a powerful disincentive to individuals to dedicate themselves to developing important specialist expertise.

How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

5. A good example is the Integration and Maintenance of Expertise project (ED1043) led by the Veterinary Laboratories Agency (VLA), though similar arrangements will apply at organisations like the Institute for Animal Health. This project provides Defra with expertise that can be mobilised during a disease outbreak and/or other emergencies. It is not restricted to, but in practice does focus on, disease outbreaks such as FMD (foot and mouth disease), AI (Avian Influenza) and BT (Blue Tongue). The main activities of the project currently include:

- Veterinary epidemiologist training, including workshops, on-the-job training at Defra and disease outbreak exercise participation.

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- A peacetime duty veterinary epidemiologist role, where CERA (Centre for Epidemiology and Risk Analysis—of VLA) vet epis (once trained) will participate in the Defra rota maintained by FFG (Food and Farming Group—of Defra). This ensures that trained and experienced veterinary epidemiologists are available every day in case of urgent queries and in case of emergency.
 - Ongoing epidemiological advice and consultancy, eg survey design, participation and advice for expert working groups, eg Foot and Mouth and Blue Tongue.
 - Running, developing and maintaining in-house models, such as Exodis-FMD, so that the model, and the staff running it are fully current and outbreak prepared.
 - An intelligent customer function providing modelling consultancy to Defra on all matters modelling in peacetime.
 - Developing a cross-cutting modelling conference to include participants from Defra, VLA, Animal Health (AH) and others from the UK modelling community, the aim being to improve and harmonise modelling expertise in order that outbreak responses and modelling are optimal.
 - An information support service which includes data management, database development and management and ongoing training and involvement with Defra and AH on the requirements of the NEEG (National Emergency Epidemiology Group) and NDCC (National Disease Control Centre) during an outbreak.
 - Development and maintenance of the VIRDO (Veterinary Information Required During an Outbreak) database, which would be used in conjunction with MOSS II, across Defra in an outbreak.
 - Project management of all activities within the project during peacetime and development of expertise in outbreak processes; during an outbreak this would extend to the project management of the NEEG and would co-ordinate and support the provision of all of the above activities and expertises to the NEEG and feeding into the NDCC.

6. The current year's work programme does not include GIS, risk analysis and risk communication but this expertise is also readily available within CERA and during an emergency this expertise, and the expertise developed within the project could, and would, be used to provide epidemiological data, GIS modelling, risk analysis and project management to Defra and to the Government. For example, during the swine flu pandemic and the volcanic ash eruptions some or all of these specialisms could have been called upon.

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?

7. Prospect would highlight two key obstacles: funding and expertise.

8. As indicated in our submission on the impact of spending cuts, there are now many examples of decisions being taken for short-term financial reasons that will impact on UK scientific capacity. Another specific example arises from cuts in the Environment Agency. If an incident or emergency requires a national response, the Environment Agency will often provide expert support to Defra or DECC as appropriate. One consequence of reduced grant-in-aid is that the provider of groundwater advice during emergencies, for example on issues such as emergency burials following animal disease outbreaks, has been designated as a redeployee and nobody else has been identified to take up these responsibilities. This gap was highlighted during a recent FMD exercise, and is symptomatic of a wider concern that funding cuts at the Environment Agency are likely to reduce technical resilience and ability to support emergency response.

9. Another area of concern relates to perceived lack of urgency in the Home Office, again apparently linked to budgetary pressures, to evaluate the possible effects of chemical, microbiological and radiological agents that might be used in a terrorist attack. Over several years, a handful of these agents have been evaluated to identify exposure standards to be used for protecting the health of first responders at incidents and of the general public and working groups will meet later this year to assess further agents. However, there are no plans to identify exposure standards for the majority of substances on the Home Office list. Instead, the intention is that the methods used for setting exposure standards for those substances that have been evaluated could be used for other substances should they be used in a terrorist attack. Of course, it is not possible to predict precisely what agents might be used in a terrorist attack. However, our understanding is that this would involve commitment of modest resources (a few weeks of the time of a handful of experts already employed by government departments) into evaluating all of the dozen or so chemicals on their list. By contrast under the preferred approach, although the working group meetings to assess the substances have taken a couple of days, it takes many weeks to collect and collate the data for the working groups to evaluate. Thus, in the event of a terrorist attack, it could take an unacceptably long-time to fully evaluate the risk from exposure to the agent used. Instead safety evaluators would need to make rapid decisions based on the data readily to hand, with the result that the emergency services and the general public could be exposed unnecessarily to health risks as a result of hasty judgements made on the basis of incomplete information.

10. Professor David King very quickly found a lack of in-house expertise after his appointment as Chief Scientific Adviser at the onset of the FMD crisis. He noted that an "enormous" amount of work was needed to build this expertise and to strengthen the evidence policy for policy making. Subsequently a great deal of

work has been done, including through the new code on use of scientific advice in policy-making and the establishment of the Government Science and Engineering Community of Interest (GSE). However progress takes time—scientific expertise cannot simply be turned on or off at will—and advances to date are now threatened by widespread funding cuts. Ironically, disingenuous use of the term “frontline” often results in deprioritisation of scientific advice that will be absolutely vital at the “frontline” in times of emergency.

11. There are also broader cultural challenges: Prospect has responded to previous inquiries by the Select Committee, for example on “Putting science and engineering at the heart of government policy” (December 2008), illustrating the lack of specialist expertise in departments. Another problem is that scientific advice to government is generally filtered through relatively inexperienced generalist civil servants in policy roles without technical/scientific qualifications. Further, it may not be challenged at senior levels since scientists and engineers are significantly under-represented in the Senior Civil Service. This is not a question of devaluing the contribution of staff without STEM qualifications, but the reality is that many of the most pressing challenges that currently face government are of such a technical and complex nature that such expertise is essential to ensure appropriate advice and decision-making.

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?

12. Although the previous Government’s “Ten Year Framework for Science and Innovation” demonstrated a welcome appreciation of the essential and underpinning role of science and technology, it fell short in delivering strategic co-ordination:

- Decision-making is largely devolved to departments and research institutes that proceed to cut or close facilities on the basis of business cases that have no regard to the impact on national scientific capability. Nobody in government has been prepared to take on this key responsibility of care for the national science base.
- The level of core funding for research institutes leaves many of them highly vulnerable to shifts and reductions in competitive funding that owe more to changes in short-term priorities than to the quality of work being undertaken.
- The Government simply does not know how many scientists it employs, let alone their areas of expertise. It therefore cannot make any credible assessment of its own capability to meet future needs.

13. In Prospect’s view a strengthened Government Office for Science could help to address these deficiencies through:

- Exercising effective powers of scrutiny over proposals to close research institutes or facilities and publishing its findings on a timely basis.
- Establishing and maintaining a database of public sector scientific capability.
- Collating and analysing annual returns from all government departments, agencies and non departmental public bodies of scientists in their employment, their location and areas of expertise.

14. Such initiatives would enhance the UK’s ability to respond quickly and effectively to immediate needs for advice and expertise, including during emergencies. It would also facilitate better longer-term planning of skills requirements.

Prospect

September 2010

Memorandum submitted by Geoffrey H Sherrington (SAGE 12)

This is a general submission from an Australian scientist (chemist) with long experience in the philosophy of science.

There are four guidelines which might prove to be useful to the Committee when evaluating the submissions of others. The Terms of Reference are not addressed in sequence herein because they are specific to Great Britain and its citizens.

1. Cast a critical eye over submissions built around the so-called “Precautionary Principle”. In many cases, those invoking this method (which has not achieved the status of a Principle) have not finished their research and are seeking more time. It is rare to find a historical case of successful use of this method. Many of the claims of success are routine, like medical prophylaxis. Particularly, there are few examples where this method has—or would have—overcome response time issues in emergencies.
2. Beware of submissions that seek continuation of research funding, or seek large new grants. The idea is to deliver the goods, not to maintain employment.

3. Do not downplay submissions made by non-University or non-Government research organisations. Industry is often ahead of the pace, as evidenced by readiness of some to brand its work as “tainted” or “self-serving”.
4. Do not try to pick winners too quickly—avoid choosing if you can. Consider the relevance of the Nobel Prize awards to Australians Barry Marshall and J. Robin Warren for their work on the cause and cure of ulcers.

http://nobelprize.org/nobel_prizes/medicine/laureates/2005/warren-lecture.html

Please pardon the direct wording of this submission. The last decade has seen a rise in scientific obfuscation, to the detriment of all.

Geoffrey H Sherrington

July 2010

Memorandum submitted by Magnetosphere, Ionosphere and Solar-Terrestrial (MIST) (SAGE 13)

EXECUTIVE SUMMARY

1. The UK, like all advanced countries, is significantly exposed to the risks posed by solar storms (space weather). These can affect a range of advanced technologies including communications and meteorological satellites, aviation, location and timing services (GPS), electrical power grids, and digital and wireless devices.

2. Our knowledge of the threat from space weather has developed substantially over the past decade and that better knowledge is driving concerns now that solar activity is rising towards its next maximum, expected in 2012–13.

3. The Government has recently begun to engage with UK space weather experts to develop a more coordinated view of the risk from space weather. This should be welcomed and encouraged.

4. There should be a national coordination on space weather, akin to that in other advanced countries, to provide a forum that can pull together national needs and link them to national and international capabilities.

5. International cooperation on space weather is critical given that severe events threaten the whole planet. This cooperation involves exchange of data, models and research results. UK should contribute at a level appropriate to its technical and economic standing, especially in European activities such as the ESA Space Situational Awareness programme and the EU COST and Framework programmes.

INTRODUCTION

6. MIST (Magnetosphere, Ionosphere and Solar-Terrestrial)¹ is an informal community of UK-based scientists with interests in physical processes within the Sun-Earth system and other planets. This area of science provides knowledge that is critical to understanding the impact of solar storms on our planet. The MIST community encompasses about 250 scientists based in 19 groups spread over the universities, NERC and STFC institutes and industry.

7. The role of MIST is to help promote its scientific interests to the public, wider scientific community and other stakeholders as well as provide a platform for scientists to present their work to the rest of the UK community. In particular, MIST works closely with the UK Solar Physics community.

8. From its inception in 1970, MIST has been strongly linked with and supported by the Royal Astronomical Society.

What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?

9. This memorandum focuses on the effects of solar storms. This is often termed “space weather” in our community and we will use that term in the rest of this memorandum. Annex 1 is a briefing paper on space weather recently produced by our community.

10. Space weather may be summarised as severe disturbances of the upper atmosphere and near-space environment that can disrupt technology. These disturbances are already known to have many impacts including:

- Space-based infrastructure supporting key applications such as communications, meteorology, location and timing, and security surveillance. These are at risk from radiation and electrical charging as well as orbit decay due to atmospheric drag.
- Aircraft control, navigation and communications. These are at risk from space radiation effects on avionics and aircrew as well as disruption of radio links used for communications and navigation.

¹ <http://www.mist.ac.uk>

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- Location and timing systems (eg GPS, Galileo, eLoran) for a wide range of ground-based services: eg. marine and land transport., mobile phone networks.
 - Power grids and railway signals. Space weather can generate electric currents in long metal structures on the surface. These can disrupt power grids and cause incorrect railway signalling.
 - Digital technology in many ground-based systems. Space radiation can cause errors in the digital chips now used in a huge range of devices. Intense solar radiation storms, such as that of 1956, may cause widespread disruption to these devices.
 - Wireless technologies (mobile phone, Wifi, short-range device control) are at risk from strong bursts of radio noise during intense solar activity. Such bursts may jam wireless links causing widespread loss of service. Service losses may become significant as activity on the Sun ramps up to the next solar maximum.

11. Space weather may be regarded as an emerging natural hazard. The UK, like all advanced countries, has become exposed to this hazard through the spread of advanced technologies as outlined above.

12. Space weather has gradually been developing as a field of scientific study over the past twenty years, especially following major space weather events in 1989 and 2003. The importance of severe events has also led many scientists to exploit data from records of major historical events such as those of 1859, 1921 and 1956. This research has demonstrated that we need to be concerned about future space weather events, eg. during the forthcoming solar maximum in 2012–13. But much research still needs to be done to fully scope the risk.

How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

13. Government engagement in space weather issues has long been focused on a few specific niches (eg. radio communications) with little or no coordination between niches. This is now changing and government bodies are now building links with the scientific community in order to develop a more coordinated view of the threat from space weather.

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?

14. There is a need for a UK national coordination on space weather on lines similar to that coordination undertaken in, for example, Belgium, France, Germany and the US.² This would enable a full assessment of both national needs and national and international capabilities to address those needs. A key objective should be to raise awareness in the scientific community on the forms of advice and evidence that will help government bodies.

15. Following the recent transfer of earth-orientated solar-terrestrial physics to NERC, the scientific community and NERC have started to explore the possibility of including space weather in NERC's research programme on natural hazards. This can provide a robust intellectual framework for linking space weather research to the needs of government and industry.

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?

16. The proposed national coordination on space weather will address this and should also involve private bodies—in particular companies offering specialist services on space weather risks as well as companies whose activities are affected by space weather.

How important is international coordination and how could it be strengthened?

17. Space weather is unusual in that extreme events pose a hazard to the whole planet. Its effects are not localised to particular countries or regions. Thus international coordination is essential—to exchange and share resources such as:

- data from measurements of space weather conditions, whether made in space or on the ground;
- environmental and engineering models to assess the risks from space weather; and
- research results that can improve measurements and models.

18. There is a strong heritage of international cooperation in the science of space weather. In particular UK scientists have been actively engaged with their European counterparts for many decades. They also have good links to work in other countries, for example the US, Japan, China, India and Brasil.

19. UK scientists have led, and continue to lead, many relevant European projects—via international programmes such as ESA and EISCAT, and via EU-funded programmes such as COST³ and FP7. It is important to sustain UK participation in these programmes.

² <http://www.nswp.gov/>

³ For example, see <http://www.costes0803.noa.gr>

20. International cooperation on space weather is now increasingly focused via the Space Situational Awareness programmes that are underway in Europe and the US. The UK is a member of the European SSA programme,⁴ which is an optional programme within ESA, but makes only a minimum subscription. This greatly limits UK participation in, and influence on, the space weather elements of the SSA programme. When economic conditions allow, the UK should participate in that programme at a level much more appropriate to its technical and economic standing.

Magnetosphere, Ionosphere and Solar-Terrestrial (MIST)

13 September 2010

Memorandum submitted by the British Geophysical Association (SAGE 14)

1. The British Geophysical Association (BGA) is a Joint Association of the Geological Society of London and the Royal Astronomical Society (RAS).

2. The aims of the BGA are to promote the subject of geophysics, and particularly to strengthen the relationship between geology and geophysics in the UK, by holding meetings and courses, by encouraging the publication of the results of research, and by such other means as are deemed appropriate to an Association by the parent Societies.

3. Geophysics is the application of physics to the study of the Earth and planetary systems, including planetary interiors, atmospheres and interactions with the Sun. It thus embraces two of the four topics being investigated by the Select Committee: the volcanic ash crisis and solar storms. The following submission refers to the Icelandic ash cloud: BGA input on solar storms was incorporated into the Royal Astronomical Society's submission. Some of the recommendations below are based on those from a European Space Agency workshop in Frascati, Italy, on 26–27 May 2010, in which UK experts participated.

What are the potential hazards and risks and how were they identified? How prepared 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? Did the Government have sufficient powers and resources to overcome the obstacles? Was there sufficient and timely evidence to inform policy decisions?

4. The modelling of natural processes, in this case ash eruption and dispersion shaped the assessment of the emergency and decisions that were made. These needed to be more firmly based on observations and wherever possible validated against datasets of observations from past similar events.

5. Relevant observations include satellite and ground measurements of the distribution and optical properties of the ash; meteorological measurements, geophysical measurements on the ground both proximal and distal, such as continuous monitoring of earthquake occurrence and position, temperature, gravity and geodetic (shape) measurements of both the volcano and its ice cover, and quantifying emission rates of gas and ash from the vent.

6. The prediction of ash dispersion, based on the UK Meteorological Office modelling, required a number of assumptions to be made in the absence of direct observation, such as the volume and speed of mass ejection and using *a priori* optical properties of the fine ash particles. However, given the then present level of knowledge, it is unlikely that air space could have been opened earlier without unacceptable risk.

7. The BGA notes that many of these essential measurements require a long lead-in with diligent data collection when there is no obvious threat. A good example is satellites which may take around 20 years from conception to launch and operation. Better risk awareness demands “baseline” geodetic and seismological measurements that long precede major volcanic activity. Continual calibration of models on a fine spatial scale, from ground and airborne meteorological stations is required to improve modelling of weather patterns and hence atmospheric dispersion of ash. (We also note that effective emergency preparedness for a major explosion involving radioactive material presents similar requirements for atmospheric modelling and an additional requirement for baseline measurements of environmental radioactivity).

8. More basic research on volcanic eruptions of this type is vital, because the geological evidence is that other volcanoes on Iceland and elsewhere erupt from beneath ice caps. In particular, the fine grain size of ash was highly unusual in modern observations but should be included in risk assessments of future volcanic activity (see paragraphs 4 and 5). The BGA urges the Government to provide the resources necessary for this research to be pursued with vigour, so that the UK can have both time-critical advice and the means to verify it.

9. One long-running issue is the major shortage of qualified geophysicists. If this deficit is not addressed it will hinder future research in this area. Geophysical skills required for both measurement and modelling depend on a solid maths and physics background at school level. The BGA report “Geophysics Education in the UK” (Khan 2006, from http://www.ras.org.uk/images/stories/ras_pdfs/Geophysics%20Education

⁴ <http://www.esa.int/ssa>

20in%20the%20UK%20(12b).pdf) showed that school students were hindered in proceeding to study geophysics at university by the lack of both sound careers advice and the general shortage of teachers with a qualification in physics.

10. Crises such as the Icelandic ash cloud spark a short term interest in geophysics, but the maintenance of UK capability for future events depends on the continuous support of geophysical education and research careers. The BGA therefore recommends that the Department for Education work closely with the geophysics community to better promote careers in this area.

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?

11. One critical issue is that the operational community lags behind the scientific research community in its use of modelling algorithms by as much as decades. The BGA recommends that cooperation between these two groups is greatly improved on an ongoing basis, rather than just being triggered by emergencies. Both communities need to be sensitive to the changing needs of the Government as the end user and be given the resources to adapt to provide advice in a useable form, in particular probabilities or yes/no thresholds for closing airspace as required.

How important is international co-ordination and how could it be strengthened?

12. The Icelandic ash cloud affected a large part of Europe and eventually North America, making international co-ordination an essential part of the response.

13. A large body of evidence and data relevant to eruptions already exists. The BGA recommends that its value is maintained by being kept up to date and readily available to the international scientific community. Observations need to be assembled from where they are dispersed across European countries and institutions in different formats and accessibility. Resources for making these data available need to be pinpointed and the effort required to make them readily available rewarded.

14. The American Geophysical Union (AGU, Eos Transactions 91/34, August 2010) has recently commented on the need for better citation practices and peer review of data (rather than scientific papers based on the data) to encourage greater recognition and more critical use of data. We commend to the Committee the AGU's "position statement" on geophysical data (see http://www.agu.org/sci_pol/positions/geodata.shtml) that applies directly to the Icelandic ash crisis.

British Geophysical Association (BGA)

13 September 2010

Memorandum submitted by the Institution of Mechanical Engineers (SAGE 15)

1. The Institution of Mechanical Engineers is the fastest growing engineering institution in the UK, with a membership of over 90,000 professional engineers in the UK and overseas. As a Learned Society the Institution is committed to providing impartial engineering perspectives on a wide range of topics, from transport systems, an engineering response to climate change, education and critical skills, to energy production and distribution.

The answers to the questions below refer specifically to the Icelandic volcanic ash eruptions in spring 2010.

What are the potential hazards and risks and how were they identified?

2. The hazards of aircraft flying into volcanic ash are, at the extreme, potential damage to critical airframe surfaces and systems and potential loss of engine power leading to crashing of the plane. At medium ash densities, there can still be damage to engines and airframe causing economic loss but at very low ash densities, there is no hazard or risk. These hazards have been identified from past flying experience where 126 incidents have been reported over the 55 years of jet engine travel. Unfortunately no quantitative demarcations have been established between the high, medium and low levels of ash density that allow us to be certain of the safety risks in each actual volcanic eruption.

How prepared is/was the Government for the emergency?

3. The Government was very well prepared in the sense in that it had a clearly defined regulatory body (the Civil Aviation Authority) and a clearly agreed international safety procedure (of zero tolerance to exposure to atmospheric ash) that controlled the UK response to the risk.

4. The circumstances leading to the closure of European airspace were therefore predictable but unprecedented. The new and unique conditions that prevailed consisted of a very large and energetic volcanic eruption which caused ash to be ejected to high altitudes in the atmosphere coupled with sustained wind directions which carried it over Ireland, the UK and Western Europe.

5. It is arguable that the consequences of the closure of airspace should have been considered prior to the event through scenario planning and thereby contingencies being better organised. For example, an important consequence of the closure of airspace was the stranding of UK citizens abroad. The solution chosen appeared to be ad hoc, uncoordinated and largely dependent on the differing reactions of the individual airlines concerned. As the closures stayed in place for longer then the consequences on the UK economy became multiplied. The situation confirmed the role important of international air transport as a facilitator of the economy and greater consideration should now be given to future possible disruptions.

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?

6. The time needed to collect new data is much greater than that available as the economic and social consequences of an airspace closure develop. The advice and evidence therefore need to be those available prior to the event. The Government has powers to ensure the quality of that prior data through the regulator (the Civil Aviation Authority).

7. The difficulty is with the infrequency of the risk in UK controlled airspace. The best data is obtained from real life field measurements which by definition are rarely possible. The opportunities until now have always been in overseas jurisdictions. In common with many other low probability, high consequence, risks International sharing of experience is essential to maximise the understanding of these rare events.

8. The sufficiency of the powers therefore relates to the ability of the UK Government to influence others overseas to collect data as the opportunities arise. These opportunities generally have not been taken to date as another, easier, cheaper, option has been to avoid flying through the ash clouds at all.

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?

9. The Government has a role in bringing together the various parties which are responsible for informing this decision and it appears that this role was discharged during the volcanic ash event. It appears that this coordination (between the regulator, the operators and the manufacturers) was extensive and effective notwithstanding the International limitations expressed above. However, there was a lack of background data and hence understanding of three key issues:

- (a) The amount and type of ash actually present in the controlled air space.
- (b) The sensitivity of different aircraft and engine types and flight paths to the ash cloud.
- (c) The process necessary to balance the unknown safety risks with the social and economic costs of a flight ban.

10. As the element of risk could not be quantitatively assessed, a high degree of caution was properly exercised. However, we consider there should have been more open engagement on the risks by various public agencies during the crisis, both with the learned institutions and especially with communication with the public at large. Arguably, inadequate quantitative demarcation of the hazards, together with insufficiently accurate and timely scientific measurement and forecasting of the density, composition and position of the ash clouds, were significant obstacles to more effective policy decisions.

How important is international coordination and how could it be strengthened?

11. In 1991 the aviation industry decided to set up Volcanic Ash Advisory Centres (VAACs), one for each of nine regions of the world, acting as liaisons between meteorologists, volcanologists, and the aviation industry. The UK and Western Europe is covered by a VAAC embedded in the Meteorological Office. There is therefore in existence extremely good framework for international collaboration for the interaction between volcanic ash and air operations, possibly because air transport is an international activity. An alternative safety solution however (zero tolerance) has been applied because it was effective in the overseas territories. There was no motivation amongst our partners to solve a problem of flying through ash clouds when it has not been necessary to do so until now. This latest episode gives impetus to using the current framework to create and share data on exposure.

Professor Roderick A Smith, FREng, ScD
Deputy President Institution of Mechanical Engineers

13 September 2010

Memorandum submitted by the Royal College of General Practitioners (SAGE 16)

This document offers the College's view on how the Government used scientific advice and evidence during the swine flu pandemic in 2009. The RCGP is not responding to any of the other case studies.

The College has been involved in preparing for an influenza pandemic for a number of years. Dr Maureen Baker, RCGP Health Protection Lead, has worked closely with organisations including the Department of Health's pandemic team and the BMA's General Practitioners Committee to ensure that pandemic planning is put in place.

During the H1N1 outbreak in 2009, the College formed an excellent working relationship with the appointed Government "flu tsar", Ian Dalton, who used RCGP Members' feedback on the situation to inform his discussions with Strategic Health Authority Leads in England. The College found that this feedback mechanism helped inform policy and that most issues were addressed—at least in part—by forwarding on Members' concerns and comments.

At the time, a joint RCGP-Health Protection Agency panel was also formed to discuss how the situation was operating on the ground and to examine what guidance was required for GPs.

The following provides the College's views on the questions outlined in the Commons Science and Technology Committee Inquiry:

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

(a) The potential hazards and risks relating to the swine flu pandemic in 2009 include:

- Possible large numbers of excess deaths.
- Severe pressure on the NHS and social care systems, affecting people with both flu-related and non-flu related conditions.
- Supply chain difficulties for food and essential services (eg power).
- Public panic and the potential for public disorder.
- Accelerated spread of the virus due to modern travel.
- Potential side effects of the pandemic vaccine due to lack of thorough testing.

The College would like a good evidence base for the potential hazards in future so that it can respond to emergency situations appropriately.

(b) Government preparation for the emergency:

The Hine⁵ report notes that the UK's current central government crisis management arrangements have been in place since 2002 and have been tested in various crises and exercises and refined through those experiences. It also states that the pre-pandemic planning, set out in *Pandemic Flu: a national framework for responding to an influenza pandemic*, ensured that many decisions had already been made in principle prior to the pandemic and that key personnel had already had the opportunity to work together.

Our view has been that the Government was extremely well prepared for the challenge of pandemic flu. This was largely because of well-documented evidence from previous flu pandemics in the 20th century and recognition by the global public health/health protection community that failure to plan for entirely foreseeable crises—such as a severe flu pandemic—could result in far greater numbers of deaths and adverse outcomes than would be the case if effective preparations had been made.

The College is best placed to comment on preparations within the health sector—although other work had gone on in terms of dialogue with essential services, business and government agencies. Within health, there was a national clinical director for pandemic preparedness; professional advisory committees; managerial flu leads at Strategic Health Authority level; advance purchase of antivirals and advance contracts for pandemic vaccines.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

For flu, once identified as an issue for preparatory work, the Government used those standing structures that it already had in place—specifically the Scientific Advisory Group for Emergencies (SAGE). Other groups were established, in particular SPI (Scientific Pandemic Influenza group) and PICO (Pandemic Influenza Clinical and Organisational group).

SAGE is a standing group that brings together scientific and technical experts and draws on their expertise to ensure co-ordinated and consistent scientific advice underpins the Government's response to emergency situations. Membership of the group depends upon the nature of the emergency. The other structures were

⁵ Dame Deidre Hine (2010). *The 2009 Influenza Pandemic: An independent review of the UK response to the 2009 influenza pandemic*. London: Cabinet Office. <http://www.cabinetoffice.gov.uk/media/416533/the2009influenzapandemic-review.pdf>

established as part of pandemic preparedness and individuals had worked together on preparedness. This meant that once the situation became active, there was already a pool of people with knowledge and commitment on whom the Government could draw.

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? Was there sufficient and timely scientific evidence to inform policy decisions?*

In the case of pandemic flu, the College believes there were no particular obstacles—the experts had been identified in advance and were willing to contribute to the Government’s response.

There was an issue regarding the amount of time and input needed. Commenting on the situation at peak activity, I feel that pandemic work took over most of my working life and also consumed much of my leisure time. I suspect that was the case for many and this probably means that many of the individuals involved worked for institutions or organisations that were prepared to release them for at least some portion of the working week.

The RCGP Research and Surveillance Centre (RCGP RSC)—best known for its twice weekly reporting and surveillance of influenza-like illness and other respiratory diseases—was crucial during the pandemic. As we move forward this important function should be reserved. The College relies on data from epidemiological surveillance systems—such as the RCGP RSC—and this is the type of information we need to respond appropriately to emergency situations in future.

Interestingly, the Hine report states that during the early stages of the pandemic definitive scientific evidence was not always available but adds that once better data was to hand, modelling became extremely accurate. It recommends that in order to further enhance scientific advice in future pandemics, ministers and key officials should be briefed on the strengths and weaknesses of the likely available information; officials should consider whether it would be possible to derive more robust information earlier to support decision-making; and the balance of contribution in SAGE should be reviewed to ensure that it benefits from the expertise of key disciplines.

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?*

In the case of pandemic flu, I feel this was extremely effective, although my view of this was as a representative of a professional organisation that was in receipt of requests for assistance. I am unable to comment on how easy or difficult it was to co-ordinate from the Government’s perspective.

Core to all of this was the effective communication cascade and regardless of the reorganisation of the health service under the new Government, we still need relevant communications from Government channels in order to act appropriately in emergency situations.

We also need effective electronic communication systems and, if impaired through a technological breakdown or reduced workforce through sickness, we would need a replacement mechanism to ensure communication continues to be cascaded.

5. *How important is international coordination and how could it be strengthened?*

The College believes it is extremely important and appeared to work well in terms of exchange of information and scientific developments (eg the virus genome; the development of vaccine; and emerging information on clinical features of the illness). The RCGP does not have any specific views on how international coordination could be strengthened.

Dr Maureen Baker CBE DM FRCGP
RCGP Health Protection Lead
Royal College of General Practitioners

9 September 2010

Memorandum submitted by the UCL Institute for Risk & Disaster Reduction (SAGE 17)

1. ABOUT UCL AND THE IRDR

University College London (UCL) (<http://www.ucl.ac.uk/>) is an academic powerhouse and one of the world’s leading multidisciplinary universities. It is ranked fourth in the 2010 QS World University Rankings, second only to Cambridge of the UK universities. UCL is a world leader in the fields of hazard, risk and disaster reduction, with at least 70 academics across 12 departments and seven faculties involved in world-class research and practice in these areas. The UCL Institute for Risk & Disaster Reduction (IRDR) (<http://www.ucl.ac.uk/rdr/>) was launched in 2010 with the aim of maximising the impact and value of UCL activities in risk and disaster reduction, and to increase and enhance interdisciplinary collaboration and cooperation.

As part of UCL's commitment to addressing global issues and global problems, the IRDR also seeks to contribute to the UCL Grand Challenges of Global Health, Sustainable Cities, Intercultural Interaction and Human Wellbeing.

2. PREAMBLE

Researchers and practitioners at UCL were involved to some degree in the responses to both the Icelandic ash crisis and the swine flu epidemic. Submissions from individuals, guided by the questions raised in the Committee's enquiry announcement, are provided in the relevant sections below. Additionally, submissions are provided from UCL experts in relation to the potential threats presented by cyber attacks and solar storms. General issues, relating—in particular—to threat recognition, preparedness and the importance of international coordination, are addressed separately.

3. THE ICELANDIC ASH ERUPTIONS

Submission from Professor Bill McGuire. Co-director of the UCL Institute for Risk & Disaster Reduction & Co-director of the UCL Environment Institute.

During the 2010 Icelandic ash eruption crisis, I was a Member of the UK Government Scientific Advisory Group for Emergencies (SAGE), established within a few days of the effects of ash being felt in UK airspace.

Iceland is home to 18 volcanoes that have erupted—some of them many times—since the island was settled in 874AD. Volcanic activity in Iceland is typically effusive (in other words is dominated by the production of lava flows), but more explosive events are not uncommon. In this sense the 2010 activity of Eyjafjallajökull cannot be regarded as unusual and volcanic events comparable to this occur in Iceland every 20–40 years. The questions posed by the enquiry are particularly pertinent to the exposure and vulnerability of the (volcano-free) UK to volcanic activity beyond the country's borders. My views, in response, are provided below:

What are the potential hazards and risks and how were they identified?

While many UK volcanologists and others in the UK scientific community are and were aware of the potential hazard presented to the UK and UK air-space by eruptions in Iceland, knowledge of this hazard, and associated risks, do not appear to have penetrated government circles. Notably, the threat from remote volcanic eruptions was not included on the National Risk Register, although I am given to understand that this situation will now be remedied.

The generation of an ash cloud across the UK and much of Europe as a consequence of an eruption in Iceland is far from unprecedented. A number of ash horizons preserved in the peat-lands of Scotland and northern England, testify to Icelandic eruptions around 4300, 2176, 1150, and 500 years ago that deposited ash across parts of the UK, while Iceland-sourced ash layers are also found in Ireland, Germany and elsewhere in Europe. In 1875, the explosive eruption of Askja, resulted in visible ash falls across Norway and Sweden, and most recently, in 1947, a moderate eruption of Hekla produced significant ash across the region. In the context of aviation safety, the critical difference between 1947 and 2010 was the advent and rapid expansion of mass air transport.

The danger presented by ash clouds to jet aircraft has been recognised for more than 30 years, and following two near-fatal encounters between ash and large, passenger aircraft in the 1980s, an international protocol was established that required air traffic managers to divert aircraft if a discernable ash cloud was evident. While this protocol functioned well in the open skies of regions of high volcanic hazard, such as South East Asia and Alaska, across the crowded and confined UK and European airspaces, enforcement of the protocol required the closure of air space while there was discernable ash in the atmosphere. The reason for this was primarily the fault of the airline community, which had failed to agree a safe, lower limit of ash in the atmosphere that would allow aircraft to continue to fly in dilute ash clouds remote from the erupting volcanoes. In this context, the opening up of airspace was only permitted following the establishment of *ad hoc* ash safety limits, drawn up by the airlines and aircraft manufacturers.

How prepared is/was the Government for the emergency?

The government was not at all prepared for the emergency, and as pointed out above, the threat from Icelandic ash is not included in the 2010 National Risk Register. Whether or not specific departments (for example, the Department of Transport), or individuals within departments, were aware of the threat is not known. Certainly, in a report that I wrote in 2007 for the Ministry of Defence, on future geophysical threats in Europe and its neighbours, the potential threat to aviation from Icelandic eruptions was mentioned.

The Eyjafjallajökull volcano is currently quiet, but the potential threat from ash and volcanic gases from Iceland and elsewhere remains. For Iceland, there is good evidence to suggest that volcanic activity since AD1200 has a 130–140 year periodicity, with intervals of lesser activity lasting 50–80 years alternating with higher activity of similar duration. Since 1980 Iceland may have entered a new cycle of more frequent activity, which could equate to 6–11 eruptions per 40 years. The sources of future ash hazard across the UK and Europe may be volcanoes located outside Iceland. Within the north Atlantic and the western half of

Europe there are a number of volcanic regions that have the potential to produce highly voluminous ash plumes that reach high altitude. In particular the Azores (eg, Furnas), the Canary Islands (eg, Tenerife), Italy (eg, Vesuvius, Campi Flegrei and Etna) and the Aegean (eg, Santorini) are worthy of mention.

Coupled with appropriate meteorological conditions, there is no doubt that future explosive eruptions in Iceland and elsewhere have the potential to cause further disruption to air transport. It is not possible, however, to predict either when this will occur, or at what scale. A worst-case scenario, however, could be provided by the 1783 Laki eruption in Iceland.

The Laki event lasted for over six months, ejected more than 15 km³ of lava, and produced more than eight million tonnes of fluorine, which resulted in the deaths of 50% of the island's livestock. This, in turn, led to serious famine and the deaths of between a quarter and a third of Iceland's inhabitants. In the UK and Europe, the 120 million tonnes of sulphur gases ejected into the atmosphere led to a persistent sulphurous haze that resulted in widespread respiratory problems and many thousands of excess deaths—perhaps up to 23,000 in the UK alone. The sulphur haze also affected the European and North American climate for several years, leading to an extremely cold winter in 1783–84. In North America, the Mississippi froze at New Orleans and ice was reported in the Gulf of Mexico. A repeat of the Laki eruption could again have serious health consequences for the very old, very young and infirm, result in weather conditions detrimental to UK industry, and generate ash clouds capable of closing UK airspace and, potentially, curtailing or stopping air traffic on the polar routes, perhaps for months.

How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

As the threat was not identified in advance, the government's response to the emergency was purely reactive. In relation to geological and meteorological aspects of the crisis, individual scientists were invited to join SAGE, under the leadership of Government Chief Scientific Advisor, John Beddington. The nature of the invitation process was not clear, but appears to have been focused on scientists already known to the government and to the Office of the Chief Scientific Advisor (for example, I was a member of the Natural Hazards Working Group, established in the wake of the 2004 Indian Ocean tsunami under the leadership of David King). During the course of the crisis, the SAGE grew by the addition of further scientists on the recommendation of those already on-board.

What are the obstacles to obtaining reliable, timely scientific advice and evidence to inform policy decisions in emergencies?

Access to reliable and timely scientific advice during an emergency, such as presented by the Icelandic ash, is hamstrung to a considerable degree by the failure to recognise in advance the cause of the emergency and—therefore—by a complete absence of preparedness. As a consequence, particularly in a rapid-onset emergency such as that triggered by the Icelandic ash, the government is always playing catch-up. It takes days to establish a SAGE to address the problem, and longer for its members and associated government officials to come up to speed in relation to the characteristics of the emergency. Consequently, it is possible for an emergency to come and go with such rapidity that advising scientists have little or no role to play. This problem can only be solved by: (i) making concerted efforts to identify and evaluate all possible threats; (ii) establishing for each, and in advance, groups of relevant scientists who have given a commitment to provide advice; (iii) ensuring that communication mechanisms are established that permit advising scientists to be contacted rapidly.

Has the Government sufficient powers and resources to overcome the obstacles?

In principle, yes. As mentioned above, the Icelandic crisis arose primarily from the failure to recognise the threat in advance, which resulted in the absence of any real effective preparedness. Had the threat been recognised and considered prior to the arrival of the ash, then the opportunity would have existed for government to talk with scientists, airlines and aircraft manufacturers to identify potential obstacles and to plan for how these could be overcome. In such circumstances it is highly likely that the absence of a safe ash limit would have been identified as a problem and addressed in good time.

For case study (ii) was there sufficient and timely scientific evidence to inform policy decisions?

My opinion is that the scientific advice provided via SAGE was sufficient to inform policy decisions during the crisis. In terms of timeliness, however, such advice would have been far more useful in advance of the event.

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?

In relation to volcanic threats, the strategic coordination between government departments, the scientific community and research base and private bodies (in the latter case the airlines and aircraft manufacturers) was poor to non-existent prior to the Icelandic ash crisis. Links have now been developed, however, which—if built upon—can support a pro-active approach towards managing such hazards in future. Since volcanic threats to the UK are sourced outside national boundaries, cooperation with relevant organisations in those countries that host volcanoes that are potentially hazardous to the UK is particularly critical (see below).

How important is international coordination and how could it be strengthened?

International coordination is critical to reducing the risks presented by volcanic eruptions in other countries to the UK, its business sector and its population. Firstly, links need to be improved with the relevant scientific bodies (volcano observatories and national weather services), so as to improve provision of notice of unrest at volcanoes that may present a threat to the UK. At the same time, communication mechanisms should be established that ensure that this information reaches those in government who need to know. Secondly, international coordination is required in order to establish safe ash thresholds that permit commercial flights to continue where dilute ash clouds are present. In this regard, the current *ad hoc* limits, established in the heat of the crisis, need to be re-evaluated, and limits set that are based upon considered scientific and engineering studies. While this should be the responsibility of the international airline community, evidence of the past slow response to the problem suggests that “encouragement” from national governments may be required.

NB. The UCL IRDR report: *Volcanic Hazard from Iceland: Analysis and Implications of the Eyjafjallajökull Eruption* (eds: Sammonds, P, McGuire, W J & Edwards, S) can be downloaded at: <http://www.ucl.ac.uk/rdr/publications/iceland>

4. THE SWINE FLU PANDEMIC

Submission from Professor Martin Utley, Director, UCL Clinical Operational Research Unit.

During the 2009 swine flu pandemic I served on the Critical Care Working Group convened by the Department of Health. My involvement stemmed from work that I'd been doing since late 2008 with intensive care consultants at Great Ormond Street Hospital on the topic of triage in the context of an influenza pandemic. Reflections below represent a personal view and I'd not claim any authority on these matters. I work closely with the Health Protection Analytical Team within DH so have some (limited) insight into what was going on behind scenes.

How were potential hazards and risks identified?

Pandemic influenza was reasonably prominent in the National Risk Register.

The clinical community was making its own preparations, in part stimulated by development of the national plan.

How prepared was/is the government?

Well prepared, but it is probably fair to say that the planned response was geared to a more severe avian flu scenario.

How does/did the government use scientific advice and evidence to identify, prepare for and react to an emergency?

A considerable amount of work had been done by DH/HPA linking with mathematical epidemiologists and others, which is hardly surprising given SARS and previous avian flu outbreaks. Emerging advice was assimilated reasonably well as far as I can tell—the decision to go against the reported advice to close all schools seemed carefully considered (and with hindsight vindicated).

What are the obstacles to obtaining reliable, timely, scientific advice and evidence to inform policy decisions in emergencies?

Analytical capacity within Government departments is severely stretched, despite the fact that these are the people with the skills and experience of interpreting/packaging scientific advice in a way that can inform policy.

For case studies 1. and 2. was there sufficient and timely scientific evidence to inform policy decisions?

In relation to swine flu (case study 1), my view is that most policy decisions were evidence based, albeit geared to a more severe pandemic.

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?

One point I'd make here is that there are/were problems around the interpretation of model output and public bodies had difficulties interpreting/using the "worst case scenarios", which DH decided (correctly in my view) were the only estimates worth sharing.

5. CYBER ATTACKS

Submission from Dr. Peter Trim. Centre for Advanced Management & Interdisciplinary Studies, Birkbeck College.

Dr. Trim is co-author of: *Strategizing Resilience and Reducing Vulnerability* (ISBN: 978-60741-693-7). He is a member of the Information Assurance Advisory Council (IAAC) Academic Liaison Panel and has contributed to the Global Forum for Law Enforcement and National Security and contributed to a security agenda for the Prime Minister. One of his areas of expertise is in reducing organizational vulnerability through countering cyber attacks. Dr. Trim makes the following points in relation to the cyber attack threat:

- At present, it can be argued that governments are not engaging with the private sector (which owns a high percentage of the nation's critical information infrastructure) as fully as they should and that much more needs to be done to advise society of the potential risks associated with cyber crime. Issues such as identity fraud, social networking activities and the international dimensions of cyber crime all need further attention.
- Law enforcement agencies need greater powers and more resources in order to effectively tackle cyber crime.
- Universities need to be investing in facilities and staff to provide increasing numbers of skilled graduates that are better able to deal with cyber attacks than is the case at present.
- There needs to be greater cooperation between national governments and more active participation between the private and public sectors (eg sharing information and knowledge in relation to trends, threats and solutions).
- Society in general needs to be educated to appreciate what security is and in particular needs to better understand what information security and information assurance entail.
- It is frustrating and worrying that some criminal acts do not carry sufficient penalties to deter people from undertaking internally orchestrated fraud.
- More attention needs to be paid to rogue governments and how they aid terrorist networks and organized criminal syndicates.

6. SOLAR STORMS

Submission from Professor Christopher Owen. Head of Space Plasma Physics Group, UCL Mullard Space Science Laboratory, and colleagues.

This submission deals specifically with the potential threat of solar storms to the UK. Herein, the term "solar storm" is used to mean all phenomena driven by enhanced activity at the Sun that can have a measureable effect on the Earth environment, specifically in terms of space-based infrastructure (eg GPS and communication satellites), other navigation systems, power transmission systems, trans-polar airline flights, etc. Members of the UCL/Mullard Space Science Laboratory (Department of Space and Climate Physics) have much accumulated *scientific* experience of these phenomena, specifically in the areas of the origin of solar activity (within the Solar Physics Group) and its effect on the near-Earth space environment (within the Space Plasmas Group). Most recently, joint efforts between the groups have been aimed at understanding how phenomena originating at the Sun evolve as they propagate out through interplanetary space and towards the Earth. In this document we attempt briefly to indicate where this expertise may be put to use in understanding the risks to UK society and infrastructure that are associated with enhanced solar activity or solar storms.

Defining the problem: solar storms: phenomena and associated risks

Solar activity affecting the near-Earth Space environment can be classified in three main ways. Firstly, Solar Energetic Particle (SEP) events occur when penetrating high energy particles (a form of radiation) are expelled from the Sun during solar flares and fill much of interplanetary space, including that near the Earth. Secondly, the Sun sporadically expels vast amounts of hot, dense plasma, together with its associated magnetic field, sometimes at speeds in excess of 1000 kilometres per *second*. Such events are termed "Coronal Mass Ejections" (CMEs) and, although many head harmlessly away from the Earth, those that are Earth-directed are capable of inducing major and damaging changes to the Earth Space environment. Finally, extended periods of particularly fast solar wind flows are known to be a major contributor to enhancement of dangerous fluxes of radiation belt electrons and can persist much longer than CMEs.

The magnetic field of the Earth provides a "bubble" around the planet, known as the magnetosphere, which in some circumstances is able to mitigate, but not completely eliminate, the effects of solar activity from those parts of space that currently host significant levels of human activity (eg the geosynchronous

orbits that hold telecommunications satellites or low-Earth orbits used by the space shuttle, surveyor satellites (eg climate change) and navigation (GPS) satellites). For example, energetic particles from SEP events are largely excluded from the magnetosphere and have a limited number of entry routes, which are generally confined along the magnetic field lines descending into the polar ionosphere and atmosphere. These can, however, provide undesirable radiation doses to passengers, and particularly crew, flying frequently on transpolar airline routes. They may also damage electronic systems and stored software codes on polar orbiting satellites. Knock-on effects from such damage have the potential to severely damage or destroy the spacecraft if critical systems are affected.

Secondly, CMEs that encounter the Earth system also have the potential to disrupt infrastructure through the coupling of the magnetic fields of the CME with that of the Earth itself. In some circumstances, this can result in a “stirring” of the terrestrial magnetic field, which may cause very high voltages to build up within the magnetosphere and ionosphere, and a very significant build up of energy within the night-side magnetosphere. Ultimately, this energy has to be shed by the magnetosphere, resulting in intense electric currents flowing in the magnetosphere and auroral-zone ionosphere (under these circumstances the auroral zone often descends to UK latitudes), in disturbances to the terrestrial magnetic field and in the acceleration of particles to very high energies. Many of these particles subsequently can be trapped within the Earth’s radiation belt regions for many weeks after the passage of the initial solar disturbance, and can readily affect space-based electronic systems and software throughout that period.

Some of the risks to human technology and society are:

- Loss of spacecraft due to effects of enhanced levels of penetrating radiation (eg deep dielectric charging within semiconductors and single event upsets within memory chips). Loss of individual spacecraft due to such effects is known to have occurred in the past, with consequent loss of capability, or the necessity to re-assign that functionality to other spacecraft, or to replace the spacecraft completely. However, a major “storm” has the potential to knock out networks of satellites, such as those involved in the delivery of GPS, communications, TV and telephone signals. Modern society’s dependence on satellite infrastructure is very extensive and pervasive—much of it is taken for granted. Solar Storms have the potential to be a common-mode failure for many of these space assets with dire consequences to transportation, defence, telecoms, etc. Replacing key elements of this infrastructure would take months or years, which could have long-term effects on our defence and navigation systems, and our general society, while expensive spacecraft are built and launched. More often temporary losses of service will occur when spacecraft operations are interrupted by radiation induced anomalies. This is naturally less expensive than a defunct spacecraft, but still may have significant commercial impact for the operator and users. High radiation belt particle fluxes (especially protons) and SEP’s will also damage solar arrays and thus reduce spacecraft lifetimes accordingly.
- Large voltages being induced in power lines and pipelines beneath the current systems driven in the ionosphere. Again there are documented cases of large areas (eg most of Quebec during a storm in 1989) being left without power after these induced voltages knocked out power substations, transformers and relays during a solar/magnetic storm. During large storms these current systems, and associated auroral activity, can descend to UK latitudes, and thus provide a potential risk to UK infrastructure. Although such damage to the national power grid may not immediately seem as expensive to repair than damage to satellites, even several days power outage during repairs is likely to be both very costly to the economy and very inconvenient to the populace.
- To date the risks associated with solar storms have been realised only in confined instances. The last recognised “perfect storm” occurred in 1859, which, of course, predated the current technological and space age and before the development of national scale power grids. However, there were recorded problems with the then nascent telegraph systems at that time. Moreover, solar activity is known to strongly vary during an approximately 11 year cycle, with the next “solar maximum” predicted to occur in mid-2013. It should be noted that the Sun has recently come out of an unexpectedly prolonged and particularly deep minimum, in which there was almost no solar activity for several years. This was both unpredicted and unprecedented in the space age, indicating that despite experiencing several solar cycles during this era, our ability to predict the general level of solar activity across this cycle is rather poor. In particular we have yet to gain the “prior experience” on which to base our expectations for activity as the Sun rises from the current deep “minimum” to “maximum” over the next few years.

Responses to questions posed by the Committee:

How are potential hazards and risks identified?

As documented above, the potential hazards and risks associated with solar activity are, in general terms, understood on the basis of scientific study and limited previous experience. The general conditions which lead to solar activity having a significant effect on the Earth are understood, and there have been a number of examples of spacecraft being lost and power systems being destroyed by these effects. The times of heightened risk can generally be identified as those years in which the Sun passes through the solar maxima (although there is no guarantee of only low-activity at other times). What is lacking is the ability to

specifically identify a period of particular risk with more than a few days notice. A fleet of scientific spacecraft continues to monitor the Sun, and can provide an identification of, for example, a potentially hazardous CME leaving the Sun a few days before it will reach the Earth. We cannot yet determine, however, the likely level of coupling of such a CME with the Earth system until it reaches our most Sunward satellites, about an hour before reaching Earth. Thus the knowledge of whether this will pass harmlessly or initiate a major magnetic storm within the Earth system can currently only be established about one hour before the event. We continue to study this scientifically, in an ongoing effort to understand and predict both the timing and nature of CMEs and their coupling to the Earth system. For example, better understanding how regions of solar activity evolve towards eruption could lead to warnings about a month ahead of time through identification of potential “problem” regions during their previous rotation across the face of the Sun. In addition, understanding how the magnetic orientation of the ejecta relates to the observed conditions in the solar active region would allow a better prediction about how effectively these ejecta will disrupt the near-Earth space environment, and thus the level of the potential hazard to spacecraft and power systems.

How prepared is the government? How does/did the government use scientific advice and evidence to identify, prepare for and react to an emergency?

The UK government does not currently support a coherent civilian program to identify and assess near-term risks associated with solar activity (given the risks to satellite technology and navigation systems it would be understandable if there existed a military capability in this area, but we are not aware of this). Currently warnings of increased risk come from the agencies of other governments (eg NASA and NOAA in the USA, see eg <http://www.swpc.noaa.gov/>) or through the actions of individual scientists who are engaged in the *ad hoc* monitoring of the Sun for research purposes. No formal channels of communication for warnings exist, however, and no strategy for government action in the event of an identified high-risk period has been developed. At present satellite operators and power companies either ignore the potential problem, or have their own bespoke solution to monitor and assess the risk. Moreover, little work has been done in fully assessing our dependency on space assets and how this might be mitigated in the case of a major failure. For instance, it is difficult to answer the question “what would be the consequences of losing GPS for six months?”

What are the obstacles to obtaining reliable, timely, scientific advice and evidence to inform policy decisions in emergencies?

The biggest obstacles in obtaining scientific advice during emergencies associated with solar storms are the lack of dedicated real-time monitoring and the short timescales involved. Monitoring could be achieved semi-automatically if relevant and currently existing observational datasets could be assembled at a single location and routine algorithms developed to test for potentially hazardous conditions. An automated alert to a duty officer or scientist would initiate human assessment of the situation until the alert is past or until a formal warning to interested parties (eg satellite operators, power companies, and even members of the public wishing to observe the aurora in the UK) needs to be issued to initiate implementation of contingency plans. However, even if continuous monitoring identified each potential solar storm, we currently expect only to be able to provide accurate warnings of its geo-effective coupling with about 1 hour notice. Hence policy decisions and these contingency plans need to be prepared in advance, such that a coherent response can be initiated immediately the occurrence of a significant and geo-effective storm is confirmed.

Has the government sufficient powers and resources to overcome the obstacles?

In principle, yes. Real-time monitoring of solar activity and its effects on interplanetary and near-Earth space, specifically for the benefit of the UK, could be undertaken using currently available international scientific assets. A small team would need to be established to set-up and run the monitoring centre, and would need to be resourced sufficiently in order to routinely gather and assess available data sets. Since the activity would be sporadic, with several alerts per month at solar maximum, this team could usefully be drawn from the pool of current UK researchers in this field and/or attached to a University group engaged in research into solar activity and its effect on the Earth system, perhaps using PhD students as duty scientists in the first instance. Lines of communication to potentially vulnerable parties would need to be established for rapidly distributing information about alerts.

Reducing the obstacle of short lead-times for accurate predictions of hazardous events can only be achieved through dedicated research into the detailed nature of solar activity, its evolution through interplanetary space and its effect on the Earth environment. Although the UK is already strong in science related to this field, we have yet to generate the detailed level of understanding required to make sufficiently accurate predictions in the days or weeks ahead of a hazardous event. Indeed the focus of this research has been to understand the underlying science rather than to predict and identify mitigating actions. The government currently funds such research through the UK Research Councils, but could usefully increase funding to research specifically related to enhancing our predictive capability, perhaps through a programme which specifically links researchers with the monitoring centre for the duration of their funded project. This research effort should also address the likely degree and probability of extreme events. An example of

extremes is the biggest solar flare on record, which occurred in 2003 and had a massive CME. This was significantly bigger than the 1989 events that affected Quebec, but fortunately was not Earth-directed and did not affect us.

(see <http://sohowww.nascom.nasa.gov/hotshots/X17/>).

As, in absolute terms, we have not been monitoring solar activity for very long (only a few decades), we most likely do not yet know the full range of behaviour within the capability of our Sun.

Development of a mature and accurate monitoring and prediction system could in time provide a financial return on the investment as interested parties (satellite operators, power companies and their insurers) learn that valuable assets can be protected from damage and loss through the use of these predictions to initiate contingency plans. This could perhaps be done through the introduction of a subscription system for alerts.

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?

At present there is little coordination within the UK in relation to preparations for a “perfect” solar storm. The UK has no dedicated monitoring of solar activity in the civilian arena. The UK has no assessment of potential damage to its assets should a storm of the 1859-class occur during the next solar maximum. The UK has no strategic line of investment aimed at developing a useful prediction capability, nor in providing support for the sciences that underpin the understanding of these phenomena and thus offer the path to better predictive capability. Despite an increased emphasis on “impact”, the UK research councils currently spend considerably less money on understanding our local star, the Sun, and its effects on Earth, than they do on understanding phenomena far beyond the solar system. This is despite the fact that the former could potentially have a devastating effect on our economy and lifestyle tomorrow, whereas the astrophysical phenomena we are so interested in occurred long, long ago. We thus conclude that the UK is not at all prepared to deal with a major solar storm and will have to assume the full risk of a potentially costly aftermath unless it is prepared to support some disaster preparations in this area.

How important is international coordination and how could it be strengthened?

At present international coordination is critical to this area. The observations and data sets necessary to monitor and predict the effects of solar activity are largely derived from a wide variety of scientific spacecraft which are either assets of another country (eg NASA missions) or are only partly supported by the UK (eg ESA missions and bi-lateral missions). Withdrawal of access to these observations by international partners would leave the UK vulnerable to unmonitored solar activity. Although such withdrawal would seem unlikely at present, the UK could act to secure its position through the deployment of its own monitoring satellite(s) or by sponsoring development of small monitoring packages which could be deployed “piggyback” on larger commercial spacecraft. Investment in the development of miniaturised sensor packages would be an important step in establishing this latter capability. This would also provide the UK with a more significant contribution to bring to the table when considering the international collection of assets required to fully monitor solar activity and understand and predict its effect on the Earth and its technology systems.

It should also be noted, in terms of providing an improved national or international effort in this area, that ESA have a growing “space situational awareness” activity (<http://www.esa.int/esaMI/SSA/index.html>) which the UK has not yet signed up to, as we understand it. Given that the UK already invests heavily in ESA, this may be a cost-effective collaboration in which the country could participate.

Summary

The increased reliance of UK society on high-tech space-based assets for communications, navigation, defence and information gathering creates a greater risk of disaster should these assets be lost or significantly damaged by the effects of solar activity on the near-Earth space environment. Isolated examples of such losses have occurred in recent decades through the loss of power grids and individual satellites. We have not, however, suffered a storm of the 1859-class during the space age, so the losses have been relatively light. Over the last few years the Sun has unexpectedly been extremely quiet, indicating that we really have little idea how active it might become as it rises to “solar maximum” over the next three to four years, or what extremes of behaviour we might see as we experience the effects of future solar cycles. A “perfect storm”, which will result in significant loss of UK and other assets, is a possibility. Developing a strategy for enhancing our predictive capability and establishing a system to recognise hazardous periods and initiate contingency plans requires modest investment, but given the relative cost of replacing just one satellite in space (> > £100 million), has a very high probability of significant value returned on that investment. The UK government would be well advised to consider investment in such capability.

Footnote: A report of the results of a recent US National Academies workshop on the societal and economic impacts of extreme magnetic storms is available at http://www.nap.edu/catalog.php?record_id=12507.

Submission from Professor Alan Aylward. Head of the UCL Atmospheric Physics Laboratory.

Professor Aylward's expertise lies in so-called "space weather" (changing environmental conditions in near-Earth space, governed to a large degree by changes in solar activity) rather than in preparedness in relation to extreme space weather events. Nevertheless, he makes the following points in response to the Committee's request:

- I don't think there is a specific government organisation that would have responsibility to respond to a serious solar storm—or who would have responsibility for effecting a warning and distributing it to relevant bodies. The Met Office has taken some initiatives in this area, but has not been very successful in getting funding. As such, the Met office is following the US Model, within which space weather forecasts are seen as logical extensions of terrestrial weather forecasts.
- The fact the Sun seems to be very quiet at the moment doesn't necessarily mean that a "big" event couldn't happen. The great solar storm of 1859 (sometimes known as the Carrington storm), which was so intense that the current induced in telegraph wires almost electrocuted some of the operators, actually occurred in the middle of a rather unexceptional solar cycle.
- Our communications and power systems are probably more susceptible to big current surges now than they were in Carrington's time. There are unlikely to be events that we couldn't deal with as long as we were prepared (the event that "killed" the Canadian grid in the '80's is unlikely to have the same effect again because the Canadians have upgraded their systems)—but new and critical technologies, such as the GPS system have never been effectively tested for such contingences.
- There is a new European Space Agency initiative on Space Weather (or Space Situational Awareness as the current buzz phrase goes: <http://www.esa.int/esaMI/SSA/index.html>) but the UK has not bought into this at the level of other countries and our contribution—despite historic strength in this area—is minimal. It should be possible to set up warning systems for intense CMEs or growing solar strength but the UK government is not likely to be a priority recipient of the necessary data at its current level of interest.
- By subscribing to the ESA Space Situational Awareness programme (which is fairly low cost and could be done fairly cheaply, especially if we insisted on getting our "juste retour" from it) we would have access to a great deal of data needed to make decisions. Then the possibility of having a nominated Space Weather Awareness Centre (or whatever you may want to call it) comes into play. This could be set up in the Met Office or in one of the major research groups where a lot of the expertise would be to hand and where the monitoring could be done cheaply using research students.
- As with (terrestrial) weather prediction models can play an important part and continual forecast models could be run to try out different scenarios and try to "nowcast" the space weather. While it is true we currently only get an hour's warning of the most geoeffective CMEs, work with the STEREO space mission (to which the UK contributes) has begun to show ways that we may get some warning of what is going on once a CME leaves the Sun. Predicting a CME's path is currently very inaccurate, but some warning is better than none. Also modelling of different scenarios (including those that have not yet occurred since the start of the "Space Age") will help to build up a portfolio of predictions about how bad things could be, with suggestions for mitigation procedures that could be enacted immediately a situation arose. For example, tabulating the area affected by solar proton events could produce a "safe latitudes" and "safe altitudes" guide for aircraft operators: modelling of induced currents under a range of input and response conditions could inform power companies as to where their major vulnerabilities lie, and whether mitigating procedures could be brought into play when large events were predicted. The British Geological Survey already sends out warnings to oil companies and others about disturbances to the geomagnetic field (the oil companies use the field direction to guide their drilling rigs) but I am unaware that they have a predictive capability or have done work on "Perfect Storm" type conditions.
- A lot of work has been done in a research capacity that addresses some of these issues, but what is needed is a government initiative to establish a commercially and societally aware infrastructure designed to use this knowledge. I would have thought the MoD would have already been switched on to this since they could lose security capability if a Skynet or other military satellite was crippled. There is a reluctance of commercial companies to contribute to the infrastructure as long as the government is paying. The data from the ionosonde chain was used by the MoD and companies like BAe and the aircraft companies, but they would not contribute to the cost of running them until PPARC/STFC decided to close them as national facilities. Reluctantly some users have now started to contribute, though not at the level that is needed to continue a full service, but it may be possible to boost this if government guidance is issued.

7. GENERAL ISSUES

In relation to the government's use of scientific advice and evidence in emergency situations, four general points seem to merit highlighting:

1. *Threat identification.* While some threats that are capable of leading to emergency situations are widely recognised in advance (eg swine flu), and possible consequences reasonably well constrained, others (eg Icelandic ash) are not. Threat awareness is critical if there is to be effective preparedness. This, in turn, is crucial, if an emergency situation is to be handled effectively and in a reasoned manner, as opposed to in a purely reactive and *ad hoc* way. It is recommended, therefore, that the National Risk Register is re-evaluated, and scientific advice sought in order to ensure that—in future—it is far more inclusive in relation to potential threats to the nation. Such an evaluation may be undertaken by a panel along the lines of the Natural Hazards Working Group, which reported to the government in 2005 a strategy for addressing the global threat of extreme geophysical hazards.
2. *Scientific advisory panels.* Because some emergency situations may be very short-lived, consideration should be given to establishing—in advance—appropriate advisory panels and determining their composition. Some thought should also be given, perhaps, to the mechanism by which panels are filled which, currently, appears to be pretty *ad hoc*.
3. *Channels of communication.* By their very nature, advisory panels have to be small. As a consequence, however, they are exclusive, with most scientists in the relevant field having no involvement. There may be an argument for providing a mechanism whereby scientists in the field are able to communicate their ideas and concerns to the panel and, through it, the government.
4. *International cooperation.* As many of the threats to the UK have an international dimension, international collaboration and cooperation would seem to be of critical importance. Through limiting engagement with initiatives designed to address future threats that have the potential to be particularly damaging to the UK, notably in the case of solar storms, the government may be making it more difficult for future emergencies to be tackled effectively.

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UCL Institute for Risk & Disaster Reduction

13 September 2010

Memorandum submitted by SolarMetrics Limited (SAGE 18)

This submission is for the Science and Technology Committee inquiry, examining the Government's use of scientific advice and evidence in emergency situations. Specifically, this letter addresses these issues with relation to the potential emergency situation that solar storms could cause.

The views expressed here are those of SolarMetrics Limited, a UK company that specialises in the field of space weather, space radiation and solar activity, and the impacts these have upon commercial operations, safety, people, the environment and the technological systems used in civil and military aerospace.

TERMINOLOGY

The term solar storm, while it articulates an image of something that most people can relate to, is both an oversimplification and misleading particularly when the term is hijacked by the media for sensationalising news stories. It will be important that Government departments, public and private bodies, scientific advisors and the research base, all work together to make sure that better definitions are agreed for the various aspects of solar activity and space weather, and how they impact systems. The space weather hazards and the systems they can impact are quite diverse: therefore, correct terminology, as well as correct cause and effect will need to be stressed by all that understand these issues in order to help decision-makers enact good policies.

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

A solar storm is a generalisation for a number of different phenomena that can take place in the space environment that exists between the Sun's surface and the Earth's protective magnetic field, known as the magnetosphere. The phenomena that concern aerospace operations most are those that increase the radiation environment, and those that disrupt operational systems.

The most important phenomena are Solar Energetic Particles (SEPs), Coronal Mass Ejections (CMEs), geomagnetic storms and sub-storms (and more directly, the ionospheric disturbances). (Note: Galactic Cosmic Rays (GCRs), which originate from exploding stars outside our solar system, also affect technological systems and endanger human life and health, but their effect can be considered as a longer term manageable risk rather than causing emergency situations due to a sudden storm onset.)

These different storm phenomena mentioned above can impact on aerospace operations in different ways. The hazards include the direct effects on avionics, communications and GPS navigation systems, and the indirect effects upon the airspace management through loss of critical infrastructures, ie, the National Grid.

IONOSPHERIC DISTURBANCES LEADING TO DEGRADATION OR LOSS OF RF COMMUNICATIONS

Many communication systems utilise the ionosphere to reflect radio signals over long distances. However, if the ionosphere becomes disturbed by storm activity, HF or low VHF radio communication at all latitudes can be affected. If the effects become especially strong, it can cause a total communications blackout. Even modest storms that occurred during the last solar cycle (23) produced disturbances that lasted for many days and affected traffic flow rates over and around UK airspace because Air Traffic Control (ATC) had to increase separation between aircraft entering the North Atlantic Track System. When very energetic particles enter the atmosphere over the Polar Regions, the enhanced ionisation produced at these low ionospheric altitudes (50–100 km) is particularly effective in absorbing HF radio signals and can render HF communications impossible throughout the Polar Regions. Airlines, on polar flights, have diverted flights due to HF communication loss, which have caused en route time penalties of up to 180 minutes.

Disruption to communications from severe solar storms (ie 1859) would likely render large airspace regions unusable for many days, in a similar way to the recent Icelandic volcanic ash closures.

Satellite communication coverage is not yet global, it can also suffer degradation or outages, and airborne installations are not sufficiently widespread to make it a viable replacement for HF.

RADIATION DAMAGE TO AVIONICS

The electronic components of aircraft avionic systems are susceptible to damage, and/or incorrect logic processes, from the interactions with high energy particles from SEPs and CMEs (and GCRs). And as these micro-electronic components become increasingly smaller then the risk of damage also increases dramatically.

Awareness of damage to, or failure in, electronics became more widespread with the start of the launch of satellites. Satellites incorporating sensitive Random Access Memory (RAM) chips have had upset rates from one per day at quiet times to several hundred per day during SEP events. Aircraft in-flight measurements of Single Event Upset (SEU) sensitivity in 4Mb SRAM produced a rate of 1 upset per 200 flight hours, and agreed well with the expected upset rate variations due to changing latitude. Research has already shown that 100MB of modern RAM found in laptops and PC's may suffer upsets every 2hrs at 40,000ft, or 1 upset/minute in 1GB of memory due to the 1989 SEP event.

Known failures in commercial airliners auto-pilots and flight instruments have occurred during non-storm conditions. Australian air accident investigation of flight QF72 includes single event effects as one of the causes it is investigating (http://www.atsb.gov.au/media/1363394/ao2008070_ifr_2.pdf). Modelling of major SEP events (1989, 1972, 1956, and 1859) to reflect the possible radiation environment at aircraft altitudes suggests that such storms could cause irreparable damage to many onboard flight and engine critical components, posing significant flight safety hazards.

RADIATION OVER-EXPOSURE TO PASSENGERS AND CREW

The principal space weather hazard to humans is exposure to cosmic radiation while flying, which is caused primarily by GCRs. The dose rate at an altitude of 39,000 ft (12 km) in mid-temperate latitudes is typically up to about 6 microSieverts (μSv) per hour, but near the equator only about $3\mu\text{Sv/hr}$. Typically, a London to Los Angeles flight in a commercial aircraft accumulates $\sim 65\mu\text{Sv}$ ($6\mu\text{Sv/hr}$); however, the solar cycle can give $\pm 20\%$ variations in dose from solar minimum to maximum.

However, of concern are those SEPs that increase the dose at aircraft altitudes. Using data collected onboard aircraft and then modelled to large SEP storms (ie, 23 February 1956, 29 September 1989) it is estimated that the additional radiation dose received at 40,000ft (12km) on a subsonic transatlantic flight would have been approximately 10 mSv and 2 mSv respectively.

Under present ICRP guidelines, the recommended dose limit for the general public is 1mSv, and for aircrew in the EU a maximum working level of 6 mSv has been adopted by the airlines.

SATELLITE NAVIGATION OUTAGES AND POSITION ERRORS

Future airspace management is reliant upon the increasing use of GNSS for navigating aircraft so that the separation between aircraft can be reduced, to position the aircraft on approach, and for landing in all weather conditions. However, the accuracy of the satellite signals, which must pass through the ionosphere, is affected by ionospheric variations due to storm activity. Dual-frequency satellite receivers actually measure the effect of the ionosphere on the satellite signals and can better adjust to, but not eradicate, these difficult circumstances.

The WAAS was commissioned in 2003 for use in all phases of air navigation, which through the implementation of GNSS Approach with Vertical Guidance (APV), to provide users with the capability to fly approaches with vertical guidance throughout the U.S. national air space to 250 feet above a runway, even in conditions of poor visibility. Quarterly performance reports have shown that the WAAS system generally meets or exceeds these requirements. However, the performance reports also verify that one of the greatest challenges for WAAS is maintaining continuous APV availability during extreme geomagnetic storm events. During the extremely disturbed days of October 29 and 30, and November 20, 2003 the APV service was unavailable over the entire contiguous U.S. (CONUS) region for periods of approximately 15 and 10 hours, respectively.

Until recently, the ionosphere has been considered as the sole source of space weather effects on GNSS signals, systems, and navigation accuracy. New research (Klobuchar et al, 1999; Cerruti et al, 2006) now suggests there is a different class of space weather effects on these signals: solar radio bursts. Solar radio bursts affect the GNSS system by attenuating the carrier-to-noise ratio, thereby degrading the received signals. These bursts can have durations from tens of seconds to a few hours. In December 2006, there was widespread loss of the GPS signal over the US caused by such an event.

FUTURE AIR TRANSPORT AND NATIONAL INFRASTRUCTURE

The plans for SESAR (EU) and NextGen (US) will address critical safety and economic needs for civil aviation in future years. However the impact of space weather and severe solar storms upon a more highly integrated infrastructure and more technologically susceptible aircraft will potentially cause greater disruption and reduced safety. It must be recognised that space weather forecasting and warnings must be integrated into these systems.

The impact of severe solar storms upon critical National infrastructure like the electric grid is currently undergoing close scrutiny. The widespread loss of electricity even for a short period would have serious consequences for all aspects of society. Air traffic contingency planning would likely manage to safely recover all aircraft on to the ground, albeit with severe disruption to operations and people (ie, post 9/11 airspace closure over the US). However, if the loss of power grids extended over continents, and was so severe that restoration and repairs were to take weeks or months, then the ability for aviation to function would all but cease.

HOW PREPARED IS THE GOVERNMENT FOR A SOLAR STORM EMERGENCY?

The awareness and understanding in the UK aviation community (civil and military, CAA, NATS, operations and senior managers) of the space weather environment and the potential hazards from severe solar storms upon technology and operations is considered to be extremely poor. (Note: Space sector operators and manufacturers (satellite operators, avionics) are likely to be more aware, but they tend to operate in isolation, and are reluctant to admit to any issues due to commercial sensitivities.)

Presently, in the event of a solar storm that had a major impact upon aviation, the UK response could only be totally reactive and would likely be ill-informed and ill-judged. UK aviation does not receive space weather information or warnings as standard practice. The UK Met Office does not do space weather per se for aviation operations. It would be up to the CAA and NATS, in the first instance, to resolve immediate operational matters that were directly affecting safety, but they would affectively be making decisions without any real understanding and without developed hazard mitigation strategies and protocols.

The recent problems experienced with the Icelandic volcanic ash with regard to understanding of preparedness provide a good analogy to the solar storm. However, even in that case where there were established ICAO, UK and airline, procedures and checklists, the ability to clearly assess the hazard and understand whether safe operations could go ahead was severely lacking. Therefore, given that there is less understanding and awareness of solar storms, and there are as yet no ICAO (see 5 below) or National procedures in place, the ability to react effectively to this emergency would be poor.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

UK Cosmic Radiation Advisory Group (UK CRAG)

In May 2000, EU Directive “96/29/EURATOM of 13 May 1996 laying down basic safety standards for protection of the health of workers and the general public against the dangers arising from ionising radiation” was implemented in to the UK Air Navigation Order. Article 42 of the Directive imposes requirements relating to the assessment and limitation of air crew members’ exposure to cosmic radiation and the provision of information on the effect of cosmic radiation.

The majority of UK airlines did not have the relevant in-house expertise to understand this cosmic radiation science and the medical implications of radiation exposure and protection. In order to guide the UK airlines with implementing correct compliance policies for this ANO, a Government led (DfT) Cosmic Radiation Advisory Group was created in Sep 2000. The UK CRAG comprised CAA, HPA (then NRPB), space weather academia and industry, airlines and union representatives.

Although UK policy on compliance requirements for monitoring of air crew exposure is considered overly slack, the CRAG did provide informative guidance material on the protection of air crew from cosmic radiation, but only where the radiation was GCR in origin. Although increased radiation doses received from SEPs is included in the material, and numerous SEP events occurred during the CRAG’s five year sitting (it was never formally disbanded), the ability of the Group (and desire by some members) to provide useful and timely information for the airlines was never fully exploited. As Solar Cycle 24 gets under way it would be advantageous to resurrect the UK CRAG, strengthen its terms of reference and implement a technical activity programme for investigating solar storms that affect human exposure.

The UK CRAG, in its past form, would not be considered appropriate to tackle the other, wider reaching, hazards of solar storms upon operations and flight safety. Nor tackle the future space weather requirements specified by NextGen and SESAR. In order to model the risk and evaluate vulnerabilities from solar storms upon every facet of daily operations and air traffic infrastructure on a National (and European) scale then the Government should consider convening relevant expertise from academia, government and industry and reinsurance.

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?*

Obstacles

There is no doubt that space weather is in its infancy still, but information, forecasting and warnings are available in some form and can be made available to the operational and policy decision-makers. This can only happen once the UK develops a coordinated National space weather approach for all impact areas.

In order to achieve this there has to be a highly visible and high-level supported education and outreach programme (see Terminology above).

Aviation is another area, like power grids, where space weather scientists have a fairly mature understanding of the threat. But by fairly mature, it is meant that we know enough to know that we need to know and do more. Again the analogy with the volcanic ash issue would appear to be relevant in that we thought we knew enough to work a plan. And the plan was found wanting because we needed to know and do more.

However, reliable and timely information that a solar storm is about to occur, what its magnitude and severity of impact will be on different systems is currently not possible. Therefore, as well as coordination of assets, the Government will need to renew investment in Solar Terrestrial Physics, such that the UK’s world-leading research can continue to make a difference by providing hazard and disaster information where and when it is needed.

As well as improving our understanding the Government should lead discussions amongst all impact stakeholders about defining and collecting operational data that can be used to assess the different impact areas, cost of improved services, and return on investment. The UKSA, NERC and MOD should also link aviation (and other impacted areas) space weather cost benefit analysis to UK requirements for ongoing consistent data collection from ground and space.

Like volcanic ash, improving the understanding of the space weather hazard should be considered in the context of environmental monitoring (air pollutants, radiation, weather, etc). Every aircraft should be aware of, and be able to monitor the environment it is flying through and communicate that to other aircraft and a wider-area network fed to the ground. Network centric operations are nothing new: the concept has been under development by the military for many years already. Consider what we would know already about the disappearance of flight Air France 477 in the South Atlantic if aircraft communicated the full picture.

The idea of such a network is already envisaged for NextGen and SESAR. The required improvements in weather data assimilation and forecasting, as well traffic free-flow management can only happen by turning every aircraft into a “node” and then communicating the “big” picture in real-time.

Implementing a network for environmental monitoring, regardless of target data, would be quite feasible: aircraft manufacturers and airlines already carry out certain levels of airborne systems monitoring. Although getting their buy-in to extend this monitoring for other processes would be difficult in the current financial markets. However, if the longer-term benefits of NextGen and SESAR are to be realised then the industry will have to become willing participants.

SolarMetrics deploys radiation monitoring equipment onboard aircraft and spacecraft specifically to assess the radiation environment. We believe there is a valid argument for installing real-time communicating radiation monitors onboard every aircraft. Only by pursuing this goal will it be possible to provide reliable and timely information to the pilots, controllers and dispatchers in the event of significant or severe solar storms, such that better operational decisions can be made. Besides enhancing the capabilities of space weather forecasting and warnings, this real-time data has also been identified as potentially beneficial for climate issues.

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?*

Action for a National Space Weather Programme

Meetings have already taken place between a number of UK space weather experts together with representatives of NERC and UKSA with the aim of exploring how to progress UK space weather activities in the context of NERC and of UKSA. On the NERC side a particular aim was to discuss how to propose that space weather be added to the scope of the Natural Hazards programme. It was recommended that the space weather community should establish a formal body to represent and promote space weather understanding in the UK. This body should be inclusive of all the UK community affected by space weather (not just aerospace) and be able to engage at National and European level.

Discussions also touched on the involvement of MOD in space weather issues. The MOD does support a number of space weather activities, but this support is rather patchy and it tends to come as a side effect of other programmes. There appears to be a lack of MOD coordination and an excessive dependence on the US. Currently, the MOD uses space weather predictions provided by the US Air Force Weather Agency, but was unaware that those US predictions are based, in part, on data from UK indigenous sensors. In a public planning document the MOD argues that US space weather measurements in UK were essential to national security, but in another part would not support similar but better run UK measurements. It seems that at a high level the MOD fails to grasp the need to trade UK-sourced space weather data and services with the US. With an ever increasing need for better Space Situational Awareness in the US, UK and NATO, the MOD and UK plc is not well placed to make the most from the emerging opportunities.

Coordination of all these agencies and efforts into a National Space Weather programme as part of the UK Space Agency is considered highly beneficial.

5. *How important is international coordination and how could it be strengthened?*

International coordination on space weather and the hazard mitigation strategies and technologies required for global air travel will be vitally important.

The UK space weather community already participates in many international activities: working with COST, DoD, ESA, FAA, JPDO, NASA, NATO, and many others.

In the US, a policy workshop report (American Meteorological Society and SolarMetrics, 2007) on “Integrating Space Weather Observations & Forecasts into Aviation Operations” presented recommendations that, if implemented, could increase the safety, reliability, and efficiency of civil aviation operations through more effective use of space weather forecasts and information. The AMS Policy Program and SolarMetrics developed this workshop as part of a broader three year policy study, funded by the National Science Foundation, and endorsed by the FAA, to examine policy issues in implementing effective application of space weather services to the management of the aviation system.

American Meteorological Society and SolarMetrics’ follow on work to this policy report has been the defining and writing of aviation space weather user requirements that the FAA is now incorporating into a “Concept Development Plan for a current space weather capability in the National Airspace System”. NextGen is also including elements of these requirements into their weather development programme.

In addition, the FAA has been tasked by ICAO to develop the aviation operational requirements for space weather information that are to be ready as an amendment by 2011, endorsed in 2014, and officially implemented into ICAO Annex 3 Standards and Recommended Practices (SARPS) in 2016.

And from the 60th session of the WMO Executive Council in Geneva, June 2008: *“In view of the considerable impact of Space Weather on meteorological infrastructure and on a growing number of human activities...the Council fully endorsed the principle of WMO activities in support of international coordination in Space Weather.”*

Considering the extent of the above international activity in space weather for aviation it is extremely important that the UK Government begins to participate in this arena.

Thank you for the opportunity to comment to this inquiry.

Captain Bryn Jones
CEO
SolarMetrics Limited

13 September 2010

Memorandum submitted by Professor W P Aspinall (SAGE 19)

I am responding to the committee's invitation for written submissions on the issues identified in relation to their inquiry into scientific advice and evidence in emergencies.

I am a consulting Chartered Scientist and Cabot Professor in Natural Hazards and Risk Science at the University of Bristol. My comments are informed by my experience as a member of the Foreign Office Scientific Advisory Committee on Volcanic Activity in Montserrat, as a member of the CSA's advisory group SAGE on the recent Icelandic volcanic activity, and my other professional experience in relation to hazard assessment and risk assessment in safety critical industries, flight operational safety and medical issues requiring expert judgment. These comments are made on a personal basis and should not be construed as representing the views of any organization, institution or committee with whom I had been associated.

Before making some generic comments, I will provide brief responses to the five points identified by the Committee in relation to the four case studies they are considering. In the main, my responses relate to the Icelandic volcanic ash eruption in April 2010.

1. The hazard created by the volcanic eruption was airborne ash, which entered UK and neighbouring airspace, and the two main risks were (a) risks to flight safety (airworthiness), and (b) operational disruption. Having been one of the people called in to provide advice to SAGE, it was clear that the UK government was little prepared for this emergency.
2. In this case, and in the case of the ongoing eruption of the Soufriere Hills volcano on Montserrat, which started in 1995, there was little if any preparation for such an emergency and the government's response was, therefore, almost totally reactive. For instance, in the case of the Montserrat crisis, the setting up of a formal scientific advisory committee to provide advice to the FCO was done at the instigation of scientists involved in monitoring that crisis, and not as initiative of government itself.
3. Unquestionably the government has sufficient powers and sources to overcome obstacles, but an efficient and unambiguous framework for obtaining reliable timely scientific advice and evidence to inform policy decisions is not well established within government. Moreover, in the case of the Icelandic ash crisis this year, there was a signal absence of will to fund support for urgent work to be done in the universities, in the British Geological Survey, or by other outside specialists in industry and consultancies with significant relevant experience. The imminence of a general election seems a very questionable and lame excuse for failing to properly mobilise and support vital hazard and risk appraisal work for an emergency of such massive economic impact, and one with a residual potential for mass casualties when some airlines started operations while conditions were still uncertain.
4. Strategic coordination between government departments, public bodies, private bodies, sources of scientific advice and the research basis has not been and is not fully effective in preparing for or reacting to emergencies. A major problem, which was manifest both in the recent Icelandic crisis and in the Montserrat crisis, was the failure for one department in government to take full ownership of the "problem"; in the case of Montserrat, there was (and still is to some extent) a continuing division of responsibility between the FCO and DFID, despite a Select Committee recommending that one or the other take control of the crisis after people were killed in 1997. In relation to co-ordination between government and specialists other than those in the government service or in universities, successful working relationships are, not unnaturally, difficult to establish in an emergency—prior liaison, breaking down silos and barriers, invariably produces dividends, and the benefits can be attested to from many other emergencies.
5. International coordination is very important with respect to volcanic activity, and although the UK itself has significant—possibly world-leading—volcanic risk assessment and crisis management experience from the Montserrat eruption, international collaboration is essential—such activity can be very complex, is not confined to national borders, and needs the best expertise for handling the many-faceted aspects of the threats. This said, there have been some obstacles to strengthening such collaboration imposed by the UK government: for instance, an invitation was extended to me as a volcanic hazards specialist to attend a major volcanic emergency exercise in Italy a few years ago, but the invitation was not acted upon officially simply because I was not a government employee—and this despite having sat on the Montserrat SAC since its inception!

Moving on to more generic issues, any decisions in relation to emergencies arising from the sorts of situations mentioned in the Inquiry need to be “risk informed” to the maximum extent possible. For the best and most defensible policy decisions to be made where scientific uncertainty is a key factor, comprehensive quantitative risk assessments (QRAs) are needed. One thing that has struck me forcibly has been the limitations in the extent and detail of application of good practice QRA principles to the Montserrat and Iceland eruption scenarios, when compared with the rigorous and exhaustive assessments undertaken in this country for, say, external hazards to nuclear power stations, for instance. [As well as participation in the two volcanic crises at issue, I have been involved also in UK nuclear safety work for more than 25 years, sit on various IAEA hazards committees, and therefore have a wider than usual perspective on the issues].

The present selective scenario-based approach for risk appraisal for national contingency management, such as has followed on from SAGE deliberations over the Icelandic ash crisis, is unable to capture all the intrinsic variabilities in volcanic processes, and I think it fair to say that nearly all, if not all, of the volcanologists involved in SAGE were dismayed by the approach that has been taken. The point here is that identification and quantification of uncertainties are absolutely key—uncertainty in relation to the true strength of contributory factors and, in particular, those which can be described as having heavy or long statistical tails, can drive up the estimated level of hazard, and hence risk. If these uncertainties are not adequately captured or otherwise are under-stated, there is the prospect of events happening that lead to major surprises, sometimes involving situations falling outwith the scope of policy decisions that were intended to deal with all eventualities.

In this regard, the approaches to the Soufriere Hills volcano and Icelandic ash crises were *ad hoc* and insufficiently formalized, in my view. Such events may be very low probability but the consequences can be major, either in terms of calamitous loss of life or disastrous economic costs (or, indeed, both). The pathway from scientific uncertainty, through judgment to advice and thence to crucial decision-making should be made as explicit, auditable and traceable as possible. In essence, a simplified approach was adopted in both cases, contrasting with the sort of “scorched earth” risk assessments that are customary for major safety-critical industries. In both cases, the spectrum of expertise that was mobilized has been limited—for the recent Icelandic ash episode, academics, government agency staff and others acted on a *pro bono* basis, and a whole range of other expert knowledge and professional judgment, that exists in other domains, was effectively eschewed. In the Montserrat case, the risk assessment work has also been done on a shoe-string and, in many ways, it has been a matter of good fortune rather than sound mitigation that no one there has been killed or injured since the fatalities of June 1997 [n.b. also there have been at least three significant civil airliner ash encounters near Montserrat during its fifteen years eruptive activity].

In the case of the Icelandic ash crisis, one important consideration is the very high level of safety that is achieved in normal operations by the civil aviation industry. The occurrence of extraordinary and highly unpredictable scenarios—involving extensive volcanological uncertainty and meteorological variability, and contingent engineered system impact uncertainties, such as ash-induced engine failure modes—can easily produce a situation where margins of safety are (or might be) eroded to the extent that, inevitably, such reduction, perhaps tolerated unwittingly, could appear indefensible *post hoc*, if disaster ensues. In this particular case, I was concerned in SAGE that there was no comprehensive end-to-end uncertainty/hazard/risk assessment with which to inform the urgent decisions being made; a detailed and thorough assessment was required that needed much more attention to detail and much more effort than was possible under the imposed *ad hoc* conditions. As the economic costs of the flights disruption were massive, even a major cost incurred in producing better hazard and risk assessments would have been justified, in this case at almost any imaginable cost—especially given the possibility that such advice, if well-founded, could have been used to sustain, at the earliest possible opportunity, a restart of flights on a reasoned evidence-supported basis. The impatience of some airlines to get flying again was not properly evidence-based and hence not completely rational in the circumstances, but this could happen because no one government department seemed prepared to grasp the nettle and contemplate all the issues fully and with funding support.

This latter point, about when an emergency can be considered ended, is important: it is a common feature of many unusual threats, such as a volcanic eruption, solar storm or pandemic, that determining when to declare a crisis over is frequently much more difficult than raising the alert in the first place, when things are obviously escalating. Premature decisions in sounding the “all clear” can incur unintended risks—having successfully negotiated previous, on-going activity, declaring a false dawn can be disastrous. Avoiding this pitfall requires a significant measure of expert judgment and a judicious way of acquiring it, under pressure.

Thus one element in the provision of sound scientific advice to government in response to national emergencies, which calls for some new thinking, is finding an optimal structured procedure for the elucidation of expert opinion to derive a rational consensus as the basis for decision support. My professional experience in this regard includes facilitation of performance-based (ie scored and differentially weighted) expert elicitations for forecasting and mitigating volcanic eruption scenarios, for ranking and managing flight operational safety issues, and for modelling emergent virus and other medical challenges [eg SARS risks to health workers; vCJD risks from blood products; emergence of the XMRV virus, a gammaretrovirus first described only in 2006, with potential associations to chronic fatigue syndrome and prostate cancer].

It seems to me that adopting this formalized approach to expert judgement—when the circumstances are appropriate—would be a valuable addition to the toolkit of decision support techniques, especially in the matter of quantitative risk assessment in the face of significant scientific uncertainty. In addition, there are available nowadays useful (Bayesian) graphical techniques for weighing and combining different strands of uncertain scientific evidence, so that the import of such evidence can be thoroughly and efficiently adduced for decision support. It also seems clear to me that further work is needed to establish government-spanning protocols and a decision framework for accessing scientific advice and scientific evidence in emergencies, and for utilizing the best techniques and methodologies—bearing in mind the latter is an evolving domain that warrants those involved keeping current with developments. Again, reliance on outmoded, inferior or casual approaches can expose government to censure if things go pear-shaped.

Professor W P Aspinall

13 September 2010

Memorandum submitted by the Royal College of Paediatrics and Child Health (SAGE 20)

Our comments relate to the first case study: Swine Flu pandemic in 2009.

The Royal College of Paediatrics and Child Health believes that the response to the H1N1 pandemic with regard to the production of vaccine and the stock piling of Tamiflu was appropriate. The CMO had to act assuming the worst case scenario. The papers published from Australia and the US had shown that this flu was very virulent with a high mortality, particularly among the young. However, it proved to be less transmissible than had been predicted and numbers of affected cases were therefore less than expected. It is conceivable, if not likely, that a H1N1 pandemic will recur at some point; in this respect, the response may represent a very good dress rehearsal.

NATIONAL INSTITUTE FOR HEALTH RESEARCH (NIHR) MEDICINES FOR CHILDREN RESEARCH NETWORK (MCRN) SUPPORT FOR DEPARTMENT OF HEALTH PRIORITY SWINE FLU TRIAL

In September/October 2009, constituent parts of the NIHR worked together to support a key study comparing the Baxter H1N1 vaccine and GlaxoSmithKline H1N1 vaccine in children six months to 12 years of age. The study was funded by Health Technology Assessment and the Lead Applicant was Professor Liz Miller, Health Protection Agency, and the Chief Investigator was Professor Andrew Pollard, University of Oxford.

Usually such studies take many months, even years, to develop from an agreed protocol through regulatory and ethical approvals (both national and at each local participating site), recruitment of staff, then participants and completion of the study. In the context of the H1N1 pandemic, the Department of Health gave high priority to relevant H1N1 studies and the relevant governance bodies fast-tracked their approvals assessments as a result. The NIHR had in the summer of 2009 made contingency plans to allow the research networks to support priority H1N1 studies.

In this case, the trial was a collaboration between the lead site, The Oxford Vaccine Group at the University of Oxford, Centre for Infections at the Health Protection Agency and other sites, namely: St George's Vaccine Institute, London, University of Southampton, Wellcome Trust Clinical Research Facility, Bristol Children's Vaccine Centre, and Royal Devon and Exeter NHS Foundation Trust. The study was adopted into the NIHR MCRN Portfolio following review by the MCRN Study Assessment Committee which was completed within 48 hours.

Research staff within the MCRN Local Research Networks (LRNs) and Comprehensive Local Research Networks (CLRNs) were mobilised to undertake this study. Support from senior management within participating Trusts facilitated access to Trust resources to ensure swift and efficient study set up and running (eg pharmacy, Research & Development, laboratories, space in Out Patients, PALS, security, cleaning, Finance, HR, Public Relations departments).

This trial required the recruitment and follow-up of a large number of study participants (see Table 1) within a short time frame (one month for recruitment). This was achieved by close collaboration between the study team and (C)LRN-funded staff during an intense recruitment period when children and families were recruited outside normal working hours. Key to success was the ability to achieve approvals and training (eg nurse contracts and training) to allow staff to work in new sites or facilities (eg schools, primary care sites) to facilitate recruitment, vaccination and follow-up. As a result of this tremendous collaboration, recruitment to the study was not only fully achieved but in a very short period of time. This is unprecedented in a complex research study involving so many children. As a result of this study, the Department of Health was able to institute a timely and evidence-based vaccination programme for children.

Table 1

RECRUITMENT TO THE TRIAL

<i>Site</i>	<i>LRN/area</i>	<i>Recruitment</i>
Oxford	South Central Area	275
Southampton	South Central Area	277
St Georges	SENCE	133
Bristol	SWEST	255
Exeter	SWEST	

DEPARTMENT OF HEALTH GUIDANCE

The RCPCH is committed to ensuring that all advice to Paediatricians during a Swine Flu pandemic is evidence-based, appropriate and consistent, in order to best serve the interests of children and young people.

During the recent Swine Flu emergency, the Department of Health issued some helpful guidance for paediatric services. The use of algorithms was particularly helpful. However, at the time the College had concerns that the Swine Flu paediatric hospital pathway did not make clear under which circumstances the advice should be followed.

The College feels it is important that all guidance issued in an emergency is produced with a summary document and that any key information is highlighted, so as not to be missed by health professionals. It is also essential that any guidance issued is consistent with existing best practice. For this reason, the College feels it would be of benefit for the Department of Health to work closely with the College from the outset to produce paediatric guidance in an emergency to ensure consistency with other evidence based guidance and meets the College's standards for endorsement.

Dr Jan Dudley

Clinical Standards Committee Chair, RCPCH

With thanks to:

Brian Gennery, Joint RCPCH/NPPG Standing Committee on Medicines member

Dr William van't Hoff, Joint RCPCH/NPPG Standing Committee on Medicines Chair

Linda Haines, Head of Science and Research, RCPCH

Rita Ranmal, Clinical Standards Co-ordinator, RCPCH

Susan Mitchell, Head of Health Services, RCPCH

Royal College of Paediatrics and Child Health

14 September 2010

**Supplementary memorandum submitted by the Royal College of Paediatrics and
Child Health (SAGE 20a)**

Our additional comments relate to the first case study: **Swine Flu pandemic in 2009.**

The Joint Royal College of Paediatrics and Child Health/Neonatal and Paediatric Pharmacists Group Committee on Medicines was pleased to be involved with the Distribution Vouchers, which were designed to ensure children received the right dose during the pandemic. While being integral to the whole review process to these vouchers, it was right that committee members should lead on the construction of dose banding charts for the liquids in circulation. When dose banding some children will always receive a dose very slightly different to the ideal mg/kg dose that is being used and it is essential that pharmacists and clinicians combine their skills and judgement to ensure that these variations are as small as possible and clinically appropriate.

Royal College of Paediatrics and Child Health

4 October 2010

Memorandum submitted by the British Antarctic Survey (SAGE 21)

RICHARD B HORNE, MERVYN P FREEMAN AND ALAN S RODGER
BRITISH ANTARCTIC SURVEY, CAMBRIDGE UK

The response here is directed to case study questions on solar storms where the British Antarctic Survey has particular expertise. It is supplementary to the input from the Research Councils UK.

CASE STUDY (III): SOLAR STORMS

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

Solar storms are a source of Space Weather disturbances that disrupt modern technology at the Earth. The term Space Weather is more generally used, and will be referred to here. Space Weather is described more fully in POSTNOTE 361 (July 2010) "Space Weather".⁶

Over the last 30 years our society has become much more reliant on technology that is susceptible to Space Weather, particularly satellites, power networks and aviation on polar routes. This trend is likely to increase, for example there has been a 10 fold increase over the last 10 years in patents to exploit the satellite-based global positioning system (GPS).⁷

Large space weather events occurred in 1989, which caused power blackouts across the North-Eastern Canada, in 2003, which affected more than 30 satellites resulting in loss of service and satellite capacity, and in 2005, which disrupted trans-Atlantic aviation. The largest event on record occurred in 1859. If a major event like this occurred today it is most likely that there would be widespread disruption to the following systems:

- Satellites (including failures) and satellite services caused by energetic particles and increased radiation.
- Power generation and electrical distribution grids as a result of geomagnetically-induced currents (GICs) in transformers.
- GPS navigation signals as a result of ionospheric disturbances.
- Aviation through disruption to communications and increased radiation.
- Secondary systems that depend on the above, such as financial services.

In the past, large events have destroyed infrastructure on the ground and in space. The time to replace infrastructure following a major event, for example, to replace transformers in the national power grid or satellite capacity, could be significant and lead to knock-on effects. It takes about two years to order and replace a power transformer and longer for satellites. If several satellites and or transformers were lost in a major event it would take years to replace the infrastructure. It is essential that sufficient capacity is held in reserve for critical systems.

Space weather hazards have been identified as a result of basic research into Solar Terrestrial Physics (STP). For example, the British Antarctic Survey has shown that there is a higher risk of satellite damage during geomagnetic storms at the Earth, and that the risk varies with the 11 year solar cycle. The risk will increase over the next few years as the sun becomes more active.

Research shows that the hazards to ground based systems and aviation peak at high latitude and over the polar regions, whereas the hazards to spacecraft peak in the Van Allen radiation belts. The UK has considerable experimental facilities in the polar regions, access to satellite data, computer models and scientific expertise that can be used to address Space Weather. There is a need to provide strategic funding for these activities otherwise they will come and go according to scientific priorities rather than a national need for hazard assessment and mitigation.

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 NOAA in the USA which are not tailored to UK needs.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

The Government has only just started to recognise the risks associated with Space Weather through the National Risk Register.

⁶ <http://www.parliament.uk/documents/post/postpn361-space-weather.pdf>

⁷ News briefing, *Nature*, 466, 12 August 2010

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?*

The UK has a major investment in industries that are affected by Space Weather including satellite construction and satellite services, power distribution, aviation, and insurance. For example, the UK space sector accounted for 9% (\$11 billion) of the global market in 2007.⁸ The UK has the expertise and knowledge to help protect these assets, but it is not organised and several areas need to be developed. For example, more research is required, particularly on geomagnetic storms, models to forecast risk and assess hazards are needed, and a strategy to respond to extreme events is required. This could be achieved through a UK Space Weather programme that works in collaboration with other countries but which is tailored to meet the national interest.

Space Weather affects a broad range of industries and organisations such as the MoD, space agencies, funding agencies, scientists and others. The UK lacks a body that could respond to an emergency or that could provide a source of authoritative advice. The UK Space Agency provides a new opportunity to bring together these different areas to coordinate activities.

Research funding is split between the Natural Environment Research Council (NERC), which funds Earth orientated solar terrestrial physics, and the Science and Technology Facilities Council (STFC) which funds space based activities. These Research Councils have different research priorities. There is a need to develop a research strategy for solar terrestrial physics in support of Space Weather hazards and risks which could be part of a national Space Weather programme.

Most measurements are done by instruments designed and operated for scientific research which may not provide long-term continuous monitoring tailored for hazard warning or assessment. The NERC has a framework to support such long-term environmental observation as part of a national capability which could be utilised for Space Weather.

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?*

Strategic coordination for Space Weather emergencies has yet to be put to the test, but without a recognised coordination structure in place it is likely to be problematic.

5. *How important is international coordination and how could it be strengthened?*

Space Weather is a global problem. International collaboration is essential and cost-effective in providing access to Space Weather measurements, expertise, and other resources worldwide worth many times the national investment. However to safeguard continued access it is important to contribute to this international effort at an appropriate level.

The EU has recently allocated €22 million to space hazards including Space Weather through the Framework 7 programme (FP7). The British Antarctic Survey is leading one FP7 project to protect space assets and contributes to other projects in Europe and the USA.

The European Space Agency (ESA) has a new Space Situation Awareness programme (SSA). The UK could make the most of its membership of the ESA by fully signing up to this programme which would allow the UK to lead ESA-SSA projects. This would bring a UK dimension that meets the needs of UK industry and give them a competitive edge.

British Antarctic Survey

14 September 2010

Memorandum submitted by the Manchester Airports Group (SAGE 24)

1. This submission is made by the Manchester Airports Group (MAG) in response to the Science and Technology Committee's Call for evidence. MAG welcomes the opportunity to respond.

2. MAG is the second largest UK airport operator and comprises the airports of Manchester, East Midlands, Humberside and Bournemouth. 24 million passengers travelled through MAG airports in 2009–10 (across all four airports) and the Group handled 409,000 tonnes of air freight. MAG generates around £3.2 billion for the UK economy and supports over 130,000 jobs nationwide.

3. MAG's comments will be restricted to its experience obtained during the volcanic ash cloud crisis earlier this year. Our experience in that crisis was exclusively concerned with handling the consequences of the large-scale closedown of European airspace on our airline customers and passengers respectively. We

⁸ Department for Business, Innovation and Skills, "The Space Economy in the UK: An economic analysis of the sector and the role of policy", Feb 2010.

were not involved in any way in the resolution of the crisis from a scientific point of view. Our remarks therefore are of a general nature only and will not attempt to answer in detail each of the Committee's specific questions.

4. At the start of the crisis an extremely cautious approach was apparently being taken by those responsible for the management of UK and European airspace and those on whose advice they were relying. Whilst this is understandable as an initial reaction, it soon became apparent that, firstly, such an approach was not being based on much hard evidence, for example the use of "predicted" ash cloud coverage rather than actual measurements and secondly, that there seemed to be relatively poor coordination between the parties who were involved at the start of the crisis, ie the Volcanic Ash Advisory Centre (VAAC), the Met Office, the CAA and NATS. There also appeared to be no direct input from Government.

5. It was apparent at the start of the crisis that in spite of the International Civil Aviation Organisation (ICAO) plans for a response to volcanic ash in airspace, there had been no prediction for an event to affect UK airspace and therefore no analysis and planning of such a scenario had taken place for contingency planning. As the UK regulatory authorities grappled with a response to the developing events, 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.

6. What also seemed surprising was that—to the public—the UK and European reaction to the crisis appeared to be unique, yet volcanic eruptions have occurred in other parts of the world with regularity, and the disruption to air traffic routes has been far less extensive. The closure of airspace was seen as a gross overreaction when the sky above was seemingly clear. (In fact it is well known within the industry that the issue was that Europe and the Atlantic are the densest concentration of air routes in the world and it is simply not possible to redirect them all to avoid the ash. In other volcanic parts of the world, conveniently, there is very little in the way of air traffic routes. This only became clear to the public after the crisis).

7. It was also apparent that forecasting was very poor. For whatever reasons, the industry was getting forecasts that were changing significantly every time they were updated. Airport operators needed to know in the evening what the forecast for the following day was, so airlines could decide what they intended to fly and passengers could be kept informed. Forecasts issued in the morning could change completely from the night before. If flights are to be cancelled, this should happen in a timely manner, not at the last moment. Eventually the airlines realised that the information being produced by the Met Office was of very poor quality and made their decisions based on their own view of the situation, not of the official forecasts.

8. In the first few days of the crisis, nobody appeared to take responsibility for restricting flights. The NATS response was to close controlled airspace for six hours and then repeat the process every six hours. All airport operators knew that airspace would be closed for six hours when the reality was that nobody would be flying for days. Announcements such as "no flight in airspace x for the next 36 hours at least but we will review the situation", would have been far more preferable from an operational point of view.

9. The solution to the crisis came about as a result of three factors, within two of which scientific evidence was used:

- (i) The scale of the crisis, the number of "stranded" passengers and the inability of land and sea transport alternatives to cope with repatriation, meant that finding a "solution" became much more of an imperative. No form of contingency planning had prepared for such a scenario. The crisis provides clear evidence of the massive reliance on air transport for the UK.
- (ii) Coupled with this, was increasing airline impatience with the airspace closedown, and their willingness to test-fly aircraft through ash clouds, or reputed areas of ash cloud, as a means of ascertaining whether it was safe to fly.
- (iii) The decision of the CAA to take the initiative in resolving the crisis, by involving engine manufacturers, airlines and others in working out safe rules, allowed much wider areas of airspace to be opened up. Hence the CAA embarked on a very rapid attempt to conduct some form of scientific certification with the engine manufacturers. The CAA led it because the European Aviation Safety Authority (EASA) team didn't seem to have the expertise—a concern given the fact that that EASA is also now taking command of ATC and Aerodromes.

10. In the end, the resolution of the crisis involved hard evidence from engine manufacturers about the ability of their products to withstand moderate ash cloud exposure, and from the airlines about their level of confidence in being able to fly their aircraft safely. The solution was entirely science and evidence based and involved all of the agencies working together to find an acceptable solution.

11. The resolution of the crisis was also achieved in a way that showed how different agencies can work together to achieve quick solutions, when clear leadership, in this case, by the CAA, was shown. “Normal” bureaucracy was not allowed to delay matters. Less clear was the international relationship and leadership from relevant EU agencies. Since the event, the EU has begun to implement clearer means of responding as a Single Sky entity to such an event. In spite of several years of development of both Single Sky and EASA, it was clear that a true European combined approach to the issues was not present.

12. Q3 asks about obstacles to timely scientific evidence to inform policy decisions. The public and policy messages throughout were often unclear, delivered by a range of agencies or bodies and most frustratingly, often conflicted or changed over time. The key weakness in managing and responding to the dynamic situation reactively was the poor accuracy of the forecasting models and also the models used for weather prediction, particularly winds. At one point, the London VAAC had issued no-fly zones, only for the Toulouse VAAC to discredit it by issuing advice that those over France did not exist.

13. There are fundamental differences in the ash forecasting models used throughout the world, in spite of it being a global response plan. An example is that on some models, ash is assumed to disperse or sink to ground after three days, whereas the UK model continued to calculate forecasts using ash data that was several days old and increasingly likely to be inaccurate. In addition to the principles of the modelling, the lack of ability to take scientific measurement must have been a significant detriment to making improved forecasts.

14. Very few aircraft were equipped to take samples and measurements (and certainly not any of the commercial aircraft offered and used by a number of airlines and manufacturers) and the sparse coverage by Light Detection & Ranging (LIDAR) equipment severely hampered both the ability to check the accuracy of the forecasting and to add scientific data to improve the process of predicting ash concentration. In considering where improvements could be made for future resilience, MAG would propose that it is in the forecast modelling and the LIDAR coverage. Neither will make a perfect arrangement for forecasting or to directly permit flight in more dense concentrations, but they are reasonably deliverable.

15. Q4 mentions sources of scientific advice and a research base. It should be remembered that research comes at a cost that budgets rarely permit, even in the “good times”. What was experienced during the ash crisis was a once in 100-years event—how much effort and investment could reasonably be considered justified? Research involving aircraft engines is inevitably very costly—the work on biodiesel residue on aviation fuel is evidence of that (now at least two years into a programme but one that is still not fully funded to get to a clear conclusion with all the relevant aircraft and component manufacturers).

16. In conclusion, 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. There is no reason why such a scenario could not work in any future crisis: it will work better when such leadership is shown from the outset.

Manchester Airports Group

14 September 2010

Memorandum submitted by the Science Media Centre (SAGE 25)

The Science Media Centre was set up in 2002 in the aftermath of media frenzies on BSE, GM crops and MMR with the goal of supporting and encouraging more scientists to engage with the media more effectively in times of crisis and emergencies.

Over eight years of responding to stories like Sudan 1, Polonium 210, SARS, foot and mouth disease, natural disasters, etc. we have built up a huge body of expertise in this area and hope that the following evidence will be useful to your inquiry into scientific advice and evidence in emergencies.

While on the whole the Science Media Centre works very positively with government at times like these, we feel there are some areas that could be improved. These are elaborated on over the next two pages but in summary they are:

1. *Use of credible third party independent experts*—government should see credible independent third party experts as an opportunity rather than a barrier to a “single public health” message. The way to overcome the challenge of conflicting messages from experts is to ensure more and wider briefing of those experts.
2. *Never leave a vacuum*—the message scientists learned from the GM crisis in particular (and more recently from the UEA climate emails saga) is that if the best scientists refuse to comment, others less expert will take their place. It is critical that while the Government is formulating a unified response, the media has easy access to the most accurate evidence-based information—even when this is necessarily incomplete!

3. *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.
4. *Do not fear openness*—being open and honest about differences of opinion and scientific uncertainties is particularly scary in the midst of a media feeding frenzy but the SMC is convinced that the benefits of greater openness outweighs the risks. Almost everyone in the debate over “climate-gate” believes that scientists should have been more open about the uncertainties in climate science—even if those would have been seized on by critics.
5. *Risk communication*—governments have become better and better at this but the infamous 65,000 deaths projection during the swine flu crisis shows that we all need to continue to improve risk communication.

We hope this evidence will be useful to your Inquiry and would be quite happy to appear before the Committee if that would be useful. We also attach two very short summaries of the nature of the SMC’s involvement in swine flu and volcanic ash and would refer you also to the references to that role in the recent Hine Review of the H1N1 emergency

Fiona Fox
Director
Science Media Centre

NOTE:

The Science Media Centre (www.sciencemediacentre.org) specialises in working with scientists and UK national journalists on the biggest and most controversial news stories. We work with over 2,500 scientists, 1,000 press officers, and journalists on every major press and broadcast outlet in the UK on topics ranging from animal research and the use of stem cells to train crashes and flooding. On H1N1 swine flu and the effects of volcanic ash alone we issued statements from over 120 scientists, organised over two hundred interviews and ran six press briefings. We also gave written and oral evidence to Dame Deirdre Hine’s independent review of how the Government handled the pandemic.

In one interesting development, the Science Media Centre partnered with GO-Science and the Chief Scientific Adviser’s office to produce a “Glossary on swine flu” specifically for news journalists which was launched at a press briefing at the British Science Festival last year.

POINTS FOR CONSIDERATION:

During the swine flu pandemic, the CMO, DH and HPA handled the communications well. Weekly press briefings bringing in experts were welcomed by the journalists, who on the whole felt well briefed with information and access to the best experts. Daily updates from HPA and DH helped the Science Media Centre enormously in terms of basic facts on spread, etc.

The ash from the Icelandic volcano caused different problems with respect to the media as the story ranged from the territory of one official body to another and some engaged more than others. We organised interviews with scientists who could discuss volcanology, impact of ash on health, assessing risk to aeroplanes and meteorology.

Using Independent third party experts in midst of crisis

1. In times of crisis evidence shows that people respond well to a single unified message and that is the ideal.
2. However, we operate in a 24-hour rolling news environment where journalists and the public are sceptical of official Government messages and will ALWAYS look to other views. There is a strong need for independent third party experts; when the press aren’t given reputable experts, it doesn’t stop them running the story, but instead they use less and less credible figures. The SMC co-ordinates many independent experts from Universities and agencies like the Wellcome Trust, MRC, etc.
3. We fear that DH and some official agencies can be wary about these independent voices and the risk that there might be conflicting expert advice. We understand that completely but feel that the reality of today’s media climate is that there is a need for them.
4. There is also evidence that at times of crisis people seek out multiple sources. We feel that the Government should embrace the fact that authoritative voices are commenting outside the official response—even if some of the advice is conflicting. In fact, most of it is not.

5. We propose that, rather than worry about these independent experts briefing media, Government departments should organise briefings for independent third party experts to ensure that key spokespeople are well briefed. We understand that the Ministry of Defence already does this successfully.

6. The public dismissal of Prof David Nutt served to make some scientists wary of engaging with Government. The roles of independent advisors should therefore be protected and the Principles on Scientific Advice to Government should be adhered to.

Filling the vacuum

1. Leaving a vacuum is always dangerous and can easily be filled by less credible experts. During the swine flu pandemic, whilst the journalists were delighted with the regular weekly briefings by the CMO, they did rely on the SMC to fill the huge vacuum in between the briefings. During the gaps where official sources were not responding to media enquiries, the SMC ran background briefings, issued fact sheets and supplied experts for back to back interviews. We think the combination of official briefings backed up by proactive expert comment coming out of the SMC helped the overall communication of evidence based messages.

Don't remove independent scientists from public debate by asking them to become Government advisers

1. When SAGE was set up for pandemic flu, several of our top scientists felt unable to brief the media while also advising Government.

2. These are the top experts in the country and are needed to advise Government but also needed to advise and inform public opinion. We feel that they could be asked to keep discussions at SAGE confidential while still being allowed and indeed encouraged to brief the media and inform the public in their general areas of expertise.

3. We lobbied for a change to this with SAGE (Volcanic Ash) and would like to see this extended to all SAGE committees.

4. 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.

More transparency and openness

1. We think there could be more openness about the nature of discussions within SAGE. Questions, for example, about whether to mass vaccinate or hand out anti-virals more widely were widely debated amongst scientific and medical experts and trying to suggest that there was absolute agreement led to suspicions amongst journalists.

2. We were especially disappointed when a press briefing on vaccine safety with David Salisbury was cancelled at the 11th hour during the swine flu pandemic, despite huge interest from journalists. We fear that sometimes there is too much caution from government media advisers when actually the specialist reporters are almost all responsible and careful.

Risk communication

1. There was much discussion about the 65,000 deaths figure issued by the CMO after seeing Imperial models of the spread of swine flu. It is our strongly held view that the CMO had to give the media this figure as if he had attempted to hide it in any way it would have been seized upon. However, the SMC has successfully run many, many briefings where a range of risk is communicated and we believe that it is possible to emphasise the caveats and appeal to the responsible journalists not to emphasise the upper range without heavily qualifying.

2. All scientists need to get much better at saying "I don't know" and admitting that there is often huge uncertainty and differences of opinion about the actual level of risk. Attempting to reassure the public and journalists by asserting a level of uncertainty and agreement has backfired badly in the case of climate change and, to some extent, in volcanic ash and swine flu. The truth is that in the midst of a crisis neither the government nor experts may know, nor could possibly know, exactly how severe a problem may be. There should be honest and open discussion about any levels of uncertainty.

Summary of Recommendations

1. Government should establish a system of regular briefing of third-party experts who are likely to do media work in the midst of an emergency—this could operate through the Science Media Centre.

2. Government should proactively encourage independent scientists to continue briefing journalists (and therefore informing the public) after they have been appointed to advise government on groups like SAGE.

3. The Official Secrets Act and Confidentiality Clauses should not be used for independent experts advising Government apart from in extreme circumstances where national security is at stake—experts trusted enough to advise government should be trusted to keep some information confidential where appropriate.

4. Governments should be braver about being more open about the scientific advice they are receiving—even when this is conflicting or uncertain. An ever-more sophisticated public can cope with uncertainty if it is communicated effectively.

Science Media Centre

September 2010

Memorandum submitted by the Campaign for Science and Engineering (CaSE) (SAGE 27)

1. The Campaign for Science & Engineering (CaSE) is a member organisation aiming to improve the scientific and engineering health of the UK. CaSE works to ensure that science and engineering are high on the political agenda and that the UK has world-leading research and education, skilled and responsible scientists and engineers, and successful innovative business. It is funded by around 750 individual members and 80 organisations including industries, universities, learned and professional organisations, and research charities.

2. We would like to restrict our comments to general points on the mechanics of scientific advice in emergencies, rather than the specific case studies.

Question 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?*

3. While the Government has access to scientific advisers, MPs have fewer resources with which to scrutinize the scientific basis of Government responses to emergencies. The Parliamentary Office of Science and Technology (POST) provides independent advice to parliament to inform parliamentary debate. Its work includes publishing short briefing notes and more lengthy reports on current issues, supporting select committees, and horizon scanning. However, it does not have the remit to provide information as a rapid response to an emergency.

4. The House of Commons library has a science and environment section that can respond to MPs' requests for information, briefings and analysis. The library also produces reports and standard notes on bills and other topics of public concern—but it did not publish anything on either the swine flu pandemic or the Icelandic volcanic ash eruptions. Responses to MPs requests are confidential so it may be that many requests for information were made regarding such emergencies, possibly with much duplication.

5. We recommend that a system is put in place to provide MPs with rapid independent scientific and expert briefings on emergencies or other rapidly-developing policy subjects. This should help to make sure that any relevant debates are suitably informed and reduce the possible duplication or overlap of requests submitted to the library.

Question 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?*

6. The government can seek scientific advice in an emergency through its Chief Scientific Adviser and network of departmental scientific advisers and scientific advisory committees. Unfortunately the Treasury has still failed to appoint a departmental scientific adviser, although all other Government departments now have one and will be able to gain from their insights and analysis.

7. Government departments fund research and development (R&D) out of their departmental budgets to support their policy analysis, evaluation and development. It is this capacity for research that is likely to be drawn upon in developing the scientific background to responses in an emergency. Unfortunately, this capacity has seriously diminished in recent years—with civil departments spending just £1.25 billion on R&D in 2007–08, compared to £2.08 billion in 2003–04—a decline of over a third.

8. Chapter 3 of the House of Lords Science and Technology Select Committee's Third Report of Session 2009–10, *Setting Priorities for Publicly Funded Research* (HL 104-I), further makes the point that such departmental spending could be evaluated better than it currently is. We are not aware that there is currently an agreed definition of what each department treats as its "research budget". Given that such spending forms an important part of the UK's national emergency response capability, this is a serious concern.

9. Because departments independently allocate their funds for R&D, there is no mechanism or oversight to guard against dramatic drops in R&D across the whole. It is a real risk that departments will see their R&D budgets as an "easy cut" under the current financial pressures, leaving the UK vulnerable to future crises needing scientific input. There should be a mechanism to oversee government departmental R&D spending to make sure that its capacity does not fall below minimum levels—this would also help deal with the problem of research that does not fall directly into a specific departmental remit. The Government Office for Science, and in particular the Government's Chief Scientific Adviser, should be given this role.

10. A possible mechanism would be a central governmental “research budget”, overseen by the Government Office for Science, which other departments would make bids for, for specific research projects. This would prevent duplication of research, raise research standards, allow for strategic planning and evaluation of research (including inter-departmental priorities), and provide a guaranteed capacity for research into an emergency response.

Campaign for Science and Engineering (CaSE)

14 September 2010

Memorandum submitted by The Geological Society of London (SAGE 29)

1. The Geological Society is grateful for the opportunity to respond to this inquiry. In addressing the questions raised, we have focused on the Icelandic volcanic ash cloud case study, while attempting also to draw some wider lessons. Several of the questions raised, such as those relating to how advice was sourced and used, are principally for Government, and for those who have clear sight of its workings. We can, however, attempt to reflect the perceptions of those in the Earth science community we represent regarding these issues, and have interpreted these questions correspondingly broadly.

2. We note that a separate submission has been made by the British Geophysical Association (BGA) (a Joint Association of the Geological Society and the Royal Astronomical Society (RAS)), again focusing on the ash cloud case, and that the BGA also provided input to the RAS submission on solar storms.

What are the potential hazards and risks and how were they identified? How prepared was the Government for the emergency? How did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

3. Potential risks of volcanic ash, including those to aviation, were well known prior to the 2010 eruption of Eyjafjallajökull. For example, a British Airways flight narrowly escaped disaster following the 1982 eruption of Mount Galunggung in Indonesia (see www.geolsoc.org.uk/flight9). In particular, 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.

4. The impression of some in the volcanological research community is that when the emergency arose, initially the gathering and use of advice was not well coordinated, despite the willingness to help of a wide range of those with relevant expertise. However, those who were directly involved in working with Government, particularly in the British Geological Survey (BGS) (see below) report that coordination and communication of geoscientific advice was prompt and effective. Those in the wider community, who were most likely unaware of much of this activity, acknowledge that the situation improved, and that overall the Government took appropriate geological advice and used it effectively—though there is little understanding in the community of how key experts were identified, or of the institutional arrangements employed. Some of the responsibility for any lack of understanding must fall to the Earth science community itself.

5. BGS, as a Research Centre of the Natural Environment Research Council (NERC), will make its own submission to the inquiry as part of the Research Councils UK response. We highlight here the role BGS played, in its role advising Government on natural hazards, and as a major centre for UK volcanology which was central to the input of the geoscience community in this case. BGS led geoscientific liaison with Icelandic authorities, and alongside the National Centre for Atmospheric Science (NCAS) provided information and advice to the civil contingency secretariat on decisions relating to aviation. Together with NCAS and the Met Office, BGS was represented on the Scientific Advisory Group in Emergencies (SAGE), chaired by the Government’s Chief Scientific Advisor. We welcome the news that NERC is to lead a joint interdisciplinary research programme with ESRC on resilience and vulnerability to seismic and volcanic-related natural hazards, as a contribution to the RCUK “Global Uncertainties” programme.

6. Regarding future risks, it is widely recognised that other volcanoes on Iceland might cause similar problems to Eyjafjallajökull, possibly on a considerably greater scale. Volcanoes in other parts of the world may also produce ash clouds, and these too could cause disruption. Mapping of major, in particular, polar air routes to the distribution of active and recently dormant volcanoes could be instructive, for example, in assessing potential risk posed by volcanoes on the west coast or North America (Mount St Helens, Mount Rainier, etc) and Alaska, especially the chain of Aleutian volcanoes.

7. A further issue is the extent of monitoring. Volcanoes such as Mount St Helens and, in Europe, Vesuvius, are surrounded by extensive ground based seismic networks which should provide early warning of possible eruption. But on a worldwide scale many volcanoes are not monitored and erupt with no warning. It may be possible to supplement ground monitoring with remotely sensed data from satellites. Key factors in determining whether this would be feasible or useful are the nature of onboard sensors and their utility, as well as the extent, frequency and sensitivity of the coverage which could be furnished in this way.

8. Not all volcanic eruptions produce ash clouds, but among those which do, the chemical composition of the material ejected and the style of eruption (ie the mechanism by which it happens) vary. These factors will affect the physical properties of any ash created, such as the melting point, particle size and density of

the ash; and the size, density, location and optical properties of the cloud. These properties in turn affect the possible risks. In continuing to improve our understanding of past, present and future eruptions and their impacts, factors to consider therefore include likelihood of volcanic activity by location, chemical composition of the magma, potential explosiveness, and interaction with other elements of the Earth system (in the case of ash clouds, the atmosphere).

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?

9. To position the government to access and use expert advice in all of the more or less foreseeable emergency situations which might arise is clearly a huge challenge. Suggestions for addressing this challenge among those we consulted included setting up an appropriate “rapid response” group, to be on stand-by ahead of an event—though clearly a large number of such groups would be needed to provide even reasonable coverage of those possible emergencies which have been identified, let alone those which have not.

10. A more realistic approach might be to improve the means by which those in Government can rapidly identify and contact those with relevant expertise (recognising that useful advice may come from sectors and disciplines which those seeking it have not thought of). There may be a significant role here for the learned societies. For example, the Geological Society is in preliminary discussions with officials at the Government Office for Science, as well as colleagues at other scientific societies, to explore the scope for an administratively light mechanism to help officials looking for rapid expert advice (not necessarily in emergency situations) to address their questions to a central point, from where it would be picked up by those societies who believe there may be relevant expertise among their membership. Resource constraints, particularly at smaller more specialist societies, however modest the requirements, are likely to be the main obstacle to such a scheme, along with lack of uptake on either side.

11. There is a perception, perhaps undeserved, among some in the Earth science community that the Government is poorly set up to receive advice (whether or not it is explicitly sought), particularly at times of crisis. Some also questioned how effectively and rapidly such advice is scrutinised and filtered. Experience from other crises suggests that it can be difficult to communicate a serious scientific concern, particularly if it is not founded in the discipline(s) which are assumed primarily to inform the policy issue in question (eg if an issue of physics is raised during a veterinary crisis). The reception on the part of Government to representations and advice about the eruption of the Soufriere Hills volcano on Montserrat from 1995 onwards (which forced most of the island’s population to flee and destroyed its capital) clearly did lasting damage to the confidence of the volcanological community in these advice structures. Perceptions among research communities that Government is ill equipped or even unwilling to hear external expert advice, even if they are misplaced, represent a serious challenge to future effectiveness in this area, and warrant putting effort into confidence building, both on the part of Government and the Earth science community itself.

12. In its submission to the Government Chief Scientific Advisor’s consultation on guidelines on scientific analysis on policy making, the Geological Society recognised some of the competing demands on Government’s use of expert advice, potentially across multiple disciplines and in the context of public and stakeholder engagement. We noted the value, but also the difficulty, of paying attention to the sectors in which expertise originates (academia, industry, government agencies and regulatory bodies, NGOs, etc), of embracing plural and diverse viewpoints (including among scientists who disagree), and of valuing the dissent and unorthodoxy which are at the heart of science—and drive its development. The challenges of such an approach to sourcing and using advice is all the more challenging in emergencies, but may be no less important, since moments of crisis can also be those in which public confidence is most at stake and Government’s use of expertise is likely to come under scrutiny.

13. The scientific community can only provide excellent advice if it is supported by continuing excellent research. Regarding volcanic ash clouds, the research priorities suggested above span the applied and the more basic, and a similar range of research will underpin many other known risk areas. But it is also vital to maintain a vibrant culture of high calibre curiosity-driven research, among other reasons, so that society is as well positioned as possible to respond to the “unknown unknowns”—future novel risks and emergencies which we have not yet anticipated. Much of the research being done on volcanic ash would have been regarded as basic only a few months ago, before the phenomenon was widely recognised as a threat, but can now reasonably be characterised as applied (or at least applicable). In the long run, the supply of excellent science researchers and communicators will depend not only on research funding, but on high quality science education at all levels, and on the nurturing of those seeking research and other science careers.

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?

14. As noted above, there is some perception that central coordination of information was weak, particularly in the early stages of the emergency. A particular concern is a lack of awareness, even now, among the relatively small UK volcanological research community, of the work other researchers and groups are engaged in (or seeking funding for), and this situation is common to other sub-disciplines, impairing not

only the community's ability to function and communicate effectively amongst themselves, but also to provide advice to Government. It would be a major challenge to try comprehensively to identify and record in a useful way all the research being undertaken across universities and research institutions, but if an attempt is not made to address this issue, and in the absence of more strategic coordination of research, we risk wasting resources by duplicating effort, and missing out on available knowledge and expertise in addressing policy issues. The data held by the Research Councils (both as funding bodies for university research, and as research institutions or contractors in their own right), taken together with the information gathered for the REF, could be a useful starting point.

How important is international coordination and how could it be strengthened?

15. Sharing advice, information and best practice internationally is clearly to be encouraged, and is essential in addressing phenomena whose impacts cross national boundaries (such as the Eyjafjallajökull ash cloud). Research groups in universities and other institutions routinely engage in such international collaboration. Further to its involvement in providing information and advice during the crisis, the BGS is currently collaborating with the Iceland Institute of Earth Sciences, the Icelandic Meteorological Office, the UK Met Office and several UK universities on a major research project in this area. Government should seek not only to benefit from the research results which ensue, but also to build on such initiatives to improve communication and sharing with those responsible for scientific advice in overseas governments. (We are aware that SAGE is working with Icelandic colleagues to address volcanic activity and its impacts on the UK, and to develop scenarios for planning and mitigation in the case of future potentially larger volcanic eruptions.) It should actively support collaboration of this kind, enhance the capabilities of UK institutions to engage in it, and seek to ensure that participation is not threatened for example by funding constraints.

Conclusion

16. This submission identifies a number of areas in which we suggest that Government should act to address real or perceived shortcomings, or to maintain and capitalise on capabilities. It is important too that scientific communities examine critically their own strengths and weaknesses, and act to improve communication within and between research communities, and between these communities and policy-makers, regarding policy-relevant science. Learned societies are among those best placed to broker such discussions, and the Geological Society takes seriously its responsibilities with respect to the Earth science community. We are keen to engage closely with relevant policy-makers as we seek to improve our performance in this area.

The Geological Society

13 September 2010

Memorandum submitted by the National Centre for Atmospheric Science (SAGE 31)

I contributed substantial input to the part of the submission by Research Councils UK regarding the response to the Icelandic volcanic ash emergency and so this submission covers only additional points not in the RCUK submission. My role is that of Director of the National Centre for Atmospheric Science (NCAS), which is the research centre of the Natural Environment Research Council (NERC) responsible for atmospheric science. The Facility for Airborne Atmospheric Measurements (FAAM) is a joint facility between NERC and the Met Office. Within NERC it is managed by NCAS and so is my responsibility. The FAAM BAe-146 aircraft played a central role in the response to the volcanic ash hazard.

1. *What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?*

My views on this point are fully covered by the RCUK submission.

2. *How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?*

The Government Chief Scientific Advisor convened the Scientific Advisory Group in Emergencies (SAGE) quickly. This was effective in gathering expert advice and making it available to Government departments. It was effective in developing a coordinated understanding of the risks from volcanic ash, in providing sufficiently well articulated assessments of the possible development of the risk through time, and in translating the perceived risk into a draft for inclusion in the national risk register. The Government Office for Science was highly effective in supporting SAGE and the individual scientists contributing to SAGE.

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?*

There were significant shortcomings in the ability of Government to gain assured access to the research aircraft response which it required:

- there was failure of Cabinet Office and the Department for Transport to recognise that the Met Office only had access to the research aircraft via a contract with the Natural Environment Research Council, and hence an appropriate response required cooperation of parties other than the Met Office;
- there was failure to properly engage with the owners (BAe Systems), operators (Directflight Ltd) and service providers (Natural Environment Research Council) concerning the cost of emergency operations; and
- there was a refusal on occasions of the Department for Transport to take account of scientific advice, but instead to mandate research flight operations which were ultimately of little value and caused some opportunities to gather more genuinely useful scientific data to be missed. Political imperatives were cited as the reason for this.

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?*

The satisfactory outcome to the scientific response was the result of good will on the part of the Natural Environment Research Council, Met Office, BAe Systems and Directflight, who were prepared to make their assets available with far from satisfactory guarantees that Government would meet the costs (subsequently, vague promises that costs would be covered have proved worthless). Government was therefore exposed to the possibility that had the good will been withdrawn, access to research aircraft data would have been impossible. This could also have an impact on willingness of the parties to cooperate in future emergencies. From the outside, it appeared that there was a absence of clear responsibility and authority to make the required decisions to commit resources.

5. *How important is international coordination and how could it be strengthened?*

My views on this point are fully covered by the RCUK response.

Professor Stephen Mobbs

Director, National Centre for Atmospheric Science

14 September 2010

Memorandum submitted by the Wellcome Trust (SAGE 35)

INTRODUCTION

1. The Wellcome Trust is a global charity dedicated to achieving extraordinary improvements in human and animal health. We support the brightest minds in biomedical research and the medical humanities. Our breadth of support includes public engagement, education and the application of research to improve health. We are independent of both political and commercial interests.

2. It is vital that policy makers and practitioners can access robust scientific evidence to ensure appropriate preparation and effective responses to public health emergencies. The Trust therefore welcomes the Select Committee's inquiry on "Scientific advice and evidence in emergencies".

3. Given the Trust's remit, our response is focused on the 2009 H1N1 flu pandemic case study, and the importance of research and scientific evidence in informing and strengthening the public health response in an infectious disease outbreak. Key issues that we discuss include:

- the importance of strategic co-ordination between Government departments, public bodies, private bodies and the research community to ensure a timely and rapid response to the H1N1 pandemic;
- the need to address regulatory issues to facilitate research that can inform policy during a pandemic and infectious disease outbreak;
- the importance of international co-ordination to enable effective preparedness and response to global diseases such as the H1N1 pandemic; and
- the need to enhance pandemic preparedness, by maintaining key skills and research programmes during the inter-pandemic period.

4. Emerging and re-emerging infectious diseases, such as influenza, carry an immense and growing global health burden. It is important therefore to learn from the H1N1 pandemic and continue to support research that will strengthen evidence-based policies and healthcare practices.

 STRATEGIC CO-ORDINATION BETWEEN GOVERNMENT DEPARTMENTS, PUBLIC BODIES, PRIVATE BODIES AND RESEARCH COMMUNITY

5. The Department of Health played a central role in co-ordinating the UK's response to the 2009 H1N1 pandemic, by providing timely advice, co-ordinating with UK and international partners and directly supporting research in the area.

6. The Health Protection Agency (HPA) also played a pivotal role in the rapid co-ordination of the public health management of the 2009 H1N1 flu pandemic. It conducted a number of important virology and epidemiologic surveillance studies and supported work for the vaccine studies (including facilitating private-public partnership). Indeed, the regional H1N1 flu response centres set up by the HPA in collaboration with the NHS during the containment phase of the H1N1 pandemic, were recently recognised by a Cabinet Office Innovation in Resilience Award at the Emergency Planning Society Awards

7. It is crucial that these important functions of the HPA, which enabled it to mount a rapid and effective public health response to the H1N1 pandemic, are not lost under the Government's proposed plans to disband HPA and transfer its functions to the Secretary of State as part of the new Public Health Service.

8. It was also important that the research community was able to respond quickly to the pandemic, working together with Government to conduct new research to inform policy-making and to provide valuable evidence about the effectiveness of potential interventions. This was achieved in response to the 2009 H1N1 pandemic. The Wellcome Trust and other UK partners, including the Medical Research Council (MRC) and Department of Health, rapidly convened meetings of the clinical research community (in May 2009) and the veterinary research community (in June 2009) to identify and develop new or enhanced research responses to the pandemic. In a short time-frame, the funders fast-tracked applications using existing robust processes (which the Trust had previously used in response to the Avian flu outbreak in 2005), to enable a rapid initiation of key research projects. In addition, to circumvent potential delays caused by recruitment issues, the funders also agreed to be flexible in deploying skilled clinical and research staff from other grants to the newly funded H1N1 pandemic research projects.

9. Three UK studies were funded through this fast-track process in 2009 following recommendations from the two meetings:

- **The Mechanism of Severe Acute Influenza Consortium (MOSAIC)**—Led by Peter Openshaw, a wide-ranging multi-centre study of influenza pathogenesis in patients hospitalised with severe H1N1 disease during the pandemic, funded by the MRC and Wellcome Trust. This study built on the existing work of the Centre for Respiratory Infection at Imperial College London to study pathogenesis of respiratory viral diseases and to enhance pandemic preparedness and response.
- **FluWatch surveillance programme**—Led by Andrew Hayward, a large collaborative, community-based cohort study of national households, examining epidemiology, severity, treatment and vaccination strategies of influenza. Jointly funded by the Wellcome Trust and MRC, it is the largest study of its type. This programme builds on an existing study funded initially by the MRC in 2006.
- **The Combating Swine Influenza Initiative (COSI)**—Two inter-linked studies led by Ian Brown and James Wood, to monitor and compare the evolution, transmission, infection dynamics and immunopathology of H1N1 in pigs and humans jointly funded by the BBSRC, DEFRA and Wellcome Trust.

10. These studies are still being conducted in the post-pandemic period. The initial results are currently being analysed and can be reported to the Select Committee in due course, if it would be helpful. Community-based surveillance programmes such as FluWatch are not only valuable for providing crucial data on transmission patterns but can also serve as a platform for large-scale public-health intervention studies (eg hygiene measures and face masks). For example, preliminary analyses in the FluWatch study indicate that frequent hand washing reduced the risk of acquiring influenza infection, a finding that should inform the advice given regarding risk reduction. The hospital-based cohort is anticipated to provide invaluable data regarding the viral and host factors associated with progression to severe influenza and eventually lead to studies of new interventions that might reduce the risks of complications and fatal outcomes. Furthermore, a better understanding of the animal-human interface of zoonotic influenza will help reduce the risks of zoonotic infections that might lead to new influenza outbreaks, reduce transmission of influenza between household members, and improve care of those infected and help inform surveillance and reporting procedures.

11. Unfortunately, the MOSAIC and FluWatch studies could not be completed in time to inform the response strategies for the H1N1 pandemic due to regulatory hurdles (see below, paragraphs 12–15). However, the findings from all three studies will be invaluable in informing the strategies and policies for the next influenza pandemic and strengthen the UK's preparedness and capacity to respond effectively to the next influenza pandemic and to seasonal epidemics.

OBSTACLES TO CONDUCTING RESEARCH TO INFORM POLICY DURING THE PANDEMIC

12. While the research community and funders were able to respond rapidly during the first wave of the pandemic, both the MOSAIC and FluWatch studies were unable to roll-out their studies in a timely manner during the autumn wave of the pandemic due to unnecessary delays in gaining regulatory approval.

13. The MOSAIC group were delayed primarily by the multiple and disparate NHS Research and Development (R&D) approval processes at the various hospitals involved in the study. In one instance it took eight months to secure R&D approval from a participating hospital. Similarly, the FluWatch study was delayed in rolling-out its large scale community study by the R&D approval process for recruiting subjects through multiple primary care sites, with applications taking over a month to be approved. Consequently, the researchers (especially MOSAIC) missed the peak in cases, which hampered recruitment of a sufficient number of subjects.

14. In order to effectively respond to outbreaks of infectious disease and pandemics such as the H1N1 pandemic, it is crucial that there are appropriate mechanisms in place that are capable of “fast-tracking” approvals to facilitate research in the context of public health emergencies. We note that, for the flu vaccine trials, it was possible to fast-track approvals to allow these trials to progress in a timely manner.

15. There are increasing concerns that regulatory burdens and unnecessary red tape are significantly delaying biomedical research in the UK, and the Government has commissioned the Academy of Medical Sciences (AMS) to undertake an independent review of these issues to inform future policy. In our response⁹ to the AMS call for evidence we highlight concerns from researchers that NHS R&D offices as the single biggest barrier to medical research. There is an urgent need for R&D offices to be made more efficient and harmonised, and for rationalisation of multiple layers of approvals and bureaucracy. The proposals to introduce a single research regulator provide a real opportunity to simplify and streamline the approvals process. We strongly urge the Government to ensure that any new governance framework facilitates research, and includes appropriate mechanisms to enable a fast response in a public health emergency situation.

16. At a Satellite workshop meeting at the Pacific Health Summit 2010 hosted by the Wellcome Trust Influenza Research team, researchers also suggested a system whereby there was ethics pre-approval of projects and pre-positioning of generic protocols at qualified sites as a way to reduce delays in the event of a pandemic or novel outbreak. This would be worth exploring in more detail. Establishing a network to study severe acute respiratory infection was also suggested as a way forward to help overcome regulatory hurdles. Such a network could also provide an established research platform that could address relevant research questions in the inter-pandemic period and be rapidly scaled up during a future influenza pandemic (also see paragraphs 22–24 on preparedness).

17. In addition, FluWatch faced significant delays recruiting appropriately qualified research staff, with international expertise often crucial. We are concerned that the current visa restrictions brought in early 2010 by the Labour Government and the proposed restrictions on Tier One and Two visa criteria would prevent or significantly delay the timely recruitment of talented and highly skilled researchers from non-EU countries that would be needed to carry out urgent research during a future pandemic or infectious disease outbreak.

INTERNATIONAL CO-ORDINATION AND RESEARCH

18. Infectious diseases such as influenza are global threats that the international community must work together to address. An effective response requires a co-ordinated global approach. With the H1N1 pandemic, this was effectively led by the World Health Organisation (WHO), with local support from member countries.

19. Effective communication and rapid sharing of information, as achieved in the UK, are an integral part of international co-ordination and key for an effective global response. These key factors are particularly important in the complex and challenging pandemic setting in which there is usually a limited time-frame to mount an effective response.

20. On the research front, the Trust was an active partner with WHO on the development of the WHO Public Health Research Agenda for Influenza,¹⁰ on a range of influenza vaccine-related activities¹¹ and on meetings related to clinical aspects and management of pandemic H1N1 patients.¹² A summary of the Trust’s full range of activities can be found at www.wellcome.ac.uk/influenza.

21. The South East Asia Infectious Disease Clinical Research Network (SEAICRN) is an international and collaborative partnership of hospitals and research institutions in Thailand, Vietnam, Indonesia and Singapore, with technical and administrative support provided by the Centre for Tropical Medicine, University of Oxford. Formed in September 2005 and funded by the US National Institutes of Health’s National Institute of Allergy and Infectious Diseases and the Wellcome Trust, SEAICRN focuses on clinical

⁹ http://www.wellcome.ac.uk/stellent/groups/corporatesite/@policy_communications/documents/web_document/WTX060175.PDF

¹⁰ http://www.who.int/csr/disease/influenza/2010_04_29_global_influenza_research_agenda_version_01_en.pdf

¹¹ <http://www.who.int/csr/disease/influenza/inforesources/en/index.html>

¹² http://www.who.int/csr/resources/publications/swineflu/clinical_management_h1n1.pdf

research on human and avian influenza and other infectious diseases of public health importance in the South East Asia region. The network is key for preparedness, providing a clinical monitoring system in a region where new infectious diseases can emerge and serving as a clinical research platform to respond to new threats. Further examples of some of the international influenza-related projects funded by the Trust are provided below.

INFLUENZA-RELATED RESEARCH IN THE TRUST'S MAJOR OVERSEAS PROGRAMMES IN AFRICA AND ASIA

- Studies of severe pneumonia and respiratory viruses at hospital and community level in Kenya (led by James Nokes).
- Hospital-based surveillance for influenza in an African population with a high burden of HIV, malaria and malnutrition in Malawi (led by Rob Heyderman).
- A range of clinical research on serious human, including H1N1, and avian influenza and other infectious diseases of public health importance in the South East Asian region (through the SEAICRN).

ENHANCING PANDEMIC PREPAREDNESS AND SEASONAL RESPONSE

22. While the H1N1 pandemic is now over, the virus is still circulating and the long-term threat of a future influenza pandemic remains high. In addition, the annual toll of seasonal influenza outbreaks continues. The UK is already considered to be one of the best prepared countries in the world for a new pandemic, as recognised by WHO. The UK must maintain this status as well as enhance its responses to seasonal influenza and other respiratory illnesses.

23. Effective preparedness and response is dependent on a number of essential factors, in particular:

- Having a surveillance system in place to monitor changes in influenza virus activity and patterns in people and animals nationally and globally on a year-round basis. Continued support of national surveillance, which provides essential data on virus strains and their sensitivity to antiviral drugs, and of WHO's Global Influenza Surveillance Network is key.
- Ongoing support for the research platforms and skill base of the type put in place during the H1N1 pandemic. Having skilled staff, for example research nurses already on the ground with the experience and knowledge, will enable ongoing studies in the inter-pandemic period and a much more rapid research response to new infectious disease events. This skills base will facilitate the rapid scale-up and launch of clinical research and acquisition of valuable data during the initial wave of a new threat. Indeed, at the third scientific advisory group meeting the European Centre for Disease Prevention and Control reported that those European countries that did not have skilled and dedicated staff already in place before the H1N1 pandemic were not able to carry out any studies in response to the pandemic.
- Ongoing support for research projects. Continued basic and applied research on zoonotic influenza viruses and maintaining momentum of the research initiated during the H1N1 pandemic is crucial to advance our understanding of the H1N1 virus (and other influenza viruses) and the disease. For example, the H1N1 studies MOSAIC and FluWatch benefited from the influenza virus sequencing "pipeline" at the Wellcome Trust Sanger Institute set up in 2006 to sequence large numbers of influenza viral genomes, to track the evolution of viruses, which is important for not only monitoring virus with pandemic potential but also in the development of vaccines in general. The state-of-the art sequencing technology was used to rapidly analyse samples from both studies.

24. Further research is needed to understand the emergence, transmission, pathogenesis and control of influenza caused by zoonotic viruses such as H1N1 at the global level. Many of the research gaps identified during the H1N1 pandemic (some examples are provided in Box 2 below) and on the WHO public health research agenda for influenza remain to be addressed, and most can be tackled during the inter-pandemic period. The UK is in a prime position to capitalise on its strong research and skill bases to address these research questions during the inter-pandemic period. The lessons learned should serve the UK and global community in formulating robust evidence-based policies and strategies for better preparedness and response to future pandemics and other infectious disease outbreaks.

EXAMPLES OF KEY RESEARCH GAPS FOR INFLUENZA

- **Communication and behavioural research:** further research is needed in order to develop more effective and evidence-based health communication strategies and behavioural interventions in response to future pandemic. For example, investigating how to improve compliance with recommended public health measures and examining why attitudes among professionals are crucial for successful vaccine programmes.
- **Clinical research:** epidemiologic, pathogenesis and intervention studies in the inter-pandemic period, both in the community and in those hospitalised with more severe illness. Such initiatives would serve to not only build this clinical research capacity as a platform for response to new

threats but also to understand the impact of annual outbreaks of influenza and other respiratory pathogens and test measures to mitigate their impact through studies on patient management, particularly those with severe illness.

- **Modelling:** mathematical modelling, a current strength in the UK, can be used to help improve understanding of the epidemiological factors and population processes shaping infectious disease spread in human and animal populations (eg, modelling influenza transmission and the impact of intervention strategies such as closing schools and wearing masks).
- **Surveillance and operational research** in households and at the human/animal interface to understand viral evolution, risk factors for emergence of threat pathogens and transmission to humans, and interventions to reduce transmission.

LOOKING TO THE FUTURE—EFFECTIVE PUBLIC HEALTH RESPONSE IN DISASTERS AND EMERGENCIES

25. Emerging infectious diseases, such as influenza, carry an immense and growing global health burden. It is important therefore to learn from the H1N1 pandemic and continue to support research that will strengthen evidence-based policies and healthcare practices.

26. In the broader context, it is important to note the growing number of emergencies which are triggered by extreme weather events eg floods, storms and droughts, both in the UK and particularly in low- and middle-income countries (LMIC). The need for robust scientific evidence to inform the response to such disasters is widely acknowledged by practitioners and policy makers alike. Nevertheless research to strengthen the public health response in such complex settings is challenging.

27. The Trust, as part of scoping work to identify gaps and potential opportunities to strengthen the public health response in disasters and humanitarian emergencies, held a “Frontiers Meeting” in June 2010 bringing together NGOs, academics, and representatives of multilateral agencies.

28. A number of common challenges and barriers to undertaking research in the field immediately post-emergency were identified. These included for example, the need for a robust pre-agreed ethical framework to guide research in such situations; improving the understanding and cooperation between practitioners and between human and animal health experts; the need for improved and timely evaluation of research studies and their findings; and more rapid dissemination of research findings. Importantly, all agreed on the need for a robust evidence base to inform policies and the public health response in disaster settings.

29. We would happy to provide further details about any of the issues raised in this response.

The Wellcome Trust

August 2010

Memorandum submitted by Rolls-Royce Plc (SAGE 36)

Rolls-Royce has prepared the following submission in response to the request for evidence for the Science and Technology Committee’s inquiry into scientific advice and evidence in emergencies. The committee posed five general questions in relation to the government’s use of scientific advice and evidence in emergency situations. Of the four emergencies identified, the Icelandic volcanic eruption in 2010 has most direct relevance to Rolls-Royce. Having examined the events surrounding the eruption, we feel best qualified to answer three of the five questions.

Rolls-Royce has relevant knowledge as a principal manufacturer of aero engines, with more than 13,000 engines currently in service with some 650 airlines.

Question 1: *What are the potential hazards and risks and how were they identified?*

It is known that flying in ash clouds above a certain density poses a significant risk to the safety of passengers and flight crew. Following a small number of serious but non-fatal incidents some years ago, in particular, a British Airways incident over Indonesia in 1982, general guidance was drawn up by ICAO (International Civil Aviation Organization) relating to safe flight in areas of volcanic ash. This guidance dictated that where volcanic ash could be detected pilots should “avoid” the hazard.

Since then, industry practice has been to avoid flying in areas where visible ash is present. This regime has enabled safe flying in volcanic areas for many years. However, since these conventions were established, computer modelling has allowed the presence of volcanic ash to be predicted at far lower levels of concentration, and at distances far greater from the eruption than the immediate proximity to a visible plume. Put simply, regulation had not kept pace with technology, leading to confusion over the level of detectable volcanic ash that should be avoided. The eruption of the Eyjafjallajökull volcano exposed this tension. Consequently when the Icelandic eruption occurred, and Meteorological Office computations predicted the presences of volcanic ash over large parts of Europe, the CAA acted upon the interpretation of the ICAO procedures that any level of detectable ash should be avoided and closed UK airspace. The disruption to travel and business has been well documented. Discussions between the various authorities,

regulators, airlines and engine manufacturers subsequently agreed to a “safe to fly” limit of up to and including 2X10⁻³ g/m³, thus establishing a common base of understanding that allowed European airspace to be systematically re-opened.

Question 2: How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

The events following the Eyjafjallajökull volcanic eruption demonstrate the importance of rigorous process, and robust data. The release of volcanic ash into airspace should invoke quick, definitive and systematic action among key stakeholders. These actions should be defined and agreed to, creating a process that includes data collection and processing, hazard and risk analysis, information management, coordination between relevant bodies and clear communication.

It is important that in the future, volcanic activity is monitored appropriately, while more work needs to be done to validate and improve computer modeling. In the event of volcanic unrest a rigorous process needs to be followed to proactively prepare for an eruption.

Question 5: How important is international coordination and how could it be strengthened?

Aviation is a global industry and the threat of disruption from volcanic eruptions is present throughout the world, therefore it is essential to achieve international coordination. Regulatory bodies such as FAA and EASA must work closely with bodies that govern sovereign airspace (such as the CAA in the UK) during emergency situations. The matrix of stakeholders and regulatory bodies that play a part in emergency situations can quickly become complex. This emphasises the need to work with international bodies, specifically ICAO and its International Volcanic Ash Task Force (IVATF). International collaboration, if well coordinated, will provide opportunities to share best practice among scientific bodies, governments, regulators and businesses. Each region of the world is likely to have unique needs and abilities related to monitoring volcanic activity and evaluating scientific data in the event of an eruption. Yet regardless of regional differences, the processes followed and the technologies utilized to evaluate the safety of airspace will be similar. International collaboration is essential to ensure that all the European and UK airspace is properly managed in emergency situations that affect a number of countries. As each country in Europe may not necessarily have the highest level of expertise or technology available to assess the presence of ash in the airspace, collaboration would provide a benefit to travellers and industry alike. As airframers, airlines and engine manufacturers are international businesses with products operating around the world, it is important that there is consistency in the standards of notification and engagement in the event of an eruption.

CONCLUSION

The Icelandic eruptions demonstrate the potential of volcanic ash to severely disrupt the business and family lives of millions of people, and to inflict significant economic damage well beyond the aviation industry. Rolls-Royce has relevant expertise, and would be more than willing to participate in establishing best practice in preparing appropriate responses to future volcanic activity.

Rolls-Royce Plc

17 September 2010

Memorandum submitted by BALPA (SAGE 38)

What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?

The potential hazard to flight was visible ash emanating from the Eyjafjallajökull volcano.

The hazard was being tracked by direct observations by manned aircraft and the use of satellite technology.

However, the use of computer predictions of ash dispersal in the atmosphere caused excessively large areas of airspace to be declared “at risk” from volcanic ash as there was no lower limit of ash concentration agreed prior to its usage.

An anti-cyclonic situation blocked airflows and delayed the volcanic ash’s full dispersion. This should have been anticipated by the Government’s metrological services.

How does/did the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

During the early stages of the incident reliable evidence was lacking—this was particularly true of the Civil Aviation Authority. There existed no clear figures for how much volcanic ash is necessary to cause critical damage to an aircraft.

Furthermore, there was little scientific data to analyse the quantity and type of ash present in a particular section of airspace. This led to the situation where large swathes of unaffected areas were closed-off to flights.

The estimates that we have are not much better than guesses; misjudgments could have serious results.

We do now have a numerical indication from engine manufacturers of ash concentrations which are considered to present no risk, but for many years pilots have heeded the need to remain clear of visible volcanic ash and this has served us well.

Volcanoes erupt constantly around the world, and our significant weather charts have provided the information needed for flight planners and pilots to avoid these areas of visible ash. Indeed in Europe operations have continued over many years to Catania during Mount Etna's activity even when ash visibly contaminated the ground of the airport.

The difference this year is that a need to avoid visible ash was reinterpreted, we believe erroneously, to mean a requirement to avoid ash at any concentration, enforced by an Air Navigation Service Provider reducing the IFR flow rate to zero.

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?

There exists a method of estimating the density of ash that might be encountered, however this only applies to relatively large blocks of airspace and time. Therefore, an airfield that lies within a block of airspace within which critical density has been shown to be exceeded it will be closed for a minimum of six hours, even though there may exist an absence of ash below FL or within a large, though unspecified, distance.

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?

Primarily, it was not clear to us who was holding centre stage on the key decision making. Responsibility seemed diffuse with no clear line of command. Clarifying how decisions are made should be an important focal part of this review.

The Civil Aviation Authority, on 20 April called an "emergency meeting" of aviation stakeholders; billed as to include experts in the industry. However this meeting nearly wholly comprised of mostly management from airlines.

Excluded from this meeting were those that were going to be asked to operate an aircraft in potentially dangerous conditions. This lack of input from representatives of pilots was not acceptable. We have members working across all UK airlines and not just those that were present at 20 April meeting—thus only BALPA represents the broad spectrum across the aviation industry.

Aviation safety is predicated on an open culture where problems are owned up to and improvement is driven by experiences. We do not think that this precedent was followed during the Eyjafjallajökull incident.

Finally, there exists public perception of pilots as professionals and custodians of their safety during a flight. Should BALPA have commented that the Association was unaware of what had been agreed behind closed doors and therefore could not vouch for flight safety during that period the results would have been serious indeed. We should not underestimate the public reassurance that BALPA and pilots provide to the travelling public.

How important is international coordination and how could it be strengthened?

In the aviation industry international coordination is of paramount importance to Governmental action. However whilst aircraft operators have international experience of crises, this knowledge is often purely commercial.

BALPA's international umbrella organisation [the International Federation of Airline Pilot Associations] holds a wealth of information that transcends commercial interests.

It represents the international piloting community, and has experts that have dealt with volcanic ash incidents previously, including in Sicily, Indonesia and Montserrat. We believe that making use of collective knowledge of pilots at a cross-national level will strengthen the international coordination of domestic governments in dealing with crises that affect the aviation industry.

BALPA

1 October 2010

Memorandum submitted by the Airport Operators Association (SAGE 39)

INTRODUCTION

1. The Airport Operators Association (AOA) is the trade association that represents the interests of British airports and is the principal body with which the UK Government and regulatory authorities consult on airport matters.

2. Our mission is to influence governments and regulators, at national, European and international levels, in order to secure policy outcomes that contribute to conditions for sustainable growth in the airport sector.

3. Our airport members, some 70 in number, represent the UK's international hub, major regional airports as well as many serving community, business and leisure aviation. AOA actively brings these members together to share expertise and develop common approaches across the full spectrum of airport issues.

4. Working closely with our members, partners and other stakeholders we play a lead role in promoting aviation security, economic development, and environmental sustainability.

THE CRISIS AND HOW IT DEVELOPED

5. At the start of the crisis, members observed poor coordination between the parties involved, namely: the Volcanic Ash Advisory Centre (VAAC), the Met Office, the CAA and National Air Traffic Services (NATS). Moreover, there appeared to be no direct input from the government.

6. As a result, in the first few days, nobody appeared to take responsibility for restricting flights. NATS's response was to close controlled airspace for six hours at a time, when the reality was that nobody would be flying for days. More realistic announcements on how long airspace would be closed for would have been much more helpful.

7. This reflected the highly cautious attitude taken by those responsible for resolving the problem and those advising them at the start of the crisis. While this might have been expected at the very start, of what was after all a new situation for the UK, we do not think the parties should have continued in this vein.

8. Moreover, while the International Civil Aviation Organisation (ICAO) had plans for a response to volcanic ash in airspace (see point five, below); such an event had never been considered for the UK and consequently there was no analysis, or contingency planning.

9. As the authorities addressed events, it soon became clear that the ICAO volcanic ash plans were outdated. They relied on assumptions that later proved not to have been based on scientific evidence.

10. Moreover, 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.

11. What also seemed surprising was that—to the public—the UK and European reaction to the crisis appeared to be unique, yet volcanic eruptions have occurred in other parts of the world with regularity, and the disruption to air traffic routes has been far less extensive. The reaction in the UK and Europe seemed highly disproportionate. Part of the reason for this was the businesses of UK and European airspace, whereas in other part of the world, aircraft can simply be diverted in the event of a volcanic eruption.

12. Official forecasting by the Met office was also found to be heavily lacking. Airport operators required a good and stable forecast to work with their airlines to plan operations that would continue and those that would be cancelled for the following day. However, often, forecasts issued in the morning could change completely from the night before. This meant that flights were not cancelled in a timely manner, but rather at short notice. As a result of this poor forecasting, many airlines began to make decisions based on their own assessment of conditions.

HOW THE CRISIS WAS SOLVED

13. The solution to the crisis came about as a result of three factors. Two factors involved the use of scientific evidence. The three were:

- (a) The sheer scale of the problem. The inability of land and sea transport alternatives to cope. This left thousands of stranded passengers and in effect public crisis in both real and PR terms. The crisis provides clear evidence of the massive reliance on air transport for the UK.
- (b) The increasing airline impatience with the airspace closedown and their willingness to test-fly aircraft through areas where there were, or were supposed to be, ash clouds.
- (c) The decision of the CAA to take the initiative in resolving the crisis, by involving engine manufacturers, airlines and others in working out safe rules. This resulted in wide areas of airspace to be opened up.

14. The CAA embarked on a very rapid attempt to conduct some form of scientific certification with the engine manufacturers. This showed how different agencies can work together to achieve quick solutions, when clear leadership is shown.

15. The CAA led it because the European Aviation Safety Authority (EASA) team didn't seem to have the expertise—a concern given the fact that that EASA is also now taking command of ATC and Aerodromes. Since the event, the EU has begun to implement clearer means of responding, as a Single Sky entity, to such an event. In spite of several years of development of both Single Sky and the existence of EASA, it was clear that a joint European was lacking.

16. In the end, the resolution of the crisis involved hard evidence from engine manufacturers about the ability of their products to withstand moderate ash cloud exposure, and from the airlines about their level of confidence in being able to fly their aircraft safely.

SCIENTIFIC EVIDENCE AND RESEARCH

17. Question 3 is about obstacles to timely scientific evidence to inform policy decisions. The key weakness in managing and responding to the dynamic situation reactively was the poor accuracy of the forecasting models and also the models used for weather prediction, particularly winds. At one point, the London VAAC had issued no-fly zones, only for the Toulouse VAAC to discredit it by issuing advice that those over France did not exist.

18. There are fundamental differences in the ash forecasting models used throughout the world, in spite of it being a global response plan. An example is that on some models, ash is assumed to disperse or sink to ground after three days, whereas the UK model continued to calculate forecasts using ash data that was several days old and increasingly likely to be inaccurate. In addition to the principles of the modelling, the lack of ability to take scientific measurement must have been a significant detriment to making improved forecasts.

19. This meant the public and policy messages throughout were often unclear, delivered by a range of agencies or bodies, and most frustratingly, often conflicted or changed over time.

20. Very few aircraft were equipped to take samples and measurements (and certainly not any of the commercial aircraft offered and used by a number of airlines and manufacturers) and the sparse coverage by Light Detection & Ranging (LIDAR) equipment severely hampered both the ability to check the accuracy of the forecasting and to add scientific data to improve the process of predicting ash concentration.

21. Q4 mentions sources of scientific advice and a research base. It should be remembered that research comes at a high cost. What was experienced during the ash crisis was a once in 100-years event—how much effort and investment could reasonably be considered justified? Research involving aircraft engines is inevitably very costly—the work on biodiesel residue on aviation fuel is evidence of that (now at least two years into a programme, but one that is still not fully funded to get to a clear conclusion with all the relevant aircraft and component manufacturers).

CONCLUSIONS

22. In considering where improvements could be made for future resilience, we propose that it is in the forecast modelling and the LIDAR coverage. Neither will make a perfect arrangement for forecasting or to directly permit flight in more dense concentrations, but they are reasonably deliverable.

23. In conclusion, 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. There is no reason why such a solution would not work in any future crisis: it will work better when such leadership is shown from the outset.

Airport Operators Association

12 October 2010

Memorandum submitted by Symantec (SAGE 40)

Today the very foundations of our modern society and economic stability are increasingly being built on electronic communication infrastructures that span across national, European and international borders and the data that is shared, processed and stored within these networks. Safeguarding these electronic networks and systems from possible cyber attack or disruption has therefore become a component of countries emergency preparedness and critical national infrastructure protection. In light of the increasingly complex and evolving online threat environment and the possible impact of cyber related attacks Symantec welcomes the Committee's inclusion of cyber attack as one of the potential case studies in this inquiry.

The following submission aims to provide input to the questions raised in relation to a potential cyber related emergency in the UK given the current online threat environment. It should however be noted that the following input is not based on, or related to any specific cyber security incident in the UK.

What are the potential hazards and risks and how were they identified? How prepared is/was the Government for the emergency?

For the last seven years Symantec has produced its Internet Security Threat Report which provides an overview and analysis of worldwide Internet threat activity and a review of known vulnerabilities and trends in activities such as phishing, denial of service attacks, botnets and spam. According to the latest report in 2009 alone Symantec created over 2.8 million new malicious code signatures which represents 51% of all malicious code signatures ever created by Symantec.¹³ Not only is the sheer number of new malicious codes, and therefore new cyber threats, increasing worrying but what is also key is how these malicious codes are being used by attackers to support multistage and increasingly sophisticated and targeted attacks on systems and networks. For example the recent Stuxnet incident represents an example of a threat designed to gain access to and reprogram industrial control systems specifically.

The Stuxnet incident provides a real life case study of how such an organised and structured cyber attack on critical infrastructure systems can succeed and how they could be used in the future. While details of the attack are still unfolding, with further analysis currently taking place, it is estimated that at least four zero day vulnerabilities attacks were involved in the incident which allowed attackers to steal confidential Supervisory Control and Data Acquisition (SCADA) design, usage and control documents for industrial systems such as those used by the energy sector. This is the first time that so many zero-day vulnerabilities have been exploited in one attack and indicates that the people needed to develop and execute such an attack were not amateurs. It is understood that once the attackers gained entry into the targeted systems a root kit was used to hide their presence while they targeted software within the systems used to control industrial assets and processes. It is also believed that stolen digital certificates were used in the attack to mask their trail through the compromised systems. The use of zero-day vulnerability, root kit, stolen digital certificates, and in-depth knowledge of SCADA software are all high-quality attack assets and points to an estimated group of at possibly up to ten people involved in developing this specific, targeted and technically sophisticated cyber attack.

In the past this type of cyber attack focusing on critical national infrastructures were seen by many as theoretically a possibility however it is fair to say that most would have dismissed such an attack as simply a movie-plot scenario. Symantec believe the Stuxnet attack is clear evidence that such attacks are real and a possible threat and are no longer just a theory but a reality that countries need to prepare for. According to a recent survey by Symantec 53% of all firms surveyed suspected or were pretty sure that they had experience an attack on their systems waged with a specific goal in mind.¹⁴ The Stuxnet incident has shown that such targeted, organised threats do exist where external actors motivated possibly by organised crime, terrorism or even hostile nations, attempt to gain control of industrial processes and then place that control in the wrong hands.

Overall cyber attacks are becoming increasingly complex, sophisticated and organized. No longer are online attackers motivated by notoriety but by economic gain with access to systems for information being a key target. Information that can then be sold as a commodity on the underground economy and possibly used in further attacks such as through social engineering or more targeted attacks on institutions. In fact in a number of cases there have been reports of attacks aimed at not causing disruption, but rather at collecting intelligence and stealing confidential information.

While the Committee's focus on the UK's preparedness for a potential cyber related incident is understood, from the perspective of the computer security industry, and on the basis of experience to date, it is suggested that the Internet itself has been resilient to possible large scale cyber attacks. The Internet is simply a series of interconnected computer networks, systems and essentially large servers based all around the world. As with any electronic or computerised system these computers are reliant on electrical power to function. Therefore it may be possible that a natural disaster or perhaps offline traditional emergency, such as the other case studies being considered by the Committee that impacts or disrupts power within a country or region, could potentially affect the ability of the Internet users to gain access to online networks or systems. Physically, therefore the internet is susceptible to regional interruption such as when cables are broken. Such outages have occurred when an undersea cable providing network connectivity to the Middle East were damaged.

Clearly though the risks and threats to the security, integrity and resilience of the Internet have certainly increased over recent years. This together with the shift towards greater interoperability between internet based networks and systems means that a targeted cyber attack has the potential to have a cascading effect and impact on other connected systems. It is therefore vital that adequate levels of protection are in place that can identify risks quickly and effectively particularly given the significant increase in criminal use of the Internet for purposes such as identity theft and extortion.

In response to the question of how prepared the Government is for a potential cyber related emergency it is important to recognize that ensuring the ongoing resilience and stability of the Internet is a responsibility that is shared by all those using the Internet. While the Government has a role to play in considering and

¹³ Symantec Internet Security Threat Report April 2010
http://www.symantec.com/business/theme.jsp?themeid=threatreport&inid=us_ghp_banner1_istr

¹⁴ Symantec Internet Security Threat Report April 2010
http://www.symantec.com/business/theme.jsp?themeid=threatreport&inid=us_ghp_banner1_istr

addressing preparedness for cyber related issues, it should be noted that cyber security issues cannot be solved by ISP's, software manufactures, law enforcement, government or even individuals alone. The nature of the internet and IT technology is such that no single person can be held accountable and we all share a collective responsibility to protect ourselves and our customers whether they be businesses, users or citizens.

Overall Symantec believes that a modern approach to cyber security must be balanced between protection against and preparedness to address possible incidents. Symantec therefore welcomed the creation of the Office of Cyber Security and the Cyber Security Operations Centre. The role of these bodies to provide coordination across government of activities in this area and operational response to cyber incidents are seen as key for ensuring efforts across government to recognise, identify and therefore address cyber related issues. In addition the willingness of the Office of Cyber Security to engage and work with industry is also welcomed given the shared responsibility to prepare for and address cyber incident as and when they occur. In addition to the Office of Cyber Security, it is recognised that the UK has a number of different bodies that are active in addressing cyber security related issues at many different levels ranging from e-crime to critical national infrastructure protection that, as explained above, can be interconnected given the multi-layered cyber security risks and attacks being perpetrated. These bodies include the important work of CPNI and the UK e-Crime Police Unit which also play an important role in addressing cyber security issues in the UK.

How does the Government use scientific advice and evidence to identify, prepare for and react to an emergency?

From the perspective of the computer security industry Symantec is supportive of government efforts to gather advice and information as needed and remain committed to assisting in this work as and where appropriate and within the boundaries of the law.

Given the complex cyber ecosystem of the internet it is suggested that the threat information, technical intelligence and cyber security related expertise and advice that may be needed in a cyber related incident will reside across a number of different sources both inside and outside of government. For example it is estimated that 90% of critical national infrastructures that are increasingly reliant on interconnected networks and systems, and therefore a possible target for cyber attacks, are privately owned and managed. As a result public and private sector co-operation and collaboration is seen as a key factor to assisting not only the government but also industry to identify, assess and evaluate the level of seriousness of a cyber related incident and better prepare for and react. Symantec believes that information sharing is a fundamental component of a modern cyber security strategy and that the development of trusted information sharing networks and systems is a key element to the development of successful public and private cooperation.

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?

It is suggested that a main obstacle to obtaining timely information in a cyber related incident is the online threat environment itself as it continues to evolve at an ever increasing pace with risks and attacks emerging, mutating or evolving into new variants and therefore new attacks. It is suggested that cyber attacks are unlike the other case studies being considered by the Committee as the online threat environment is constantly shifting and changing. As a result in order to respond to this changing threat landscape having the most up to date information, threat intelligence and situational awareness of the changing threat landscape is vital to making decisions in a timely manner and deploying effective countermeasures as and where necessary.

Symantec believe early warning capabilities and real time online threat intelligence are vital components of a cyber security response strategy. Having the right information at the right time can provide an effective means to guarantee a timely response to an attack on critical information and/or communication systems. Having real-time information collection, correlation, analysis and response capability can provide organisations with the ability to identify recognise key threats or emergencies and have the timely information to assess priorities and address cyber incidents quickly and effectively. Collecting and analysing threat intelligence is a complex process however that requires significant engineering skills, specific technical infrastructures to be in place and in some cases human intelligence skills.

Having the right information at the right time is clearly important in preparing for and reacting to an emergency situation. However in the event of a situation where online networks and the information that flows through such systems is attacked or compromised it is also suggested that the ability to gain access to critical information assets is also important to an organisation's ability to respond and recover from an attack. Organisations are increasingly being targeted by online threats focused on gaining access to their data. Information is seen as a valuable commodity for cyber criminals that can be sold on the underground economy or used to develop more targeted sophisticated attacks. In addition attacks are also being seen where the aim is simply to disrupt or even suppress the availability of information or the network and systems upon which information is transmitted, for example in the case of distributed denial of service attacks. As a result the ability of organisation to recover from a cyber incident can rely not only on the ability to identify and stop an attack, but also the ability to gain access to key information assets needed to restore the availability of affected online systems. However, with the increasing take up of data virtualization and cloud computing the way in which organisations manage and store information is changing. However, in

the event of a cyber incident the ability to gain secure access to the data needed to restore online services will be vital to the ability of organisations to recover quickly and effectively. Therefore it is considered important that organisations, both in the public and private sector, have in place the ability to gain access to key information assets securely using technological tools such as encryption and authentication as well as appropriate policies and procedures to enable the restoration of data and therefore the online systems and networks impacted.

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?

As outlined above the resilience, stability and security of the internet is a joint responsibility that must be shared by all those using the Internet. Therefore coordination and cooperation between the public and private sector on cyber related issues is seen as an important component to a cyber security strategy not only in the UK but globally. It is suggested that coordination between public and private sector on cyber related issues occurs at many different levels and areas of the UK internet community depending on the sector involved, the specific type or level of seriousness of the threat or risk.

It is suggested that an example of an effective strategic coordination and cooperation between governments and industry, not only in the UK but globally, is the role of Computer Emergency Response Teams. CERTs provide a national focal point for information, guidance and provide warning, reports and alerts on cyber incidents. The CERT model brings together both government, industry as well as academic partners and is flexible to enable countries to develop multiple CERTS, or different types of CERTS, depending on the particular requirements and needs depending on the type or risk or threat activity that may need to be covered. Symantec supports the CERT model for coordination and cooperation and see it as an appropriate means of sharing information and encouraging a collaborative approach to addressing cyber related issues within countries between key partners involved in cyber incidents and also between countries internationally.

How important is international coordination and how could it be strengthened?

As recognized by the Committee's question addressing the cyber security challenges we face requires international coordination. Internet security is a global problem that requires a global approach given that threats and attacks can travel around the world simply at the click of a button. With the move away from closed, nationally protected computer networks to a more borderless, open, accessible, Internet based, networked environment means there is a greater dependency and reliance on internet based systems and networks internationally. This shift means the need to recognise that cyber related risks and attacks could now impact and affect more than just one nation but could have a regional or international impact. Therefore there is an increasing need to highlight and consider the role of international co-operation and collaboration in identifying and addressing cyber risks and threats.

The UK's involvement in European and international forums where cyber security issues are discussed such as ENISA, UN Internet Governance Forum, ITU and OCED as well as the UK's participation in cyber security related exercises such as Cyber Storm are welcomed and supported by Symantec and should continue going forward to ensure the UK can continue to play a leading role in international efforts as they may evolve.

Looking ahead and given the increased interdependency of countries networks and systems it is suggested that information sharing has a key role to play in effective cooperation and coordination against cyber related threats. A common and shared understanding of the threat landscape is necessary to not only enable greater identification and recognition of possible threats and risks but also ensure efforts to address possible risks or specific incidents are effectively deployed as and where appropriate. The proposed creation of a European Information Sharing and Alert System (EISAS) within the recent European Commission's Communication on "Protecting Europe from large scale cyber-attacks and disruptions" could be one step towards developing greater capabilities in Europe for sharing information and providing alerts. It is important however that the development of any common European, or even international system, recognizes and takes into account the current activities already underway as well as the tools and solutions developed and implemented by industry. Given the experience of industry in this area it is important that ways are found to involve those in industry with the technical capabilities, skills and expertise in the development of any coordinated European or international approach.

To assist in the development of information sharing initiatives and as a way to ensure greater effectiveness in information sharing between European and international partners, Symantec believe consideration should also be given to the development of a common language, or terminology, for security incidents, response and escalation that could be used across the UK, Europe and beyond. The ability of stakeholder to speak the same technical language in the event of a cyber-attack could help promote greater cooperation and cohesiveness in responses to incidents not only across Europe perhaps but internationally.

However it is also important when considering how to encourage greater or strengthen international co-operation and collaboration between countries not only the action needed before an incident may occur but also the cooperation and collaboration that may be needed during and after a cyber incident. The events in Estonia and Georgia are real life examples of how sophisticated and targeted large scale cyber attacks can be.

These incidents also raised questions over the extent to which relevant parts of EU Member states national administrators possess the technologies needed and e-skills to address cyber-attacks if they occur or address issues related to the protection of the internet. It is therefore suggested that a way to strengthen or enhance international cooperation may be by developing initiatives that can enable the sharing of technical expertise and guidance on how to address cyber security related incidents. The establishment of NATO Cooperative Cyber Defense Center of Excellence in Tallinn, Estonia which is supported by Symantec is an example of a project that has developed to foster greater understanding and sharing of expertise on how to react to and address cyber related incidents.

However, while cooperation at a European or international level is important, this should not be a substitute for countries taking a national approach that is appropriate to their level of maturity, identified risk and therefore specific requirements. The publication of the UK's cyber security strategy was welcomed by Symantec as an important move forward in helping to co-ordinate, and maximise, efforts already well underway across government that currently seek to address cyber security related issues. Also supported was the importance placed throughout the strategy on the need to ensure international engagement and the importance of the UK contributing to international discussions on how to address the current and future online threat environment not only in the UK but on the global stage.

Symantec

October 2010

ABOUT SYMANTEC

Symantec is a world leader in providing solutions to help individuals and enterprises assure the security, availability, and integrity of their information. Headquartered in California, Symantec has operations in more than 40 countries. Further information can be found at www.symantec.com.

Memorandum submitted by the Local Government Association (SAGE 43)

1. Introduction

1.1 The LGA is the single voice for local government. As a voluntary membership body, we are funded almost entirely by the subscriptions of over 400 member authorities in England and Wales. We lobby and campaign for changes in policy and legislation on behalf of our member authorities and the people and communities they serve.

1.2 The LG Group is made up of six organisations—the Local Government Association, Local Government Improvement and Development, Local Government Employers, Local Government Regulation, Local Partnerships and the Leadership Government Leadership. Our shared ambition is to make an outstanding contribution to the success of local government.

1.3 In an emergency that requires national coordination the roles and responsibilities of key agencies, including the LGA, is set out in the Central Government's Concept of Operations (CONOPS). Since 2006, the LGA has attended meetings of the Civil Contingencies Committee, colloquially known as COBR, on an ad-hoc basis. We believe that there needs to be a presumption that the LGA should be invited to attend COBR to represent the views and interests of councils and their communities during times of national emergency.

1.4 The following submission is based upon the experience of LGA Lead Members and officers involved in the national response to recent emergencies and comments received from local authority officers in their capacity as advisors to the LGA Group. It concentrates on the three issues identified as being of interest to the Committee in the letter sent to the LGA on 11th November.

2. How local authorities receive information from central Government and whether the process is felt to be satisfactory

2.1 The majority of communications from central Government on emergency planning come via Regional Resilience Teams based in Government Offices, who forward information to the secretariats of Local Resilience Forums (LRFs), who then pass the information on to local responders including local authorities. One of the primary sources of information is the Resilience Gateway, which is essentially an email from the Civil Contingencies Secretariat (CCS) in the Cabinet Office which is circulated to RRTs, who then pass this on to LRFs.

2.2 The disadvantage of the current cascading approach is that it frequently results in significant delays in the communication of information from central Government to the local level. This indirect approach relies on the recipients at the regional level being available, having sufficient understanding of the issues and up to date contact lists, which is not always the case. This is of particular concern in times of emergency when it can result in delays of several days before local authorities receive top-line briefs and requests for

information on local and impacts and issues, which means that the information is often out of date or difficult to respond to. There is a need for a more direct, targeted approach which would ensure that critical information is communicated in a timely manner to those who need it during emergencies.

2.3 There is also concern that the RRTs make judgements about what information they need to pass from central Government to LRFs. While this may be done with the intention of reducing the burden on LRF secretariats, there is the danger that this filtering process may result in LRFs not receiving all the information that they need from central Government.

2.4 The disbandment of Government Offices in March 2011 will have implications for Regional Resilience Teams and we understand that the Government is currently considering options for support for resilience activity at the sub-national level. There is a need for the Government to consult with local government and other responders on future arrangements and how these might impact upon communications relating to emergencies.

2.5 The Government has promoted the National Resilience Extranet as a quicker and more effective means of communicating and sharing information with local authorities and other local responders at times of emergency. Due to concerns about the cost of NRE subscriptions and the value of the information currently available through the NRE, not all local authorities have subscribed to the NRE. As a result, the LGA is concerned that if the Government were to use the NRE as the primary means of communicating information with local authorities during an emergency, a significant number might not receive important information.

2.6 The LG Group has played a key role in communicating key national messages to local authorities during recent emergencies, including the 2001 and 2007 Foot and Mouth Disease outbreaks and other subsequent animal disease outbreaks, the 2007 floods, the 2009 swine flu pandemic and the severe weather in the winters of 2008–09 and 2009–10. The LGA is able to assemble and disseminate essential information and guidance to local authorities very quickly via its website and database of emergency planning contacts in all local authorities in England and Wales. For example during the swine flu pandemic the LGA set up a dedicated policy unit, drawing on resources from across the LGA Group and implemented a set of regular briefings and tailored guidance for councils. Key outputs included:

- A special LGA Group swine flu briefing event in Birmingham in July 2009 aimed at sharing lessons learnt from the first wave.
- A special swine flu guide for elected members which helped other parts of the country gear up for the second wave.
- A survey sent to all emergency planning officers across England and Wales. The final report was published in December 2009.
- Online advisory notes on the human resource implications of swine flu.

3. How local authorities contribute to the development of the National Risk Register and whether the process is felt to be satisfactory

3.1 In theory the development of the NRR is a two way process. The risks identified in the publicly-available NRR should inform the development of Regional Risk Registers (RRRs) by the RRTs and the Community Risk Register (CRRs) developed by LRFs. In return the risks identified in RRRs and CRRs should be fed back into the classified National Risk Assessment which informs the NRR.

3.2 In practice the process is very top-down and provides very little opportunity for local authorities to input. While local authorities usually have the opportunity to contribute to CRRs via LRFs, the NRR is rarely informed by issues identified at the sub-regional and regional level. The two-way process is hindered by the fact that the NRR and RRR use different criteria from CRRs for assessing risks. There is often pressure to include national risks identified in the NRR in CRRs which may not be relevant in a sub-regional context.

3.3 There is also 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.

4. Whether local authorities feel they have adequate access to scientific information for making risk assessments, understanding information from central Government and for emergency management

4.1 In general local authorities tend to rely on local contacts with key agencies or partners in LRFs to share relevant scientific information and provide advice needed for risk assessment and emergency planning at the local level. In the event of an emergency the primary source of scientific advice to local authorities tends to be the Science and Technical Advice Cell formed collectively by local responders to advise the Strategic Co-ordination Group of the LRF.

4.2 Experience of accessing scientific information held centrally varies across local authorities and different types of emergency, with some local authorities reporting a good flow of scientific information from central Government Departments and agencies, but many citing concerns about delays in distributing information similar to those highlighted in relation to the circulation of more general information on civil contingencies.

4.3 Some authorities have also highlighted that scientific advice from central Government often does not provide a clear view on key issues which have implications for the emergency planning, for example in relation to planning for excess deaths resulting from emergencies.

Local Government Association

22 November 2010

Memorandum submitted by Lloyd's (SAGE 45)

Lloyd's is the world leading specialist insurance market and consists of 87 separate syndicates managed by 55 managing agents. While managing agents are responsible for the business of underwriting, the Society of Lloyd's has responsibility for central functions. As part of this the Society runs a performance framework to ensure managing agents are taking the actions necessary to achieve or exceed the targets set for syndicates. The performance framework is prudential and seeks to ensure the Central Fund, Lloyd's brand and ratings are protected. A key element of the performance framework is Exposure Management, which looks at potential for aggregations of risk arising through underwriting. In this capacity we have established an Emerging Risks team which monitors for potential new threats and assesses their possible impact to the insurance industry. We also have an initiative called "360 risk insight" which aims to bring new risks to the attention of risk managers in a variety of the companies that we insure, always with the intention of suggesting action to manage the risk.

The risks of space weather are well known to space underwriters at Lloyd's due to the direct damage it can inflict on satellites and Lloyd's assesses the potential impact of a major proton flare on the market in our annual Realistic Disaster Scenarios exercise. For the purposes of the scenario it is assumed that either a single anomalous flare or a number in quick succession result in an insurance loss of 5% for all satellites in synchronous orbit, except for those policies that exclude power loss. Capital held at Lloyd's is therefore annually tested to ensure adequacy against such an event.

The Emerging Risks team has been looking into the terrestrial effects of space weather in more detail since the end of 2009. The impact of space weather on terrestrial systems has grown along with society's increasing reliance on digital technology and electrical infrastructure. These risks were captured in our 2009 emerging risks report on digital risks which highlighted for example the pervasive use of GPS. Cyber risks will be discussed further in our 360 risk insight report to be published 1 December 2010 which highlights the actions businesses can take to mitigate this risk. Space weather has been the direct focus of our most recent 360 risk insight report entitled "Space Weather: Its impact on Earth and implications for businesses". This report, published on 8 November was produced in partnership with Professor Mike Hapgood from the Rutherford Appleton Laboratory. Professor Hapgood gave oral evidence to the House of Commons Science and Technology Science Committee on 10 November 2010 and made reference to many of the findings in our report.

It is clear that we do not know the probability of a Carrington sized Coronal Mass Ejection event. We suggest that a critical first step to guide mitigation strategies would be to increase the sophistication of modelling of these events—so that the return period can be estimated with greater accuracy. Lessons can be learnt from the approach taken by climate scientists ie a mixture of physical modelling and paleo-science should be helpful. If the return period were to be shown to be less than 200 years (ie events occur more frequently than a 1/200 annual probability) then it would require consideration under the regulatory capital calculations undertaken by the UK insurance industry.

Our report examines the potential effects of a large space weather event on: aviation, oil and mineral industries, pipelines, communications, automotive industries, rail, water, sewage, medical establishments, finance and, most critically, power. With all these areas of modern society being affected simultaneously and possibly across an entire hemisphere in a matter of seconds society should prepare for significant impacts over an extended period. An extended loss of power could lead to a cascade of operational failures that could leave the global economy severely disabled. Other smaller catastrophes, for example hurricane Katrina have demonstrated how society can struggle to rebuild when critical services are disrupted simultaneously. These events also show that, the longer recovery takes the larger the costs. At present there is much uncertainty surrounding this issue. A scenario leading to loss of power over many months and possibly years seems extreme but plausible and the onus on policymakers should be to consider this seriously unless it can be shown that the probability is appropriately small.

Our report notes that 90% of critical infrastructure is not under Government control. Whilst we appreciate the security implications, it would be helpful, where possible, to share information on the location of such infrastructure with insurers. This will enable better modelling of all manner of catastrophes ranging from

flooding, earthquakes and windstorms to space weather. We believe that businesses owning such infrastructure have a responsibility to protect it against a variety of threats. However, we also recognise that commercial competitive pressures are very strong so adequate regulation is often required to level the playing field: in the presence of uncertainty only the weakest response will typically arise.

In January 2010 we published an emerging risks team report on Behavioural Risks. This report highlights the work of behavioural theorists of the past 50 years as it applies to emerging risks management. We believe the impact of cognitive biases should not be underestimated when considering new risks like space weather. Cognitive dissonance can lead to people “explaining away” new risks because they conflict with their desire to continue life as before. Scenario biases arise because, if people cannot conceive how harm will occur, they will often miscalculate its probability (assuming it is far lower than it really is). Representation bias can distort perception of risk as people argue a new risk is “like” an old one—“how can something as pleasant as the aurora borealis be risky?” People find chain risks (when a number of connected failures occur one after the other) very hard to envisage and this is linked to our well known inability to estimate conditional probabilities. Emerging risks continually expose all these human cognitive failings and highlight the importance of taking account of behavioural factors and using computer models to augment our intuition.

Insurance coverage in a space weather event will be a function of the precise policy wording and we cannot make general statements here. However it is important to realise that policies generally only pay out when physical damage has occurred. Hence a power surge leading to a fire may lead to an insurance payout; whereas a surge leading to power failure (but no actual physical damage) lasting many months may not lead to insured business interruption payouts. Some risks do exceed the capacity of the insurance industry to respond—material aggregations over a wide geographical area are typically where the principles of insurability start to break down. Therefore we believe the first line of defence with space weather will be to mitigate its risks up front (for example rail signals that default to red after a power failure).

We would like to thank the House of Commons Science and Technology Science Committee for giving Lloyd’s the opportunity to contribute to this debate.

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SUPPORTING INFORMATION

www.lloyds.com/space

Lloyd’s 360 Risks Insight report: “Space Weather: Its impact on Earth and implications for businesses”
www.lloyds.com/The-Market/Tools-and-Resources/Research/Exposure-Management/Realistic-Disaster-Scenarios

Lloyd’s Realistic Disaster Scenarios

<http://www.lloyds.com/The-Market/Tools-and-Resources/Research/Exposure-Management/Emerging-risks>

Lloyd’s Emerging Risk report: Digital risks: Views of a changing landscape (2009)

Lloyd’s Emerging Risk report: Behaviour: Bear, bull or lemming?

See www.lloyds.com/360 for our forthcoming report on cyber risks.

For more details about Lloyd’s in general see: <http://www.lloyds.com/Lloyds/About-Lloyds>
