



Met Office

The Public Weather Service's contribution
to the UK economy

May 2007

"The Met Office is a big success story. You are world leaders in your field. Renowned and respected throughout the world to the extent you're practically a global brand. We in the MoD are absolutely determined to make sure you stay that way."

Under Secretary of State for Defence

"The Met Office have set up a unit internally which is excellent at providing emergency response data, critical to our ability to plan for a nuclear incident."

Defra

"The independent capability of the Met Office provides a latitude in decision making for the MoD that otherwise would not be possible."

MoD

"The work of the Met Office based on PWS' model allows the UK to punch above its weight in terms of climate change insight."

Defra

"The work being carried out by the Met Office is integral to the ongoing success of the National Traffic Control Centre, reducing loss of life, injury, and damage to property."

Highways Agency

"The Met Office bring a clear, well considered and precise view to the table. This was particularly evident in the Buncefield incident which allowed our team to make appropriate decisions at critical times."

Cabinet Office

The Met Office's model is great. It provides an invaluable input to our preparations for dealing with bluetongue - enabling us to have an idea of when the midges might arrive on these shores."

Contingency Planning Director, State Veterinary Service

"The Severe Weather Warnings issued by you last week made sure the country was able to prepare and plan. And it is widely recognised you – quite literally – save lives."

Under Secretary of State for Defence

Foreword

The Met Office is critical to the efficient and effective running of the UK. Its services are wide and numerous including: keeping the nation safe by providing severe weather warnings; modelling climate change; contributing to flood prediction; ensuring safe and efficient transport links; supporting military operations; advising on government policy; predicting and limiting the damaging effects of disease and pollution; and a great deal more.

Within the Met Office, the Public Weather Service (PWS) is responsible for providing the forecasts that are seen and heard throughout the UK. Its principle objective is to produce an accurate and timely weather forecast for the general public. In doing so however, it is also able to support and provide benefit to numerous other areas of the public sector and the economy. The public in general sees only a relatively small amount of this benefit when forecasts are distributed via the media – that part of the weather service that affects them directly. The majority of benefits, particularly those relating to wider government services, are less visible. This set of circumstances, combined with the difficulty in calculating the value of a public good, means that there is a gap in understanding the economic value of the PWS.

In February 2007, the PWS Customer Group (PWSCG) commissioned the support of PA Consulting Group (PA) to document and quantify where possible the benefits the Met Office PWS delivers to the UK. The PWSCG acts as the customer on behalf of the public for free-at-point-of-use weather services. It ensures that these services are aligned to the operational needs of public sector users of PWS outputs, and that they provide value for money. It also acts as guardian on behalf of public sector users of the Met Office's underpinning operational capability. It is responsible for setting the PWS requirement and specifying PWS outputs, supporting research and development to meet future requirements, and providing independent advice and recommendations to the Under Secretary of State for Defence.

The approach taken by PA was to review how the PWS impacts the public in their daily lives and build upon existing research to show the economic benefit to the public. In addition, PA reviewed a number of public sector customers of the Met Office, assessing the services provided, the actions taken as a result of the information received and the subsequent benefit of these actions.

The PWSCG welcomes the findings of this report. In completing this study, PA has clearly shown that the PWS, and the Met Office as a whole, benefits society in a significant number of ways in addition to the public service provided via the media. Based on existing research into the public's valuation of the Met Office's weather service and the findings from the three case studies covered in this report, the Met Office delivers a financial benefit that represents a substantial return on investment. Combined, the two pieces of research show annual contributions from PWS worth £614m to the UK economy based on the public's valuation and just a small sample of the services provided. The overall value can be expected to be many times more than this figure – in marked contrast to the PWS budget of £83m. Just as important as the financial benefit however, the Met Office additionally provides a service of invaluable proportions when it comes to issues such as climate change, military activity and human health.

In the future, the PWSCG will continue to work with the Met Office and its customers and other stakeholders to assist them in realising even greater levels of benefit that, as yet, remain untapped.

The PWSCG wishes to thank all those stakeholders who gave up their valuable time to provide input for this report.

Nick Baldwin

Chair of the Public Weather Service Customer Group

Notes on the report

This report has been prepared by PA on behalf of the Public Weather Service Customer Group. It was prepared in May 2007 and as such refers to titles (departments) that may subsequently have altered and future events which may have occurred. In particular it refers to the Blue Tongue virus as a potential future event which eventually came to be a real situation.

The report has been prepared by PA on the basis of information supplied by third parties and that which is available in the public domain.

No representation or warranty is given as to the achievement or reasonableness of future projections or the assumptions underlying them, management targets, valuation, opinions, prospects or returns, if any.

Except where otherwise indicated, the report speaks as at the date hereof. This proposal does not constitute any form of commitment or recommendation on the part of PA.

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1. Executive summary

The Met Office's Public Weather Service (PWS) provides the weather forecasts that the UK public depends upon. It funds and is responsible for: gathering observations of the current weather; developing and operating the computer-based Unified Model that predicts future weather; and the analysis of observations and model output to create the Met Office's weather forecasts. In this way the PWS underpins all that the Met Office provides – weather forecasting and climate prediction. Longer-term prediction is carried out by the Met Office's Hadley Centre, which produces internationally recognised and esteemed work on future climate change, based on the PWS' Unified Model.

In February 2007 PA Consulting Group (PA) were asked by the Public Weather Service Customer Group (PWSCG) to review the annual economic and social benefits associated with the PWS. The PWSCG acts as the customer on behalf of the public for free-at-point-of-use weather services and ensures that these services are aligned to the operational needs of Public Sector users of PWS outputs and provide value for money. It also acts as guardian on behalf of public sector users of the Met Office's underpinning operational capability. It is responsible for setting its requirement and specifying its outputs, supporting research and development to meet future requirements, and providing independent advice and recommendations to the Under Secretary of State for Defence. In order to complete the review PA carried out numerous in-depth interviews with internal and external stakeholders and examined research from over 70 referenced sources.

Summary findings

- **The PWS delivers an exceptional return on investment** – The economic value created by the PWS is many times the scale of the investment that it receives. Whilst the study does not derive a value for all elements of the work carried out by the PWS, external research commissioned by the Met Office shows that the public values the Met Offices' services at £353.2m. Furthermore, the valuation of benefit from three case studies (the Cabinet Office, Environment Agency and Civil Aviation Authority) gives a minimum additional contribution to the UK economy and society of at least £260.5m per annum. Given the prudent approach taken throughout this study and the many other areas of benefit that are provided by the PWS, the overall value can be expected to be many times more than this figure. This is in marked contrast to a total PWS budget of only £83.2m (of which the Ministry of Defence's (PWSCG) share is £62m), which serves over 10 different government departments, over 600 different agencies and the general public of the UK
- **The PWS saves lives** – Hundreds of lives are saved every year as a result of the services provided, and thousands of incidents are mitigated against by the early provision of information that is based on underpinning PWS infrastructure and expertise. This can be witnessed directly through, for example, the improvement of road, flight and marine safety, and indirectly through, for example, the preparation and practice of contingency procedures for national emergencies and nuclear disasters
- **The PWS output is world class** – The PWS provides a level of output and value to its customers in terms of depth of information, accuracy and timeliness that is many times the value of individual funding from each of those organisations. In effect the PWS provides a fixed asset, an entire infrastructure containing one of the most sophisticated and important computer models in the UK public sector, which is used by hundreds of beneficiaries. Individual customers could not gain access to such world class output without the funding provided by the Ministry of Defence on behalf of all users of the PWS. The international meteorological community endorses this quality with numerous other meteorological services wanting to license the PWS Unified Model
- **Greater benefit could be achieved with a more accurate forecast** – It is clear from the research that when the forecast is accurate and used appropriately, lives are saved and financial benefit delivered. However, many public customers are not using the forecast as widely as they might within their planning processes. This is because many see the current forecast as insufficiently accurate to be relied on as an input into their planning approach. The accuracy of the weather forecast is

currently at a level of c.80%. Should the accuracy of the forecast be improved through greater investment, more departments and agencies would use the forecast in their planning processes, and potentially even more lives would be saved, property damage avoided and efficiency savings delivered.

The approach

The Met Office provides services to the public, government, and commercial entities. The commercial element operates at arms length, on equal terms with its competitors in the private sector. This study is therefore focused on the PWS and the key benefits that its models and forecasts provide to the public and the various government departments that it supports.

The study therefore describes in detail the value derived by the public from the Met Office. In addition, it analyses the value created through the government and the public sector. As there are numerous different elements of the government however, the approach focused on analysing three key organisations in detail: the Cabinet Office; the Environment Agency; and the Civil Aviation Authority. In order to show the sheer breadth of benefit provided by the Met Office, however, stakeholders were also interviewed from seven other areas where the Met Office creates value, including the Ministry of Defence, the Department for Environment, Food and Rural Affairs, and the Highways Agency.

As a complex organisation, the study required a clear view of the value chain to show how information and value passes across the organisation to its customers. The study therefore developed a *causal map* (page 3-2) to show how the PWS fits into the structure of the Met Office. The map demonstrates the pivotal role that the PWS plays in the Met Office. It also highlights the importance of the Direct Services and the Climate Prediction Programme, that are based on the PWS, in driving overall benefit and reputation.

Benefits provided by the Met Office were categorised as follows:

- Casualties avoided / lives saved
- Property damage avoided
- Social and environmental benefits
- Efficiency savings.

These different types of benefit are used in order to ensure that the report captures both the fiscal and non-fiscal value of the Met Office's services.

Specific findings

Benefits were found in all of the four categories described above. In pure economic terms, research carried out by ORC International in 2006/07 estimated the annual value of the Met Office to the UK public to be £353.2m, based on the average value of £7.30 p.a. that UK adults placed on the direct services provided to them by the Met Office. In addition, the three government agencies that we reviewed in detailed case studies gave a value of £260.5m per annum, discounted to take into account a proportioned direct service payment (detailed below).

Department	Lives saved	Financial equivalent of lives saved*	Property savings / efficiency gains	Total fiscal benefit
Cabinet Office	54	£79.8m	£4.1m	£83.9m
Environment Agency	-	-	**£47.9m	£47.9m
Civil Aviation Authority	20	**£29.6m	**£99.1m	***£128.7m
Total	74	£109.4m	£151.1m	£260.5m

* Cost of a life is estimated at £1.478m¹ **EA and CAA figures discounted to incorporate their respective direct service spend
 *** Excludes environmental savings of 352,000 tonnes of CO₂ p.a.

Whilst the £353.2m public valuation and the £260.5m benefit from three government departments represent a significant contribution to the UK economy, it is clear that these form only a small proportion of the overall value provided by the Met Office. The conservative nature of the methodology used, combined with the numerous other areas of the economy impacted by the Met Office, mean that we would expect to see a number many times this value were the whole customer base analysed in detail.

Key benefits provided

Direct to the public through the media – First and foremost, the Met Office's PWS exists to serve the UK public. Weather forecasts and warnings help the general public and industry to plan a wide range of daily activities that are sensitive to the weather. Observations and warnings relating to the weather are used by the general public to protect lives and property, and by small businesses in particular to help plan their activities and resourcing. A key example of a small business group heavily dependent on the Met Office's service through the media is the country's farming community.

Three Case Studies

Environment Agency – The aim of the Environment Agency (EA) is to protect and improve the environment in England and Wales, which includes protection against flooding, and cleaner, healthier air and water, both now and in the future. The EA's main use of the Met Office is through weather and storm tide information which it uses to provide its Flood Forecasting Service. The EA pays for direct services based on PWS output.

Cabinet Office – The aim of the Cabinet Office is to ensure that the UK is resilient to any disruptive challenge. This challenge often presents itself in the form of severe weather and as a result the ability to prepare and react effectively is a Cabinet Office priority. The Met Office provides information that enables emergency responders to make critical decisions to mitigate the effects of severe weather, providing both social and economic benefit. The Cabinet Office makes no payment to the Met Office.

Civil Aviation Authority – The Civil Aviation Authority (CAA) is the UK's independent aviation regulator. Amongst other roles, CAA ensures that the UK meets its meteorological commitment to the International Civil Aviation Organisation (ICAO) of providing weather information for the aircraft in UK airspace. Beyond this, the CAA oversees the UK's commitment to act as one of only two global en-route weather data providers, a specialist regional volcanic ash advisory centre (monitoring and advising aviation about Icelandic volcanic activity) and operating a meteorological information satellite dissemination system, as part of the official ICAO telecommunication system. The Met Office delivers huge economic and environmental benefits by providing both of these services on the CAA's behalf. The CAA both contributes to PWS funding and pays for direct services based on PWS outputs.

¹ Department for Transport, *Highways Economics Note No.1 2005: Valuation of the Benefits of Prevention of Road Accidents and Casualties*, Office of the Deputy Prime Minister, January 2007. Also: Office of the Deputy Prime Minister, *Economic cost of a fire*, 2004

	Event / activity	Description	Estimated annual value
Environment Agency	Flood	<ul style="list-style-type: none"> The Met Office inputs into the EA's Flood Warning Service, which helps people to protect their property in advance of a flood, reducing damage and disruption and therefore limiting the impact on public health and welfare. 	<ul style="list-style-type: none"> £47.9 million annual flood damage avoided in England & Wales from Met Office services
Cabinet Office	Wind	<ul style="list-style-type: none"> On receipt of Met Office warnings of strong winds, local Emergency Planning departments pass information on to ensure all work stops on high level structures thus saving lives. 	<ul style="list-style-type: none"> 23 lives (£34m) saved in sections of the construction industry in the UK
	Cold	<ul style="list-style-type: none"> In severe weather the Severe Weather Emergency Protocol, triggered by Met Office forecasts, provides key social benefits for the community, saving lives by bringing vulnerable individuals off the street; preventing misuse of the emergency services; and preventing subjectivity from interfering with critical decision making. 	<ul style="list-style-type: none"> Vulnerable lives are saved
	Heat	<ul style="list-style-type: none"> The government's new Heatwave plan relies on Met Office forecasts of severe heatwaves. The 'Heat-Health watch' monitors and assesses the impact of the heat on people's health, in order to save lives. 	<ul style="list-style-type: none"> 31 lives (£45.8m) saved in England and Wales through the 'Heat-Health watch' programme
	Severe weather	<ul style="list-style-type: none"> The Met Office's National Severe Weather Warning Service, combined with the support from its PWS advisors, helps the emergency services and other Cat 1 responders to make critical decisions on the resourcing capabilities of their teams. 	<ul style="list-style-type: none"> Enables emergency services in the UK to achieve efficiency savings of £4.1 million
Civil Aviation Authority	Storms/ice	<ul style="list-style-type: none"> The use of WAFC London, UK TAF and Sigmet data, all provided by the Met Office, allow pilots to divert around storms, avoid turbulence and ice, and proactively manage UK landings. All these Met Office service benefits have helped to dramatically reduce the rate of fatalities from flying. 	<ul style="list-style-type: none"> 20 lives (£29.6m) saved across 60% of the globe through improved weather services
	Wind/storm	<ul style="list-style-type: none"> Using Met Office data (amongst numerous other inputs), commercial flight planning systems are able to identify more cost efficient routes, burning less fuel and making enormous operational cost savings. Improved flight efficiency reduces flight delays. Important environmental benefits are delivered as a result of reduced fuel use. 	<ul style="list-style-type: none"> £95.5 million saved in the UK through improved routeing £3.6 million reduction in flight delays for the UK 352,000 tonnes of CO2 saved across 60% of the globe from reduced fuel use

In addition to the areas of benefit described in detail above, the Met Office provides significant wider value to the rest of its public, defence and civil customers, both fiscal and non-fiscal. Below are just a few examples of some of the benefits provided to a selection of these other organisations, based on the underpinning capabilities of the PWS:

Ministry of Defence (MoD) – The independent capability of the Met Office provides latitude in decision making for the MoD that otherwise would not be possible. Given the consequences both politically and financially of getting these decisions wrong, the value of the Met Office's service is invaluable. In the words of the Under Secretary of State for Defence, “**The Met Office is absolutely crucial in our defence effort**, both in this country and overseas”. Examples of MoD benefit include: Crisis Area Modelling; decisions on the operability of aircraft in Iraq and Afghanistan; bombing techniques; training exercise efficiency; the ability to model the spread of noxious gas in war zones; and air safety within the RAF.

Department for Environment, Food and Rural Affairs (Defra) – The units within Defra gaining the most benefit from the Met Office's services, the Flood Management Unit and the Climate Prediction Unit, are covered in the Environment Agency and a separate Climate Prediction section respectively. Met

Executive summary

Office benefits provided to Defra are confined in this section to the State Veterinary Service, the Nuclear Emergency Response team of Defra, and air pollution.

The benefits to the State Veterinary Service from Met Office's services are two-fold – increased effectiveness and efficiency in the deployment of Defra resource, and a potentially reduced impact from viral disease through more timely identification and mitigation. In the modelling of Blue Tongue spread amongst farm animals, **the Met Office's services are particularly critical in highlighting periods and areas at high risk**. The cost to the UK economy of the Foot and Mouth Outbreak was estimated at being between £5-8 billion in direct cost. Reducing the impact of a Blue Tongue outbreak in the same arena delivers significant financial benefit to the country.

The benefit derived from the Met Office's services to the Nuclear Emergency Response team is primarily evident during nuclear emergency exercises. Benefits can also be modelled on how improvements in Met Office accuracy and speed of response would improve the UK's response to a Chernobyl style incident, the results of which are still being seen today in the form of animal movement restrictions. Should another overseas nuclear accident occur and the weather conditions be less favorable for the UK, the Met Office's services and the Nuclear Emergency Arrangements Team will become critical elements in the UK response. Ensuring specific areas of radiation are located earlier and more accurately will result in an increased efficiency and effectiveness in responding to the event: more efficient use of the emergency services; more efficient disposal of contaminated life-stock; and more efficient clean up processes.

Met Office meteorological information helps to monitor and minimise the impact of air pollution. The Met Office runs two atmospheric pollution services, PACRAM and CHEMET. These are funded by the Department of Trade and Industry, Defra, and the MoD, and provide response to nuclear and chemical events respectively. They provide the emergency authorities with meteorological forecasts, advice and specialist services in the event of a nuclear or chemical release into the atmosphere.

Highways Agency – The Met Office supports the Highways Agency in its objective of facilitating safe and reliable journeys on strategic national routes and reducing the loss of life and injury from road traffic accidents across England. This helps to **save lives and deliver more efficient and improved journeys**, reducing fuel burn and thus delivering environmental and other benefits.

Maritime and Coastguard Agency (MCA) – The Met Office, through the Shipping Forecast and related services, enables the MCA to meet its obligation to the Safety Of Life At Sea (SOLAS) convention, thereby **supporting the safety of individuals and property at sea**. The Shipping Forecast also provides data to in-shore (recreational) sailors who would not otherwise have access to detailed information, again saving lives.

Health Programme (Department of Health) – Using its weather forecast data, the Met Office provides a service to Chronic Obstructive Pulmonary Disease (COPD) sufferers by highlighting periods of exacerbating conditions. During the winter of 2005/06, health practices that used the Health Forecasting service saw a 76% reduction in admissions. Some Primary Care Trusts have estimated savings of £100,000 each, directly attributable to the service. Extrapolated, this would equate to a conservative **NHS saving across England of £7.6m per annum**. The Met Office's Health Programme has also delivered benefits in the field of asthma inducing thunderstorms, and is now looking at models to predict the weather-related exacerbation of heart failures, strokes and mental health problems.

Climate prediction – The benefits to the UK from climate prediction research are enormous. By advising on the extent of climate change, Defra can better prepare the country for dealing with the consequences. However, by providing world class climate prediction output, **the UK is in the enviable position of being able to lead the world in the quest to address climate change**. From a political perspective it ensures that the UK is placed at the centre of global issues and gives the UK a competitive advantage in wider political negotiations. There are also benefits to the MoD in supporting the decision on future equipment requirements and even highlighting where future areas of conflict or humanitarian disaster may occur.

International – The Met Office actively supports the World Meteorological Organisation's (WMO) Voluntary Cooperation Programme, and works closely with other national meteorological services around the world. In doing this the Met Office helps to: improve the protection of life and property from the effects of natural disasters; restore life-critical services when countries have been affected by natural disasters; improve understanding of the effects of global climate change; and archive existing records of countries

which cannot support these activities themselves. The Met Office is also involved in a number of international collaborative projects that play a key part in developing all areas of meteorology. **In these various ways the Met Office supports governments in less developed countries save lives and build capability.**

Conclusion

In conclusion, the study shows that the Met Office impacts multiple areas of modern life and that in both fiscal and non-fiscal terms it is **delivering a contribution to the UK economy which is many times its budget**. First and foremost, this benefit can be seen in the many areas where the public are served by the PWS, as demonstrated by the public valuation of the PWS' weather information. In addition however, as a result of delivering this service to the public, the Met Office provides a substantial contribution to the economy through its work with government departments. This return on investment is a reflection of the outstanding work of the staff in the PWS, and more widely the Met Office, a point which was repeatedly made by the stakeholders interviewed in this study.

Acknowledgements

During the course of this study, the authors interviewed some 60 stakeholders. PA is grateful to them all for their contribution.

2. Introduction and methodology

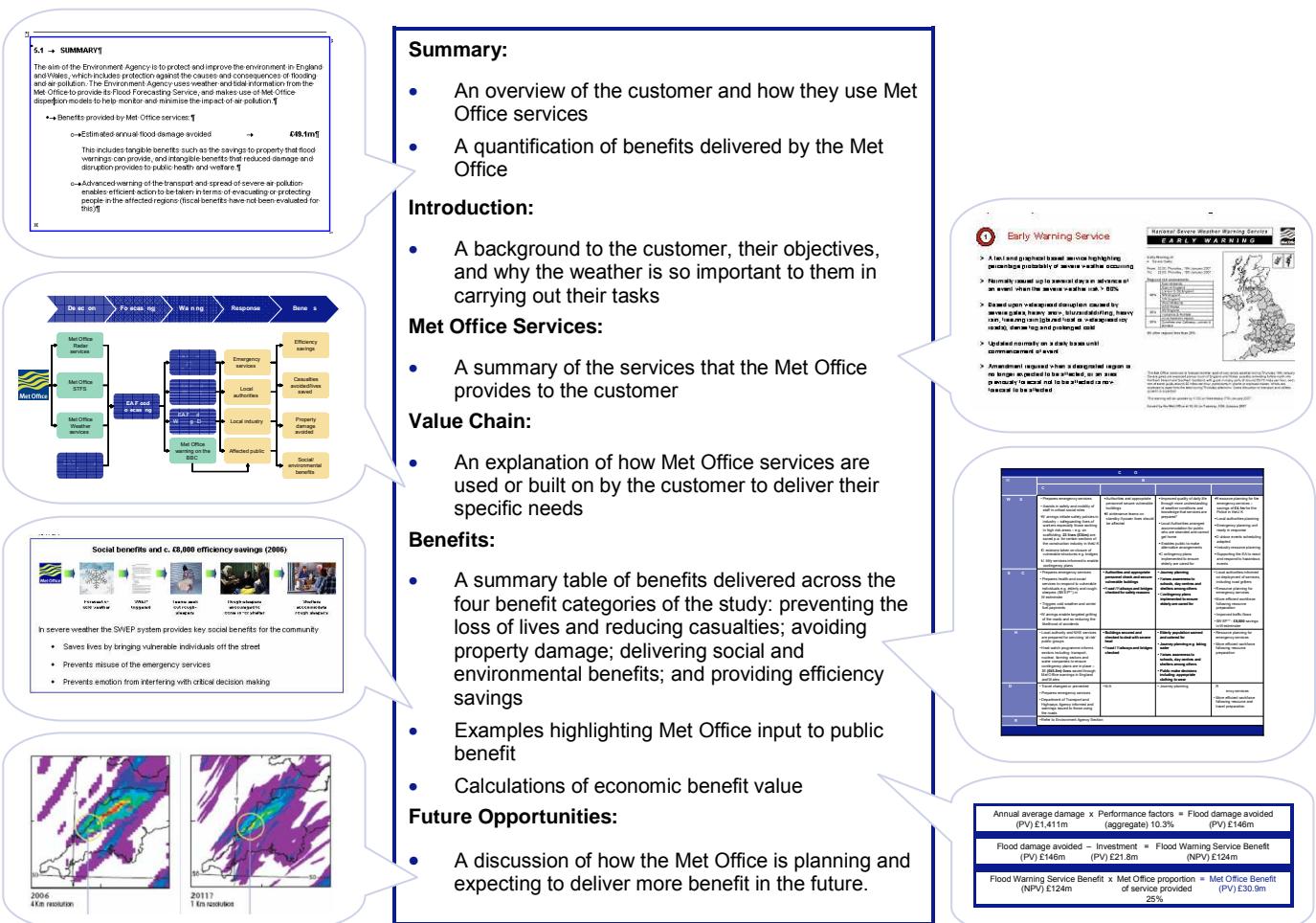
2.1 Purpose

The report was commissioned to assess and demonstrate the economic contribution made by the Public Weather Service (PWS), in its role within the Met Office, to the UK economy.

2.2 Structure of report

The principal aim of the PWS is to deliver an accurate and timely weather forecast to the general public. Section 4 of this report assesses the success of PWS in delivering this objective, and the value that the public and small businesses place on the forecast. However, as a result of providing this, the PWS is able to offer additional services to numerous customers.

The main body of the report (sections 5 – 8) assesses the value provided to some of these numerous customers. It has been written in four sections; three in-depth case studies of specific government departments and a section which describes the benefits of a further seven examples of where the Met Office creates value. The case study sections have been written to provide clear and precise description of the benefits provided, real life examples of benefit value chains, and quantification as to their economic value. Each case study section has the following structure:



Following these case studies, section 8 of the study considers the wider value of the Met Office. It covers five further government customers and two further areas of Met Office benefit. The five examples of wider benefits from government customer reviews (sections 8.1 – 8.5) are structured in a similar way to the case studies, although in a more summarised form. Each section covers: the background to the customer and their relationship with the Met Office; Met Office Services being provided to the customer; the extended service value chain whereby customers use Met Office data to deliver specific benefit; and the benefits delivered to the customer as a result of the service they receive (again broken down across the four benefit categories).

Sections 8.6 – 8.7 discuss examples of benefits of the Met Office not directly delivered through a customer. These include the benefits delivered through the Met Office's work on climate prediction, and the benefits provided by the Met Office to the international meteorological community.

2.3 Methodology

The study first assessed the benefits that the Met Office delivers through meeting its principal objective of providing an accurate and timely weather forecast to the general public and the additional benefit delivered to the owners of small and medium sized enterprises who also use this service. As a result of delivering this service, the Met Office is able to provide its many other customers with weather services, which ultimately deliver economic benefit to the UK economy. To assess the economic value of this, the study used a methodological framework for an evidence-based appraisal. The following sections detail the case study selection and rationale, the method of analysis employed and the core economic assumptions.

Case study and wider examples selection

In order to offer depth of insight, a fiscal valuation, and an appreciation of the breadth of services, the study focused on three government departments and eight further examples of benefit from the Met office. The three organisations which were looked at in detail were:

- Environment Agency (EA)
- Cabinet Office
- Civil Aviation Authority (CAA).

The seven small examples of additional Met Office benefit come from the following:

- Ministry of Defence (MoD)
- Department for Environment, Food and Rural Affairs (Defra)
- Highways Agency
- Maritime and Coastguard Agency (MCA)
- Health Programme (Department of Health)
- Climate Prediction (on behalf of Defra and the MoD)
- The Met Office's role in the international meteorological arena.

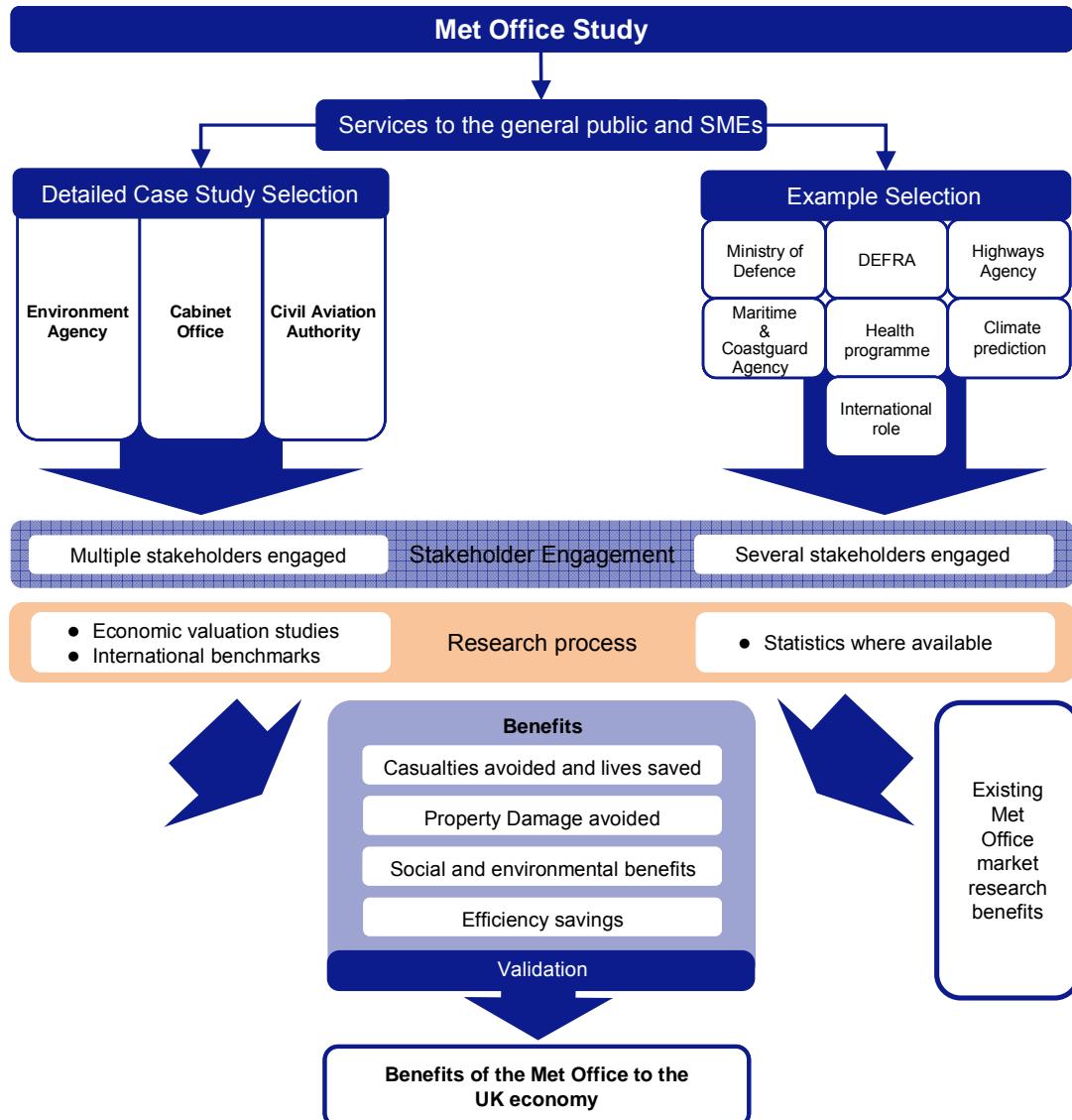
Rationale

The rationale for the case study selection centred on two key aspects:

- Value chain – based on the number and depth of interactions the Met Office services experience through the value chain to the end user / beneficiary
- Benefits – based on the ability to identify measurable outcomes in terms of the range and depth of socio-economic benefits provided to the public from the agency or organisation.

The rationale for choosing the further examples of where the Met Office supports government and society was to demonstrate the breadth of the support provided by the Met Office and the breadth of benefit that the Met Office creates including both fiscal and non fiscal outcomes.

Summary of approach



Method of analysis

In order to structure the findings, the study looked at benefits based on the following:

- Casualties avoided and lives saved
- Property damage avoided
- Social and environmental benefits
- Efficiency savings.

Deriving the benefits

Methodology for the detailed studies

For each case study, a three-stage research process was used:

- Interviews
 - Internal stakeholders: A number of Met Office employees were interviewed who hold key relationships with the external relevant user group
 - External stakeholders: Users and beneficiaries of the Met Office services were interviewed to understand the value chain of information flow and ascertain how the service achieves an economic impact on the UK economy
- Research
 - UK and international benchmarks were consulted from a host of organisations including the US National Oceanic and Atmospheric Administration (NOAA) that have conducted similar socio-economic assessments of their services
 - Published data on severe weather events was sourced to identify the economic impact of the weather on the UK economy
- Collation
 - A validation process was used which drew on all the data points captured from the interviews and research carried out, ensuring that all the information gathered was triangulated as accurate, reliable and credible in line with the HM Treasury Green Book.²

Methodology for the additional benefit examples

For the additional examples of benefit, both internal and external stakeholders were interviewed. Additional statistics were used, where available, to show the benefits that the Met Office provides to the UK economy.

Economic assumptions

For each case study, the monetary value has been expressed in present value terms with the appropriate discount factor, 3.5%, being used with all figures at 2006 prices.³

Where deemed appropriate a monetary value was assigned to a human life. This figure was £1.478m, in line with the methodology used by the Department for Transport in assessing the value of prevention per casualty in road accidents.⁴

To take into account the direct service payments received from the Environment Agency and the Civil Aviation Authority, discount factors of 2.35% and 9.76% respectively were applied to their benefit totals. This represents the direct service payment as a proportion of overall cost to deliver the benefit.

In calculating the economic benefits provided, a prudent approach was taken towards the calculations with the results erring on the side of caution with the aim of being clear, fair and not misleading.

² HM Treasury, *The Green Book: Appraisal and Evaluation in Central Government*, 2003

³ In accordance with HM Treasury, *The Green Book: Appraisal and Evaluation in Central Government*, 2003

⁴ Department for Transport, *Highways Economics Note No.1 2005: Valuation of the Benefits of Prevention of Road Accidents and Casualties*, Office of the Deputy Prime Minister, January 2007. Also: Office of the Deputy Prime Minister, *Economic cost of a fire*, 2004

3. Structure of the Met Office

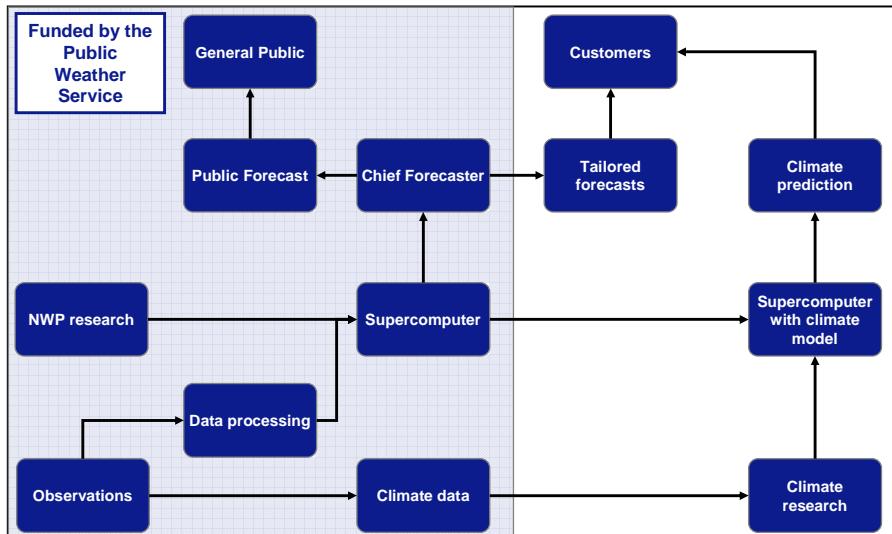
The core role of the Met Office is to deliver the UK National Meteorological Service effectively, efficiently, and against a longer term objective of progressively improving the utility of forecasts to the public. This role is discharged by delivering a Public Weather Service (PWS), which is free-at-the-point-of-use.

Overview of Met Office information flow

The objective of this study was to evaluate the economic contribution of the PWS. Whilst the focus of the analysis is on the particular work carried out by the PWS and the output that it provides, it is clear that it is part of a wider organisation with many different parts providing benefit throughout the value chain.

The study has developed a causal map to show the flows of information and the benefit provided by the interlinking elements of the wider Met Office. This

highlights where the PWS and its computer model sit within the overall structure of the Met Office, and how the Met Office creates value for the public directly, and through its customers.

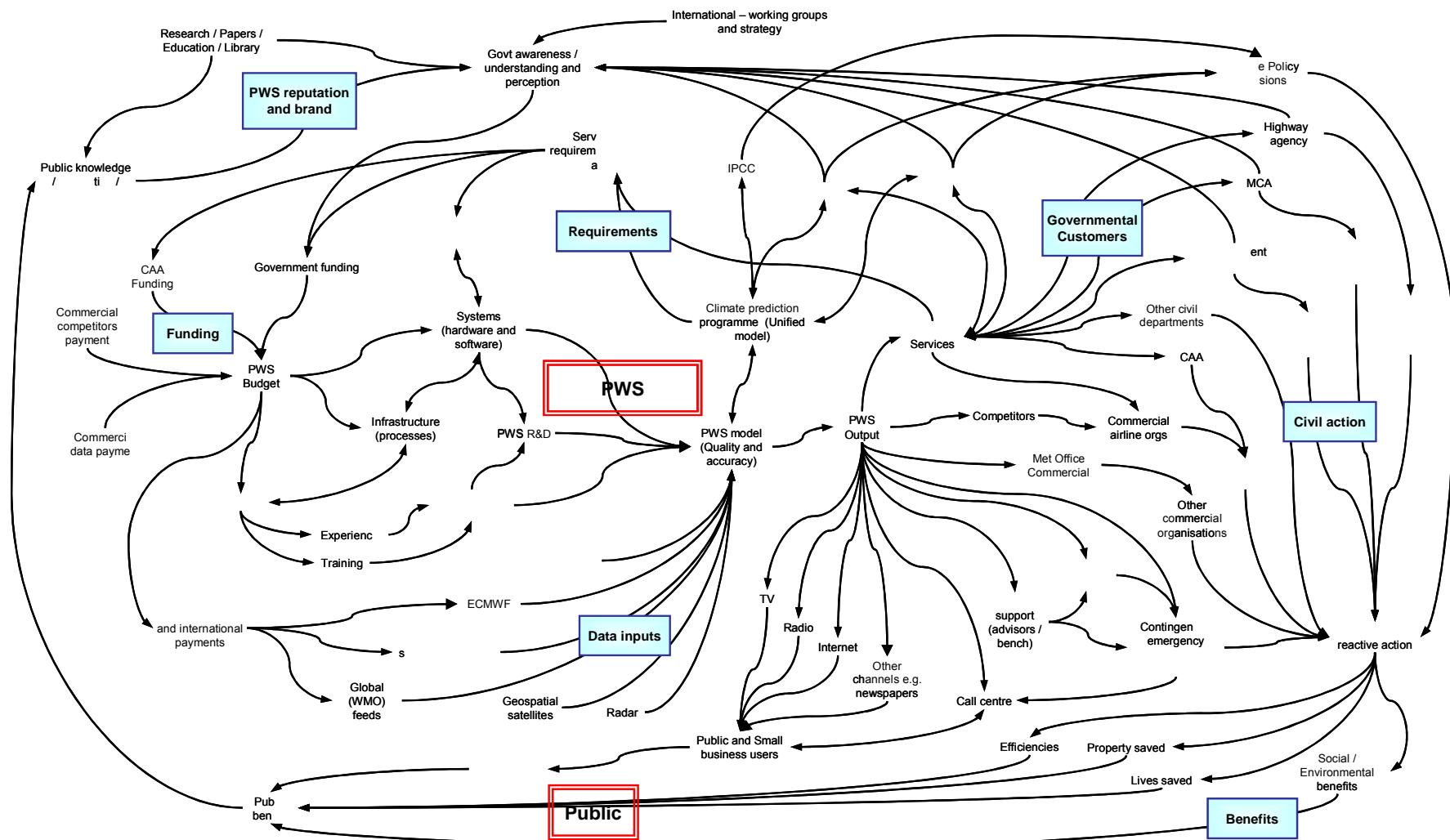


The map shows the major functions that interact with the PWS, as well as the inputs and outputs. The arrows indicate the direction of a flow of data, information or benefit. In some cases information will flow in both directions for example forecasting and other services flow from the Direct Services group to a government agency, and requests for further information or additional requirements will flow in the opposite direction. Ultimately the map shows how the quality of service and in turn benefits and reputation will influence funding for ongoing services.

The three main Met Office functions that should be noted within the diagram are:

- The Public Weather Service (PWS) – concerned with data collection, R&D, analysis, computer modelling and forecasting of weather. Provides the Unified Model with data on which most Met Office outputs are based
- Government Direct Services – concerned with providing value added services in order to support government departments and agencies in their role
- The Climate Prediction Programme – concerned with providing medium to long-term forecasts and policy advice on climate change.

Met Office Causal Map



The causal map highlights a number of key points regarding the provision of forecasting and climate data and the role of the PWS therein:

- The PWS is the hub for the collection of data, the research and development, the computer modelling and the key outputs across the Met Office. Without the accuracy and timeliness of the outputs much of what the Met Office provides would not meet the exacting standards that customers demand
- The PWS is central to all forecasting efforts ongoing at the Met Office. It also funds the primary computer model (Unified Model) which underpins the Climate Prediction Programme, although importantly there is also a flow of insight which moves in the opposite direction as lessons are learnt in the Climate Prediction Programme
- PWS' outputs can be traced back to a complex web of different inputs. These range from the quality and experience of its staff through to the underlying systems and hardware, the innovation of its systems and scientific team, to national and international weather data inputs. Each of these inputs plays an integral part in providing decision making information
- Through its Direct Services, and in the case of the Cabinet Office via a direct relationship, the PWS impacts most of the key government departments. Each of these departments ultimately supports preventative or reactive activity which can be equated to benefit for the economy and the public
- The PWS also has a direct influence over the public's behaviour in response to the weather through the media, its website and its call centre. The media, in particular television, will often start a process resulting in a direct change of public behaviour to minimise risk to life or property, and maximise opportunity for benefit.

In summary, whilst the focus of this study is the PWS, the report uses the title of the Met Office throughout the document to reflect the extended value chain which provides services to the customer. It is the case however, that in all instances the PWS output is the major underpinning element of that service.

4. Services to the general public

4.1 Summary

The Met Office's PWS exists to serve the UK public. It provides significant benefit to the public and small businesses through the weather forecasts and warnings it distributes via the media and other direct channels.

- Some of the benefits provided by direct Met Office services in the UK include:
 - ORC International's estimated benefit to the general public **£353.2m**
 - Additional benefits are also provided to SMEs, particularly those in the construction, agriculture, retail and manufacturing, and leisure and tourism industries. SMEs are able to better plan day-to-day activities and maximise productivity by anticipating customer demand and making significant efficiency savings.

4.2 Introduction

First and foremost, the Met Office's PWS exists to serve the UK public. Whilst the rest of this study concentrates on the public benefit created by the Met Office via various public agencies, this section examines the benefit that the Met Office provides to the public via the media and other direct channels.

"The Public Weather Service (PWS) provides a coherent range of weather information and weather-related warnings that enable the UK public to make informed decisions in their day-to-day activities, to optimise or mitigate against the impact of the weather, and to contribute to the protection of life, property and basic infrastructure."

Met Office website⁵

Weather forecasts and warnings help the general public and industry to plan a wide range of daily activities that are sensitive to the weather. Observations and warnings relating to severe weather are used by the emergency services and the general public to protect lives and property, and are used by industry to improve the efficiency of weather-sensitive organisations. Small businesses in particular use weather forecasts and warnings delivered via the media to help plan their activities and resourcing.

4.3 Met Office services

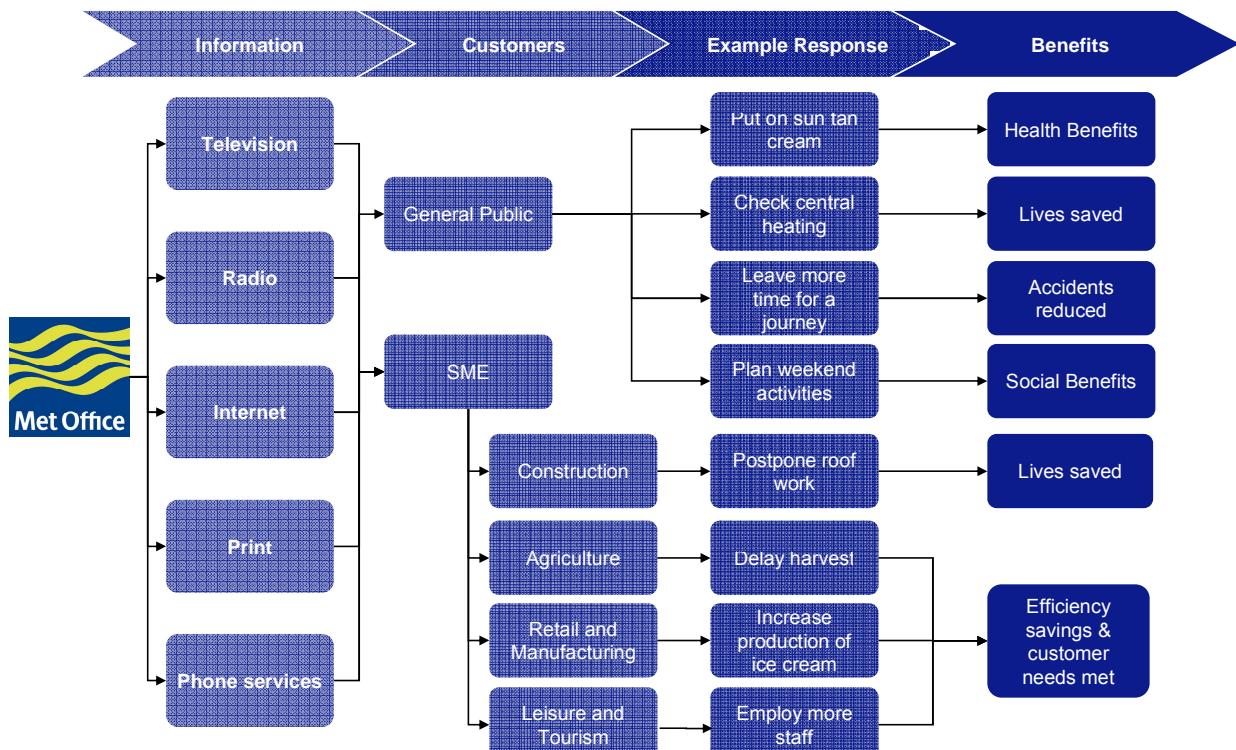
The Met Office provides extensive public weather information and communicates severe weather warnings by a number of methods, including television, radio, print, the internet and telephone, which help both individuals and businesses to plan for the weather.

- **BBC Weather Centre** – 30 Met Office staff produce over 120 weather broadcasts per day with more than 1,000 hours of television and radio per annum. Weather reports for the world are brought to the public 24 hours a day, 365 days a year. The Met Office also provides up-to-date weather information for BBC Ceefax

⁵ <http://www.metoffice.gov.uk/corporate/pws/index.html> [Accessed April 2007]

- **ITV Weather** – The Met Office provides a 'one stop shop' production facility for ITV's weather programming across the network. Graphics and forecasts are supplied by the Met Office, enabling individual regional bulletins to be presented in the ITV house style. ITV Weather accounts for more than 800 hours of weather programming per annum. ITV Teletext also shows up-to-date weather information which it received from the Met Office
- **Other television services** – The Met Office provides additional television weather services to GMTV, Channel 4 and More 4
- **Radio** – The Met Office provides radio services to the BBC and commercial radio channels. This includes providing broadcast meteorologists to present weather bulletins, bespoke services, weather warnings and radio scripts. Met Office meteorologists are also used to provide content within radio programmes, discussions and news bulletins, particularly at times of extreme weather
- **Met Office website** – The Met Office's comprehensive web site provides in-depth weather information, including global weather forecasts and climate information
- **Print** – Met Office forecasts and the Met Office brand are used in a number of weather pages in the UK press. Other services are also provided and printed in the press, such as a monthly synopsis of UK weather and a summary of the weather around Britain yesterday. Met Office meteorologists are also often quoted or interviewed in the press, particularly at times of extreme weather
- **Phone services** – The Met Office's Weathercall service provides daily forecasts direct to an individual by telephone, fax, SMS, Multi Media Messaging or WAP, as purchased by the user. Its Marinecall service provides the latest marine forecasts and warnings by telephone or fax. The Met Office also provides a 'Talk to a forecaster' chargeable service where the public can talk directly to a Met Office forecaster 24 hours a day to get a forecast up to 5 days ahead. In addition, the Met Office provides 'Mountain area forecasts' for the main areas of higher ground around the UK to members of the public who call their customer centre.

4.4 Value chain



The most recognised Met Office services used by the general public and SMEs are the regular weather forecasts and warnings provided by the media, which are used and provide benefit in a number of ways.

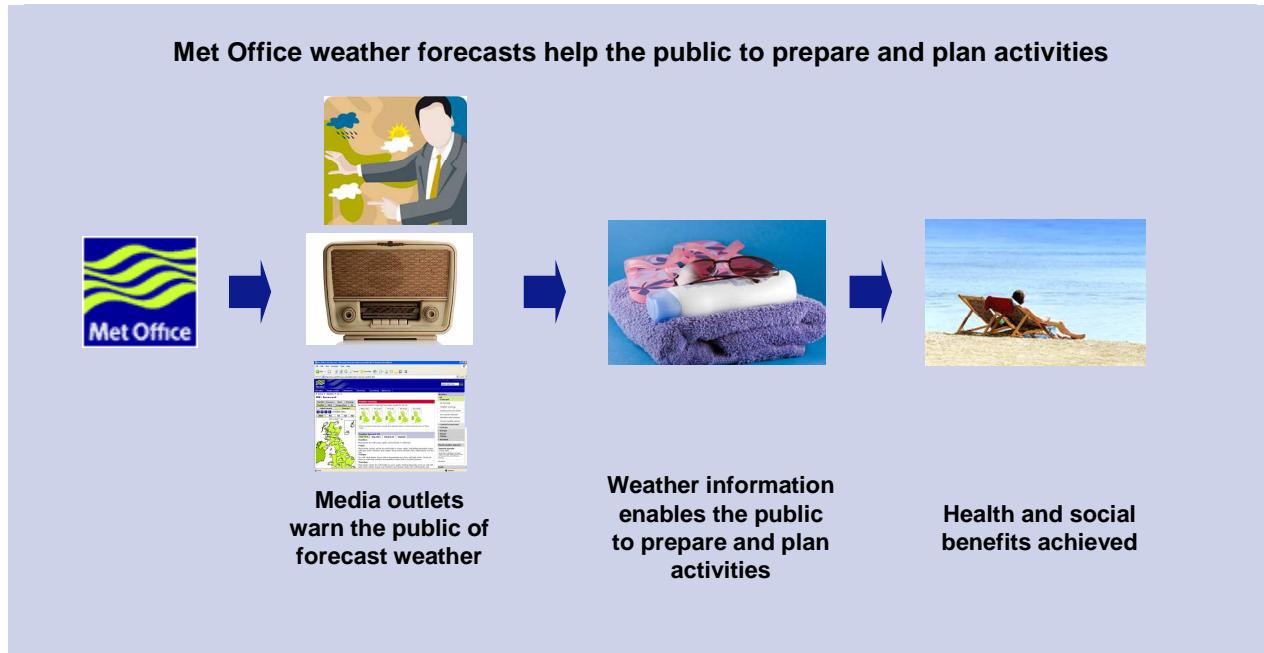
4.5 Benefits

General Public

ORC International carried out consumer research on behalf of the PWSCG to examine national public perceptions towards Met Office services.⁶ From September 2006 to March 2007, an unbiased cross-representative sample of 2,833 UK adults was interviewed. Of this sample:

- 83% believed that the Met Office provided a valuable service to the public
- 36% stated that the weather forecast had some influence on the activities they chose to take part in
- 69% believed the forecast to be more accurate than it was 5 years ago.

As would be expected, the vast majority of citizens received their weather forecast through the media. Television was the most common method of receiving information, with over 66% of people regularly receiving a forecast through this medium. Radio and internet sites were also popular methods of accessing the forecast.



When ORC International asked members of the public in their sample group how much they felt the Met Office service was worth to them in monetary terms per year, the average amount provided by the response equalled £7.30 p.a. Extrapolating this figure to the rest of the UK, based on the current UK adult population of 48.4m,⁷ provides a total value of £353.2m for Met Office services provided direct to the UK public.

$$\begin{array}{l} \text{Average annual worth per} \\ \text{adult in the UK} \\ \text{£7.30} \end{array} \times \begin{array}{l} \text{Current UK adult} \\ \text{population} \\ 48.4\text{m} \end{array} = \begin{array}{l} \text{Met Office} \\ \text{Direct Public Benefit} \\ \text{£353.2m} \end{array}$$

Source: ORC International

⁶ ORC International, *Met Office National Survey*, September – March 2007

⁷ Based on July 2006 estimate sourced through the CIA

International benchmarks

Similar studies have been conducted in other countries which further demonstrate the benefits that weather forecasts and warnings provide for the general public. The figures provided by international research suggest that the UK value supplied by ORC International's 2007 research is only a conservative amount. The UK value of £7.30 per adult is far below the estimated values from other countries, which range from £12.50 in Australia, to £65.60 in Ontario, Canada.

For ease of comparison, all values in the table below have been converted to 2006 GBP, on a per adult basis (16+ years):

Type of information	Annual value of Weather Information per adult	Source
Australian Public Weather Service	£12.50 in Australia	Anaman and Lellyet (1996)
Ontario Canada public weather forecasts	£65.60 in Ontario, Canada	Brown (2002)
NOAA weather service	£28.00 in the USA	Stratus Consulting, Inc (2002)
Willingness to Pay research	£35.10 in the USA	Lazo and Chestnut, 2002

Source: Houston, Adams and Weiher, *The Economic Benefits of Weather Forecasts*, May 2004

Small and medium sized enterprises (SME)

Many small and medium scale businesses rely on weather reports to make decisions which directly affect their profitability and contribution to the UK economy.

Examples of such sectors where knowledge of the weather is critical include:

- Construction
- Agriculture
- Retail and manufacturing
- Leisure and tourism.

Although many of the larger companies within these sectors receive a commercial service for meteorological data, smaller companies are reliant on the information they receive from the Met Office via the media and other publicly available services.

Some examples of the benefits provided by the Met Office's public services to different SME sectors are shown below:

Example of users	Use	Examples of benefits
Construction	Used for safety purposes, risk management, and resource and construction planning. Historic weather reports may be purchased to help settle contractual claims.	Enables managers to agree necessary weather stops in advance with the client, enabling more effective safety precautions and risk management, as well as more efficient, cost-effective resource planning.
Agriculture	Used for planning and monitoring many activities, including planting, crop spraying, irrigation and harvesting.	Helps farmers/growers to schedule work and manage day-to-day activities more efficiently. Minimises any losses relating to the weather and maximises productivity and profitability.
Retail and Manufacturing	Used for planning day-to-day activities, stock levels, resources, promotions and marketing activity for weather-dependent products.	Retailers and the supply chain able to meet weather-driven customer demands through effective stock planning. Promotions and marketing activity timed for maximum impact. Further increases profits by reducing wastage and improving resource scheduling.
Leisure and Tourism	Used for planning day-to-day activities, stock levels, resources and marketing for weather-dependent activities and events. Used to keep customers informed about expected weather at specific destinations.	Enables weather-related activities to be planned and marketed accordingly, impacting on resource planning and stock purchasing. Businesses able to mitigate against any possible costs that could be incurred. Boosts business if customers able to plan activities and clothing requirements in advance.

Source: PA Consulting; Met Office; Ministry of Transport and Energy, *Meteorology – a Revenue Generating Science*, March 2006

In February 2006, ORC International conducted a research study on behalf of the PWSCG into the impact of the weather on SMEs. 501 small and medium sized organisations were interviewed from the construction, farming, retail, pub/restaurant, leisure and tourism industries.

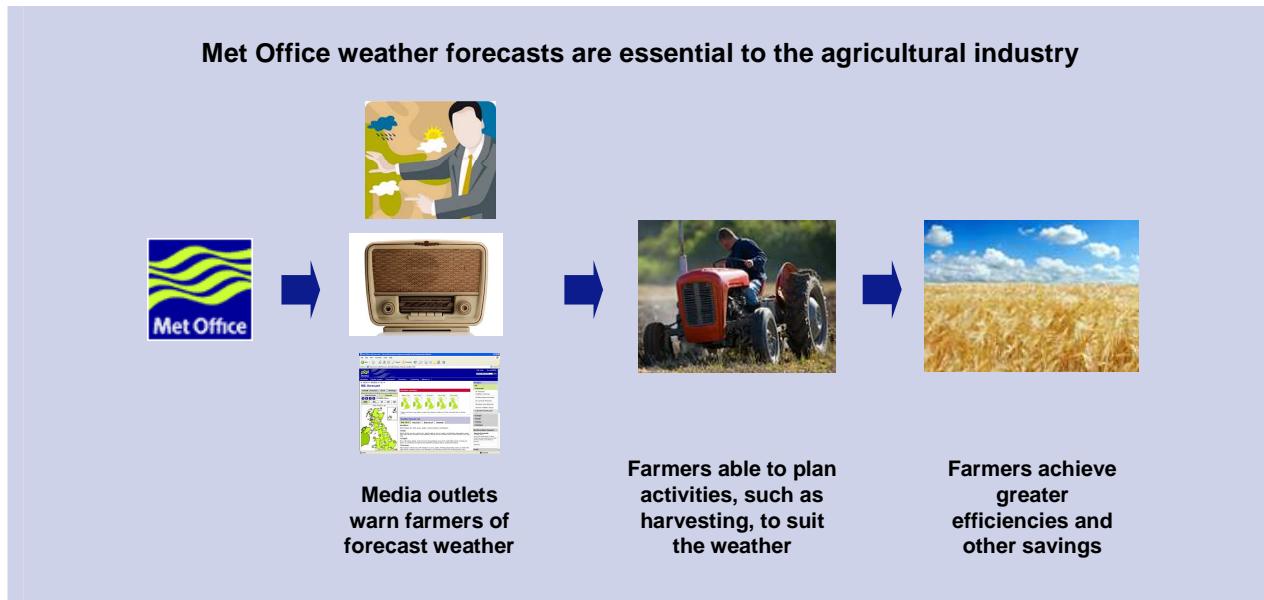
- 70% checked the forecast at least once per day, usually via the television, followed by the internet, radio and press
- 91% said that the weather forecast had an impact on their business activities, with 53% stating that the weather forecast had 'a lot' of impact on their activities
- 70% believed that weather forecasts had become more accurate over the last 5 years.

The farming industry are most impacted by the weather, with 89% stating that the weather forecast had 'a lot' of impact on their business activities. After farming, most impact from the weather was felt by businesses in the leisure, construction and retail industries.

Over 85% of all businesses interviewed by ORC International used weather forecasts to help:

- Plan day-to-day business activities
- Maximise company profitability
- Anticipate demand for products and services
- Ensure the safety of staff and customers
- Plan longer term business activities
- Effectively manage staff resources.

The numerous different actions taken across a number of industry sectors demonstrate how Met Office services deliver enormous efficiency savings to the UK.



Impacts to SMEs from poor weather can be huge, and therefore the value of weather forecasts in allowing business owners to plan in advance is very great. The UK government's rural advisor estimated that the particularly wet weather of August 2004 cost farmers approximately £1bn, based on an estimated £100 per acre. In that month there were only 10 days in which harvesting was possible, compared to a typical August in which 25 harvesting days would be possible.⁸

A study into the impact of the hot weather of 1995 on agriculture was completed by the Climatic Research Unit of the University of East Anglia. The impact of a 3°C above average temperature in June, July and August was estimated to cost farmers in the UK approximately £180m. Although this would provide some gains to arable crops (£30m), large losses (£210m) were estimated in livestock farming, fish farming and vegetable production as a result of the increased investment required for cooling and irrigation.⁹ The hot weather of 1995 also impacted small businesses selling and manufacturing clothing. Sales for the seven consecutive months from August to October fell 0.7% compared to the same period in 2004, due in part to particularly warm weather.¹⁰

4.6 Future plans

Its growing range of communication methods, combined with its increasingly accurate and reliable forecasts, means that in future the Met Office's services will provide even greater benefit to both the general public and industry. Plans are under way for the Met Office's current 4km resolution model to be upgraded by 2011 to 1km resolution, which would provide an even higher degree of forecasting accuracy.

⁸ MeatProcess.com, *Bad weather could cost UK food production £1 billion*, 1 September 2004 <http://www.meatprocess.com/news/nq.asp?id=54441-bad-weather-could> [Accessed April 2007]

⁹ Climatic Research Unit, University of East Anglia, *Impacts of the Exceptionally Hot Weather of 1995 in the UK*, 1997 <http://www.cru.uea.ac.uk/cru/projects/wise/cmpaper/article.pdf> [Accessed April 2007]

¹⁰ BBC News, *Warm weather hurts retail sales*, 8 November 2005 <http://news.bbc.co.uk/1/hi/business/4416724.stm> [Accessed April 2007]

5. Case study 1: Environment Agency

5.1 Summary

The aim of the Environment Agency (EA) is to protect and improve the environment in England and Wales, which includes protection against flooding, and cleaner, healthier air and water, both now and in the future. The EA's main use of the Met Office is through weather and storm tide information which it uses to provide its Flood Forecasting Service.

- Some of the main benefits provided by Met Office services in England and Wales include:
 - Estimated annual flood damage avoided **£47.9 million**
 - This includes tangible benefits such as the savings to property that flood warnings can provide, and intangible benefits that reduced damage and disruption provides to public health and welfare.

5.2 Introduction

"We are the leading public body for protecting and improving the environment in England and Wales. It's our job to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world."

Sir John Harman, Chairman of the EA

The EA has around 12,000 members of staff and, for 2007-08, a budget of £1bn. They are an independent public body – 61% of funding comes from government, with most of the rest from various charging schemes.

The EA's role involves: protecting people from flood; taking action against environmental offenders; looking after wildlife; restoring rivers and lakes; and influencing and working with government, industry and local authorities to make the environment a priority.

Flooding

Met Office data inputs directly into the National Flood Forecasting System run by the EA, which also uses other inputs such as telemetry data to monitor rainfall, ground water, sea and river levels. Similar services on a smaller scale are also provided by the Met Office for the Scottish Environmental Protection Agency and the Northern Ireland Rivers Agency, but are not assessed here.

"Around 5 million people, in 2 million properties, live in flood risk areas in England and Wales. The Environment Agency has an important role in warning people about the risk of flooding, and in reducing the likelihood of flooding from rivers and the sea."

EA website¹¹

Emergency responders to flood events include the police, fire and rescue service, and ambulance service, in liaison with emergency planners in local authorities and the EA. At the national level, Defra is the lead department for planning for flood emergencies.

The EA's flood risk management activities and services include:

- Floodline – a telephone helpline providing advice on preparing for a flood, and what to do if one happens
- Flood Warning including Floodline Warnings Direct – online information for each area and free flood warnings direct to the public by telephone, text, fax or pager and also by sirens, loudhailers and broadcast media.
- Flood risk maps – maps to show where flood defences are located and increase awareness of the likely extent of flooding, to encourage people in areas prone to flooding to take appropriate action
- Catchment Flood Management Plans and Shoreline Management Plans – plans to assess the affect of river and sea flood defences in a wide area
- National Flood and Coastal Defence Database – flood and coastal defences data to assist all operating authorities with flood and coastal erosion management.
- Building and maintaining its flood defences to reduce the chance of flooding.

5.3 Met Office services

The EA's main use of Met Office information is to improve flood risk management to protect people from flood.

"We use the latest technology 24 hours a day to monitor rainfall, river levels and sea conditions. Combined with weather data and tidal reports from the Met Office, we can provide local area forecasts on the possibility of flooding and its likely severity. Our operational teams remain on standby to determine which of our defences to operate and when, working round-the-clock until the threat of flooding has passed."

EA website¹²

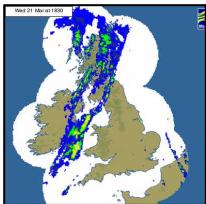
The Met Office has three main contracts with the EA, as well as other ad hoc activities and services:

- Radar Services
- Storm Tide Forecasting Service
- Weather Services
- Ad hoc activities and services.

¹¹ http://www.environment-agency.gov.uk/subjects/flood/?lang=_e [Accessed March 2007]

¹² <http://www.environment-agency.gov.uk/homeandleisure/floods/31680.aspx> [Accessed March 2007]

Radar Services



The Met Office provides management and supervision of the Joint Radar Installations to provide actual and forecast rainfall data to assist the EA in flood forecasting and monitoring. The seven radars within the network are jointly owned by the EA and Met Office.

Data are provided every 5 – 60 minutes depending on the radar:

- The Met Office's Nimrod model provides fine resolution analyses and six-hour forecasts which include precipitation type, rainfall rate, rain accumulation, snow probability, cloud and wind gust speeds.
- The Met Office's Gandolf model currently provides the best available very short-range forecast of rainfall intensity at 2km resolution.

Radar data feed into 'nowcasting' (forecasting out to 6 hours), with T+3 hours forecasts also predominantly driven by radar data. Radar Services also cover 36 hour rainfall, which is targeted at providing flood warning information.

Storm Tide Forecasting Service (STFS)

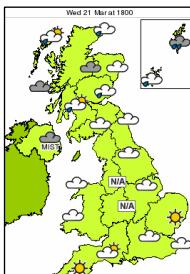


The STFS provides the EA with forecasts of coastal flooding, surge and wave activity, as well as warnings of developing hazardous situations.

The STFS provides the warnings which may influence decisions on the closure of the Thames Barrier, which is the responsibility of the EA.

The STFS model was owned and funded by the EA but is provided by the Met Office. It is fed by two main sources of data from the Met Office; 1) Wave data; and 2) Atmospheric data (largely wind). Met Office data feeds into coastal flood forecasting models, which are run by the EA.

Weather Services



Weather Services support the EA to forecast flooding that enables them to issue flood warnings. The Met Office provides bespoke daily national and regional weather forecasts to the EA's national and regional flood forecasting centres. This covers 'nowcasting', including heavy rainfall up to 6 hours in advance, and 36 hours flood forecasting. The Met Office contacts the EA's Regional Flood Forecasting Officers to bring special attention to any relevant aspect of, or variation to, a Heavy Rain Warning.

Data is used to: plan operational activity; plan when to open incident rooms; input into flood forecasting models; input into water resources ground water modelling; and assist in the management of water resource usage (i.e. supply and demand).

Ad hoc activities and services



i. Rain gauges

The EA collects approximately 86% of raingauge data in England and Wales and provides this data free of charge to the Met Office.¹³ The Met Office quality controls this data and sends it back to the EA free of charge. The EA sends a subset of hourly rainfall data to the Met Office in real time which is used to support improved calibration of weather radar products. The Met Office and the EA carry out joint rain gauge inspections. These activities are carried out as part of a long standing informal arrangement which is under review.

¹³ EA Head of Flood Risk Management Process

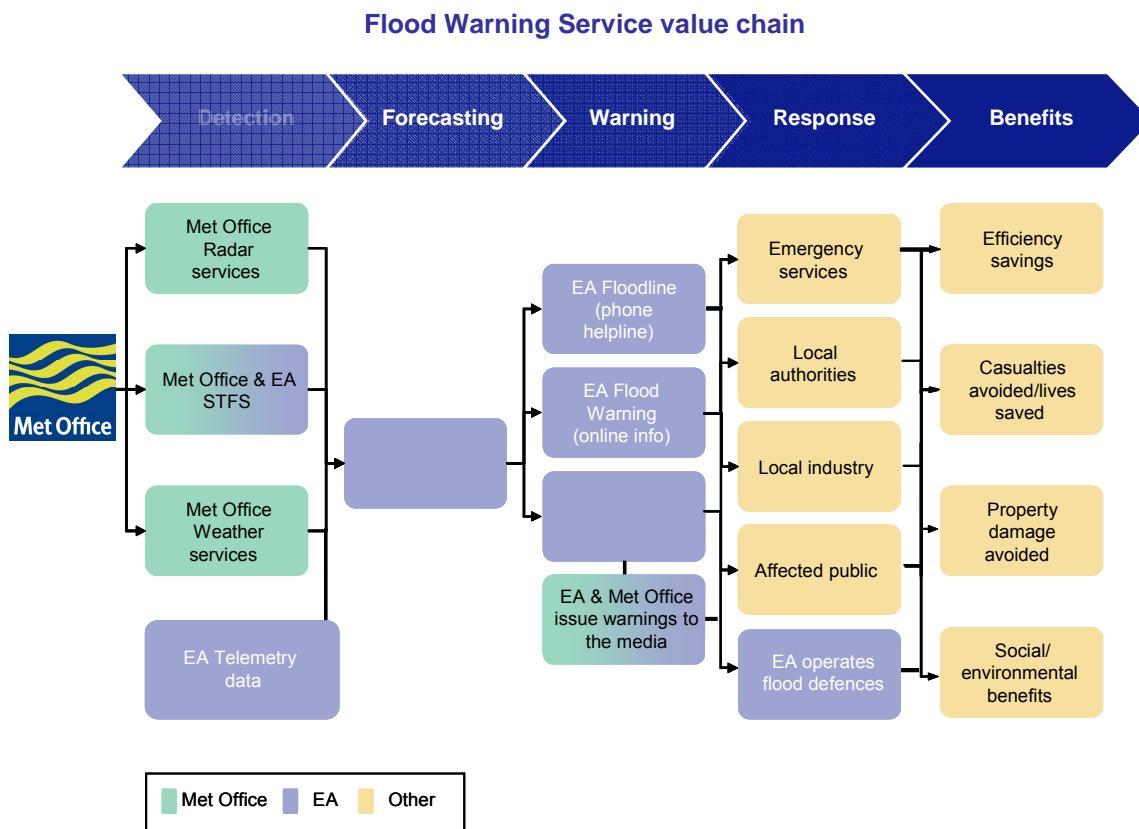
ii. Projects

Where there is some mutual benefit, the EA may jointly fund some additional projects, such as improvements in radar quality. The EA may also call on Met Office climate prediction data to avoid costly over or under-design of new flood defences.

5.4 Value chain

Defra and the EA work with Regional Resilience Forums to improve awareness, planning and capabilities for responding effectively to flooding. Defra and the EA also work with the Civil Contingencies Secretariat at the Cabinet Office to help central government identify the national capabilities needed to assist local responders.

The Met Office's services provide weather data and storm tide reports which are provided to the EA's National Flood Forecasting System (NFFS). The NFFS predominantly relies on telemetry data inputs to monitor rainfall, ground water and river levels.



i. Detection and Met Office Forecasting

Flood detection information is provided by the Met Office combined with EA monitoring sites. Rainfall conditions are monitored by the Met Office from networks of rain gauges and weather radar, sea and river levels. Meteorological observation networks and forecasting are also provided for the advance prediction of rainfall. The Met Office forecasts exceptional tide levels, wind conditions, pressure and other variables to provide advance forecasts of sea conditions.

ii. Forecasting

Two types of flooding are forecast by the EA using Met Office data, river (fluvial) flood forecasting and coastal flood forecasting.

River flood forecasting

Fluvial flood forecasting is mainly derived from the conversion of measured water levels and predicted/actual rainfall through time. The EA's NFFS incorporates complex variations that can affect the propagation of a flood. This is used to determine the extent and depth of flooding at different locations, and the effect that this will have for different areas of property at risk.

The lead-time of forecasts ahead of flooding depends largely on the position of the flood-risk area from the head of the river. Most of the larger urban areas at risk of flooding in England and Wales are on the middle to lower reaches of rivers. Floods on the largest rivers in England and Wales, such as the Severn and the Thames, can take several days to reach lowland areas.

Coastal flood forecasting

On the coast the cause of flooding is usually from high tides and waves overtopping defences, either natural or man-made. The EA funds the UK National Tide Gauge Network which measures and archives sea levels around the UK coast. Storm surges are caused by the combination of atmospheric conditions and tidal state and are usually accompanied by strong winds that cause severe waves. The Met Office's STFS provides daily forecasts of surge and wave conditions that are used by the EA, in combination with tide levels, EA flood forecasting and local knowledge, to provide coastal flood warnings.

Storm surge of 1953

The greatest storm surge on record for the North Sea occurred on 31 January and 1 February 1953. The surge height reached 2.97 m in Norfolk and 3.36 m in the Netherlands. 1,835 people drowned in the Netherlands and 300 drowned in England. Across south-east England 24,000 houses were damaged and 180,000 acres flooded. From Yorkshire to the Thames Estuary, coastal defences had been pounded by the sea and gave way under the onslaught.

The Met Office developed its STFS in response to the events of 1953. The weather data available at the time of the 1953 event were recently re-analysed by the Met Office's numerical prediction models, and the results showed accurate predictions of the movement and intensity of the storm surge.¹⁴



iii. Warning

A number of services are provided to warn those likely to be affected by a forecast flood, advising them of the likely timing and severity. The EA issue flood warnings to media outlets and its Floodline telephone helpline and Flood Warning online information provide up-to-date information to the public. The Floodline Warnings Direct service also enables the EA to contact those who have enrolled in the service by telephone, mobile, fax, pager, siren, loudhailer and radio broadcasts when their area is expected to flood.

¹⁴ <http://www.metoffice.gov.uk/corporate/pressoffice/anniversary/floods1953.html> [Accessed March 2007]

iv. Response

Response covers not only the response by emergency services and others to provide assistance in flood events, but also the response by the at-risk community to move property, valuables and themselves out of harms way. General public awareness of the risk of flooding, its consequences and how to deal with it was historically very low, which is why the EA has been undertaking public awareness campaigns since 1996.

"Despite major advances in understanding and early warning of high impact weather events, reducing vulnerability and increasing opportunity depends on effective societal response. This requires increased knowledge about the likelihood, consequences, imminence and presence of high impact weather, and the empowerment of individuals, communities, economic sectors, public authorities and the public in general with that knowledge to lower the vulnerability before high impact weather events, and to respond effectively immediately afterwards."

WMO Secretariat, Benefits of Meteorological and Hydrological Services

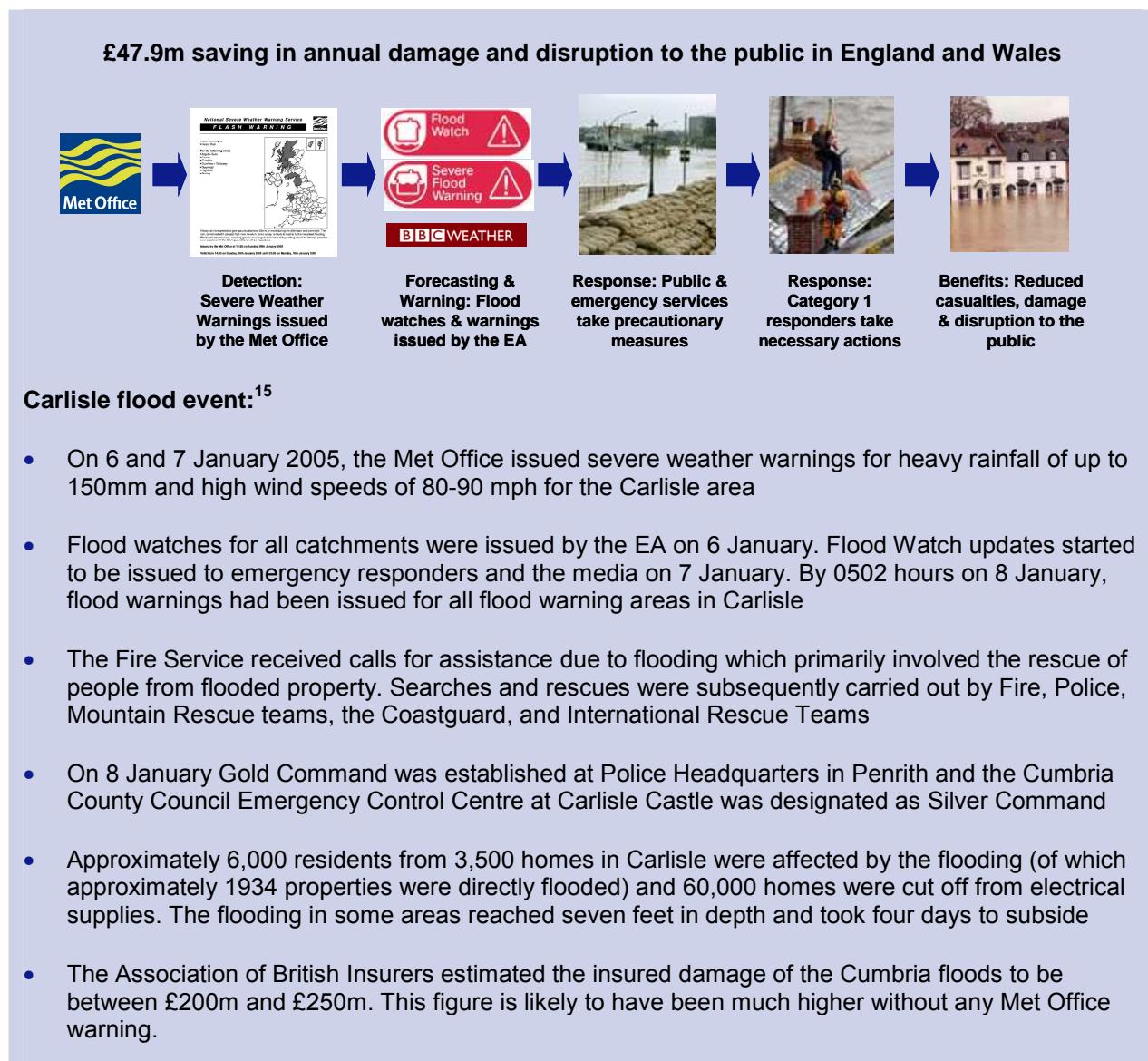
5.5 Benefits

Timely flood warnings can bring significant benefit to the public in a number of areas:

Environment Agency				
Event	Benefits (England and Wales)			
	Casualties avoided / Lives saved	Property damage avoided	Social / environmental benefits	Efficiency savings
Flood	<ul style="list-style-type: none"> Timely flood warnings enable the public, particularly vulnerable people such as children, the elderly and the disabled, to be protected and moved out of harm's way Reduced damage from flood means reduced risk to the public. 	<ul style="list-style-type: none"> The capital value of assets at risk is estimated to be approximately £240 bn (2006 prices) Almost 2.3 million properties could be affected by flooding from rivers and the sea in England and Wales Flood warnings enable people to better protect their properties with sandbags and put temporary flood barriers in place Met Office benefit to property from flood prevention = £31m 	<ul style="list-style-type: none"> 4 - 5 million people could be affected by flooding and erosion in England and Wales Reduced casualties and property damage minimises the severity of distress caused by flooding Met Office intangible social benefits (health, welfare etc) provided through flood prevention = £18.1m 	<ul style="list-style-type: none"> Resource planning for the emergency services and local authorities Resource planning for drainage clearance Business continuity plans able to be put in place Transport decisions able to be reviewed in advance.

Source: PA Consulting analysis; National Appraisal of Assets at Risk (Defra, 2001); National Flood Risk Assessment (EA, 2006)

The Met Office delivers substantial benefit to the public via the services it provides the EA.



"It has been estimated that over 5% of the people in England live lower than 5 metres above sea level, including large parts of our major cities such as York and London. It has also been suggested that about 7% of the country is likely to flood at least once every 100 years from rivers. In addition, approximately 30% of the coastline is developed and around 1.5% of the country is at risk from direct flooding from the sea."

EA website¹⁶

In 2004 the EA delivered an appraised 10-year investment strategy detailing the annual cost of flood damage, and a valuation of the estimated flood damage avoided from each investment option.

¹⁵ Preparing for Emergencies in the North-West, *Carlisle storms and associated flooding: Multi-agency debrief report*, 14 July 2005

¹⁶ http://www.environment-agency.gov.uk/commondata/acrobat/dtir_guide.pdf [Accessed March 2007]

The EA's ten-year (2003/04 to 2012/13) Flood Warning Investment Strategy identified the total investment recommended for the Flood Warning Service, as well as the total financial benefit provided by the service to England and Wales. The EA's methodology used and the values provided in their report were approved by Defra and HM Treasury in April 2004. This methodology is now under review, though it remains the best cost benefit data currently available.

The EA identified 33 different inputs which make up the Flood Warning Service and allow it to operate. These are grouped into five different categories: Management; Detection; Forecasting; Warning; Response. The "Detection" category relies in part upon data provided to the EA by the Met Office:

- Weather Radar Development
- Weather Services
- Weather Radar Data
- STFS/Gauge Network.

The EA suggests that services provided by the Met Office comprise approximately 15% of the Fluvial Flood Forecasting service, and approximately 35% of the Tidal Flood Forecasting service. As the EA weights both services equally, this represents a total contribution by the Met Office to all Flood Forecasting Services of 25%.

Direct annual benefit provided by the Met Office to the Flood Warning Service

Expected annual damages to property from flooding in England and Wales were estimated to be worth £1.4bn in 2006.¹⁷ This excludes damages to infrastructure, social impacts and environmental damages. Using the EA's methodology within its Flood Warning Investment Strategy document, this represents a total direct annual average Met Office benefit to the EA's Flood Warning Service of £30.2m.¹⁸

Total estimated annual benefit provided by the Met Office to the Flood Warning Service

The direct benefit figure of £30.2m provided above is based on expected annual damage to properties from flooding in England and Wales. Because flooding also causes intangible damages to health and welfare, a 50% uplift was added by the EA in their Flood Warning Investment Strategy to the Annual Average Damage figure. When using the same methodology here, this equates to a total 2006 annual average damage figure of £2.1bn, which results in the total estimated Met Office value provided of £47.9m.

Annual average damage x Performance factors = Flood damage avoided (PV) £2,117m	(aggregate) 10.3%	(PV) £218m
Flood damage avoided – Investment = Flood Warning Service Benefit (PV) £218m	(PV) £21.8m	(NPV) £197m
Flood Warning Service Benefit x Met Office proportion of service provided x Direct Service Discount Factor = Met Office Benefit (PV) (NPV) £197m x 25% x 97.65% = £47.9m		

The EA's performance factors measure the performance of the Flood Warning Service, based on the proportions allocated in the National Flood Risk Assessment report. These proportions include the possible pre-flooding action taken to reduce a flood event; the proportion of properties offered a flood

¹⁷ EA, *National Flood Risk Assessment 2006*, February 2007

¹⁸ The calculations are: Expected annual damage PV (£1,411m) * Performance factors (10.3%) = £146m Flood damage avoided PV. Flood damage avoided PV (£146m) – Investment PV (£21.8m) = £124m Flood Warning Service Benefit NPV. Flood Warning Service Benefit NPV (£124m) * Met Office proportion of services provided (25%) * 0.9765 (Direct Service Discount Factor) = £30.2m Met Office Benefit PV to property.

The Investment figure represents 10% of the 10-year investment (PV) amount detailed in the National Flood Risk Assessment report. Performance Factors measure the performance of the Flood Warning Service, based on the proportions allocated in the National Flood Risk Assessment report.

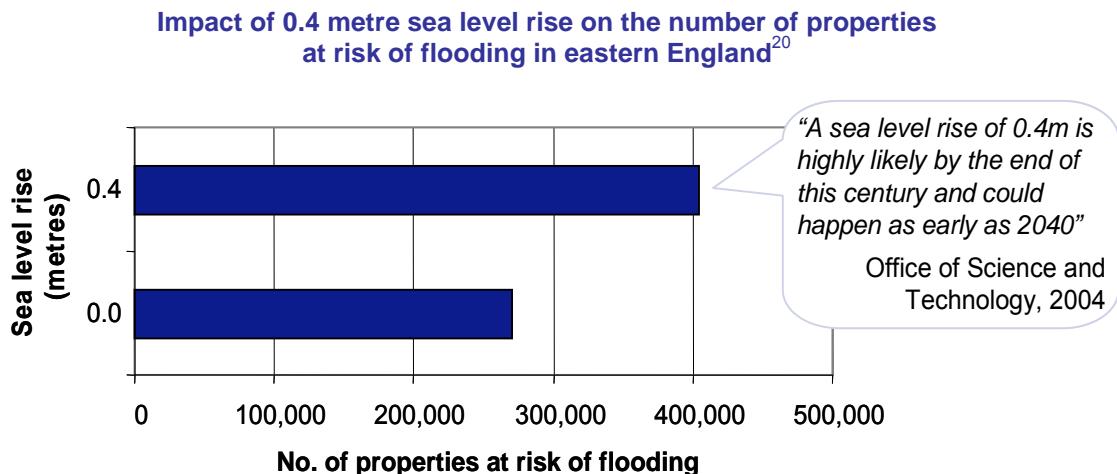
warning system; properties sent and receiving reliable and accurate flood warnings; residents able to respond to flood warnings; and the proportion of properties actually taking preventative action. Note that the benefits provided to the public by the EA, and by extension the Met Office, can only be realised if the public and professional partners act on the warnings provided.

5.6 Future plans

The value provided by the Met Office to the EA is expected to increase significantly in the future as climate change increases the instances of flooding and coastal erosion, and as the Met Office's capabilities expand.

Climate change impact on flooding

The Association of British Insurers estimates that climate change will increase flood risk on the coast through rising sea-levels and storm-surge heights, inland through increases in seasonal rainfall, and in urban areas through increases in rainfall intensity (flash-floods).¹⁹ In 2004, the government's "Foresight Future Flooding" report predicted that climate change will lead to rising sea levels and may increase the chances of extreme storm surges in the North Sea.



In 2003/04, tangible annual average damage caused by flooding in England and Wales was £784m. In 2006 it was estimated to be £1.4bn, and this trend is expected to worsen.²¹

The increased risk of flooding in the UK suggests even more potential benefit from the Met Office forecasts provided for the EA Flood Warning Service. A recent speech by the Minister of State for Climate Change and Environment reports that the Thames Barrier is expected to close 30 times a year by 2030, and some 70 times a year by the 2080s – compared with only around 5 times a year currently. The Met Office is providing its climate prediction work into the EA's Thames Estuary 2100 project, which aims to determine the appropriate level of flood protection needed for London and the Thames Estuary for the next 100 years.²²

¹⁹ Association of British Insurers, *Coastal Flooding: Future Risks and Investment Requirements*, November 2006

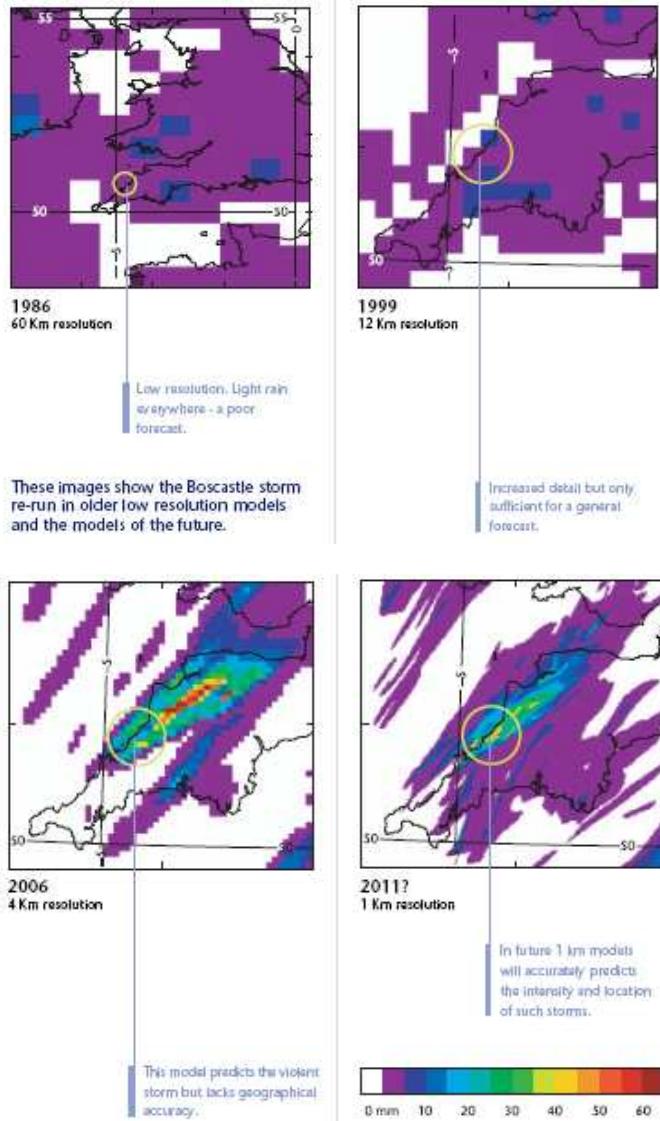
²⁰ Office of Science and Technology, *Foresight Future Flooding*, 2004

²¹ EA, *Flood Warning Investment Strategy Appraisal Report*, October 2003; EA, *National Flood Risk Assessment 2006*, February 2007

²² Keynote speech by Ian Pearson MP, Minister of State for Climate Change and Environment, at the UK Climate Impacts Programme User Forum, Oxford, 15 March 2007

Improvements to the Unified Model

In 2006 the updated Unified Model was run retrospectively to greater accuracy on the 2004 Boscastle flood event. Should super computers with greater power be provided, then an even higher degree of accuracy could be delivered by the Met Office, as demonstrated in the 2011 model below.



Source: Met Office analysis

Note:

This document was written in May 2007, before the 2007 Summer Flood events which occurred in June/July. There are a number of reviews currently being undertaken of the Summer Floods, which are due to report by the end of the year. For more information on these reviews please see:

- Independent Government Review
- Parliament's Environment Food and Rural Affairs Committee Review.

6. Case study 2: The Cabinet Office

6.1 Summary

The aim of the Cabinet Office is to ensure that the UK is resilient to any disruptive challenge. This challenge often presents itself in the form of severe weather and as a result the ability to prepare and react effectively is a Cabinet Office priority.

The Met Office provides information that enables emergency responders to make critical decisions that have both social and economic benefits to the UK:

- Some of the benefits provided by Met Office services in severe weather events include:
 - Estimated lives saved in sections of the construction industry in the UK **23 lives (£34m)**
 - Efficiency savings achieved by the emergency services in the UK **£4.1 million**
 - Lives saved in England and Wales through the 'Heat-Health watch' programme **31 lives (£45.8m)**

6.2 Introduction

The impact of weather is never far from the lives of the general public. In January 2007, a severe storm claimed the lives of more than ten people and caused millions of pounds of property damages.²³ Ensuring that the UK is resilient to the risk of any severe weather is the responsibility of the Cabinet Office, in particular the Civil Contingencies Secretariat (CCS).

The CCS was established to improve resilience against disruptive challenges through partnership with government departments, the devolved administrations and key stakeholders to anticipate, assess, prevent, prepare, respond and recover. Met Office services feed into and support the Civil Contingencies Act of 2004.²⁴ The Act aims to deliver this resilience by offering a single framework for civil protection that is capable of meeting the challenges of the 21st Century.

"There is no doubt that over the years the Met Office has provided a service that has saved a huge amount of lives and will continue to do so in the future."

Environment Desk Officer, CCS, Cabinet Office

²³ Guardian Unlimited, *Storm death toll hits 13 as insurers count cost*, January 20, 2007 <http://www.guardian.co.uk/weather/Story/0,,1994900,00.html> [Accessed March 2007]

²⁴ The Civil Contingencies Act <http://www.opsi.gov.uk/acts/acts2004/20040036.htm> [Accessed February 2007]

6.3 Met Office services

Met Office services to the Cabinet Office fall into three key areas: National Severe Weather Warning Service; Public Weather Service Advisors; Seasonal Forecasting.

National Severe Weather Warning Service (NSWWS)

As the national meteorological service for the UK, the Met Office has a vital role in public safety and as such provides a direct service, the National Severe Weather Warning Service, to Category 1 and Category 2 responders in an emergency situation.²⁵

Informing the community

The NSWWS informs the community by providing warnings of severe or hazardous weather which could cause problems, ranging from widespread disruption of communications to conditions resulting in transport difficulties or threatening lives. As well as offering a core weather service, the support and communication that encompasses these warnings is of equally high importance in ensuring the UK is in a fit state to respond.

The two stage warning process provides key information on the location, time, severity and probability of a severe weather event:

1 Early Warning Service

- A text and graphical based service highlighting percentage probability of severe weather occurring
- Normally issued up to several days in advance of an event when the severe weather risk > 60%
- Based upon widespread disruption caused by severe gales, heavy snow, blizzards/drifting, heavy rain, freezing rain (glazed frost or widespread icy roads), dense fog and prolonged cold
- Updated normally on a daily basis until commencement of event
- Amendment required when a designated region is no longer expected to be affected, or an area previously forecast not to be affected is now forecast to be affected

**National Severe Weather Warning Service
EARLY WARNING**

Regional risk assessments

East Midlands
East of England
London & SE England
NW England
SW England
West Midlands
All of Wales
NE England
Yorkshire & Humber
Rest of Northern Ireland
Dorset and Galloway, Lothian & Borders

All other regions less than 20%.

The Met Office continues to forecast another spell of very windy weather during Thursday 18th January. Severe gales are expected across much of England and Wales, possibly extending further north into Northern Ireland and Southern Scotland, with gusts in many parts of around 60-70 miles per hour, and a risk of some gusts around 80 miles per hour, particularly in upland or exposed places. Winds are expected to ease from the west during Thursday afternoon. Some disruption to transport and utilities (power) is expected.

This warning will be updated by 1100 on Wednesday 17th January 2007.
Issued by the Met Office at 10:26 on Tuesday, 16th January 2007

Fig 1: January Storm 16/01/07

2 Flash Warning Service

- A text based service issued when there is an 80% confidence in the occurrence of severe gales, heavy snow, blizzards/drifting, heavy rain, freezing rain (glazed frost or widespread icy roads), dense fog are expected to reach the agreed thresholds
- Issued 2 to 6 hours in advance of an event
- Amended when a county or unitary authority is no longer expected to be affected, or an area previously forecast to be not affected is now forecast to be affected

**National Severe Weather Warning Service
FLASH WARNING**

Flash Warning of

- Severe Gales

For the following areas

- East Midlands
- East of England
- London & SE England
- NE England
- NW England
- West Midlands
- Yorkshire & Humber
- Bournemouth
- Dorset
- Gloucestershire
- Pembrokeshire
- Swindon
- Wiltshire

Southwesterly winds will increase overnight, with gusts 60 to 70mph, locally 80mph in exposed locations, turning westerly during Thursday afternoon, then gradually easing through the evening. The public are advised to take extra care and refer to the "Highways Agency" for further advice on traffic disruption on motorways and trunk roads.

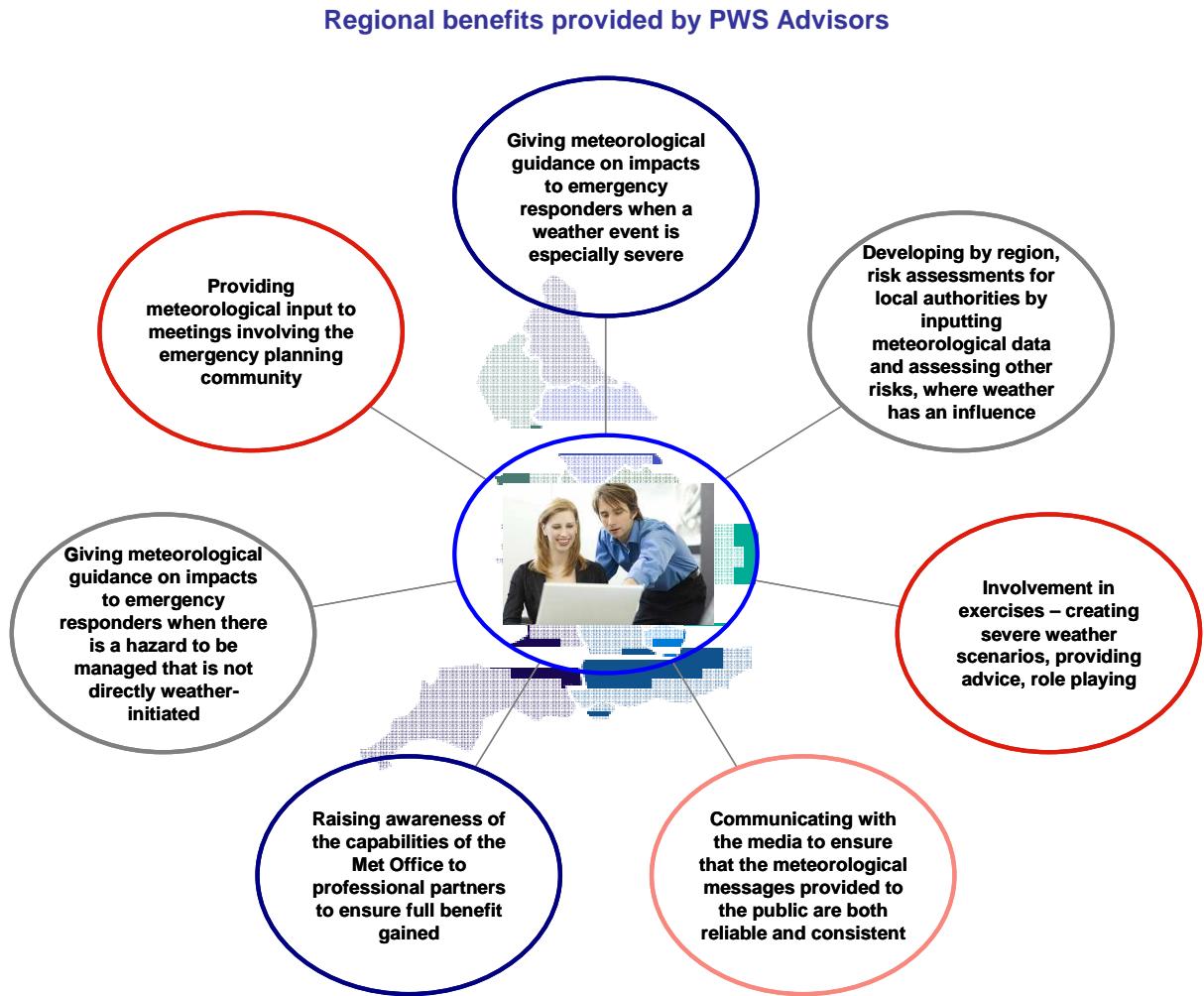
Issued by the Met Office at 22:31 on Wednesday, 17th January 2007
Valid from 05:00 on Thursday, 18th January 2007 until 21:00 on Thursday, 18th January 2007

Fig 2: January Storm 17/01/07

²⁵ Emergency as defined in The Civil Contingencies Act, <http://www.opsi.gov.uk/acts/acts2004/20040036.htm> [Accessed February 2007]

Public Weather Service Advisors

Communication and interpretation of these warnings for appropriate public authorities and the emergency services is provided by regionally based Public Weather Service (PWS) Advisors. They provide advice when there are cases that present significant risk to life, property or infrastructure. They have a role in the following areas:



PWS Advisors also feed their considerable advice into supporting courses held at the Emergency Planning College to educate the responders in the effects of severe weather, and how to react in the most efficient manner.

Since the inception of the PWS Advisors, local authorities, emergency services and other responders operating under the Civil Contingencies Act have realised considerable benefit through the targeted and precise warnings provided.

"We were able to hire a 4 x 4 vehicle which helped us safely move nearly 100 members of staff to and from our four hospitals for this morning's shift. Our community staff were able to access patients who had urgent care requirements, and we were able to reschedule care for patients whose safety would have been at risk because of the weather."

Member of North Glamorgan NHS Trust

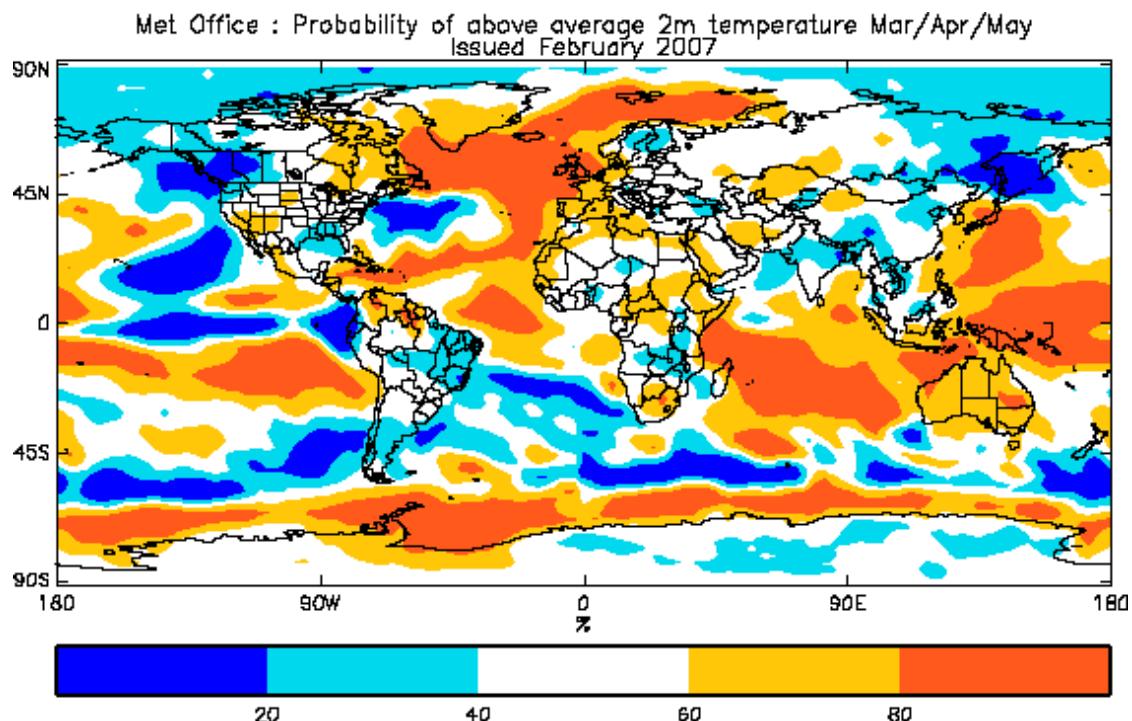
The fairly recent introduction of the PWS Advisors scheme ensures that further benefits are still to come.

Seasonal forecasting

Seasonal forecasting was identified as another key service with significant benefit for several stakeholders as they aim to prepare and plan for the months ahead.

"The long term forecast provided by the Met Office is an integral part of our planning process and it is very important to the Health Services, Defra, and the DTI among others..."

Environment Desk Officer, CCS, Cabinet Office

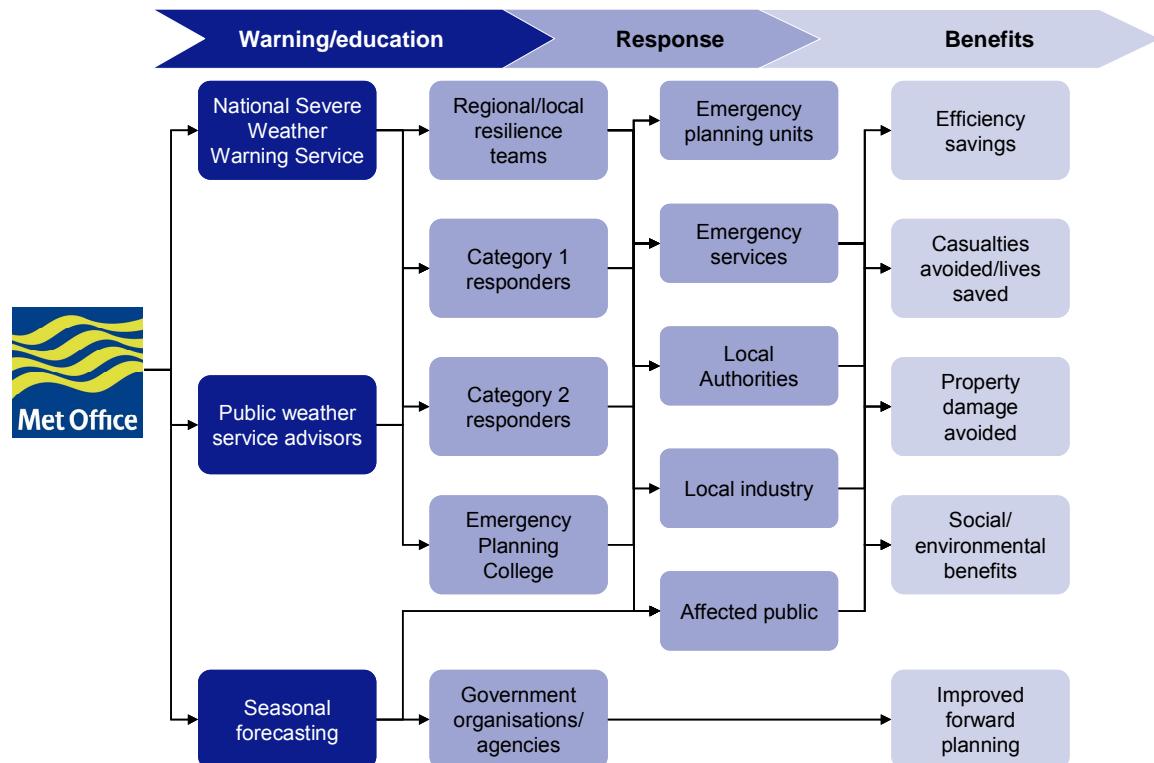


"Seasonal forecasting is still an emerging area of weather science. In September 2005 we issued our first public long-term forecast for that coming winter season. It proved to be so successful that it has now become a regular feature."

Met Office website

6.4 Value chain

To ensure that the UK is resilient to the affects of any severe weather events, there are a number of key roles and responsibilities across the UK that both facilitate and coordinate any actions taken.



The Cabinet Office

The Cabinet Office has an overarching responsibility to ensure the UK has the ability to respond to any event which could pose a disruptive challenge to the welfare and day to day activities of the UK.²⁶

The CCS, a part of the Cabinet Office, guides and co-ordinates the activity taking place across government departments and wider stakeholders. A direct channel is permanently available between the CCS and the Met Office to guarantee that the needs of the country are met when an emergency event occurs.

The Met Office provides support for many of the key roles of the CCS that include:

- Coordinating the assessment of risks to the UK public when a severe event happens, weather-related or other
- Providing a framework for response through cross-government capabilities
- Implementing legislation to support civil resilience in the UK
- Providing a centre of excellence for training on Emergency Planning at the Emergency Planning College
- During a crisis, coordinating consequence management to support the government's response.

²⁶ http://www.cabinetoffice.gov.uk/ukresilience/ccs/how_we_work.aspx [Accessed March 2007]

Regional and Local Resilience Teams are assisted by PWS Advisors and Met Office data to carry out their civil duties

Regional Resilience Teams

At a regional level the Regional Resilience Teams (RRTs) operate in each of the nine regional government offices. These teams, who draw heavily on external civil protection experience, facilitate much of the regional activity. They take the lead in managing key relationships with local responders, communicating between regional partners and between the regions and central departments. They also provide improved information-gathering and reporting back to the centre.

Local Resilience Teams

Local Resilience Teams offer a similar role to the RRTs in terms of coordination and facilitation but at a local level. Since the 2004 Civil Contingencies Act, there is a statutory framework that sets out a coordinated and systematic approach to planning for disasters, as well as providing access to emergency powers that might be needed to manage the effects of a major disaster.

Met Office acting as a key supplier – The Civil Contingencies Act 2004

The 2004 Civil Contingencies Act focuses on two main areas:²⁷

1. Local arrangements for civil protection
2. Emergency powers, establishing a modern framework for the use of special legislative measures that might be necessary to deal with the effects of the most serious emergencies.

To carry out the obligations of the Act, local responders are separated into two groups, Category 1 and Category 2, depending on their involvement in civil protection work.

The Met Office provides a direct service to Category 1 and Category 2 responders to ensure that meteorological guidance is consistent and always available whether this is before, during or after the disruptive event.

Category 1 responders are those organisations at the core of emergency response (e.g. emergency services, local authorities). Category 1 responders are subject to the full set of civil protection duties. The Met Office is involved in assisting and enabling the responders to:

- Assess the risk of emergencies occurring and use this to inform contingency planning
- Put in place emergency plans
- Put in place Business Continuity Management arrangements
- Put in place arrangements to make information available to the public about civil protection matters and maintain arrangements to warn, inform and advise the public in the event of an emergency
- Co-operate with other local responders to enhance co-ordination and efficiency.

Category 2 organisations (e.g. Health and Safety Executive, transport and utility companies) are "co-operating bodies" that while less likely to be involved in the heart of planning work, will be heavily involved in incidents that affect their sector. Category 2 responders have a lesser set of duties – co-operating and sharing relevant information with other Category 1 and 2 responders.²⁸

²⁷ Civil Contingencies Secretariat, *Civil Contingencies Act 2004: a short guide (revised)*, <http://www.ukresilience.info/ccact/15mayshortguide.pdf> [Accessed March 2007]

²⁸ Civil Contingencies Secretariat, *Civil Contingencies Act 2004: a short guide (revised)*

6.5 Benefits

Stakeholders from all parts of the value chain agreed that the Met Office provides significant benefit in any severe weather event. Severe Weather events can have devastating effects, both economically and socially:



"More than 20 people lost their lives in the January Storms of 2007, the Bill is estimated in the low 100s of millions of pounds"

Association of British Insurers,2007



"The storms of October 1987 and January / February 1990 alone resulted in insured losses of £1.4 billion and £2.1 billion respectively"

Association of British Insurers,2003

"We are in the job of saving lives; the Met Office gives us the tools to make this happen"

Chief Inspector, Met Police

The table details some of the extensive benefits that the Met Office provides in reducing and preventing the effects of severe weather:

Cabinet Office				
Weather event	Benefits			
	Casualties avoided / Lives saved	Property damage avoided	Social / environmental benefits	Efficiency savings
Wind / Storm	<ul style="list-style-type: none"> Prepares emergency services Assists in safety and mobility of staff in critical social roles Warnings initiate safety policies in industry – safeguarding lives of workers especially those working in high risk areas – e.g. on scaffolding: 23 lives (£34m) are saved p.a. for certain sections of the construction industry in the UK Decisions taken on closure of vulnerable structures e.g. bridges Utility services informed to enable contingency plans 	<ul style="list-style-type: none"> Authorities and appropriate personnel secure vulnerable buildings Maintenance teams on standby if power lines should be affected 	<ul style="list-style-type: none"> Improved quality of daily life through more understanding of weather conditions and knowledge that services are prepared* Local Authorities arranged accommodation for public who are stranded and cannot get home Enables public to make alternative arrangements Contingency plans implemented to ensure elderly are cared for 	<ul style="list-style-type: none"> Resource planning for the emergency services – savings of £4.1m for the Police in the UK Local authorities planning Emergency planning unit ready in response Outdoor events scheduling adapted Industry resource planning Supporting the EA to react and respond to hazardous events
Snow / Cold	<ul style="list-style-type: none"> Prepares emergency services Prepares health and social services to respond to vulnerable individuals e.g. elderly and rough-sleepers (SWEP**) in Westminster Triggers cold weather and winter fuel payments Warnings enable targeted gritting of the roads and so reducing the likelihood of accidents 	<ul style="list-style-type: none"> Authorities and appropriate personnel check and secure vulnerable buildings Road / Railways and bridges checked for safety reasons 	<ul style="list-style-type: none"> Journey planning Raises awareness to schools, day centres and shelters among others Contingency plans implemented to ensure elderly are cared for 	<ul style="list-style-type: none"> Local authorities informed on deployment of services, including road gritters Resource planning for emergency services More efficient workforce following resource preparation Improved traffic flows SWEP** - £8,000 savings in Westminster
Heat	<ul style="list-style-type: none"> Local authority and NHS services are prepared for servicing 'at risk' public groups Heat watch programme informs sectors including: transport, nuclear, farming sectors and water companies to ensure contingency plans are in place – 31 (£45.8m) lives saved through Met Office warnings in England and Wales 	<ul style="list-style-type: none"> Buildings secured and checked to deal with severe heat Road / Railways and bridges checked 	<ul style="list-style-type: none"> Elderly population warned and catered for Journey planning e.g. taking water Raises awareness to schools, day centres and shelters among others Public make decisions including: appropriate clothing to wear 	<ul style="list-style-type: none"> Resource planning for emergency services More efficient workforce following resource preparation
Dense Fog	<ul style="list-style-type: none"> Travel changed or prevented Prepares emergency services Department of Transport and Highways Agency informed and warnings issued to those using the roads 	N/A	<ul style="list-style-type: none"> Journey planning 	<ul style="list-style-type: none"> Resource planning for emergency services More efficient workforce following resource and travel preparation
Rain	Refer to Environment Agency Section			

*Applies to all weather events

** Severe Weather Emergency Protocol

Source: PA Consulting analysis, Cabinet Office

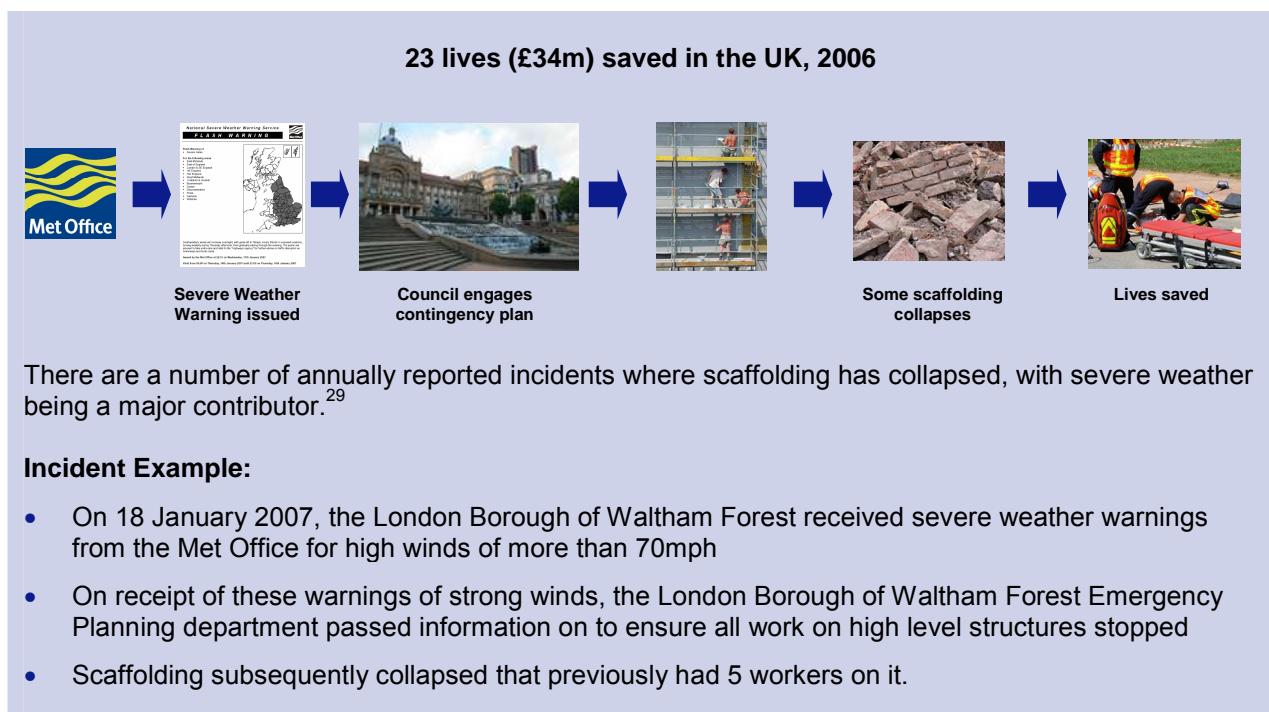
The benefits of the NSWWS are especially potent when the resulting actions lead to a potential avoidance in loss of life.

Wind and storm

Example 1: Construction

As an industry that is conducted mainly outdoors, the construction industry is particularly susceptible to the weather. Two specific examples that typify the benefits of the Met Office are damage to partially built buildings and the loss of life on scaffolding sites. This case study focuses on how the Met Office has had a positive impact on the latter. Whilst statistics are not readily available, stakeholders in both the Health and Safety Executive and the Construction Confederation acknowledge the importance of the weather in their members' everyday activities.

There are a number of incidents recorded where the actions taken following a weather warning have led to contingency plans being implemented in order to protect the safety of workers.



There are a number of annually reported incidents where scaffolding has collapsed, with severe weather being a major contributor.²⁹

Incident Example:

- On 18 January 2007, the London Borough of Waltham Forest received severe weather warnings from the Met Office for high winds of more than 70mph
- On receipt of these warnings of strong winds, the London Borough of Waltham Forest Emergency Planning department passed information on to ensure all work on high level structures stopped
- Scaffolding subsequently collapsed that previously had 5 workers on it.

To estimate the potential contribution of the NSWWS to these particular responders, the following assumptions have been employed:

- An average of 5 scaffolding workers are on any given site at any one time³⁰
- There were 9 recorded severe weather events for 2006 that may potentially have had a serious effect on the construction industry³¹
- The value of a human life is £1.478m according to the Department for Transport³²
- 50% of those receiving the warnings will take necessary safety actions.³³

²⁹ Examples include: BBC News, *Workers hurt in scaffold collapse*, 11 April 2006, <http://news.bbc.co.uk/1/hi/england/beds/bucks/4899750.stm> [Accessed March 2007]

³⁰ Waltham Forest Council correspondence, January 2007

³¹ Met Office Severe Weather Warnings – High wind / storm 2006

³² Department for Transport, *Highways Economics Note No.1 2005: Valuation of the Benefits of Prevention of Road Accidents and Casualties*, Office of the Deputy Prime Minister, January 2007. Also: Office of the Deputy Prime Minister, *Economic cost of a fire*, 2004

Number of workers on each site	x	Number of Severe Weather Events 2006	x	Percentage of councils with contingency plans	=	Met Office Benefit
5		9		50%		23 lives saved
Number of workers on each site	x	Number of Severe Weather Events 2006	x	Percentage of councils with contingency plans	x	Value of a human life
5		9		50%		£1.478m
					=	Met Office Benefit £34m

Acknowledging these assumptions, the benefits can be demonstrated as approximately 23 lives, or £34m saved in the UK for parts of the construction industry.

Severe weather

Example 2: Business continuity for the emergency services

In any severe weather event the need for the emergency services to be in a ready state to respond is critical in terms of saving lives. Severe weather places an additional strain on the emergency services, so resourcing can be the difference between lives being lost or saved.

"It is imperative that resource levels and available equipment such as 4 wheel drive vehicles are reviewed in the build up to bad weather, particularly snow conditions. It is also a problem that the very staff that we would want on duty to deal with the problems cannot themselves make it to work and we need to have some contingency to deal with that. Reliable early warnings are invaluable."

Representative of the Association of Chief Police Officers

The Met Office provides the emergency services with the ability to prepare and react to emergency situations.

³³ Council interviewees indicate that contingency plans are in place for severe weather at 50% of councils.



Incident example:

- A storm swept through the UK and Ireland in January 2007, claiming 13 lives³⁴
- There were widespread power outages and some major highways had to be closed
- The event was accurately forecast by the Met Office and a number of warnings were issued via its NSWWS and its PWS Advisors, enabling the emergency services in the UK to prepare for the likely added disruption.

Efficiency savings

The Met Office provided an accurate 3 day forecast of the impending storm to enable the police to resource plan effectively. When the weather event actually happened, the warnings, communication and interpretation of the data from the PWS Advisors ensured that the Police were able to make correct resource decisions that produced significant efficiency savings.

Category 1 responders

The Police Authority in Windsor commented on the following savings:

- On 18 January 2007, the Police Authority had 30 officers on duty for the early shift (shift patterns run from 07:00 to 16:00; 16:00 to 01:00 and 22:00 to 07:00)³⁵
- Due to adverse weather conditions, the operations unit for that area engaged a contingency that would extend the early shift by three hours until 19:00, and bring the late shift forward from 22:00 to 19:00
- This would have resulted in a recognised 180 extra hours worked by officers at Police Constable grade. With the full economic cost per hour of a Police Constable at £48.29, the cost would have been approximately £8,700 for this particular event³⁶
- However, this cost was avoided following PWS Advisor advice and support which enabled the Police Authority to make more precise resource decisions which were far less costly
- Without input from the PWS Advisor, the Operations Sergeant agreed that the additional officers would have been used
- These savings could reach £4.1m if replicated across the other Police Authorities in the UK.³⁷

³⁴ Guardian Unlimited, Storm death toll hits 13 as insurers count cost, 20 January 2007, <http://www.guardian.co.uk/weather/Story/0,,1994900,00.html> [Accessed February 2007]

³⁵ Operations Sergeant – Windsor Police Authority

³⁶ Full economic cost per hour for a Police Constable (Association of Chief Police Officers of England, Wales & Northern Ireland, *Guidance on Charging for Police Services*, p.32, 2005)

³⁷ Official Register, *Police and Constabulary Almanac*, 2006. Also Scottish Police Website <http://www.scottish.police.uk/mainframe.htm> [Accessed March 2007]; Police Force of N. Ireland <http://www.psni.police.uk/> [Accessed March 2007]

Number of extra hours planned, but not deployed 180	x	Economic cost of a man hour £48.29	=	Met Office Benefit £8,700	Single Event
Number of services affected 52	x	Number of Severe Weather Events 2006 9	x	Cost savings for one event £8,700	= Met Office Benefit £4.1m

Social benefits

- The stakeholders acknowledged that in this example, not only were significant costs avoided but there were additional social benefits gained in terms of the welfare of the officers that would have been used
- There is also a benefit to the general public regarding their confidence in emergency services' ability to respond to severe weather.

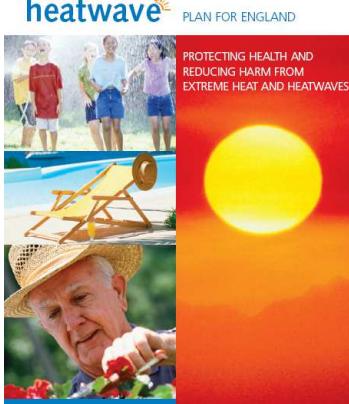
Extreme heat

Example 3: Heatwave plan

Like many other countries in Europe, the UK experienced a heatwave in early August 2003 where temperature records were broken. In England and Wales there were 2,139 excess deaths during the heatwave in August.³⁸ The full impacts of the heatwave were recorded in Northern France where there were more than 15,000 excess deaths.

The government set up the Heatwave Plan to prevent and mitigate the impact of future heatwaves.

The Plan's purpose is to enhance resilience in the event of a heatwave. The plan details the responsibilities at national and local level for alerting people once a heatwave has been forecast by the Met Office, and advising them what to do during a heatwave.³⁹



'Heat-Health watch'

NHS

heatwave PLAN FOR ENGLAND

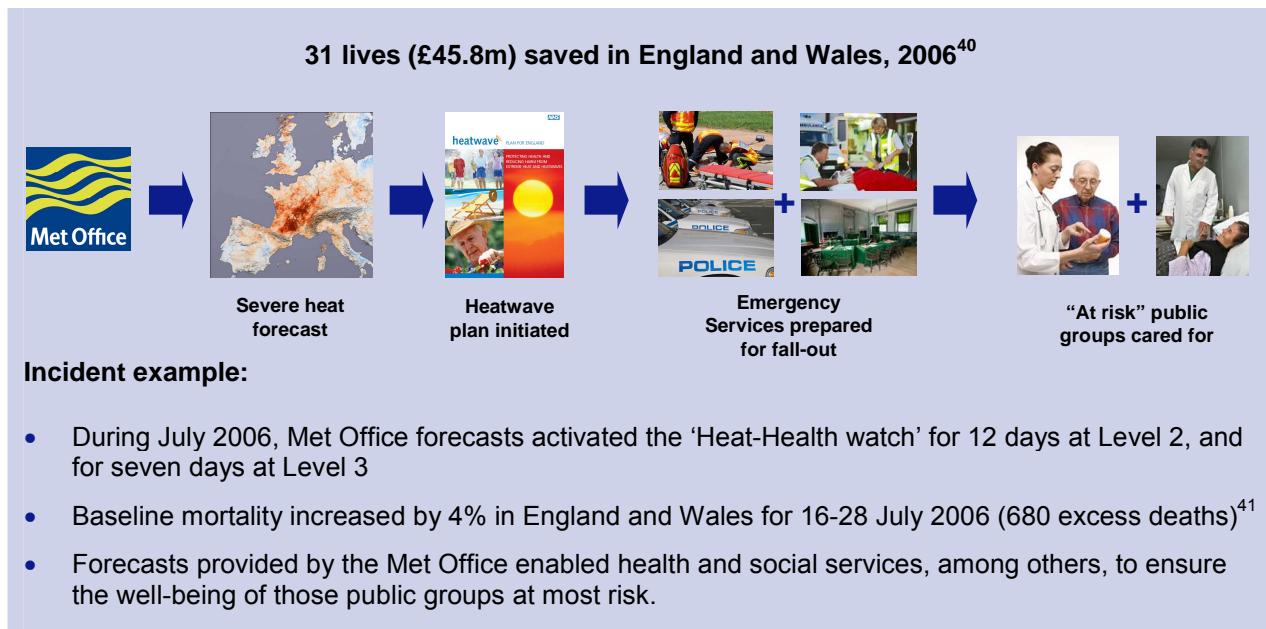
PROTECTING HEALTH AND REDUCING HARM FROM EXTREME HEAT AND HEATWAVES

'Heat-Health watch'

- A 'Heat-Health watch' system will operate from 1 June to 15 September each year. During this period, the Met Office may forecast severe heatwaves, as defined by day and night-time temperatures and duration
- While 'Heat-Health watch' is in operation, the Health Protection Agency will monitor the number of calls people make to NHS Direct and the amount of visits made to a sample of GP practices. Daily and weekly call and consultation rates will be reported to the Department of Health to assess how people's health seems to be affected by the weather
- The 'Heat-Health watch' system comprises four levels of response. It is based on threshold day and night-time temperatures as defined by the Met Office. These vary from region to region, but the average threshold temperature is 30°C during the day and 15°C overnight
- Level 1 Awareness – This is the minimum state of vigilance. Both before and during this period, preparedness must be enhanced and maintained by the measures set out in the heatwave plan
- Level 2 Alert – This is triggered as soon as the Met Office forecasts threshold temperatures for at least three days ahead in any one region, or that there is an 80% chance of temperatures being high enough on at least two consecutive days to have significant effects on health
- Level 3 Heatwave – This is triggered as soon as the Met Office confirms that threshold temperatures have been reached in any one region or more
- Level 4 Emergency – This is reached when a heatwave is so severe and/or prolonged that its effects extend outside health and social care, such as power or water shortages, and/or where the integrity of health and social care systems is threatened.

³⁸ Eurosurveillance monthly releases 2005, *The impact of the 2003 heat wave on daily mortality in England and Wales and the use of rapid weekly mortality estimates*, Volume 10, Issue 7-8, Page 168-171, July / August 2005

³⁹ Department of Health, *Heatwave Plan*, 2004



Casualties avoided and lives saved

Forecasts within the 'Heat-Health watch' programme enabled England and Wales to prepare for the 2006 heatwave in the most efficient way possible, preventing a repeat of the devastating consequences experienced in August 2003.

Using benchmarks from USA studies, estimations can be made over the number of lives saved as a result of Met Office heatwave forecasts for 2006.

- A study conducted by the American Meteorological Society in 2004 proposed that 2.6 lives were saved each warning related heat day in Philadelphia from 1995-1998⁴²
- This resulted in 117 lives being saved over the 210 heat related day period
- Assuming the same variables and performing further calculations on the July 2006 heatwave in England and Wales, the Met Office warnings would have saved approximately 31 lives.⁴³

Excess lives lost in July heatwave 680	/	Period of heatwave 13	x	USA study benchmark 4.6%	=	Met Office Benefit 2.4 lives per day
Lives saved per day with Met Office warning 2.4			x	Number of heatwave days 13	=	Met Office Benefit 31 lives saved (£45.8m)

⁴⁰ Government evaluation of the Heatwave plan is ongoing. The figure quoted is based on the American Meteorological Society Study

⁴¹ Office for National Statistics, *Health Statistics Quarterly*, Number 32, p.107, 2006

⁴² A heat day is defined as a day for which a warning could potentially have affected excess mortality. (American Meteorological Society, *Heat Watch/Warning Systems Saves Lives*, 2004)

⁴³ Calculation: 117 lives saved over 210 days means 0.6 lives are saved per day. There were 118 deaths over a nine day period equating to 13 deaths per day. (0.6/13 = 4.6%). This ratio extrapolated up to the July 2006 heatwave in the UK, where there were 680 excess deaths over a 13 day period, resulting in 31 lives being saved in this period.

Additional benefits

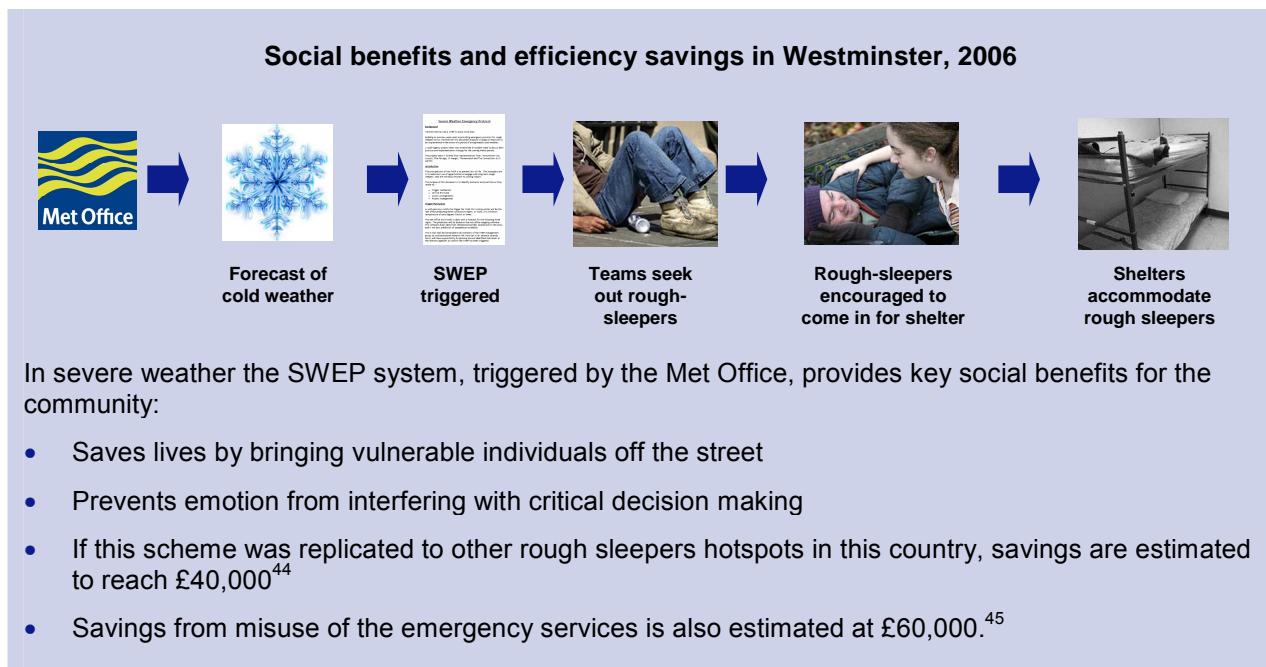
- For Primary Care Trusts and NHS Trusts, the ability to have hospital services in a state of readiness before a rise in admissions is imperative to saving lives
- Strategic Health Authorities and Local Authorities have a similar role to play in ensuring that information is communicated to all residential and nursing care home managers so that they can take appropriate action.

Cold and extreme weather

Example 4: Supporting the community through the SWEP

The Severe Weather Emergency Protocol (SWEP) was set up in Westminster in 2003 to support the process of providing emergency provision for rough sleepers across its operating locations. The principle aim of SWEP is to prevent loss of life. The secondary aim is to make best use of the opportunities to engage with long-term rough sleepers, who can often be resistant to coming indoors.

The trigger mechanism for the SWEP to be engaged is the Met Office predicting three consecutive nights, or more, a minimum temperature of zero°C or lower.



In severe weather the SWEP system, triggered by the Met Office, provides key social benefits for the community:

- Saves lives by bringing vulnerable individuals off the street
- Prevents emotion from interfering with critical decision making
- If this scheme was replicated to other rough sleepers hotspots in this country, savings are estimated to reach £40,000⁴⁴
- Savings from misuse of the emergency services is also estimated at £60,000.⁴⁵

Process

- The Met Office provides a daily email, with a forecast for the next three nights
- The SWEP is triggered if the Met Office predicts three consecutive nights or more of a minimum temperature of zero degrees Celsius or lower
- The email is then forwarded to all members of the SWEP management group (Westminster City Council, The Passage, St Mungo's, Thamesreach and The Connections at St Martin's)
- As a result, an additional 35 places are provided for the most vulnerable sleepers
- Rough sleepers are invited off the street through a number of charity teams.

⁴⁴ Crisis, *Statistics About Homelessness*, October 2006

⁴⁵ Cost of call-out and overnight stay multiplied by the number of nights the shelter is open for

Social benefits

Stakeholders agreed that while monetary values were especially difficult to realise from the involvement of the Met Office, there were considerable social benefits provided by the SWEP service:

- SWEP prevents misuse and relieves pressure on the emergency services by offering alternative shelter
 - Call out cost of an ambulance: £165⁴⁶
 - Cost of a night in the NHS: £233⁴⁷
- The system mitigates against staff resource burn out by providing clear guidelines when shifts commence and end, a critical challenge for the SWEP team
- It removes irrational decision making by offering functional procedures rather than emotive trigger thresholds.

Efficiency

- Thousands of pounds are saved every time the SWEP system is engaged as the management is able to realise the benefits from a Met Office trigger both in terms of providing the provision as well as knowing when to finish it
- For winter 2005/2006, the Met Office's forecast service provided estimated savings totalling close to £8,000⁴⁸
- If this scheme was replicated to other rough sleepers hotspots in this country, savings are estimated to reach £40,000⁴⁹
- Savings from SWEP to the economy from misuse of the emergency services is also estimated at £60,000.⁵⁰

⁴⁶ <http://www.londonambulance.nhs.uk/>

⁴⁷ NHS, *The National Treatment Outcome Research Study*, 2005

⁴⁸ Calculations: The cost of operating a night at the shelter, the cost of teams on the street, and the cost of the additional nights that would have been used without the Met Office trigger

⁴⁹ Crisis, *Statistics About Homelessness*, October 2006

⁵⁰ Cost of call-out and overnight stay multiplied by the number of nights the shelter is open for

6.6 Future plans

The Met Office continues to work closely with the Cabinet Office to understand the needs and requirements of the UK, and how best to deploy its expertise and capabilities when faced with an emergency situation. The role of the PWS Advisers is continually developing, offering greater support to Category 1 and Category 2 responders in any severe weather related event.

The infancy of the 'Heat-Health watch' programme means that future benefits are yet to be fully realised, particularly as climate change increases the number of heatwaves likely to be experienced in the UK. The Parliamentary Office of Science and Technology estimates that by 2050, heat-related deaths could increase to around 2,800 cases per year.⁵¹

"The Met Office is extremely competent, while at the same time wholly willing to adapt and change to the needs of its customers."

Environment Desk Officer, CCS, Cabinet Office

⁵¹ Parliamentary Office of Science and Technology, *UK Health impacts of Climate Change*, Number 232, November 2004

7. Case study 3: Civil Aviation Authority

7.1 Summary

The Civil Aviation Authority (CAA) is the UK's independent aviation regulator. Amongst other roles, CAA ensures that the UK meets its meteorological commitment to the International Civil Aviation Organisation (ICAO) of providing weather information for the aircraft in UK airspace. Beyond this, the CAA oversees the UK's commitment to act as one of only two global en-route weather data providers, a specialist regional volcanic ash advisory centre (monitoring and advising aviation about Icelandic volcanic activity) and operating a meteorological information satellite dissemination system, as part of the official ICAO telecommunication system.

The Met Office provides a range of tailored weather data direct to airlines, airports and flight crew worldwide in the most cost effective manner.

Some of the benefits delivered by the Met Office to civil aviation include:

- Lives saved through improved weather services (60% of the globe) **20 lives (£29.6m)**
- Efficiency savings through improved routeing (60% of the globe) **£95.5 million**
- Reduction in flight delays for the UK **£3.6 million**
- Environmental savings from reduced fuel burning (60% of the globe) **352,000 tonnes of CO₂**

7.2 Introduction

After the MoD (overseen by the PWSCG), the CAA is the second largest funder of the PWS. Approximately £18.2m or 22% of the PWS budget comes from the CAA. The CAA was established in 1972 as an independent specialist aviation regulator and provider of air traffic services. Following the separation of National Air Traffic Services from the CAA in 2001, all civil aviation regulatory functions (economic regulation, airspace policy, safety regulation and consumer protection) are integrated within a single specialist body.

One of the CAA's core roles is in ensuring the UK meets all its obligations as set out by ICAO. All countries that have signed up to ICAO agree to meet the requirements set out in fifteen Annex agreements or inform ICAO where they do not. The third Annex, entitled Meteorological Service for International Air Navigation, states that each member organisation must provide a meteorological authority, delivering or arranging for the delivery of specified meteorological services in that country. The Met Office, underpinned by PWS, provides this service on behalf of the CAA to meet the UK's commitment.

By invitation from ICAO, the UK is also one of only two countries (the other being the US) which provide worldwide weather forecasts mostly above 24,000ft for global civil aviation. The UK provides this through the World Area Forecast Centre (WAFC) London, which is based in Exeter. Again this service is delivered on behalf of CAA by the Met Office.

7.3 Met Office services

The Met Office provides a number of services to the CAA. These can be split into two areas; services based on UK output and services based on international output.

UK services

The Met Office, on behalf of the CAA's Met Authority, provides the following services:

- Terminal Aerodrome Forecasts for UK airports – Site-specific forecasts are provided to circa 50 UK airports on an update cycle of 3 or 6 hours during the aerodrome's operating hours. These provide important data for flight planning purposes
- Aerodrome Warnings – The Met Office provides all UK airports with forecast of severe weather events, enabling pilots, aerodrome operations and ATS providers to plan ahead
- SIGMET Warnings – Weather warnings to aircraft in flight of major upper air turbulence and other phenomena likely to affect the safety of flight
- Aircraft Accident Investigation Branch – The Met Office provides historical output to help in the investigation of accidents or reported incidents (e.g. near miss) to aid the ongoing pursuit for improved air safety
- Mandatory Occurrence Reports – Should pilots or other weather stakeholders believe a forecast was sufficiently inaccurate to warrant investigation, the Met Office will deliver a report to address the concerns raised
- Airport Inspections – Airport staff provide most of the basic weather observations. To ensure that observers meet minimum standards stipulated by the CAA, the Met Office trains staff and inspects the processes and facilities.

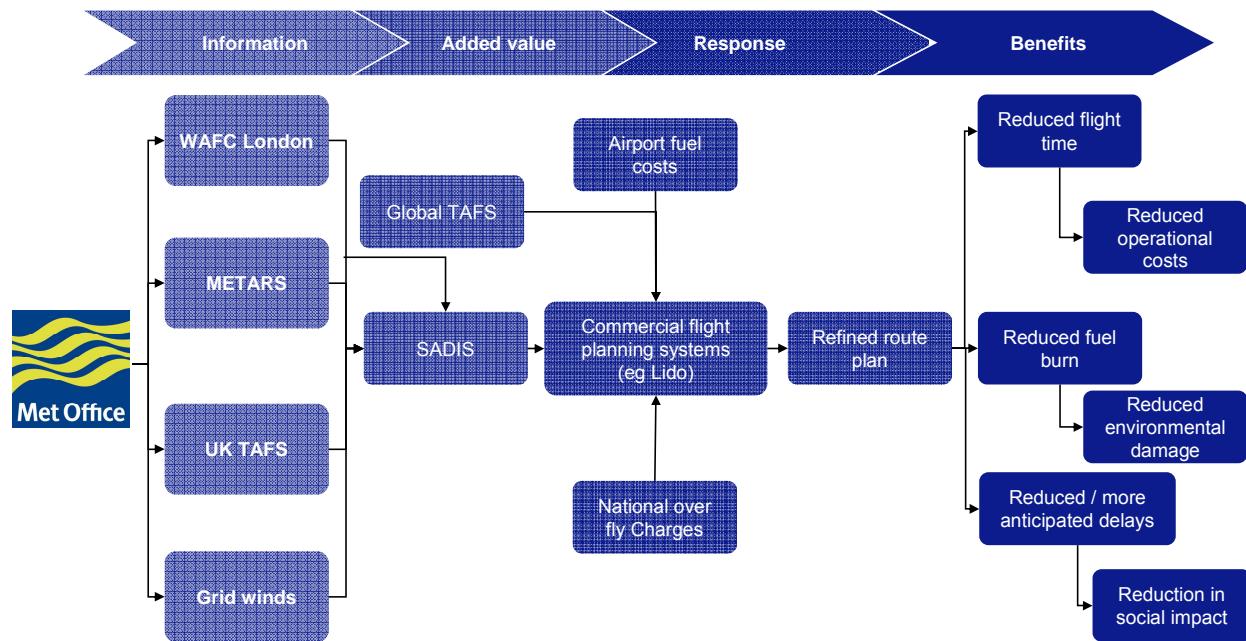
In addition to these services, the Met Office provides general aviation products on behalf of the CAA. Meteorological forecasts covering the lower levels of airspace in the UK and Europe are issued to pilots that cater for all types of flights; from large commercial jets to small gliders, as a tool to facilitate increased air safety. Further services are available to those pilots wishing to buy tailored or enhanced services direct from the Met Office.

International

The Met Office provides a specialist regional volcanic ash advisory centre (monitoring and advising aviation industry about Icelandic volcanic activity) and operates a meteorological data satellite dissemination system, as part of the official ICAO telecommunication system, for aeronautical observations, forecasts and warnings. By invitation from ICAO, there are two national weather centres in USA and UK which provide worldwide en-route weather forecasts for global civil aviation. The UK provides this through the WAFC London. This service provides weather forecasts mostly above 24,000ft for flights originating from Europe, Africa, Asia and Australasia. These forecasts are generally issued every 6 hours, and cover the next 36 hours.

Millimetre Emission Temperature of the Atmosphere observation (METAR), real time global temperature observations, International Terminal Area Forecasts (TAFs), and forecasts for destination airfields based on local and global forecasting capability, are also routed through the Met Office for dissemination via SADIS satellite and FTP services.

7.4 Value chain



Many of the data that the Met Office provides are used as an input to further models delivering user specific outputs. Within the aeronautical industry there is a complicated value chain delivering significant financial benefit to the airlines and greatly reducing the environmental impact of operations.

A number of commercial flight planning systems use Met Office data as one of many inputs into their models. This can be delivered to them by a number of means including SADIS satellite broadcast, FTP, or direct communications links. Apart from certain communication costs, the data is provided free-at-the-point-of-use. However the cost of WAFC London is recovered through airlines flying through UK airspace.

Commercial flight planning systems then calculate the most efficient way of getting from point A to point B, taking into account in-flight atmospheric conditions, over-fly charges and landing conditions. Deutsche Lufthansa's Lido System (BA's current provider), Boeing's Jeppesen system (North West Airline's Provider) and SITA are just a few examples of such tools, used extensively across the commercial airline industry.

As can be seen in the Benefits section below, the savings from such systems can be worth millions of pounds and is partly delivered through Met Office services.

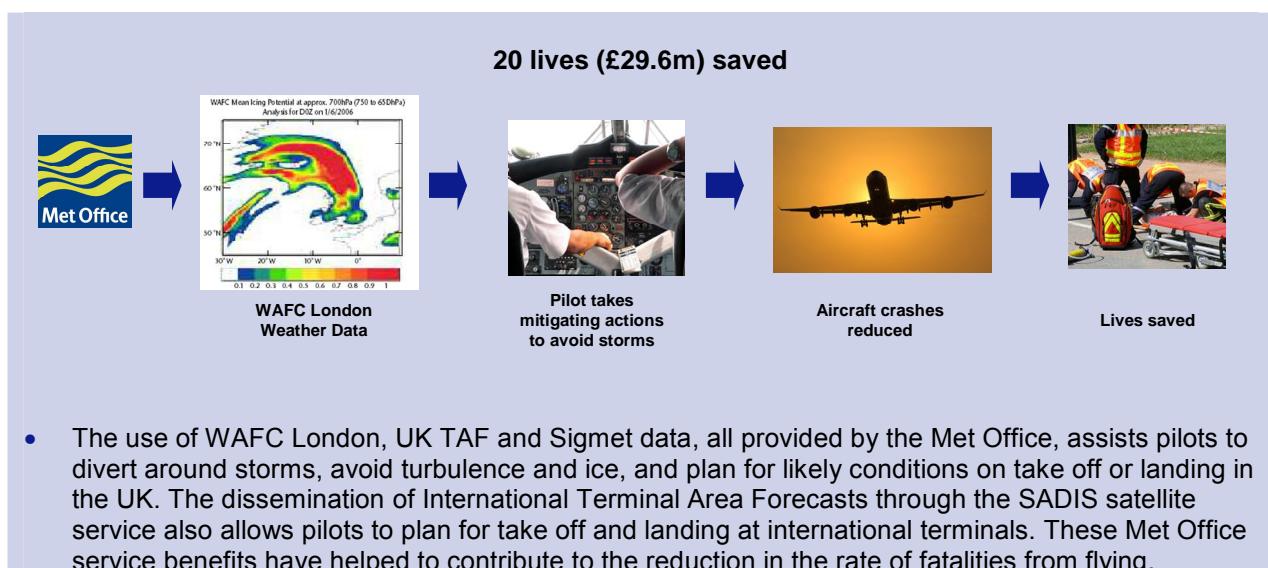
7.5 Benefits

Of the four major areas of benefit being discussed in this study: casualties and life; efficiency; property; and wider social and environmental benefits, three are delivered as a result of the Met Office's services to the CAA and the extended service value chain.

Civil Aviation Authority				
Weather event	Benefits			
	Casualties avoided/ Lives saved	Property damage avoided	Social/environmental benefits	Efficiency savings
Wind				
Ice/snow	• Reductions in aircraft death rates partly resulting from more accurate weather data, both in-flight and at UK terminals – 20 lives p.a. for 60% of the globe	• Reduction in damage to aircraft from debris and accidents	• Improved fuel efficiency delivers major benefits to the environment from reduced gas emissions – 352k tonnes CO2 p.a. for 60% of the globe • Social benefits from the reduction in delays as a result of weather inputs to flight planning systems	• Reduction in flight times and thus aircraft operating costs from weather inputs into flight planning systems – £95.5m p.a. for 60% of the globe. • Reduction in flight delays from more effective flight routeing – £3.6m for the UK • Reduction in fuel costs from reduced flight durations • Reduction in aircraft damage from the avoidance of volcanic ash plumes • More efficient de-icing process resulting from proactive planning • More proactive planning for terminal closures or reduced operating capacities resulting from weather (eg Heathrow fog)
Fog				
Volcanic ash				
Lightning				

Air safety

Improvements in global meteorological data have contributed to a substantial reduction in air accidents and loss of life. Although not directly responsible for the production of all this data, the Met Office has contributed to a large extent, both in the production of WAFC data above 24,000 feet for 60% of global flights, the production of UK Terminal Aerodrome forecasts, and the dissemination of International Terminal Aerodrome Forecasts through the SADIS satellite system.



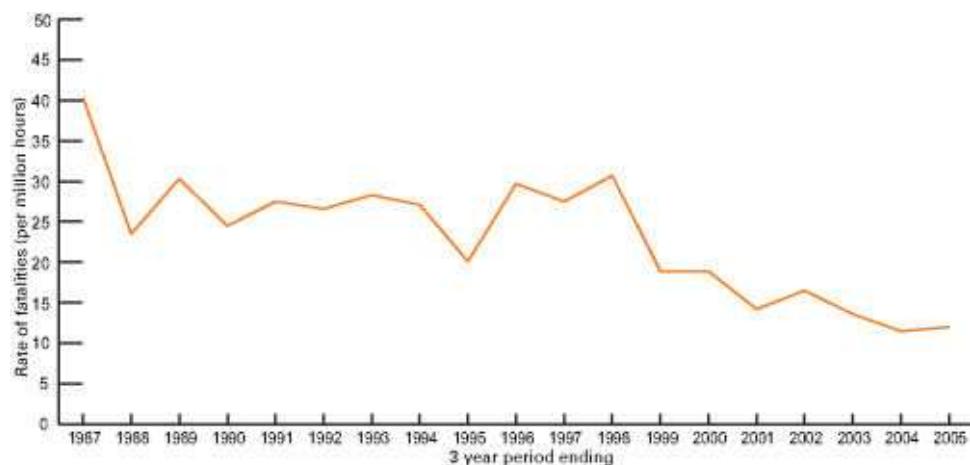
- The use of WAFC London, UK TAF and Sigmet data, all provided by the Met Office, assists pilots to divert around storms, avoid turbulence and ice, and plan for likely conditions on take off or landing in the UK. The dissemination of International Terminal Area Forecasts through the SADIS satellite service also allows pilots to plan for take off and landing at international terminals. These Met Office service benefits have helped to contribute to the reduction in the rate of fatalities from flying.

"The Met Office service is a key element in improvements to air safety"

Head of Met, CAA

Avoiding severe weather in flight and ensuring take-off and landing safety through sufficient de-icing of runways and wind speed forecast all contribute to reduced loss of life per hours flown than ever before.

Rate of fatalities – World wide large western built jets (three year moving average)⁵²



OAG, the global travel and transport information company, calculated that in 2006 the world's scheduled airlines offered 3.3 billion seats on 28.2 million flights.

Flights vary widely in length from the longest scheduled flight between Newark and Singapore with an elapsed time of 18 hours and 40 minutes, to the shortest between Papa Westray and Westray in the UK at 2 minutes.

However, it is estimated that the average flight time across the globe is approximately 3 hours, which equates to 84.6 million hours flown in 2006. The Met Office WAFC Service provides weather data for 60% of these. The Met Office is thus responsible for providing weather services for 50.8m flying hours per year.

Based on CAA's data, there were 12 deaths per million hours flown (on a three year moving average) in 2005 (the latest data available). This equates to approximately 1,015 deaths globally or circa 609 in the area for which the Met Office provides meteorological data. Assuming a similar number of hours as in 2005 were flown in 1987 there would have been 2,030 deaths for the WAFC London area (40 deaths per million hours flown).

In order to estimate the lives saved from improvements in weather services we need to understand what proportion of accidents are related to the weather. During the period 1983-1995 the National Transportation Safety Board identified weather as a causal factor in 112 US accidents and incidents representing 33% of the total in commercial aviation.

In addition, we cannot relate all reductions in fatalities to weather services alone. Although a large proportion of the continued and steady fall in air travel deaths is down to the improvement in aircraft design, technology and process, at least part of this can be associated with improved accuracy of weather services. Based on the view that avoidance of weather conditions and prior knowledge are key contributors to safety we have placed a conservative estimate that improvements in weather data have contributed to 25% of the improvements in overall safety.

⁵² <http://www.caa.co.uk/default.aspx?catid=978&pagetype=90&pageid=6277> [Accessed March 2007]

As such the estimate of lives saved across the portion of the globe which WAFC London is responsible for as a result of issuing Global TAFs is $((2,030 - 609) \times 25\% \times 33\%)$, which equates to 117 lives per year (2005 compared to 1987). The Met Office is only part of the value chain for the distribution of this data however. It disseminates Global TAFs through the SADIS satellite service and the source of this data is the local Met Service to that terminal. Therefore not all of the 117 lives per year are directly attributable to the Met Office Service. We have assumed a conservative 15% value from this dissemination leading to an estimated saving of life of 18 per year.

In addition to these actions there are two areas where Met Office services are directly related to the reduction in accidents and deaths from air travel: the reduction in accidents and deaths seen at UK airports; and the reduction in accidents and deaths from in flight turbulence in the WAFC London region (60% of global flights).

A CAA review into General Aviation Fatal Accidents between 1985 and 1994⁵³ highlighted 280 people killed in fatal accidents in the UK. Based on the reduction in number of deaths per hours flown, the reduction in fatalities over the course of this period would equate to 14 individuals per year. Again we must reduce this number for the level of deaths associated with the weather and the likely impact of improvement in weather services in conjunction with improvements in design etc. In doing so we estimate that the 1 death per year can be attributed to the Met Office ($14 \times 33\% \times 25\%$).

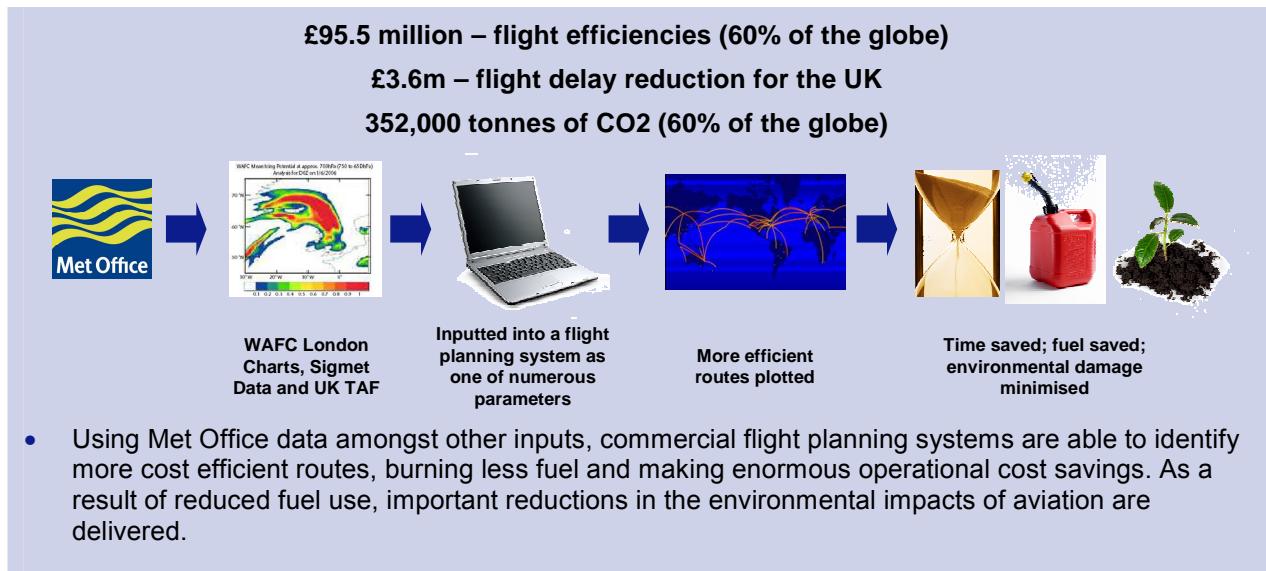
Air turbulence deaths are very rare. The FAA reported⁵⁴ that between 1994 and 2003, there were 19,562 accidents involving 19,823 aircraft of which 82 instances (0.4%) were put down to air turbulence (based on figures recorded by the US National Transportation Safety Board). Based on these figures we can estimate 1 life per year is saved through WAFC London data preventing flight turbulence. $((2,030 - 609) \times 25\% \times 0.4\%)$.

As a result, in total we estimate that 20 lives per year are saved through the Met Office's services to civil aviation.

⁵³ <http://www.caa.co.uk/docs/33/CAP667.PDF>

⁵⁴ http://www.asias.faa.gov/aviation_studies/weather_study/studyindex.html

Civil Aviation Industry Benefits



There are numerous efficiency savings resulting from the use of Met Office data in flight planning systems and the direct use of Met Office data by UK Aerodromes:

- Reduction in flight times** – International Air Transport Association (IATA) figures show that flights run at an average operating cost of £50 per in-flight minute. Using OAG data there were 28.2m flights in 2006. Just a 1 minute reduction in each flight would therefore reduce global operating costs by £1.41bn. As a result of using Lufthansa's Lido system, British Airways reduced the London to Sao Paulo flight time by 18 minutes one way and reduced fuel consumption by 1 tonne.

Met Office data provide WAFC London meteorological flight data to 60% of global flights. Assuming that as a result of commercial flight planning systems there has been a conservative 1 minute reduction in flight time for each flight that uses them effectively, and assuming 50% of air carriers do use WAFC London data effectively, this equates to a saving (specific to speed rather than over-fly charges) of £508m.

Flight planning systems do however add value over and above what Met Office data alone would deliver. If we estimate Met Office data represents one of four inputs for flight efficiency value add, and prudently estimate these have equal weighting, this equates to a direct Met Office benefit of £105.8m (£423m x 25%). This is then discounted to take into account the CAA's direct service spend to give an overall benefit of £95.5m.

Annual Global Flights 28.2m	x	Operating cost for 1mins of flight (CAA est.) £50	=	Global Operating Cost Impact (GOCI) for 1 min reduction in flight time £1.41bn
GOCI £1.41bn	x	Proportion of flights using data effectively to reduce flight time 50%	x	Proportion of global flights using WAFC London data 60% = Met value delivered through flight planning systems £423m
Met Value of flight planning systems £423m	x	Estimate of benefit proportion attributable to PWS 25%	x	Direct Service discount factor 90.24% = PWS Benefit £95.5m

- **Reduction in flight delays** – This is achieved through the avoidance of storms and the increased accuracy of weather data at terminals. NOAA (2002) estimated that improvements in forecasting accuracy and resolution allowed improved efficiency in the use of air space and thus reduced delays. This was calculated to be worth \$40m per year for US commercial terminals. If we estimate that there are one fifth of the number of aerodromes in the UK as there are in the US, this equates to a saving of \$8m or approximately £4m discounted to an overall benefit of £3.6m
- **More proactive planning** – Airport Authorities are able to plan far more effectively for major weather incidents.

The benefit of providing the general public with forward information on travel disruption was significant at Heathrow in late 2006. Passengers were able to phone in advance regarding flights, stay off the road and limit disruption at the airport itself. Estimates put the fog disruption cost to BA alone at between £10m and £15m – this could have been even larger without the Met Office's accurate and timely forecast of the fog clearing.

"As a result of the severe fog which is forecast to last for another 48 hours, British Airways will be operating a reduced short-haul flying schedule on Friday December 22nd"

BA Statement, 21 December 2006, 4pm

- **Avoidance of airborne material** – In 2002 the NOAA estimated benefits of \$18m from reduction in delays from the avoidance of volcanic ash for US flights. The Met Office provides an International Volcanic Advisory Service to ICAO, advising on the location of volcanic ash over the Northeastern part of the Atlantic (including Iceland). Aircraft avoidance of volcanic ash particulates is a significant safety and economic issue and, although the incidence of volcanic ash from Icelandic volcanoes is relatively infrequent, tests of contingency plans involving ATC and Airline organisations are held regularly
- **Fuel efficiency** – Airservices Australia (ASA) – In the first 50 days (July to mid-August 2005) of operations between Singapore and the Australian east coast, ASA reported figures indicating a 500 tonne fuel burn reduction worth A\$430,000 (£160,000) delivered as a result of flight planning systems used by Australia Air Traffic Control (Met Office WAFC input)
- **More efficient de-icing** – Forecasts allow de-icing requirements to be planned in advance. This means less wastage of expensive fluids and time.

Met Office data, delivered through flight planning systems, also brings a number of less tangible social and environmental benefits:

- There are also significant benefits to the environment from reduced fuel burning. Working on extrapolated IATA figures, if flight-planning systems were to save just 1 minute from each scheduled flight, there would be a reduction of 470,000 flying hours per year as a result of providing more efficient routes. This equates to a reduction of 4.7m tonnes of carbon dioxide, 1,500 tonnes of sulphur dioxide, 13,500 tonnes of nitrous oxides, and 23,000 tonnes of carbon monoxide⁵⁵
- Benefits to the public from fewer / better anticipated delays.

Following the earlier logic of WAFC London coverage (60%) and using the flight planning systems effectively (50%), plus a very conservative estimate of Met Office proportioned contribution to the improvement (25%), environmental savings equate to:

- i. 352,500 tonnes of carbon dioxide p.a.

⁵⁵ SAS study of an Oslo to Rome Flight on a 737-800

- ii. 112 tonnes of sulphur dioxide p.a.
- iii. 1,013 tonnes of nitrous oxides p.a.
- iv. 1,725 tonnes of carbon monoxide p.a.

7.6 Future plans

By continuing to deliver more accurate and timelier global weather forecasts, the Met Office will help to maintain the trend of reduced death rates associated with air traffic accidents. In addition, the environmental benefits that can be provided by flight planning systems will become ever more relevant following the increasingly heavy public and political focus on carbon emissions and the negative impact on climate change. The Met Office's input into flight planning systems will therefore become increasingly valuable.

8. Further examples of Met Office benefit

8.1 Ministry of Defence

Background

The Met Office, as an executive agency of the Ministry of Defence (MoD), is responsible for providing it with the meteorological information it needs. As long ago as 1944 the true value of the UK's world leading weather service gave the military a competitive edge. The Met Office correctly forecast a 36 hour weather window, said to be the only one in the whole of June of that year, in which to launch the most important operation of the Second World War, the Normandy landings.

Ever since, the Met Office has been serving the military and the country as a whole with increasingly accurate, more timely, and longer range forecasts to impressive effect.

The MoD has two key principles, which provide the basis for its work and therefore the work of the Met Office in supporting it:

- Defending the UK and its interests
- Strengthening international peace and stability.

The Met Office's role is far reaching and critical. It provides forecasting personnel on the front line in battle zones such as Iraq and Afghanistan, high resolution forecasting for mission critical geographies, and specific military modelling requirements, ultimately providing the British armed forces with a crucial information in combat situations.

Met Office also provides the weather data required by the armed forces need to plan UK and international training and operations in the most effective manner.

Met Office Services

The Met Office provides three main services to the MoD:

- **Operational services** – Delivery of underpinning information for the UK's weather and the weather of specific global positions where the MoD is active, to support military training and operations. In addition to the high resolution data modelled for UK weather, specific areas of the globe are modelled at the same resolution, using Crisis Area Models, to provide operational support
 - The RAF and the Army fund Met staff to provide regular forecasts. The Navy employs its own forecasters who use Met Office data
 - Beyond this, the Met Office provides global data, albeit at a lower resolution, to support wider military requirements
- **Research and development** – Improvements to science (including within NWP) are increasingly leveraged within the defence area and are used (for example) to improve 'first guess forecast products and make the output of Tactical Decision Aids (TDA) more accurate, leading to increased automation'. These TDAs include predictions of surface temperature to improve the performance of electro-optical sensors
- **Climate research** – The MoD uses the Met Office's model-based research to assess the future climatic conditions of areas of the globe where there might be large movements of people, and predict where global pinch points might develop in the future. Pinch points are usually driven by severe conditions such as drought or flooding, causing reduction in productivity and ultimately leading

to large-scale human migration. Military operations in the 21st Century are also concerned with humanitarian support, so knowing where events might occur and how disease might spread provides a significant advantage to the MoD. Climate information is also used by the military to gauge potential future procurement needs in areas where they may need to be active in the 0-10 year period.

Extended service value chain

The extended value to the MoD comes from the Met Office tailoring their data for specific military needs. An example of this is the production of TDAs. TDAs are then used to provide guidance to decision-making officers in the field.

Benefits

The benefits of the Met Office to the MoD are enormous. “The independent capability of the Met Office provides a latitude in decision making for the MoD that otherwise would not be possible” is the view of the MoD’s Account Manager. Given the consequences both politically and financially of getting these decisions wrong, the Met Office’s service is invaluable. The MoD could procure meteorological services from European or US providers to support decisions on operations, but the Met Office provides both world class accuracy, an aligned political objective and security assurance.

“The Met Office is absolutely crucial in our defence effort, both in this country and overseas”.

Under Secretary of State for Defence

With the MoD becoming ever more expeditionary in its strategy, there is an increasing reliance on the Met Office’s global forecasting capability.

Many of the areas where the Met Office’s service is used by the MoD are confidential in the interests of national security. However, some examples where Met Office services have provided specific value to the MoD are shown below.

Gulf



Aircraft such as Harrier jump jets and Chinook helicopters can be susceptible to extreme environmental conditions such as those found in Iraq. Therefore, the accuracy of Met Office models in correctly predicting hourly temperature changes has a major bearing on mission planning. Should the forecast be even slightly inaccurate, this can result, for example, in Harriers having to dispense unused weapons into the sea in order to lose weight to facilitate a landing at a major financial cost. However, the accuracy of the Met Office’s data is even more critical when deciding on available options to move men or machinery around an operation, and although incalculable, the Met Office’s accuracy saves a number of lives.

The Met Office’s weather predictions also have some bearing on weapon choice. For example, a different bombing technique may be used, dependent on the levels of cloud cover.

Afghanistan

Afghanistan is such a large and geographically diverse country that different aircraft can only take off and land in certain areas, or at certain times of the year or day.



Efficiency

The service that the Met Office provides to all three defence services helps each to plan UK and international exercises to their maximum efficiency. Although there is a “train as you fight” approach, certain exercises deliver more value when carried out in certain conditions and as such the Met Office provides the information to make this possible.

Casualties avoided / lives saved

The service that the Met Office provides to the RAF for UK and International exercises, both at the airstrip and in the air, helps to improve safety and reduce accidents that might result in casualties or loss of life. Met Office forecasts in Crisis Area Modelling zones can also be used to assess the dissemination of noxious gas or biological contaminants when released on the battle field by the enemy. Mitigating actions can be taken and loss of life avoided.

8.2 Department for Environment, Food and Rural Affairs

Background

The core purpose of the Department for the Environment, Food and Rural Affairs (Defra) is to improve current and future quality of life. The department was set up to bring together the interests of numerous stakeholders concerned with the environment and the rural economy. Defra's principal aim is to deliver sustainable development enabling people to satisfy their basic needs and enjoy a better quality of life without compromising the quality of life of future generations.

Defra has a complex structure acting as the route to government for a number of executive agencies, non-departmental public bodies, public corporations and charities. Many of these have an interest in Met Office services. However, there are four core areas where Met Office information has a major input to policy and the decision making process:

- Flood avoidance (covered in the Environment Agency case study in section 5)
- Climate change (covered in section 8.6 – Climate Prediction)
- Infectious animal disease planning
- Nuclear emergency planning
- Air pollution.

Met Office Services – Infectious animal disease planning and control

The Met Office provides regular data to support scenario modelling for the outbreak of specific animal diseases, monitoring the direction and speed of dissemination. This allows Defra to develop response plans should an outbreak occur, and deliver their resources in a more effective and efficient manner. Examples of this came in 1981 and 2001 when Met Office modelling was able to effectively predict the spread of an outbreak of Foot and Mouth.

More recently the Met Office model has been used by the Institute for Animal Health to model the likely spread of Blue Tongue and identify particular periods of the year when the virus may impact the UK. Blue Tongue is a viral disease affecting cattle, with midges (*Culicoides*) acting as the vector. The midges suck on the blood of infected animals and spread the virus from animal to animal in much the same way as malaria is spread through mosquitoes. This disease was thought to be unlikely to impact northern Europe, but from August 2006 to May 2007, approximately 2,000 Blue Tongue cases had been diagnosed. Met Office information is particularly valuable in forecasting and providing warning of specific weather conditions in which Blue Tongue is more likely to spread. Midges are particularly prevalent in the air at certain temperatures and are blown in certain directions by specific speed and directional wind flows.

Extended service value chain – Infectious animal disease planning and control

During the winter of 06/07, the Met Office together with the Institute for Animal Health used the Met Office's model to develop a risk assessment approach for the spread of Blue Tongue. This, if accepted, will provide Defra with a daily assessment of risk to the UK on a 4 level scale from no risk to heightened risk. Defra will then inform farmers in areas highlighted within the model as having a heightened likelihood of infection, to be increasingly vigilant for an outbreak. A ten-day incubation period for the virus means Defra can more effectively and efficiently target resource, monitoring animals for a potential outbreak.

"The Met Office's model is great. It provides an invaluable input to our preparations for dealing with bluetongue - enabling us to have an idea of when the midges might arrive on these shores."

Contingency Planning Director, State Veterinary Service (SVS)

Benefits – Infectious animal disease planning and control

The benefit to the UK from the Met Office's services is two-fold:

- Increased effectiveness and efficiency in the deployment of Defra resource
- Potential reduced impact from viral disease through more timely identification and mitigation.

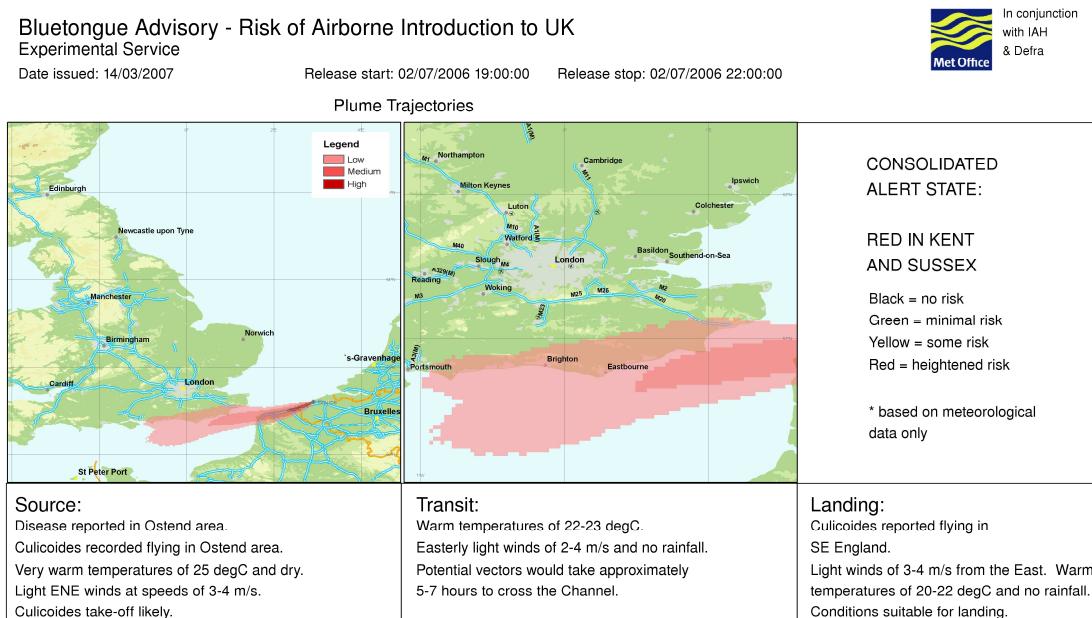
Efficiency

When an outbreak of Blue Tongue occurs in the UK, Defra is required to place two monitoring rings of 100km and 150km around the source of the outbreak. This compares to outbreak rings of 3km and 10km for Foot and Mouth. The extended size of the ring is because the midge vector carrying Blue Tongue can be carried far further by the wind than the Foot and Mouth virus without a vector. For Blue Tongue it is therefore highly valuable to Defra to be able to target resource as effectively as possible within the 100km and 150km rings. The Met Office provides the data to allow Defra to do this.

Social and environmental

As the spread of Blue Tongue is reliant on certain weather conditions, using the Met Office's forecast model, Defra can forecast the likelihood and whereabouts of Blue Tongue outbreak.

Below is an illustrative example of the model:



Using the model Defra can monitor where an outbreak may take place and on what days, making farmers aware, and increasing the likelihood of identifying an outbreak early. The earlier an outbreak is spotted, the earlier action can be taken to reduce its spread, thus limiting the impact.

"The Met Office genuinely helps Defra forecast the likelihood and location of potential outbreaks"

Contingency Planning Director, SVS

The cost to the UK economy of Foot and Mouth outbreaks was estimated at being between £5-8 billion in direct cost to government, farming and tourism. Although an outbreak of Blue Tongue would have a lower impact (due to the virus spreading by vector rather than directly between animals), the cost is still significant. In developing an early warning system using the Met Office's data, Defra could save the country millions of pounds of costs through early detection and mitigating action.

Met Office Services – Nuclear emergency planning

The Met Office provides global atmospheric models, allowing the Nuclear Emergency Arrangements Team, based within the Forecasting Programme, to run scenario events and test nuclear accident response systems. Scenarios to work against are usually provided once per week, but the prediction model is run on an almost daily basis.



Key to the value of the service is the 20 minutes response speed with which the Met Office can return a model associated with an incident scenario.

"The Met Office has set up a unit internally which is excellent at providing emergency response data, critical to our ability to plan for a nuclear incident"

Head of Nuclear Emergency Arrangements

The Met Office also provides data to 'back-fit' weather, in order to answer specific questions relating to radiation hot spots. Should a hot spot be found, recent Met Office data is used to assess where the radiation might have originated from.

Extended service value chain – Nuclear emergency planning

The extended service value chain is based on the Met Office's vital contribution to the overall nuclear emergency response arrangements which enable necessary actions and resource planning to mitigate the effects of radiation, as a result of the Met Office forecast.

Benefits – Nuclear emergency planning

The benefit derived from the Met Office's services is primarily evident during nuclear emergency exercises. Benefits can also be modelled on how improvements in Met Office accuracy and speed of response would improve the UK's response to a Chernobyl style incident, the results of which are still being seen today in the form of animal movement restrictions.

The effects of an overseas nuclear accident could be enormous. In September 2005, a draft summary report by the Chernobyl Forum, comprising a number of UN agencies, put the total predicted number of deaths due to the accident at 4,000. The full version of the WHO health effects report adopted by the UN, published in April 2006, included the prediction of 5,000 additional fatalities from significantly contaminated areas in Belarus, Russia and Ukraine, and predicted that, in total, 9,000 will die from cancer among the 6.8 million most-exposed Soviet citizens. Far from exaggerating the impacts this report has been criticized for trying to minimize the consequences of the accident.

Should another overseas nuclear accident occur and the weather conditions be less favorable for the UK, the Met Office's services and the Nuclear Emergency Arrangements Team will become critical elements in the UK response.

Casualties avoided / lives saved

- Met Office data will be used to more accurately model specific areas of nuclear fall-out (usually in the form of precipitation). This in turn will allow the areas most greatly affected to be identified and appropriate precautions initiated, thus reducing the time citizens are exposed to the immediate effects of nuclear fall-out
- Greater accuracy of fall-out area identification will also allow decisions to be made regarding the location of animals affected by the incident, thus quickly preventing radiation entering the food chain.

"As far as reaction is concerned for such events, timing is critical, and the Met Office is able to provide a very valuable service"

Systems Manager, Nuclear Emergency Arrangements

Efficiency

Ensuring specific areas potentially affected by radiation are located earlier and more accurately, will result in an increased efficiency and effectiveness in responding to the event: more efficient use of the emergency services; more efficient disposal of contaminated live-stock; and more efficient clean up processes.

Met Office Services – Air pollution

Met Office meteorological information helps to monitor and minimise the impact of air pollution.

The Met Office runs two atmospheric pollution services, PACRAM and CHEMET. These are funded by the Department of Trade and Industry, Defra, and the MoD, and provide response to nuclear and chemical events respectively. They provide the emergency authorities with meteorological forecasts, advice and specialist services in the event of a nuclear or chemical release into the atmosphere.

The EA, Local Authorities, the Highways Agency and other bodies work together to deliver the government's Air Quality Strategy in England and Wales, which sets air pollution standards to protect people's health and the environment. The EA regulate the release of pollutants into the atmosphere from large and complex industrial processes, which will soon include emissions from some large-scale agricultural activities. Various measures at European, national and local level control air pollution from other major sources of pollution, such as transport.

Extended service value chain – Air pollution

The Met Office's CHEMET service is available to the emergency services in the event of a chemical incident. CHEMET deals with approximately 350 incidents a year. Experienced Met Office forecasters will give immediate verbal indication of expected weather conditions and anticipated behaviour of any contamination. As soon as possible afterwards (normally within 20 minutes), a more-detailed forecast and a map of areas at risk is sent to the emergency services, with updates given until the emergency is over.

Applications covered by the Nuclear Accident Model (NAME), the Met Office's largest dispersion model, include plume rise; realistic boundary layer simulation; and upper level transport. All spatial scales are catered for, and it includes a powerful suite of diagnostic tools. 3D trajectories of air particles are used to compute air concentrations and ground deposits.

"This world-renowned atmospheric pollution dispersion model is an invaluable and versatile tool for accident and episode analysis, and for pollution forecasting."

- Met Office website⁵⁶

In the event of a nuclear incident, or larger industrial incident such as the Buncefield oil depot fire in 2005, the Met Office's NAME atmospheric dispersion model may be used. This provides trajectory data of any contamination, with forecast information on the transport and spread of the plume provided to the relevant local authorities and emergency services as appropriate.

The NAME model is a service to HM Government, though is also used by the EA on behalf of Defra. For example, in the case of an overseas nuclear accident, the EA would use the NAME model information on Defra's behalf to decide whether to invoke the UK's national response plan.⁵⁷

Benefits – Air pollution

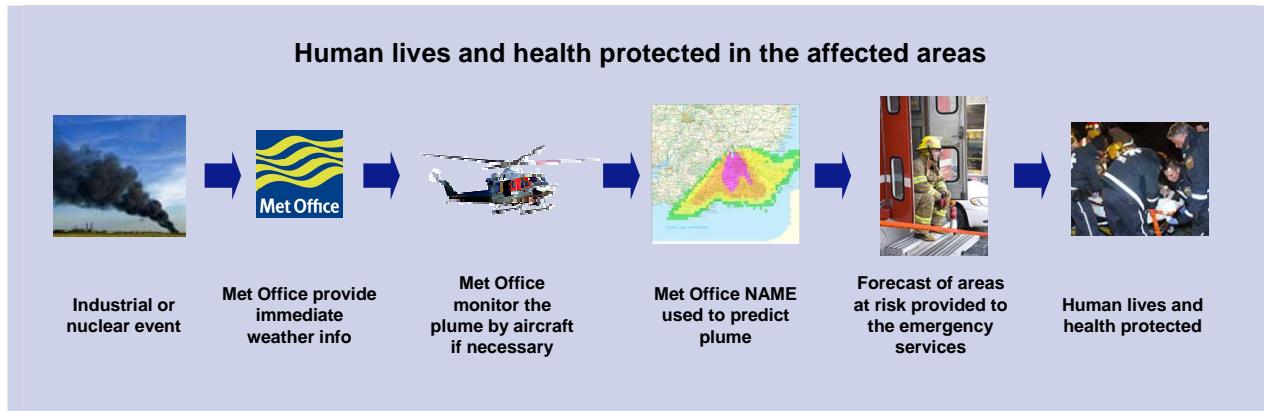
Air pollution				
Event	Benefits (UK)			
	Casualties avoided / Lives saved	Property damage avoided	Social / environmental benefits	Efficiency savings
Air Pollution	<ul style="list-style-type: none">• Early, specified warning of air pollution enables people to be evacuated in advance of the pollution, or to take the right precautions to protect themselves, protecting human health.	<ul style="list-style-type: none">• Urban building erosion and the cost of repair• Urban statue erosion and the cost of repair.	<ul style="list-style-type: none">• Reliable warnings of air pollution in a specified location ensures disturbance or evacuation of only the minimum number of people and animals likely to be affected• Meteorological data enables the EA to assess the impact of potential control options for industry and set emission limits which balance the cost of controls against benefits to human health and the natural or built environment.	<ul style="list-style-type: none">• Reliable early warnings of air pollution enables efficient action by the authorities to warn, and potentially evacuate, residents in the areas affected.

Source: PA Consulting analysis; National Appraisal of Assets at Risk (Defra, 2001)

Accurate weather information is vital in dealing with chemical incidents. By monitoring the direction and composition of air pollution following an industrial or nuclear event, the Met Office is able to provide warning of the extent and location of air pollution in advance of its arrival. This enables efficient action to be taken, evacuating or protecting people in the affected areas.

⁵⁶ <http://www.metoffice.gov.uk/environment/name.html> [Accessed March 2007]

⁵⁷ EA Head of Flood Risk Management Process



Incident example: Buncefield oil depot fire, December 2005

On 11 December 2005, a major explosion occurred at the Buncefield oil depot in Hertfordshire, UK. The incident caused fires which burned for several days, becoming the largest ever industrial blaze in Europe. Forty-three people were injured in the explosion, one seriously. There was significant damage to local homes and offices, and around 2,000 people were evacuated.

"It quickly became apparent that the fire was a large-scale incident with potential impacts on health and the environment both locally and at the regional scale (i.e. tens to hundreds of kilometres downwind)."

Geophysical Research Abstracts article⁵⁸

The Met Office's NAME model was used to model the plume to provide advice to the emergency services and other departments involved in the emergency response. Comparisons between the NAME predicted plume and the relevant visible satellite imagery show strong correlation between the observed and predicted geographical extent of the plume.

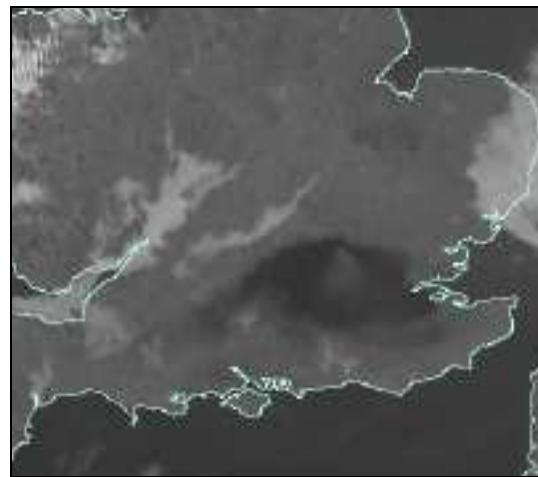


⁵⁸ A. Jones, M. Hort, A. Manning, D. Ryall, J. Taylor, H. Webster, C. Witham and S. Wortley, *The Buncefield oil depot fire: an overview of actual events and the Met Office's dispersion modelling response*, Geophysical Research Abstracts, Vol. 8, 06452, 2006

NAME 36 hour advance prediction of plume for 1400 hrs on 11 December 2005



Actual visible satellite imagery for 1400 hrs on 11 December 2005



Source: Met Office's Hadley Centre⁵⁹

"The Met Office role (as one of many agencies involved) included:

- Monitoring the position of the smoke plume through satellite imagery (primarily MSG visible imagery);
- Predicting the path of the plume and its likely contact with the ground (primarily using NAME and CHEMET);
- Deploying the Met Office/NERC Research aircraft to monitor the location of the plume and assess its contents;
- Quantifying likely smoke emissions from aircraft measurements;
- Handling media enquiries (several TV, radio and newspaper interviews)."

National Meteorological Service Annual Report 2005/06

The Met Office Operations Centre provided the first point of contact with Gold Command.⁶⁰ Met Office representatives also attended meetings with the Cabinet Office and Office of the Deputy Prime Minister. The Met Office NAME model was nominated by the Cabinet Office as the 'model of choice', and comparisons with satellite imagery and the aircraft measurements before and after proved to be accurate.

A member of the Met Office health team became the primary contact between the Met Office and the Health Protection Agency (HPA), and in January 2006 the HPA issued a statement saying: "If people followed the advice provided at the time of the fire, there is currently no evidence to suggest they will experience any significant health problems". After the event, the Met Office was also involved in post event initiatives designed to improve emergency response coordination.

⁵⁹ H. Webster, S. Abel, J. Taylor, D. Thomson, J. Haywood and M. Hort, *Dispersion Modelling Studies of the Buncefield Oil Depot Incident*, Met Office Hadley Centre technical note 69, 3 August 2006

⁶⁰ A clear structure is put in place to enable a major incident to be successfully controlled, based on three levels of command which can be applied to each Emergency Service and Agency. These are known as "Strategic, Tactical and Operational" or "Gold, Silver and Bronze" command. Gold Command is in overall charge of each service or agency responsible for formulating the strategy for the incident. (PWS Assurance Manager)

"The Met Office bring a clear, well considered and precise view to the table. This was particularly evident in the Buncefield incident which allowed our team to make appropriate decisions at critical times."

Environment Desk Officer, Civil Contingencies Secretariat, Cabinet Office

8.3 Highways Agency

Background

The Highways Agency is an Executive Agency of the Department for Transport (DfT) and is responsible for operating, maintaining and improving the strategic road network in England on behalf of the Secretary of State for Transport. It has a major role in delivering the government's Ten Year Plan for Transport. The Agency facilitates safe and reliable journeys on strategic national routes (Motorways and A-roads) by managing the traffic using the roads as well as administering the network as a public asset.

Understanding the weather plays an important part in the safe and effective management of the roads. It is estimated that up to 20% of the major incidents that occur on the roads over the period between October and April each year are weather related.⁶¹ In 2005, DfT figures stated that there were 2,913 fatal accidents, 25,029 serious accidents and 170,793 slight accidents on Britain's roads. The DfT estimates the economic cost of these accidents to be £17.9bn based on lost economic output, damage to property, medical and ambulance costs, police costs and insurance costs.⁶² This excludes the economic cost of delays to other road users. As such, clear and accurate forecasting is critical to the ongoing challenge faced by the Highways Agency in reducing accidents, and convincing the public to take alternative routes or not to drive at all in certain instances.

"The work being carried out by the Met Office is integral to the ongoing success of the National Traffic Control Centre, reducing loss of life, injury, and damage to property"

Highways Agency



Although difficult to measure, the Highways Agency is starting to achieve its communications objective of informing the public of weather related events and persuading alternative road user behaviour. Recent examples include a 20% improvement in traffic flow on the day of the worst snow of the year, 8 February 2007, compared to previous years. Given that there is a direct correlation between the number of vehicles on the road and the number of accidents, this is a clear indication of the benefit the Met Office is providing to the Highways Agency and UK road using public.

⁶¹ Highways Agency estimate.

⁶² Department for Transport, *Highways Economics Note No.1 2005: Valuation of the Benefits of Prevention of Road Accidents and Casualties*, Office of the Deputy Prime Minister, January 2007. Also: Office of the Deputy Prime Minister, *Economic cost of a fire*, 2004

Met Office Services

The Met Office provides a number of ongoing services to the Highways Agency. These include:

- Daily reports regarding weather across the country highlighting the different impacts on various parts of the country and the major road network
- Medium term forecasts e.g. up to 10 days out to help prepare for impending events
- Severe wind alerts for the Freight Transport Association
- Four on-site shift working Met Office personnel who sit in the National Traffic Control Centre in Quinton, Birmingham. This team provides on the spot information and interpretation of scenarios to support the Highways Agency make decisions on roads and routeing. (This service is provided between October and April)
- Ad hoc support including assessment of impact of weather on specific parts of the network for example heavy rain on a road which has a history of flooding.

Extended service value chain

The data and the value added support provided by the on-site Met Office staff, is used by the Highways Agency in their proactive approach to accident reduction and road efficiency improvements. The Highways Agency's outputs include providing driver-tailored weather updates, plus traffic flow and accident data through a number of channels. These include the web, an interactive voice recognition system and approximately 300 media links including radio stations and television news updates. In addition, the Highways Agency provides an inbound call centre to provide responses to all travel-related queries.

The Highways Agency extended service value chain ultimately ensures that weather data reaches drivers in a tailored, focused and timely manner.

Benefits

Benefits can be captured and explained in a number of major areas:

Casualties avoided / lives saved

- The reduction in loss of life and injury through the reduction of accidents throughout England's motorways and A-roads. This is achieved through a number of mechanisms:
 - Warnings to the public via the website, the media and the signage above the road network. The data provided by the Met Office to the Highways Agency were used, for example, to support decisions on 8th February 2007, when up to 10cms of snow was predicted and indeed fell. It is estimated that the flow of traffic across the network was 20% better than previous comparable events
 - Warnings to the other major users of the road network for example the Freight Transport Association.

Social and environmental

- The improvement in the journey experience for the driver through the provision of information by the Highways Agency regarding major incidents, including those created by adverse weather on the roads
- Reduction in environmental damage through more efficient and effective salting of motorways and A-roads.

Efficiency

- The improvement in the use of fuel through more efficient journeys

Further examples of Met Office benefit

- Efficient road choice by the driver, based on information by the Highways Agency regarding major incidents, including those created by adverse weather
- Improved efficiency in the use of grit for the motorways and A-roads.

8.4 Maritime and Coastguard Agency

Background

The Maritime and Coastguard Agency (MCA) is an executive agency of the Department for Transport. It is responsible throughout the UK for implementing the government's maritime safety policy. This includes co-ordinating search and rescue at sea through Her Majesty's Coastguard, and promoting safety at sea and on the coast. The stated aim of the MCA is as follows, 'We work to prevent the loss of lives at the coast and at sea, to ensure that ships are safe, and to prevent coastal pollution'.

Over the last 12 months the MCA has dealt with numerous requests for support from both the commercial and public arena including:

- 96 pollution incidents attributed to vessels
- 17,000 Search and Rescue incidents in which they have rescued over 48,000 people and assisted 23,000 people
- 80,000 pieces of correspondence from the general public
- 4,000 ship surveys
- 6,000 inspections of foreign and UK ships
- 14,500 certificates and other documents that allow seafarers to work at sea
- 15,000 requests for new and renewal registrations on the Small Ships Register.

It achieves its objectives through regulation, standard setting and inspection, by which it aims to improve the safety of passengers and crew and to prevent pollution from ships. The MCA also works to minimise the effects of any pollution incidents that happen by reacting quickly and effectively. The security of cargo ships and maintaining the quality of ships on the 'UK Ship Register' are also key responsibilities.

Through these and other key activities the MCA is able to fulfil a key objective namely the UK's obligation to the International Maritime Organisation's international convention for the Safety of Life at Sea (SOLAS) which covers numerous areas of maritime safety and security.



Met Office Services

The Met Office provides a number of ongoing services to the MCA and thereby supports the MCA in fulfilling its obligation to the SOLAS convention in particular chapter V (safety of navigation) which specifies the maintenance of meteorological services for ships amongst other requirements.

The services provided by the Met Office to the MCA include both day-to-day and ad hoc reactive services and support. They include:

- Latest marine observations – including hourly observations for the last six hours
- Shipping forecasts / gale warnings – a general synopsis of the weather and area forecasts

Further examples of Met Office benefit

- In-shore waters / strong winds – includes strong coastal wind forecasts, coastal forecasts and an outlook for the next few days
- High seas / storm warnings
- Responsive services – for example, supports modelling of pollution and could include advisors to work alongside disaster recovery teams in the event of a maritime incident
- Fishing fleet information in the winter months.

Extended service value chain

The MCA is responsible for the provision of Maritime Safety Information to ships at sea, which includes the broadcast of warnings and forecasts. The Met Office initiates warnings and prepares routine forecasts for dissemination on behalf of the MCA to support vessels using coastal waters and beyond and UK ports. In addition the MCA is responsible for responding to incidents of pollution which the Met Office may be required to provide meteorological data for..

Benefits

Casualties avoided / lives saved

In general the MCA delivers a critical service to the seafaring community and is responsible for minimising the rates of accidents, deaths and injuries at sea and along the coast. It does this through a number of prevention and mitigation strategies and the provision of information to that community. The Met Office supports this role through the provision of different data points including underlying observations, forecasts and models. In this way both injuries are avoided and lives are saved through greater awareness of the conditions in which an individual or commercial vessel is travelling

Efficiency savings

The MCA also plays a crucial role in ensuring the efficient and safe passage of the mariner operating into and out of UK ports. The efficiency of this process is improved through the provision of information by the MCA which is in part based on Met Office forecasts and warnings, allowing vessels to better navigate areas of poor weather and sea conditions.

Whilst the MCA proactively works to reduce incidents of pollution, where these events occur the MCA manages the response, aiming to minimise the impact of pollution. This impact is greatly reduced as a result of the MCA's actions which are partly due to the provision of meteorological models and forecasts by the Met Office.

Research commissioned by the UK Offshore Operators Association⁶³ and the UK Health and Safety Executive has estimated that the likely cost saving to operations (such as helicopter operations, rig movements, diver support vessel operations and tanker loadings), from improved meteorological data, is £10m p.a.

⁶³ Met Office, *Impacts on UK from pollution of spectral wavebands used for Meteorological Observing*, July 2006

8.5 Health Programme (Department of Health)

Background

The Met Office has been investigating the impact of weather on human health. The Met Office's Health Programme has been working with the NHS to assess how the Met Office's services can be used to improve efficiency and effectiveness of the Health Service. A number of illnesses and diseases are impacted by the weather to a lesser or greater extent. Hot weather, cold weather, high-pressure systems and lightning storms can all exacerbate medical conditions.

The Health and Social Care Awards are run in partnership between the Department of Health and the NHS Institute for Innovation and Improvement. They were set up to celebrate the immense pool of talent and initiative in health and social care and are the most important opportunity within the NHS and social care to identify, recognise and reward excellence in the provision of care at the frontline.

On the 21 March the Met Office's Health Forecasting team won the prestigious Innovative Service Award which was presented by the Chief Executive of the NHS Institute for Innovation and Improvement.

The Innovative Service Award recognises innovative, new or improved services that are benefiting the delivery of healthcare for patients, users and carers. In all there were 1400 entries for the 2006 Awards across 14 categories.



Met Office Services

The Met Office provides a number of defined and ad hoc services to help reduce the impact of weather on human health. As increased evidence becomes available about the links between weather and human health, we expect these services to grow in size and number. Below are examples of the services currently being provided and those in their infancy:

Chronic Obstructive Pulmonary Disease

The main service that the Met Office provides is aimed at proactively reducing the impact of Chronic Obstructive Pulmonary Disease (COPD) during certain weather events. In the winter months, the Met Office issues twice-weekly forecasts to 35 Primary Care Trusts (PCT) highlighting the risk of COPD being exacerbated. PCTs then use this information to contact a list of COPD patients who have signed up to a warning service. In 2004/05 the service was reliant on GP practices phoning round enrolled patients, which placed an extra burden on them. However in the winter of 06-7 an automated direct to patient version of the system was successfully trialled by the Met Office. This service has proved extremely popular due to its ability to triage the requirement for manual follow up calls.

Cold Weather

The Met Office is working with Help the Aged, Warm Front, Local Authorities and the NHS to deliver evidence based interventions to help reduce cold related illnesses and deaths. This will help address the UK's position as having one of the worst records in northern Europe for extra winter mortality rates.

Hot weather

See 'Example 3: Heatwave plan' in the Cabinet Office case study (section 6).

Thunderstorm asthma

Thunderstorm linked asthma events are rare but when they occur have a major impact on Accident and Emergency (A&E) departments. The reason for asthma attacks increasing in number during certain thunderstorm conditions is not fully understood, but the Met Office now has the capability to forecast where and when the events which trigger attacks will occur. The Met Office provides an ad hoc service in such events, contacting local A&E departments, informing them that an episode is imminent.

Influenza prediction

Evidence suggests that the presence and spread of the influenza virus could be heavily influenced by the weather and climate. Although little scientific work has been done to date, using its Unified Model, the Met Office aims to develop models aimed at improving the targeting of resources before and during an outbreak.

Extended service value chain

The extended value of the Met Office's services is very much dependent on the acceptance of Primary Care Trusts of the link between weather and disease proliferation, and the adoption of the health specific services the Met Office is offering. Where PCTs have used the Office's services to both target prevention and guide resourcing, substantial benefits have been delivered.

Benefits

During the winter of 05/06 35 PCTs in England used the Met Office's COPD service

- 82% of staff surveyed acknowledged that their patients had benefited from the service
- 64% of those who had taken part in the trial and were surveyed thought that the project had improved their lives
- In the South West of England, practices that used the Health Forecasting service saw a 76% reduction in admissions whereas those that relied on alternative methods saw only a 47% reduction in admissions
- Some PCTs have estimated savings of £100,000 each, directly attributable to the service, from a reduction in admissions and resultant hospital stays. There are 152 PCTs in England.⁶⁴ Should each PCT use this service, and with an average conservative benefit of 50% of the £100,000 figure, £7.6m savings would be delivered.

Thunderstorm induced asthma

On 24 June 2005, an asthma-inducing thunderstorm was forecast to hit a specific area in the South East of England. A blanket warning was put out to A&E wards in the effected area. However, only one A&E department (Northwick Park) altered their resourcing plan on the basis of the warning.

- The effect of the storm was an eight-fold increase in the number of asthma related A&E attendances in the area, resulting in many departments running out of the required medication, the majority missing their 4hr A&E waiting target, and some even closing. Northwick Park however met its target and effectively and efficiently dealt with the increased demand
- The Met Office is now in the process of developing standardised processes for proactively and reactively addressing such weather related impacts.

The Met Office is keen to build on its Health Programme and is now developing models to predict the weather-related exacerbation of heart failures, strokes and mental health problems.

⁶⁴ Based on 1 October 2006 figures

8.6 Climate prediction

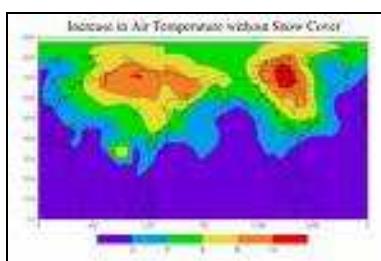
Background

Defra and the MoD fund climate research in the Met Office. This research, based on a version of the PWS funded Unified Model, now forms the basis of key global decision-making on climate change policy. An example of this can be seen in the UK government's report on climate change, published on 30 October 2006. In the report, Sir Nicholas Stern discusses the effect of climate change and global warming on the world economy, and proposes necessary actions to mitigate their effects. Much of the evidence for climate change and future climate prediction is based on the work of the Met Office's Hadley Centre.

The Met Office's Hadley Centre predictions are used by the Intergovernmental Panel on Climate Change (IPCC). The IPCC was established in 1988 by two UN organisations, the World Meteorological Organization (WMO) and the United Nations Environment Programme, to evaluate the risk of climate change brought on by humans. In February 2007, the IPCC issued its fourth report. In it the IPCC stated that warming of the climate system is unequivocal and that most of the observed increase in globally averaged temperatures since the mid-20th Century is very likely due to the observed increase in human greenhouse gas concentrations. The work of the Met Office's Hadley Centre has been fundamental to the IPCC's confident statements.

The climate prediction programme provides information and policy advice for Defra and the MoD. Defra's main uses of the data are for scientific prediction, and informing central and local government on necessary actions required given the likely future climate changes. For the MoD, data are used, for example, to inform the design and development of future weapons and equipment because of their lengthy lead times. Understanding if deserts will be 5°C warmer on average in 10-20 years, or tropical areas 2% wetter, for example, is critical in helping to define and design future equipment requirements.

Climate prediction is also used in determining where MoD services might be required in future, whether for military or humanitarian purposes. Unrest and human need are often triggered by climate change in the form of drought or flooding, leading to large-scale human migration. Knowing where these points may lie provides the MoD with the required foresight for military planning. Climate prediction can also help model the likely prevalence and spread of disease, and in using this data the MoD can vastly improve the efficiency and effectiveness of humanitarian disaster support.



Public Weather Services on climate prediction

There are three areas in which the PWS supports the climate programme:

- Observations required for input into climate databases
- The climate model itself (which is based on the PWS funded Unified Model)
- National Climate Information Centre, which collates and analyses observation data to be presented in the most useful format for Met Office customers.

Ultimately the Climate Prediction Model's output is highly reliant on the PWS, and therefore a proportion of the benefit of its research is attributable to the PWS.

Extended service value chain

Defra receives quarterly and annual reports on the Met Office's research into climate prediction. A significant benefit is also delivered by supporting Defra in responding to specific climate related requests. It is this research that enables the UK to drive climate related issues on the international platform. Britain, for example, is working with Bangladesh, China and India to help their governments understand global warming. In particular it has projects in India to help the country understand the implications of heatwaves and water shortages.

Britain is also leading the world in its policies to tackle climate change. This is only possible because of the quality of the output provided by the Met Office and its Unified Model. In March 2007, the government released the UK's draft Climate Change Bill, which sets out a framework for moving the country to a low-carbon economy. This included:

- A legally binding target of a 60% reduction in carbon dioxide emissions by 2050, with a plan for a 26% to 32% reduction by 2020
- Legally binding five year 'carbon budgets', set at least 15 years ahead, to provide long-term clarity for investment in low-carbon technologies
- A requirement for a government report at least every five years on current and predicted impacts of climate change.

Other governments are starting to respond to the UK's lead on this global issue.

Local Authorities, insurance companies and the DfT, for example, are all engaged with Defra to draft a policy to help reduce climate change.

Defra also uses climate change information to forecast the spread northwards of more tropical animal viruses such as African Horse Sickness and Western Isle Virus.

Benefits

The benefits to the UK of the acknowledged and acclaimed climate prediction research produced by the Met Office are enormous. They go beyond the direct benefits delivered to Defra and the MoD. By being foremost in climate prediction research, the UK is in the enviable position of being able to lead the world in the quest to address climate change. From an economic perspective this could lead to massive increases in investment to the UK economy, but from a political perspective it ensures the UK is seen at the centre of global issues. This in turn provides the UK with a competitive advantage in wider political negotiations.

8.7 International

The Met Office is the official national meteorological service for the UK; it is also a "world-leading provider of environmental and weather related service in the UK and around the world".⁶⁵ The Met Office has a distinguished international reputation and as such plays an enormously important role in global meteorology.

Every year there are devastating consequences from weather related events that cost national economies billions of pounds and often cause significant loss of life. To attempt to reduce these effects and sustain development, the world's leaders need to be able to draw on the meteorological information that the Met Office and similar institutions provide.



Achieving this requires an unprecedented level of international co-operation in global observations, in numerical weather prediction (e.g. multinational, multi-model forecasting systems), in research and development (climate, weather and socio-economic applications), and in the delivery of solutions.⁶⁶

The Met Office occupies a prominent role on the global stage through its participation with:

- International Organisations
- Capacity Building
- International Projects
- International Services.

International organisations

While it is acknowledged that the Met Office is a major contributor in advancing the global field of meteorology, co-operation with all other national meteorological services is essential to both developing the Met Office's own capabilities as well its counterparts. By drawing on this international pool of expertise, the Met Office can continue to provide further benefit to the UK public.

On 29 August 2005, Hurricane Katrina hit the US Gulf coast with sustained winds of 125mph at landfall resulting in major devastation, particularly to New Orleans. Met Office forecasts predicted the location of landfall to an accuracy of 60km 3 days in advance.

Less than a month later when Hurricane Rita threatened further devastation, the Foreign and Commonwealth Office (FCO); the Deputy Consul-General and the British Embassy in Washington were among the departments and organisations that followed Met Office forecasts. The Met Office now works routinely with the FCO to provide hurricane warnings for British travellers.

"I was running the American model and receiving the Met Office updates, and the Met Office model was by far the most accurate in relation to the predicted eastward shift of Rita. We are very grateful to our colleagues at the Met Office for work on these models and their continuous and timely feedback."

Vice Consul for Science and Technology, FCO

⁶⁵ Ministry of Defence, *Ministry of Defence Annual Report and Accounts 2004–05*, HC 464, p.215, October 2005

⁶⁶ <http://www.metoffice.gov.uk/corporate/international/index.html> [Accessed March 2007]

To ensure knowledge sharing between national met services, several intergovernmental organisations have been set up to co-ordinate activities, research, training and technical methodologies.

 <p>World Meteorological Organisation</p> <ul style="list-style-type: none">• A specialised agency of the United Nations, comprising of 187 Country Members and based in Geneva• WMO provides the framework for international cooperation	 <p>The European Centre for Medium range Weather Forecasts</p> <p>An intergovernmental organisation supported by 18 European States</p> <p>Prepares medium range weather forecasts</p>	 <p>The Network of European Meteorological Services</p> <ul style="list-style-type: none">• Network of 19 European national meteorological services• Aim to make more efficient use of resources	 <p>EUMETSAT</p> <p>18 European Member States</p> <p>Primary objective is to establish, maintain and exploit European systems of operational meteorological satellites</p>	 <p>ECOMET</p> <ul style="list-style-type: none">• ECOMET (the Economic Interest Grouping of the national meteorological services of the European Economic Area) was set up in 1995 to ensure fair competition in the field of meteorological services.
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The UK, through the Met Office, actively supports the Voluntary Cooperation Programme and works closely with other National Met. Services around the world to.⁶⁷

- Improve protection of life and property from the effects of natural disasters
- Rapidly restore the life-critical services provided by NMSs whose countries have been affected by natural disasters, or are emerging from conflict
- Improve understanding of the effects of global climate change by taking new climate observations
- Archiving existing records of countries which cannot support these activities themselves.



International projects

The Met Office is involved in a large number of international collaborative projects that play a key part in developing all areas of meteorology. These include, for example,⁶⁸

- **ThorpeX** – A ten-year WMO research programme to accelerate improvements in the accuracy of one-day to two-week high-impact weather forecasts for the benefit of society, the economy and the environment
- **AMDAR programme** – Met Office contributes to AMDAR (Aircraft Meteorological Data Reporting) systems that are carried on board aircraft and automatically measure various atmospheric parameters which are sent to data receiving centres and eventually are used in numerical weather prediction models. This programme involves collaboration with Australian and French Met services

⁶⁷ <http://www.metoffice.gov.uk/corporate/international/vcp.html> [Accessed March 2007]

⁶⁸ International role: <http://www.metoffice.gov.uk/research/interproj/index.html> [Accessed March 2007]

International services

The Met Office has international responsibilities for the provision of services. They are a Regional Specialised Met Centre for Emergency Response and a World Area Forecast Centre for aviation.⁶⁹ (Refer to the CAA case study in section 7 to understand the full benefits provided by the Met Office in the aviation arena.)

⁶⁹ International Services: <http://www.metoffice.gov.uk/corporate/international/index.html> [Accessed March 2007]

Appendix A: List of acronyms

A&E	Accident and Emergency
ABI	Association of British Insurers
ACPO	Association of Chief Police Officers of England Wales and Northern Ireland
AMDAR	Aircraft Meteorological Data Reporting
CAA	Civil Aviation Authority
CCS	Civil Contingencies Secretariat
CO	Cabinet Office
COPD	Chronic Obstructive Pulmonary Disease
DEFRA	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DTI	Department of Trade and Industry
EA	Environment Agency
EANFWC	Environment Agency National Flood Warning Centre
ECMWF	European Centre for Medium-Range Weather Forecasts
ECOMET	Economic Interest Grouping of the National Meteorological Services of the European Economic Area
EUMETNET	Network of European Meteorological Services
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
HA	Highways Agency
HPA	Health Protection Agency
HSE	Health and Safety Executive
IAH	Institute for Animal Health
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IPCC	Intergovernmental Panel on Climate Change
LA	Local Authority
LB	London Borough
LRT	Local Resilience Team
MCA	Maritime and Coastguard Authority
META	Millimetre Emission Temperature of the Atmosphere
Mod	Ministry of Defence
NAME	Nuclear Accident Model
NCIC	National Climate Information Centre
NERC	National Environment Research Council
NERT	Nuclear Emergency Response Team
NFFS	National Flood Forecasting System
NHS	National Health Services
NIRA	Northern Ireland Rivers Agency
NOAA	National Oceanic and Atmospheric Administration
NSWWS	National Severe Weather Warning Service
ODPM	Office of the Deputy Prime Minister
PA	PA Consulting Group
PACRAM	Procedures and Communications in the Event of a Release of Radioactive Material
PCT	Primary Care Trust
PWS	Public Weather Service
PWSCG	Public Weather Service Customer Group
RRT	Regional Resilience Team
RSMC	UK Regional Specialised Met Centre
SADIS	Satellite Distribution System
SEPA	Scottish Environmental Protection Agency
SITA	Service provider of IT business solutions and communication services to the air transport industry
SMEs	Small and medium sized enterprises
SOLAS	Safety of Life at Sea
SPNP	Stochastic Precipitation Nowcast Programme
STFS	Storm Tide Forecasting Services
SWEP	Severe Weather Emergency Protocol
TAF	Terminal Area Forecast
TKDA	Tactical Decision Aid
UKOOA	UK Offshore Operators Association
UN	United Nations
UNEP	United Nations Environment Programme
VCP	Voluntary Cooperation Programme
WAFC	World Area Forecast Centre London
WHO	World Health Organization
WMO	World Meteorological Organization

Appendix B: Bibliography

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¹⁸ The calculations are: Expected annual damage PV (£1,411m) * Performance factors (10.3%) = £146m Flood damage avoided PV.

Flood damage avoided PV (£146m) – Investment PV (£21.8m) = £124m Flood Warning Service Benefit NPV.

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Flood Warning Service Benefit NPV (£124m) * Met Office proportion of services provided (25%) = £30.9m Met Office Benefit PV to property.

The Investment figure represents 10% of the 10-year investment (PV) amount detailed in the National Flood Risk Assessment report. Performance Factors measure the performance of the Flood Warning Service, based on the proportions allocated in the National Flood Risk Assessment report.

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Cabinet Office
Civil Aviation Authority
Construction Confederation
Cumbria Council
Department for Environment, Food and Rural Affairs
Devon County Council
Environment Agency
Gloucestershire Emergency Planning Unit
Health and Security Council
Highways Agency
Local Resilience Team
London Borough of Richmond upon Thames
London Fire Brigade
Met Office
Metropolitan Police
Ministry of Defence
Norfolk Council
Oxfordshire Police
Regional Resilience Team
Severe Weather Emergency Protocol
St. Mungo's
Waltham Forest Council
Westminster County Council