

Reference Period 3, Met Office planning overview and consultation briefing note

Updated January 2019

1. Executive Summary

This note describes the key proposed areas of Met Office development and delivery of regulated aviation Met Services through Reference Period 3 (Jan 2020 – Dec 2024).

There are several drivers which provide the context to these proposals, including compliance with ICAO's regulatory framework both current and developing in line with the Global Air Navigation Plan and Aviation System Block Upgrades as well as improving the detail, accuracy and availability of weather information. In addition, the growth in UK and global traffic is increasing the relevance of weather resilience activities to mitigate disruptive weather and minimise impacts.

The Met Office regulated aviation remit can be split into two main areas:

- i. National Capability, which describes the underpinning infrastructure needed to operate a weather forecasting service; and,
- ii. Met Service development and delivery, describing the Met information services delivered to end users, utilising the National Capability.

Developments are planned through the period of RP3 for both the National Capability and Met Service development and delivery. For example, there is a need for the Met Office to enable users to access rapidly increasing volumes of higher resolution Met data, both for international (WAFS) and UK aviation requirements, continuation of the successful on-site meteorologists at Swanwick and contribution to the planned significant upgrade in satellite technology.

There are consultation questions contained within this briefing note, which seek to develop the discussion and seek feedback on the proposed developments and associated investment.

Contents

1. Executive Summary.....	1
2. Introduction, context and drivers	3
3. Overview of activities through RP3.....	5
3.1 RP3 National Capability.....	5
3.1.1 RP3 National Capability Finances.....	5
3.2 RP3 Met Service development and delivery	6
3.2.1 Met Services specified in the Met Office’s Designation arrangements to meet international and national flight operations and ATM requirements	6
3.2.1.1 Low level Aviation	6
3.2.1.2 WAFS, delivered by WAFC London	7
3.2.1.2.1 Current WAFS service	7
3.2.1.2.2 Proposed developments to WAFS during RP3.....	7
3.2.1.3 Volcanic Ash Advisory Centre (VAAC)	9
3.2.1.4 SADIS	9
3.2.2 Other Designation Met Services	9
3.2.2.1 Volcanic Ash	9
3.2.2.2 Data Services for NATS.....	10
3.2.2.3 Weather Resilience Activities.....	11
3.2.2.4 General Aviation	13
3.2.2.5 Support to helicopter operations	13
3.2.2.6 Space Weather.....	14
3.2.2.7 Other emerging requirements for meteorological information	14
3.2.3 Technology developments.....	14
3.2.4 Science developments	15
3.2.5 RP3 Met Service Development and Delivery Finances	17
4. Performance Measurement.....	19
5. Overall Met Office RP3 Finances.....	21
6. Consultation outcomes	22

2. Introduction, context and drivers

The UK and Global aviation industry is changing rapidly with increasing traffic, increased capacity demands upon airports and airspace, plus a need to limit the environmental impact of air travel. There is a need to provide accurate and detailed Met services to meet these developing demands and to allow the industry to mitigate against the impacts of disruption caused by weather to minimise delays and other inconveniences to passengers and cargo.

This briefing note is intended to provide background and details associated with the Met Office proposals to meet the regulated Met requirements through Reference Period 3 (RP3). This update follows feedback received at the Met Office RP3 consultation event, held on 7th September 2018 and subsequent written responses. The outcomes of the consultation process are included in section 4 of this note.

The Met Office is the provider of the UK's regulated aviation services, under designation of the CAA Met Authority. The cost recovery mechanism for the Met services is through the UK en-route air navigation service charge, collected directly from Eurocontrol, on behalf of all Eurocontrol Member States.

There are several drivers which are providing the direction to the Met Office's proposals for Reference Period 3.

The first of these is a need to provide meteorological services as stipulated in the Met Office Designation Document as set out by the CAA. These services ensure the UK meets its ICAO obligations in order to provide safe, efficient and regular air travel. For the UK, these ICAO Annex 3¹ services can be categorised as follows:

- i. UK low level weather;
- ii. The World Area Forecast System (WAFS) provided by World Area Forecast Centre (WAFS) London;
- iii. SADIS (Secure Aviation Data Information Service); and,
- iv. The London Volcanic Ash Advisory Centre (VAAC).

In the context of ICAO, the UK is also playing an active part in developing capabilities in line with ICAO's Global Air Navigation Plan (GANP) and the associated Aviation System Block Upgrade (ASBU) framework. This highlights some of the key considerations through the RP3 period including global air traffic growth (doubling every 15 years since 1977) and an objective for increased capacity and efficiency, whilst of course maintaining safety and minimising the environmental impact of civil aviation activities.

Within the GANP and ASBU framework and whilst there is a specific requirement for AMET (Advanced Met) through the block timeframes, many of the other concepts such as performance based navigation, flight planning, continuous descent operations and continuous climb operations are also dependent on highly accurate and globally available Met information.

In the UK, there is a clear and increasing demand for weather resilience to increase predictability and minimise weather related disruption associated with the air traffic system. This work has commenced within RP2, such as the implementation of an onsite Met team at NATS and trials of

¹ Annex 3 to the Chicago Convention, Meteorological Service for International Air Navigation, Ed

thunderstorm forecasts for use by controllers for both planning and tactical operations. The demand for these forecasts may also extend into the European area, where continental weather-related disruption has a large and increasing impact on the UK air traffic system.

Coupled with the increased traffic and demands on airport and airspace capacity, the weather resilience work is expected to become even more important in the context of a changing climate and the potential for greater extremes of weather. In recent years, there is a perception that the frequency and severity of thunderstorms has increased, an increase in autumn/winter storminess and a reduction in severe winter weather although perhaps a greater impact when a significant snowfall event does happen.

A further developing area of context for Met in RP3 is the rapidly changing technology environment. Volumes of Met data have been increasing and are expected to continue to increase significantly in terms of both detail and size. Equally, the ability to integrate Met data is also developing, including systems for flight planning, air traffic management and individual aircraft. Making Met data more accessible to users is a key part of this and the move towards a data-centric approach, developing and implementing a big-data strategy is also a key consideration for the Met Office leading up to and throughout RP3.

3. Overview of activities through RP3

The provision of regulated Met information from the UK can be split into two main areas:

- i. The National Capability of a National Met Service. This means the key underpinning infrastructure which is fundamental to being able to provide an accurate local and global forecasting capability.
- ii. The Met service development and delivery to the aviation users, utilising the National Capability.

These two areas are described in further detail below.

3.1 RP3 National Capability

This is the core capability of the Met Office and describes some of the fundamentals that are required to operate a modern and accurate weather forecasting service. Examples of the capability included are weather observations (including satellite and radar), science development and research, Numerical Weather Prediction (NWP), High Performance Computing (HPC) and forecast guidance (the forecasting unit which provides the senior operational oversight).

The oversight of the National Capability is provided by the Public Weather Service Customer Group (PWSCG) which acts as the customer on behalf of the public and on behalf of the public sector users for the free at point of use Public Weather Service (PWS) information. The CAA is a member of the PWSCG and provides technical and strategic advice and input to ensure an appropriate underpinning capability exists for aviation Met services now and in the future. More information is available here: <https://www.metoffice.gov.uk/about-us/what/pws/customer-group>

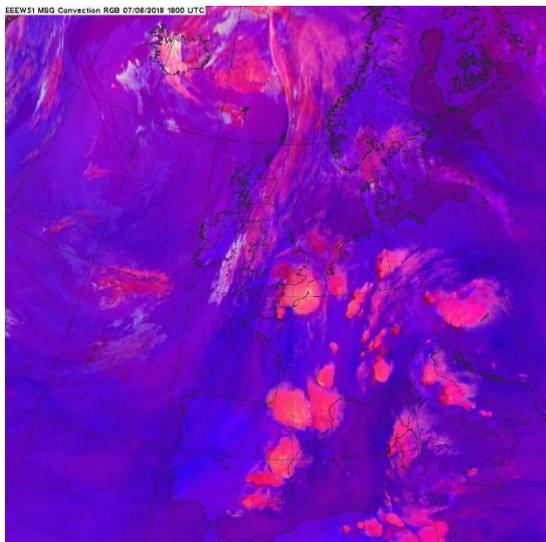


Image to the left shows an example satellite image over Western Europe specifically developed, by combining wavelength channels, to detect convection and the formation of cumulonimbus clouds and thunderstorms. The colour scheme depicts specific cloud properties, for example bright yellow identifies areas of severe convection where the air has ascended rapidly into the troposphere and the ice particles are very small.

3.1.1 RP3 National Capability Finances

Aviation, via the en-route charge, provides a proportion of the funding of the National Capability, equivalent to approximately 15%. The remainder is cost recovered from other UK contributors, principally UK government departments. The costs of the National Capability can be split into two categories, International Subscriptions and Other National Capability:

- The International Subscriptions part describes the shared commitments from several countries to support a shared capability; satellites and the UK contribution towards the European Centre for Medium Range Weather Forecasting (ECMWF) and the UN’s World Meteorological Organisation are examples; the cost is typically shared as a function of national Gross Domestic Product and in any given year is therefore subject to fluctuation (alongside currency conversion fluctuations). This currently constitutes approximately 33% of the total National Capability.
- The remaining National Capability costs include elements such as UK weather radar, UK observations, core NWP and Met Office science research and development.

Within the RP3 timescale, there are known capability costs which are expected to increase. Primarily this is through an increase in the associated international subscription costs, particularly the contribution to the European satellite upgrade and replacement program, which sees a subsequent rise in cost base through 2023 and 2024. It is proposed to maintain the aviation share of the National Capability, equivalent to approximately 15% throughout RP3.

The anticipated split between International Subscriptions and Other National Capability is as follows:

	2019 (RP2)	2020	2021	2022	2023	2024
International Subscriptions	£5,518,000	£5,611,000	£5,626,500	£6,882,000	£10,726,000	£10,726,000
Other National Capability	£11,257,000	£11,339,000	£11,373,500	£11,350,000	£11,350,000	£11,350,000
Total aviation contribution	£16,775,000	£16,950,000	£17,000,000	£18,232,000	£22,076,000	£22,076,000

3.2 RP3 Met Service development and delivery

The Met services are the main regulated outputs from the Met Office for civil aviation and are services set out in the Met Office’s Designation arrangements. They are separated below into services to meet international and national flight operations and ATM requirements, other designated Met services, technology developments and science developments.

3.2.1 Met Services specified in the Met Office’s Designation arrangements to meet international and national flight operations and ATM requirements

3.2.1.1 Low level Aviation

Included in this area are the following services:

- TAFS, for 55 airfields across the UK
- Airfield Warnings, for 108 airfields across the UK
- Airmets
- Low level significant weather (F215 and F415)
- Low level winds (F214, F414 and F614)
- Forecast QNH

- SIGMETs for London, Scottish and Shanwick Oceanic FIRs
- Trend forecasts at LHR and MAN
- Take-off data

To deliver these services requires a team of specialist aviation forecasters and a weather information visualisation and forecast production system. In addition, the services are supported by 24 hour IT teams, plus full contingency planning.

The intention is to continue to provide these services throughout RP3, subject to any adjustments as described in the Designation Agreement which stem from any changes in ICAO Annex 3 requirements. In addition, the Met Office continue to seek efficiencies with the forecasting production and delivery process and expect to see an operational delivery cost reduction of 2% per annum through RP3.

3.2.1.2 WAFS, delivered by WAFC London

3.2.1.2.1 Current WAFS service

WAFS (World Area Forecast System) is the global service, operated by the UK and US on behalf of ICAO. The service from the UK is provided by WAFC (World Area Forecast Centre) London at the Met Office. WAFC London provides a global dataset of wind, temperature and significant weather every 6 hours, as follows:

- Wind and temperature in 3 hourly time steps to T+36
- Weather hazards (Clear Air Turbulence Potential, TS and Icing Potential) in 3 hourly time steps to T+36
- Significant Weather charts, one time step per issue, valid at T+24
- The wind, temperature and weather hazard information is provided on a 1.25° horizontal grid and at the vertical levels of FL050, FL080, FL100, FL140, FL180, FL210, FL240, FL270, FL300, FL320, FL340, FL360, FL390, FL410, FL450, FL480 and FL530.

Both the UK and US produce a global dataset every 6 hours and it is utilised extensively in the flight planning process, primarily for fuel planning.

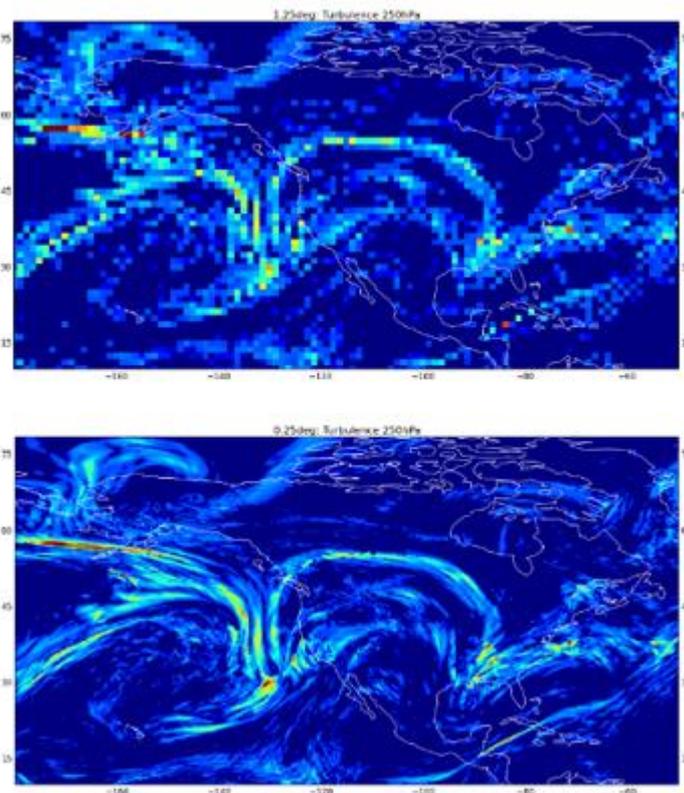
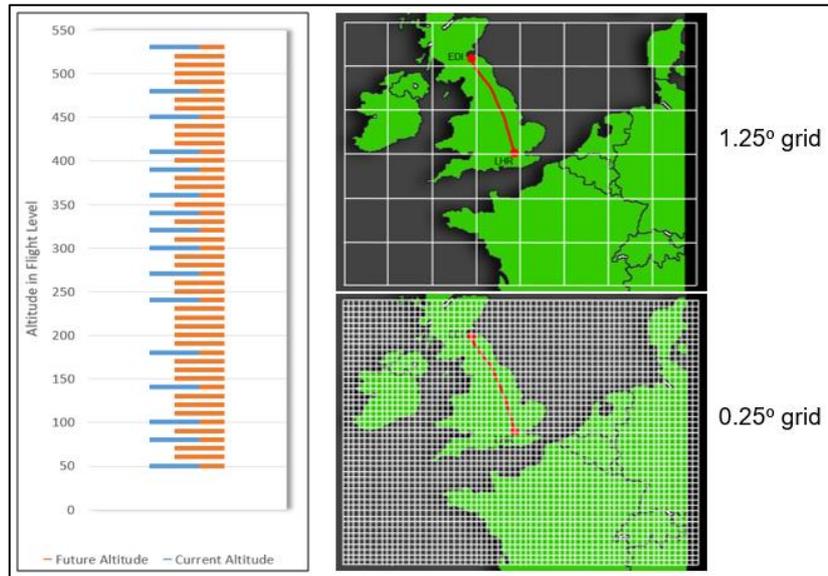
3.2.1.2.2 Proposed developments to WAFS during RP3

In response to requirements described by IATA, there has been a great deal of discussion at the ICAO Met Panel and Operations Groups to provide detailed plans for an upgraded WAFS service to meet the increasing demands of detail and accuracy. The following is a summary of the proposal which, subject to final approval at ICAO Met Panel, will be implemented during the timescale of RP3:

- Upgraded science in the turbulence dataset, now providing turbulence severity
- Upgraded science in the Icing dataset, now providing icing severity
- Increased horizontal resolution of the wind, temperature and hazard datasets to 0.25°. This means a data point approximately every 1.75 minutes flight time at cruise altitudes (the current 1.25° dataset corresponds to approximately a data point every 9 minutes flight time)
- Vertical resolution increased to every 1000FT between FL050 and FL530
- Increased temporal resolution, from the current 3 hourly timesteps to T+36, to hourly data from T+6 to T+18, 3-hourly timesteps to T+48, then 6 hourly timesteps to T+120.
- Next Generation Significant Weather (SigWx) forecasts;

- Charts and BUFR format data to be retired and IWXXM (GML format) global hazard objects will be made available for use in flight planning and in visualisation systems.
- Time steps to be 3 hourly from T+6 to T+48, issued every 6 hours (currently only T+24 charts issued every 6 hours).
- The development of the next generation SigWx forecasts are also expected to enable efficiencies to be realised in the operational staff cost base for WAFS.
- High resolution datasets are expected to become operational in November 2022, with ensemble hazard information available from November 2024.
- These developments in terms of data production and availability require a significant upgrade in technology capabilities.

Image to the right showing (left) current WAFS vertical levels vs proposed new WAFS vertical resolution; and, (right) top showing approximate current WAFS horizontal resolution and bottom showing proposed future resolution. The idealised trajectory from LHR to EDI indicates the number of additional grid points on even a short flight.



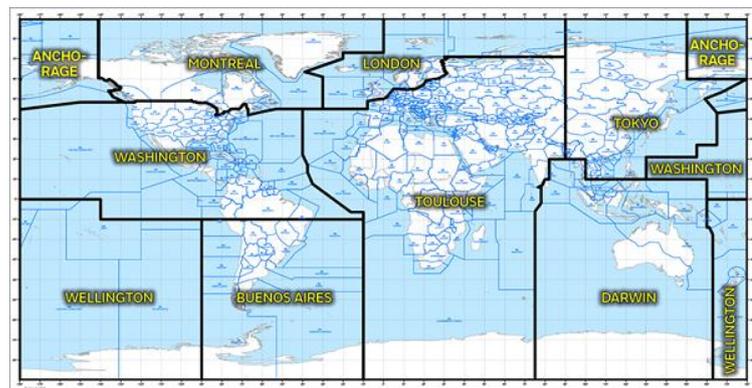
Images to the left show (top) turbulence at the current WAFS resolution of 1.25°, in comparison to the proposed (bottom) WAFS resolution of 0.25°. The higher resolution image can be seen to show a far great detail and ability to highlight where the greatest severity of turbulence is likely to be encountered. This is expected to enable a step-change in the ability to use forecast hazard data in flight planning and situational awareness.

The Met Office is commissioning an independent study to assess the benefits of the proposed WAFS developments. A summary of the findings will be made available once the study has been completed.

To ensure that the proposed changes to WAFS are publicised and to enable all involved in the flight planning process to understand the changes and to enable airlines to realise the full benefit, the Met Office is planning a series of engagements to include flight planning companies and airline flight planning representatives. This will take the format of one to one discussions with providers.

3.2.1.3 Volcanic Ash Advisory Centre (VAAC)

The UK is one of 9 VAACs (see map), providing the ICAO complaint product set during Volcanic Ash events. The VAAC capability is provided by a team of specialist forecasters, atmospheric dispersion scientists and numerical weather modelling capability. Given volcanic ash events over the UK VAAC's area of responsibility are relatively rare, the forecasting team form part of a wider environmental monitoring and response centre within the Met Office, this becoming solely dedicated to VA during an event.



Through RP3, the UK plans to continue with the operational capability, whilst also continuing to develop the science to improve accuracy and reliability, plus take an active part in scientific and regulatory discussions to develop the product set. A specific area of focus will be to develop information related to Volcanic Ash concentration products.

3.2.1.4 SADIS

This is a distribution system operated by the Met Office on behalf of ICAO. Whilst it distributes the regulated WAFS and OPMET data, the costs are recovered directly from the receiving states. The UK's share of the total cost of SADIS (£600K) is around 7%.

3.2.2 Other Designation Met Services

3.2.2.1 Volcanic Ash

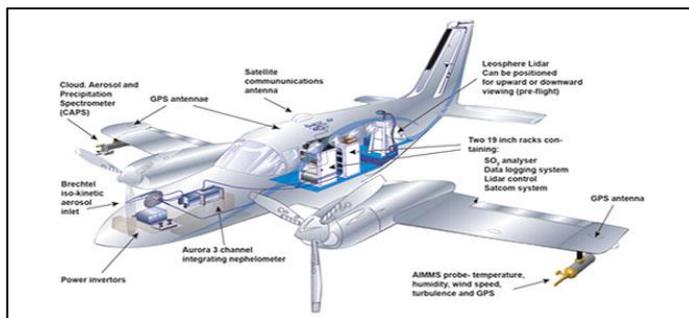
In support of the VAAC and the UK to provide accurate and timely forecast information during Volcanic Ash events, the following additional capabilities are anticipated to be part of the RP3 Met Office cost base:

- VA LIDAR. The Met Office currently operates a network of 10 LIDARs, 9 permanently located around the UK and 1 mobile LIDAR. These are designed to provide information on the height and location in the atmosphere of the mineral contaminants associated with a Volcanic Ash event. Whilst providing situational awareness of the local of ash, the LIDARs also provide a

reliable source of ‘ground truth’ to verify a forecast. The development cost of this network was funded by direct grant from DfT, the operation of the LIDARs falls within the Met Office regulated aviation cost base.

- Met Office Civil Contingencies Aircraft (MOCCA), image below; the Met Office holds a contract with Cranfield Aerospace (CAe) for the provision of a specifically equipped aircraft to fly during a volcanic ash event and measure the location and concentration of atmospheric mineral contamination. The costs of the readiness and operation of the MOCCA fall within the Met Office regulated aviation finances.

The current contract for MOCCA runs until March 2020. After this date, there are expected to be options to continue utilising the same aircraft and operational set-up or implement a new airborne monitoring platform (e.g. a different aircraft or a UAV). The work needed to determine the ongoing capability beyond 2020 needs to be completed during 2019, although set-up and operational costs are expected to be within the Met Office RP3 regulated aviation costs.



The anticipated options for a future airborne monitoring capability are:

- No capability;
- A continuation of the current MOCCA airframe;
- A new/alternative airframe with a human pilot;
- An an-manned aerial vehicle;
- A shared capability, such as with the UK military; and,
- The loan of an aircraft from elsewhere.

Feedback from the consultation process indicated that the UK should maintain a capability through RP3. Therefore, options for b to f will be investigated further, for expected implementation from May 2020.

3.2.2.2 Data Services for NATS

NATS utilise a wide range of data and information from the Met Office to enable specific concepts and to provide situational awareness within the en-route operation. This includes observational and forecast data over the UK and area associated with North Atlantic traffic.

It is proposed within RP3 to continue to provide this data and information and work with NATS to develop and introduce new concepts where there are benefits to the safe and efficient operation of UK airspace and the airline community.

It is also anticipated to be a need through RP3 to transform the way in which data is distributed to partners such as NATS. This is discussed further in the section 0 Technology Developments.

3.2.2.3 Weather Resilience Activities

On the basis of increasing traffic and worsening weather impacts, there is an increasing focus on weather resilience activities to increase the predictability of the UK air traffic system and reduce disruption.

As part of the Met Office's commitment, there have been a series of activities in the weather resilience area.

The first of these initiatives is the integration of a Met Office meteorologist team onsite at NATS, Swanwick. This 24 hours a day/7 days a week team has been in place for just over one year, funded 50% from the FAS investment board and 50% within Met Office regulated aviation costs. Whilst assessments are ongoing, it is understood that the onsite team are able to integrate weather advice into NATS' Swanwick operation to enable planning and mitigation decisions to be made within Area and Terminal control with more confidence and an improved understanding of the uncertainties of any weather situation. Indeed, in assessments so far of a limited number of case studies, the onsite Met team has been directly linked to a network saving in the order of €1.2-€2.4M (reference: NATS Report on the benefits of UK Met Forecaster in TC, June 2018).

The current funding model has been agreed to continue until the end of RP2. It is proposed that the full cost of the onsite meteorologist team falls within the Met Office cost base for RP3. Leading up to and during RP3, it is expected that the service provided by the onsite team will develop to further integrate Met advice such as increasingly being involved in the work undertaken at Prestwick, developing the Met products used at NATS and influencing the European Network weather decision making.

Following feedback received during consultation, it is understood that there is demand for the onsite meteorologists to integrate throughout NATS' operation to enable advice into Swanwick Area and Terminal controls, Prestwick Upper and Lower areas and the North Atlantic Operation, plus involvement in activities related to reducing European weather related network disruption. In addition, there are a series of activities required to develop the service to meet with the wider requirements, including some flexibility to the service during busy weather periods such as widespread low visibility or thunderstorm events. To meet this demand, it is proposed to increase the meteorologist staff resource available at NATS, to up to 9 full time equivalent staff. This will provide the headcount to provide a more flexible approach to meteorological advice, with increased effort available during severe and disruptive weather events.

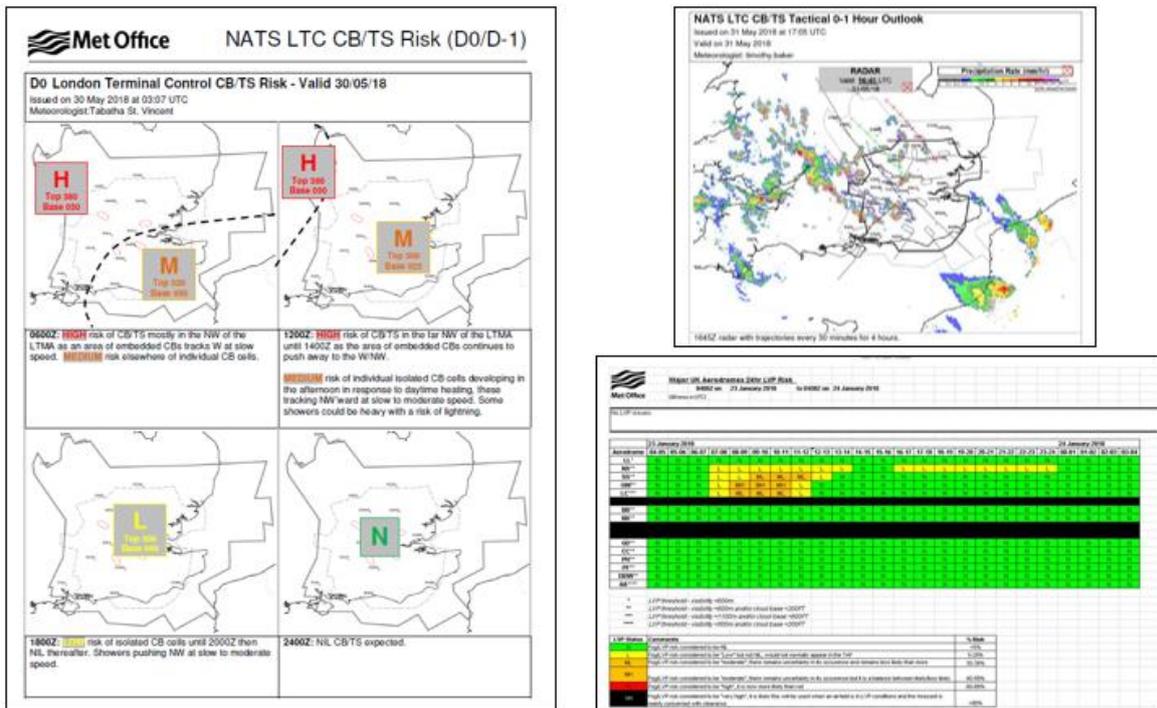
Linked to the capabilities of the onsite Met Office team at Swanwick has been an initiative to develop weather advice around specific weather phenomena. This has been focussed on achieving and accurate, but importantly also a consistent picture for all stakeholders. The two areas of primary focus are thunderstorms and low visibility:

- Thunderstorms/Cumulonimbus (TS/CB): work has been undertaken to provide planning (Day-1 and Day-0) and tactical (0-6 hours ahead) forecast information for TS/CB. A product has been designed to be issued by the Met Office team onsite at NATS, for which the planning product is then shared with a wider list of stakeholders allowing common situational awareness.

Throughout RP3, it is proposed to continue to develop these products and provide a more effective way of communicating the information to interested and impacted stakeholders.

This will be done through both utilising the knowledge gained by working with NATS and by utilising the weather science capabilities being developed within the Met Office (such as hourly updates to the ensemble modelling and improved nowcasting). In terms of an improved way of communicating the information, this is discussed further in Technology developments.

- Low Visibility: a low visibility matrix is now provided to inform NATS of the risk of low visibility conditions at the main London airports. This provides categories of risk, against which specific mitigations are considered. It is proposed to continue this provision through RP3, but continue to develop the forecast skill to inform this product and advice, through ongoing research and weather science activities.



The images above show (left) an example TS/CB planning forecast, (top right) and example tactical TS/CB forecast and (bottom right) an example low vis matrix for key airports.

Following the consultation the Met Office will invite Stakeholders to review a web based portal that will be developed to host this information.

Whilst the above is primarily focussed on the UK, the Met Office has recently started some trial activities with the Voluntary Industry Resilience Group (VIRG), to assess if the approach with regard TS/CB in the UK could be expanded into Europe to assist with the network view. This piece of work is aimed to try to enable a consistent State and Eurocontrol Network Manager weather picture, to enable planning decisions to mitigate weather impacts. In turn this has a significant impact including delay and disruption to the cross border traffic into and out of the UK. It is hoped that European weather disruption can be reduced and, where this can be assisted with the Met Office resource and cost base, it is proposed to continue to develop these activities through RP3.

Further to feedback received during consultation, the Met Office has offered and now accepted formal invitations to become members of the IRG, for both the Ops Director Leadership Group (ODLG) and VIRG.

Regarding the communication of the weather situation to the wide range of stakeholders, the Met Office are in the process of designing a weather situational awareness/network weather resilience web visualisation tool. The principle is to provide a platform to present regulated aviation Met data and provide a location for the common Met picture, accessible by all stakeholders. This includes the planning and tactical weather information, such as the recently developed products for TS/CB, rather than email distribution which presents challenges in maintaining a consistent Met forecast. It is anticipated that this will be in place ahead of RP3, but continuous improvement and lifecycle upgrades would be expected through the period, subject to user feedback and requirement.

3.2.2.4 General Aviation²

The Met Office, as the sole designated UK ANSP provider of regulated aeronautical meteorological forecasts, is required to provide a range of briefing products to support the activities of the UK general aviation and business jet communities.

Specific products provided include UK low level significant weather forecasts in graphical and alphanumeric form, gridded wind & temperature profile charts & aerodrome weather warnings, along with specialised forecasts for groups such as balloonists. These support the extensive range of other regulated products including TAFs, SIGMETs and forecast QNHs that together fulfil our broader ICAO low level provision.

These products are hosted on an aviation briefing portal, which is made available free at the point of use to all UK general aviator groups and business jets operators. A range of map based observation and model forecast data is also provided on this portal, ensuring all GA users have access to comprehensive, reliable and accurate weather information. Approximately 30,000 pilots are subscribed to this portal.

The Met Office ensures that the content of the briefing portal continues to meet the evolving requirements of the general aviation community through a combination of regular stakeholder consultation activities and routine engagement with the CAA. It is anticipated that the Met Office support to the GA community will continue throughout RP3.

3.2.2.5 Support to helicopter operations

The provision of meteorological products to support offshore helicopter operations is a global requirement defined by the International Civil Aviation Organisation (ICAO). As the designated provider of regulated aviation forecasts in the UK, the Met Office provides a weather briefing

² Certain categories of flights are exempt from en-route air navigation service charges, including flights by aircraft less than 2 tons, search and rescue flights, VFR flights by aircraft of MTOW of 5.7 metric tons or less. DfT reimburses Met Office its share of exempted flight costs.

platform and weather products are provided to help ensure offshore helicopter operations over the North Sea, Irish Sea and North East Atlantic are managed safely.

The Met Office helicopter briefing portal is called HeliBrief and is made available to all offshore helicopter operators under a contract between the Met Office and NATS. NATS recover the cost of HeliBrief and its products from the North Sea Round Trip Charge (NSRTC) levied on helicopter companies that take an ATS service.

The Met Office also provide specialised variants of HeliBrief to support helicopter emergency service operators (Police, Search & Rescue and Air Ambulance).

The Met Office work closely with the CAA, NATS, helicopter companies and emergency responders to ensure that HeliBrief continues to provide the best possible range of weather information that helicopter companies and organisations require to effectively support their operations. It is proposed that all of these activities will continue throughout RP3.

3.2.2.6 Space Weather

Further to the feedback received during consultation, it is proposed that the Met Office maintain a UK civil aviation capability with regard to Space Weather through RP3. A space weather capability already exists within the Met Office, primarily due to government department funding. For the purposes of support to civil aviation, it is proposed to utilise the current capability and add a relatively small level of resource in order to support aviation-specific demands, such as support to CAA in consultation with stakeholder engagement, product and service development and the provision of specialist advice during events and exercises.

Through the framework of ICAO, developments are also planned in the implementation of Global and Regional Space Weather Centres. Further information will be available in the near future to describe the nature of services to be provided.

3.2.2.7 Other emerging requirements for meteorological information

The consultation process also indicated a potential future requirement for meteorological information to support new and developing applications.

One such area is Unmanned Aerial Vehicles (UAVs). It is understood that there is no clear current user or regulatory requirement for meteorological information to support the operation of UAVs. Through RP3 and if determined that any activity falls within that appropriate to en-route cost recovery, the Met Office will therefore maintain a 'watching brief' and willingness to support discussions in relation to developing UAV meteorological requirements.

The relevance of contrail forecasting and possible routing for environmental reasons was also raised as a potential area of development. Again, whilst the requirement for any such research or information is in the process of being clarified, the Met Office will maintain a 'watching-brief' and a willingness to support further discussions.

3.2.3 Technology developments

As with many industries, the amount of available Met data is increasing rapidly, both from increasing frequency and detail of observational information and from numerical weather prediction models

through increased horizontal, vertical and time dimensions. In addition, the way in which users are receiving and using data is changing.

As data volumes grow ever larger, the traditional method of sending large files will likely become unviable; with the increased detail or resolution, a global file will very soon become too big to distribute without significant latency or to ingest into down-stream (e.g. flight planning) systems. Instead, it is expected that the requirements for information in the future will be based around much smaller, specific and discrete chunks of relevant information, which will enable users to access when required, for example as a single flight trajectory or a limited geographical area around an airport.

This move to technologies and concepts such as Service Oriented Architecture, Web Services and API access is the model by which concepts such as SWIM are developing. This SWIM-compliant approach will enable a much higher degree of flexibility for users to access much more detailed and relevant Met data, although it does require a significant investment and development of technology within the Met Office.

This development is key to enabling the access to the next generation of WAFS data discussed previously which, given the global nature of the data, will present very large datasets (approximately 200 times the current size for each global dataset). It will also enable the use of significant weather objects or data, available in much greater detail (temporally and spatially), to be ingested directly into flight planning systems or into visualisation systems for use in, for example, flight following software or Electronic Flight Bags (EFBs).

Further to the WAFS data, the technology development will also enable other Met data, such as low level UK data for GA and helicopter use to be available for visualisation on 3rd party systems or in flight. In addition, it is intended that the TS/CB forecast information discussed under weather resilience, will be presented in the form of 'objects' which could be automatically incorporated into flight plans and potentially more easily used in a decision making process around dynamic SID (Standard Instrument Departure) selection, up-linked displayed on EFBs in flight or on controller workstations.

To accommodate these concepts there is a significant development of IT architecture and infrastructure required. Whilst work is ongoing to determine a detailed cost analysis for the final RP3 submission, the cost of development is expected to be in the order of £10M though RP3. Where possible, however, the regulated aviation development will utilise developments and investments already made, for example, as part of the Met Office's wider PWS commitments. It is understood that a robust governance policy is required for 3rd party access to regulated data via an API.

3.2.4 Science developments

The accuracy of the information from the Met Office has improved significantly over time. Please see the image below which shows the reduction in error over time of the 250 hPa (equating to approximately FL340) winds. However, in order to utilise the capabilities of increasing supercomputing power and to continue to improve the accuracy of weather information both at the surface and throughout the atmosphere, continuing scientific research and development of the model, weather observations and the assimilation of these observations into the model is vital.

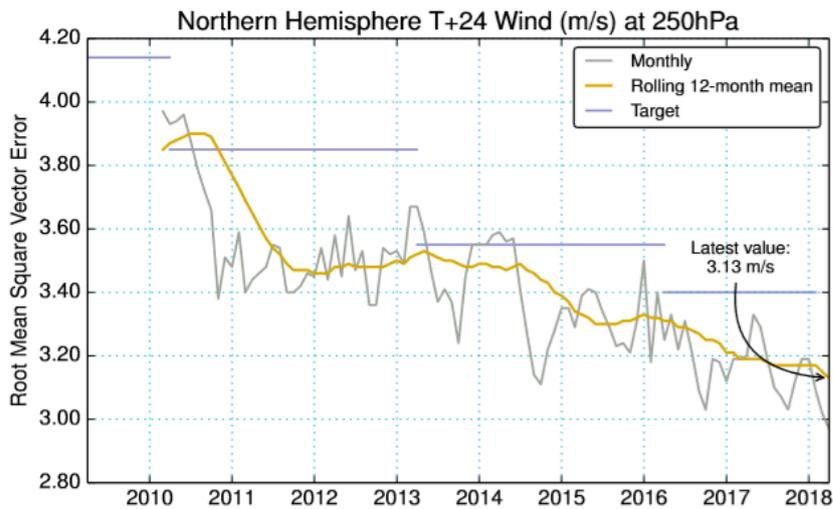


Image (left) showing the verification of 250hPa winds (approximately FL340) in the Northern Hemisphere. The error value can be seen to have decreased over time with investment in computing power and improved weather science.

In association with the National Capability, developments will occur at the Met Office to exploit increased high performance computing power, providing the ability to run higher resolution numerical weather prediction (NWP) models and NWP models with more sophisticated algorithms to represent physical processes in the atmosphere such as cloud formation and precipitation. Additionally, further improvements will be made to the ability to run similar versions of individual models (ensemble modelling) to better understand and quantify forecast uncertainty. In addition, work will also continue to develop the assimilation of weather observations within the forecast process, plus to develop the general atmospheric physics in its various constituent parts including convection, clouds and atmospheric boundary layer mixing. Key areas of focus will be nowcasting (short term forecasting) and particularly a concentration on thunderstorms and low visibility forecasting.

In addition to the National Capability, the Met Office also has a team of specialist applied aviation scientists who focus on developing applications immediately relevant and used within aviation forecasting. Particular areas of focus are:

- Improved turbulence severity information for WAFS in both deterministic and probabilistic frameworks;
- Improved icing severity information for WAFS in both deterministic and probabilistic frameworks;
- Improved CB information for WAFS in a probabilistic framework;
- Improved understanding of methods of diagnosing the presence and formation of High Altitude Ice Crystals which can cause engine icing events with potential for engine failure;
- Improved CB information for UK resilience and WAFS SigWx data and objects; and,
- Low visibility forecasting for UK airports.

In order to measure and understand the areas for improvement, a verification team is also engaged. This team enables the provision of objective verification for much of the regulated aviation forecast information, including WAFS wind and temperature, TAFs and airfield warnings. All of the current verification information is available in the following link:

<https://www.metoffice.gov.uk/aviation/national-responsibilities/caa-verification>

3.2.5 RP3 Met Service Development and Delivery Finances

As per the services, the finances can also be broadly split between ICAO Annex 3 and UK AIP Met Services and those which are UK-specific and, from a state perspective, discretionary.

	2019 (RP2)	2020	2021	2022	2023	2024
Designation Agreement Services	£7,150,468	£7,293,477	£7,439,347	£7,588,134	£7,739,897	£7,894,694
Other Designation Met Services	£3,692,876	£6,694,400	£5,754,501	£5,811,591	£5,369,823	£5,419,219
Total Met Service Development and Delivery	£10,843,344	£13,987,877	£13,193,848	£13,399,725	£13,109,719	£13,313,914

In further detail:

i. Met Services specified in the Met Office’s Designation arrangements

These are composed of staff (including forecasters, forecasting management, 24 hour IT and back-office support) and the systems required to ingest data, visualise Met data, produce and deliver forecast information. The approximate split of costs is:

- a. £5.5M p.a. operational staff and management
- b. £2M p.a. operational systems and support.

There are anticipated increases in this cost base through the RP3 period, primarily due to staff pay. However, efficiencies within the process will continue to be sought, a 2% reduction in cost per annum from the RP3 first year cost has been applied.

ii. Other Designation Met Services

As described in section 3.2.2, the costs are associated with a wide range of activities and services to provide a UK capability, both current and developing. In addition, there are ancillary elements such as insurances, data licence and UK SADIS subscription costs included.

The main categories are as follows, with approximate costs:

- a. Onsite Met team at NATS, approximately £900,000 p.a.
- b. Volcanic Ash Operations and Development, £700,000 p.a.
- c. MOCCA; aircraft operational costs of £800,000 p.a., plus £1,000,000 in year 1 for the development and implementation of a new capability.
- d. Technology developments, £10,000,000, capitalised at £2M p.a.
- e. Applied Science development capability, £700,000 p.a.

- f. IT, web delivery and updates, £100,000-£250,000 p.a., dependent on the development requirement.

On the basis of the technology development strand, there is expected to be a reduction in operational forecasting cost of approximately £500,000 p.a. in 2023 and 2024. This reduced operational cost would also be expected to continue beyond RP3.

4. Performance Measurement

The performance of the Met Office, as overseen by CAA, is provided in the following link:

<https://www.metoffice.gov.uk/aviation/national-responsibilities/caa-verification>.

This provides information on performance related to the regulated aviation products, including accuracy, timeliness and compliance. Through RP3, it intended to continue to drive an improved performance, whilst also introducing new measures which seek to recognise and measure an impact on weather-related disruption.

It is proposed to set targets initially for the period until end 2022 as a reasonable time period ahead. During RP3 the targets and services measured will be assessed and, where necessary, modified by CAA and the Met Office, including through until the end of 2024.

A summary of the proposed targets are shown in the table below:

Service	Description of verification and target	Targets
TAF accuracy	The current SQI measurement scheme is being replaced and a baseline is being assessed for the new scheme. A target will therefore be set once baseline performance is established.	TBC
Global Model performance: Wind	This a measure of the Northern Hemisphere T+24 wind (m/s) route mean squared error (RMS) at 250hPa (approximately FL340).	Current target: 3.40m/s Latest value: 2.98m/s Proposed target (by year end): 2020: 2.90m/s 2021: 2.85m/s 2022: 2.80m/s
Global Model performance: Temperature	This a measure of the Northern Hemisphere T+24 temperature (K) route mean squared error (RMS) at 250hPa (approximately FL340).	Current target: 0.63K Latest value: 0.58K Proposed target (by year end): 2020: 0.57K 2021: 0.56K 2022: 0.55K
Timeliness of BUFR data	Delivery of BUFR data no later than 7 hours after the global model run on no more than 3 instances per quarter (99.2%). Note that this will be superseded by the expected development of WAFS services and products.	Current target: 99.2% Proposed target: 99.2%
Timeliness of TREND forecasts 1	Trends: appended and sent within 7 minute limit from the validity time of observation.	Current target: 12-month rolling mean of 85% Proposed target: 2020: 86%

		2021: 88% 2022: 90%
Timeliness of TREND forecasts 2	Trends: appended and sent within 3 minutes of the time of METAR arrival into the Met Office (4 minutes in Scotland).	Current target: 12-month rolling mean of 85% Proposed target: 2020: 86% 2021: 87% 2022: 89%
TAF timeliness	Receipt into MetSwitch by HH-52, monthly.	Current target: 95% Proposed target: 2020: 95.5% 2021: 96.5% 2022: 97%
TAF compliance	From a sample of 18 TAFs per day, % classified as compliant (coding accuracy).	Current target: 98% Proposed target: 2020: 98.5% 2021: 98.5% 2022: 99%
SIGMET compliance	For all issued SIGMETs, number deemed as complaint per month. Proposal to base the target on a rolling 12-month mean.	Current target: 98% Proposed target: 2020: 98.5% 2021: 98.5% 2022: 99%
GRIB2 timeliness	The number of occasions that operational GRIB2 data sets being issued after T+4hrs 20mins, monthly score	Current target: 3 or less instances per month. Proposed target: 2022: 2 or less instances per month.
GRIB2 CB/Icing/Turbulence	The number of occasions that operational GRIB2 data sets being issued after T+4hrs 50mins, monthly score	Current target: 3 or less instances per month. Proposed target: 2022: 2 or less instances per month
Airborne holding due weather	Linked to the input of meteorological services and advice at NATS, a target to contribute to a reduction in airborne holding due to weather regulations. He exact details and baseline performance is currently being assessed.	Current target: NIL Proposed target: TBC
PWS NSWWS	On the basis of the aviation investment in National Capability, it is proposed to link to the Met Office Public Weather Service and form an	Current target: NIL Proposed target: TBC

	appropriate target. This is currently being assessed.	
NATS en-route data and products	KPIs are being developed with NERL. KPI expected to be in the form x out of y data targets met per month.	Current target: NIL Proposed target: TBC

5. Overall Met Office RP3 Finances

Combining the finances for the main two broad categories, the total Met Office cost figures for RP3 are as follows:

	2019 (RP2)	2020	2021	2022	2023	2024
National Capability	£16,775,000	£16,950,000	£17,000,000	£18,232,000	£22,076,000	£22,076,000
Met Service Development and Delivery	£10,843,344	£13,987,877	£13,193,848	£13,399,725	£13,109,719	£13,313,914
Total Met Office RP3	£27,618,344	£30,937,877	£30,193,848	£31,631,725	£35,185,719	£35,389,914

The following table provides a summary of these figures translated into an estimated unit rate for RP3. For comparison, the unit rate based on determined cost for the last year of RP2 (2019) is 2.15.

Determined/Actual Unit Cost (in real terms)

Cost details	2020 F	2021 F	2022 F	2023 F	2024 F
Total determined/actual costs	30,938	30,194	31,632	35,186	35,389
5.1 Inflation % (3)	1.70%	1.81%	1.84%	1.91%	1.96%
5.2 Price index (base 100 in 2009) (4)	126.3	128.6	131.0	133.5	136.1
5.3 Total costs real terms (5)	24,490	23,476	24,150	26,359	26,002
Total % n/n-1	11.3%	-4.1%	2.9%	9.2%	-1.4%
5.4 Total Service Units	12,119.4	12,258.2	12,524.0	12,778.8	13,016.8
Total % n/n-1	1.9%	1.1%	2.2%	2.0%	1.9%
5.5 Unit cost at 2009 prices	2.02	1.92	1.93	2.06	2.00
Total % n/n-1	9.2%	-5.2%	0.7%	7.0%	-3.2%

Costs and asset base items in '000 - Service units in '000

6. Consultation outcomes

The CAA hosted a Met Office consultation event at Aviation House, Gatwick, on 7th September 2018. The following provides a summary of this and subsequent written feedback. Any changes of the Met Office proposals for RP3 have been incorporate into the previous sections of this updated briefing note.

Question 1: Are you in broad agreement with the plan set out within this note?

You Said

- The plans were well described
- There was broad agreement from the meeting on the scope of activities presented
- There were no activities that did not receive support.

We Will

- Maintain the proposed approach (subject to the specific feedback received for the other consultation questions)

Question 2: The National Capability element of the proposal indicates the continuation of investment in science, observations and utilisation of the High Performance Computing of the Met Office, whilst increasing investment in satellite capability. Do you agree with this investment approach?

You Said

- There was broad agreement on the direction being proposed by the Met Office to the national capability element of the proposal.
- The CAA should continue to effectively represent the aviation industry through the PWSCG.
- A mechanism should be established to allow Stakeholders to submit feedback to the CAA
- KPIs should be agreed and measured, and these should have relevance and meaning to airlines (i.e. what is the quantifiable benefit seen)

We Will

The formal mechanism for consultation is through the Met Office User Forum, held annually. The CAA and Met Office attend these. The delegate list provided in the ToRs is designed to allow all Stakeholders access to this meeting. The Met Office will review this list.

Develop KPIs for RP3. The Met Office will be expected to deliver against a set of KPIs (as they have been throughout RP2). These will be monitored every 3 months and published externally (for example see <https://www.metoffice.gov.uk/aviation/national-responsibilities/caa-verification>). KPIs will also be set for the National Capability element, and these will be monitored by the CAA on behalf of Stakeholders at PWS Customer Group meetings. In setting KPIs, the Met Office will consider performance measures for weather related delays.

Question 3: Volcanic Ash monitoring: is it considered that the plan to maintain the civil contingencies aircraft remains a sound investment to provide the UK with a robust atmospheric monitoring capability, specifically associated with Volcanic Ash events?

You Said

There was agreement on the need to maintain an appropriate airborne capability to flexibly respond to and measure the type and quantity of ash in the event of volcanic ash entering UK airspace.

The meeting requested further investigation into the options available that can suitably fulfil this task, to ensure that the benefits of this 'insurance policy' are cost effective.

We Will

Provide a description and analysis of options for a new civil contingency airborne capability, including:

- a continued use of the current aircraft;
- the potential for accessing an aircraft on a shared asset basis;
- a new UK-based aircraft;
- Using a UAV;
- Combined military and civil aircraft capability; and,
- Ability to call on an aircraft from a European institution.

Reflect any agreed changes to approach arising from this review into the finalised RP3 proposal.

Question 4: Improving resilience to weather events: the Met Office proposal is to continue with a 24 hour team at NATS and continue to develop the planning and tactical information available associated with thunderstorms. Do you consider this to be the right approach and are there any other areas the Met Office should be investing in to improve resilience?

You Said

The continuation and development of the weather resilience activities that commenced in 2016, as described in the briefing note was strongly favoured.

The value of adding flexibility into the rostering of the Met Office on-site team at Swanwick to mitigate the additional demands on this team during inclement weather were also stated.

Feedback received by email ahead of the meeting is reproduced below:

We welcome your proposal to incorporate Met services within the current RP3 proposal. We believe that the service has already shown significant benefits during the trial and we would like the service to continue on a permanent basis and view that it is now appropriate for this to be included in the UK Met Office RP3 service. We look forward to continuing to work with UK Met Office to improve this service through the rest of RP2 and into RP3.

As an operational user of Met Data, we would also like to see the following items in RP3:

Expansion of the service stated above to provide UK wide support.

Work to be undertaken to provide now-casting and forecasting of CB activity for the London TMA with, ideally, a live radar picture of thunderstorm activity, their historical and forecast

tracks. This information should also be made available to airports, airlines and ATC units (akin to the services provided in the USA)

A Met Portal, available to all stakeholders with forecast and now-cast Met data, akin to CDM data at airports. This would ideally be a web based service

Improves LVP forecasting, especially for the LTMA airfields. This work should be undertaken in conjunction with the Industry Resilience Group (IRG), encompassing other Met data, e.g. snow.

We Will

Maintain our proposed approach. Additionally, the Met Office will:

Engage closely with the Industry resilience group (IRG), with a possibility of becoming a formal member

Offer an invitation to Stakeholders to review the weather resilience web portal that will be developed to help ensure consistency for NATS, airlines, airports & Eurocontrol.

Evaluate rostering arrangements to allow greater flexibility in helping NATS meet increased demands for weather information during impactful weather events.

Question 5: Technology development and the development of WAFS; the proposal outlines a significant investment in capability, which is expected to enable significant improvements in fuel efficiency and hazard avoidance. Do you consider this to be a sound prioritisation of investment and resource?

You Said

The feedback was supportive of the activities defined to make available higher quality WAFS data for the benefit of aviation safety and efficiency, and the technological enablers necessary to achieve this

Assurance is required that airlines can recognise the benefits of this increased data quality and availability.

There would be value provide quantifiable benefits to aviation (for example in terms of fuel savings, aircraft efficiency and arrival on time) from the proposed WAFS development activities.

We will

Proactively engage early with flight planners, in order that companies are fully aware of planned developments, and to allow them time to develop their systems to ingest the data for the benefit of airlines. Engagement will take the form of workshops and/or meetings.

Commission a study to quantify the benefits of improvements to WAFS high resolution global wind data to aviation in terms of fuel saving (efficiencies) and hazard avoidance (safety).

Question 6: Technology developments to support UK low level aviation products; the Met Office plan to develop an API capability that enable 3rd party system providers to ingest a range of regulated met data to support flight planning systems and EFBs – do you support this approach?

You Said

On the basis that some flight planners are already asking for this, the approach proposed was broadly supported.

There were some concerns expressed regarding data governance arrangements

Feedback was expressed as to how the meteorological requirements of drone operators was likely to be met

We Will

Progress the development of an API capability to support low level UK aviation

Develop our governance policy for 3rd parties accessing regulated data via an API. These terms will include the use of data by 3rd parties and re-selling of data as a product (it is proposed that accessed data will be cost recovered through the en-route charge).

Support the CAA in discussions with the CAA Unit responsible for drone regulation.

Question 7: Space Weather: within this proposal, there is no reference to providing a UK aviation-specific Space Weather capability. Are you in agreement with this approach?

You Said

Feedback confirmed that space weather presented a potential risk to aviation, but that thinking on these risks was not yet sufficiently developed. It was noted that ICAO Regional Space weather centres will generate warnings on AFTN to alert airlines to potential impactful events (it will be for the airlines to define in their SMS their processes for using these warnings as part of their risk mitigation strategy).

We Will

Support the CAA in their ongoing engagement with Stakeholders

Provide a summary of ICAO progress on space weather centres, and how this is funded.

Develop our RP3 proposal in respect of feedback received to whether Industry supports either:

no specific capabilities beyond that provided by ICAO Regional Space weather centres, an acknowledgement of a need for additional information, or
no specific additional capabilities at this time but to keep under review

Question 8: Science developments; the Met Office propose to continue a range of aviation R&D activities focussed on the two broad themes; development of improved forecasts of global en-route hazards and improved understanding and forecasting of weather in UK airspace. Do you consider this to be the correct prioritisation of science cost and resource?

You Said

There was strong agreement on the proposed range of Aviation R&D activities, as described in the proposal document and in this report.

There was interest in receiving information on the progress of the Aviation R&D programme

There was acknowledgement of the particular value of R&D that will positively impact the forecasting of low visibility events.

Feedback received by email ahead of the meeting is reproduced below:

As an operational user of Met Data, we would also like to see the following items in RP3:

Improved LVP forecasting, especially for the LTMA airfields. This work should be undertaken in conjunction with the Industry Resilience Group (IRG), encompassing other Met data, e.g. snow.

We Will

Progress the development of the Aviation R&D programme

Ensure that the particular focus on UK low visibility forecasting is maintained in this plan

Extend an open invitation to the next Met Office User Forum (likely to be in December). The MOUF is the formal stakeholder engagement that the Met Office runs and includes a review of Aviation R&D activities for the previous year.

Question 9: Notwithstanding the activities proposed in this paper are there any other products or services that you consider to be necessary for the Met Office to develop/deliver during RP3?

You Said

No other activities were raised.

We Will

n/a.