Met Office

NR23, Met Office activities and costs

VERSION 2, UPDATED PAPER FOLLOWING MET USER CONSULTATION

FEBRUARY 2022

Executive Summary

This paper provides information on the key proposed areas of Met Office development and the delivery of aviation Met Services, as overseen by CAA, planned for the period covered by NR23 (January 2023 to December 2027).

There are several drivers which provide the context for these proposals, including compliance with the ICAO regulatory framework and the CAA Airspace Modernisation Strategy, but also advances in Met Office capability which allow us to further improve the detail, accuracy and availability of our weather information. Furthermore, as the aviation industry continues to recover from the impacts of the Covid-19 pandemic, focus is increasingly shifting towards the need for digitalisation and interoperability between systems to achieve better performance in a more efficient and environmentally sustainable manner.

The paper breaks down what is covered by the Met Office aviation remit into two main areas:

- National Capability & International Subscriptions, specifically referring to the underpinning infrastructure and shared commitments we have that are fundamental to the provision of an accurate weather forecasting capability; and,
- Service Delivery and Development, which focusses on the delivery of aviation specific MET services and their ongoing improvement.

Significant developments are planned in both areas through the course of NR23; the upgrade of the EUMETSAT satellite systems vital to our forecasting capability, and the transition to SWIM compliant, data enriched services that offer more in terms of forecast detail and usability.

This updated paper is provided following a MET-specific user consultation exercise. Subsequent actions and activities are included, plus some additional changes from the original consultation document are referenced.

Contents

List of figures

Glossary of acronyms and meteorological terms

ADS	The Met Office Aviation Data Services programme of work
AIRMET	Forecast type: Airmen's Meteorological Information which provides information on less severe weather types than a SIGMET
AMS	The UK CAA's Airspace Modernisation Strategy
ANSP	Air Navigation Service Provider
API	Application Programming Interface
ASBU	Aviation System Block Upgrade (part of the GANP)
ATDNet	A lightning detection system
ATM	Air Traffic Management
AWS	Amazon Web Services cloud computing platform
BEIS	Department of Business, Energy and Industrial Strategy
BUFR	A binary data format
CAA	Civil Aviation Authority
CB	Cumulonimbus Clouds
CP1	European Union Common Project 1.
CTA	The volume of controlled airspace (Control Area) that exists in the vicinity of an airport.
ECMWF	European Centre for Medium Range Weather Forecasting
EDR	Eddy Dissipation Rate
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FIR	Flight Information Region
GA	General Aviation – encompasses civil aircraft operations other than those performed by commercial air transport flights operating to a schedule
GAMET	Forecast type: General Aviation METeorological forecast
GANP	The ICAO Global Air Navigation Plan
GASCo	General Aviation Safety Council
GNSS	Global Navigation Satellite System (a constellation of satellites which provide positioning and timing data which can be used to detect space weather events)
GRIB/GRIB2	A gridded data format
HF COM	High Frequency radio communications
ICAO	International Civil Aviation Organisation
IMO	Icelandic Met Office
IWXXM	ICAO Meteorological Information Exchange Model is the new format that is used for reporting meteorological information in XML format.
LIDAR	An instrument that can detect atmospheric aerosol or volcanic ash particles.
LVP	Low Visibility Procedures
MET	Meteorological Information
METAR	Observation type: Meteorological Aerodrome Report
Met Panel	A technical group that forms part of the ICAO Air Navigation Commission which defines and develops ICAO provisions for aeronautical meteorological services consistent with operational improvements envisioned by the GANP.
MOCCA	The Met Office Civil Contingencies Aircraft

MOSWOC	Met Office Space Weather Operations Centre
NATS	The UK ANSP https://www.nats.aero/
NM	Eurocontrol Network Manager
NR23	Price Control Review from 2023 to 2027
NWR	Network Weather Resilience – a Met Office web portal which provides access to aviation data.
PECASUS	A pan-European space Weather Consortium which includes the Met Office
PWS	Public Weather Service
PWSCG	Public Weather Service Customer Group
QNH	Meteorological parameter: the barometric altimeter setting that causes an altimeter to read airfield elevation above mean sea level when on the airfield.
QVA	Quantitative Volcanic Ash
R&D	Research and Development
RPAS	Remotely Powered Aircraft Systems
SADIS	Secure Aviation Data Information System – the system operated by the Met Office as part of its WAFS responsibilities
SARPS	Standards And Recommended Practices
SESAR	Single European Skies ATM Research https://www.sesarju.eu/
SIGMET	Forecast type: Significant Meteorological Information
SIGWX	Significant Weather forecast charts provided by a WAFC
SO2	Sulphur Dioxide
SVO	State Volcano Observatory
SWIM	System Wide Information Management - standards, infrastructure and governance enabling the management of information and its exchange between qualified parties via interoperable services
TAF	Forecast type: Terminal Aerodrome Forecast
UKPP	Met Office Post Processed model data
VA	Volcanic Ash
VAAC	Volcanic Ash Advisory Centre
VAG	Volcanic Ash Advisory Graphic
VFR	Visual Flight Rules
WAFC	World Area Forecast Centre
WAFS	World Area Forecast System
WMO	World Meteorological Information

1. Introduction and drivers

The UK and Global aviation industry is in a state of significant change; the industry is recovering from the Covid-19 global pandemic whilst there are major areas of development underway, such as the move towards the implementation of global, European and UK ATM concepts and an increasing demand for increased environmental sustainability.

From a Met perspective significant change is also underway in the UK, driven particularly by increasing supercomputing and weather science capabilities leading to an ability to meet and enhance many of the global, European and UK ATM concepts.

This briefing note seeks to provide a description of the Met Office activities and associated costs through NR23 to meet the anticipated needs of UK aviation through the provision of accurate and detailed Met Services and capability. The contents of this briefing note are for consultation and subject to feedback, and will be updated and published early in 2022.

The Met Office provides the services and developments under designation from the CAA. As such, the meteorological and forecasting services are provided on an exclusive basis by the Met Office as the Meteorological (MET) Air Navigation Service Provider (ANSP) and hold a certificate issued by CAA in accordance with Regulation (EU) 2017/373 as retained (and amended in domestic law) under the European Union (Withdrawal) Act 2018.

There are several drivers which shape the Met Office proposal for NR23, which are from both a regulatory and industry perspective, and include developments enabled by advances in Met Office capability (figure 1).

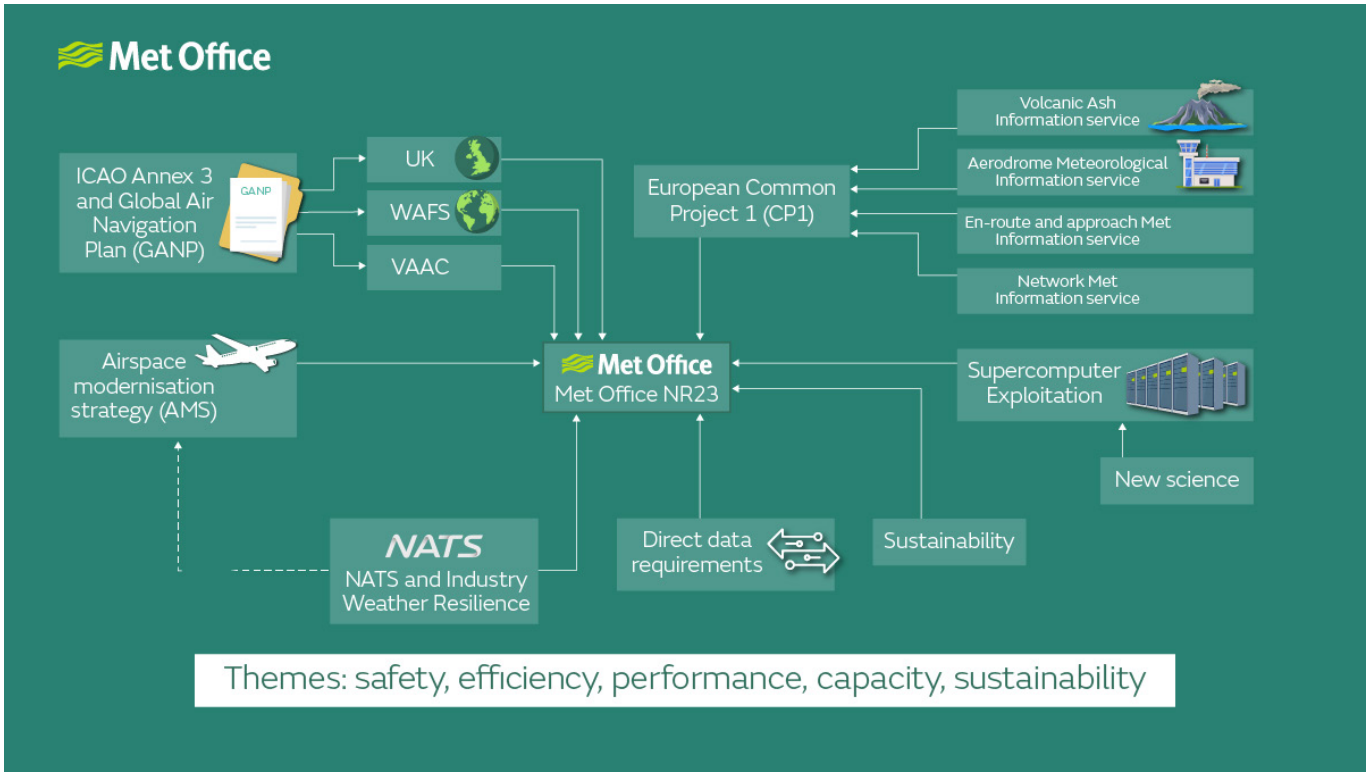

Figure 1 Drivers for the Met Office NR23 planning

ICAO's Annex 3[1] provides the main regulatory framework against which the UK is obliged to provide meteorological services which, in conjunction with the UK-AIP, the Met Office delivers Met Services against. This ensures that the UK meets the obligations to ICAO to provide safe, efficient and regular air travel. These services fall into the following main categories:

a) UK services.

b) The World Area Forecast System (WAFS), as provided by World Area Forecast Centre (WAFC) London, in coordination with colleagues in the US.

c) SADIS (Secure Aviation Data Information Service).

d) The Volcanic Ash Advisory Centre (VAAC) London.

In addition to the ICAO Annex 3 determined services, there are also a range of discretionary services that are determined as a requirement in the UK. Specific services and the provision of information to NATS is an example of this.

The three main regulatory developmental areas which are driving the Met Office NR23 considerations are ICAO's Global Air Navigation Plan (GANP) and the associated Aviation System Block Upgrade (ASBU) framework, the CAA Airspace Modernisation Strategy (AMS) and EU Common Project 1 (CP1). Whilst there are direct MET-related requirements associated with these drivers, MET information is also an enabler for many of the ATM concepts.

The **GANP** focusses on the modernisation of services that support air traffic growth, increased capacity and efficiency whilst at the same time maintaining safety and supporting the delivery of increasingly sustainable aviation activities. The requirements are set out as a series of Aviation System Block Upgrades (ASBUs) which stretch out to 2030.

There are specific requirements within the GANP for AMET (Advanced Met) (figure 2) for the provision of observational meteorological data, forecast and warning products and climatological/historical products, but many of the other requirements can also benefit from high quality meteorological information. For example, trajectory-based operations and network operations are supported by accurate forecasts of temperature, wind and hazardous weather which enable environmental savings and the arrival time of aircraft at waypoints and airports to be accurately calculated.

The GANP also sets out the requirement for System Wide Information Management (SWIM) as the way to manage the exchange of data through standardised information services, exposed via a registry, that allow the services to be integrated with downstream user systems.

[1] Annex 3 to the Chicago Convention, Meteorological Service for international Air Navigation

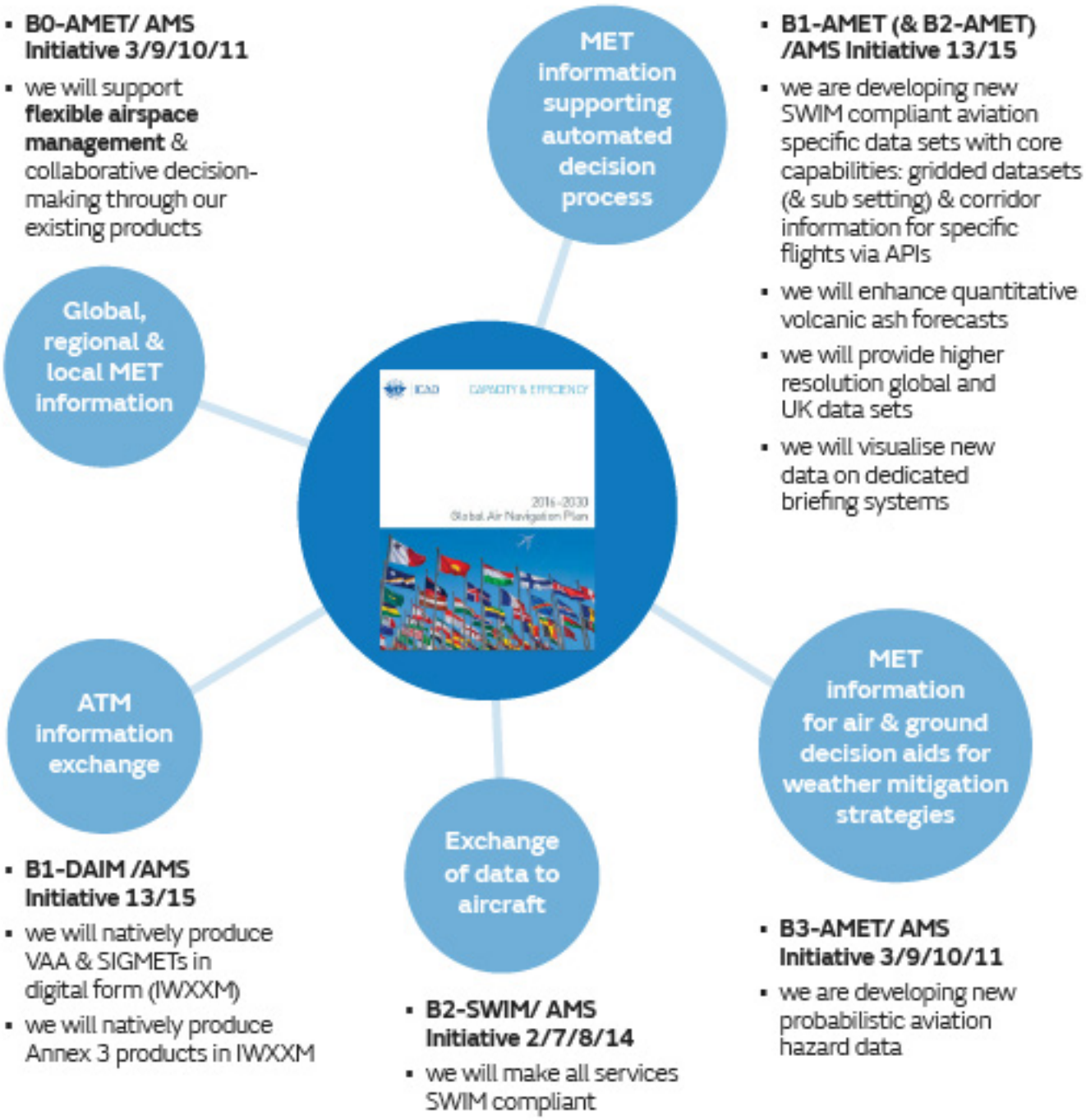

Figure 2 The role of the Met Office helping to deliver the ICAO Global Air Navigation Plan

The **AMS** talks about modernising the way UK airspace is structured and managed to enable an enhanced capacity and more environmentally sustainable approach to air traffic management. Met information is seen as an enabler for this modernisation.

Figure 3 shows the anticipated MET initiatives in support of the AMS, whilst figure 2 illustrates the link between the AMS and ICAO GANP. The provision of probabilistic aviation hazard forecasts can enhance safety and increase airspace capacity, traffic flow predictability, aircraft navigational capabilities & resilience. Enhanced 'nowcasting' of disruptive conditions at UK airports, such as convection and low visibility, can improve access to airports that may otherwise be more adversely impacted in poor weather.

Figure 3 The role of the Met Office in enabling the Airspace Modernisation Strategy

Remotely Powered Aircraft Systems (RPAS) will require high-resolution numerical weather prediction capabilities that can be used to forecast small scale hazards which will help to ensure their safe operation and integration into UK airspace.

The provision of higher spatial and temporal resolution meteorological data to NATS (via SWIM) i.e. for an area of airspace, period of time, or even trajectory, will enable NATS to use meteorological data more effectively to enhance airspace capacity.

Although the UK now sits outside of the EU, the UK CAA remains committed to CP1 which focusses on the digitalisation of air traffic information and requires specific Met information to be made available through SWIM-compliant services.

CP1 (Implementing Regulation (EU) 2021/116) mandates the implementation of 6 ATM functionalities that are essential to the realisation of the Single European Sky and that collectively should be implemented by 31 December 2027.

Of particular relevance to the MET community is ATM Functionality 5 (AF5) - System Wide Information Management (SWIM) - which specifies a functionality consisting of standards and infrastructure to enable the development, implementation and evolution of services for information exchange between stakeholders via interoperable services built on the same SWIM standards and delivered through an internet protocol (figure 4).

There are four areas of focus, all with a target deployment data of 31 December 2025: Volcanic Ash Mass Concentration Information, Aerodrome Meteorological Information, En-Route and Approach Meteorological Information and Network Meteorological Information.

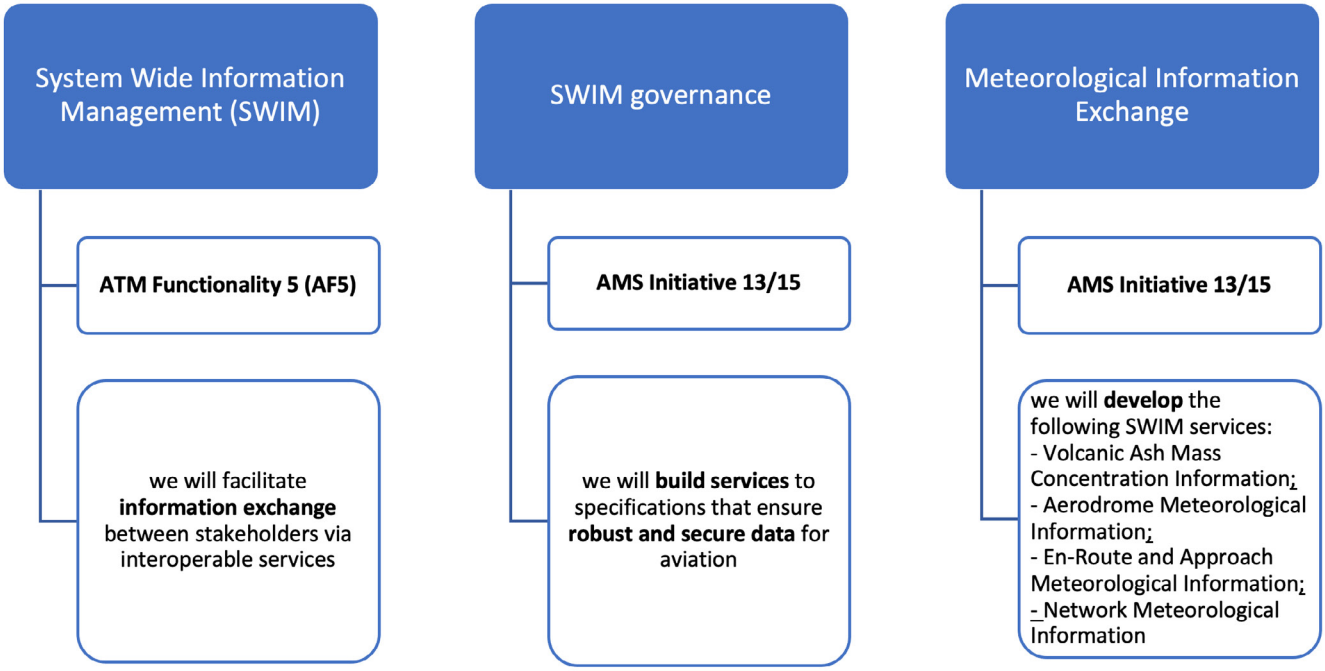

Figure 4 The role of the Met Office in supporting the development & digitalisation of SWIM compliant MET services through EU Common Project 1 deliverables.

It is noted that the aviation industry is in a state of recovery following the Covid-19 pandemic and that, at the time of writing, the UK traffic is approximately 30%[2] below 2019 levels. The network traffic forecast from Eurocontrol[3] indicates that traffic levels are expected to recover to close to pre-COVID levels in 2023 or 2024. Despite this, there has been capacity related disruption over parts of Europe during 2021 and, with the anticipated recovery of traffic levels, it is likely that weather-related capacity challenges will again become an increasing factor. Whilst this links to the longer-term aims of GANP, AMS and CP1, there is an anticipated need for direct Met Office input to mitigate weather-related disruption and input into industry resilience activities in the UK, and where relevant extending into Europe.

Whilst it is recognised that safety remains a primary focus, sustainability is increasingly becoming a leading concern in both adhering to government and corporate expectations, and to meet passenger demand for cleaner travel. The Met Office has been engaged with industry partners to develop environmentally sustainable operations[4] and, through the availability of increasingly detailed and accurate weather information, the NR23 proposals will seek to widen the use of Met Office information to help enable sustainability ambitions.

In 2020, the UK government announced a significant investment in Met Office super-computing capability, of up to £1.2billion over 10 years[5]. This investment is focussed on delivering faster and more accurate forecasting in what is expected to be the world's most advanced super-computer dedicated to weather and climate. There are specific benefits of this investment associated with aviation, including Met information for the en-route network and in the airport domains. More widely, the Met Office proposals aim to exploit this supercomputer investment to the benefit of UK aviation through NR23 with the development and availability of data services.

Figure 5 Summary of Met Office supercomputer plans

[2] Eurocontrol Daily Traffic Statistics https://www.eurocontrol.int/Economics/DailyTrafficVariation-States.html

[3] Eurocontrol COVID-19 impact https://www.eurocontrol.int/covid19

[4] https://www.metoffice.gov.uk/services/transport/aviation/commercial/green-recovery/aviationgreenrecovery

[5] https://www.metoffice.gov.uk/about-us/press-office/news/corporate/2020/supercomputer-funding-2020

2. Overview of Met Office activities through NR23

There are broadly two areas of activity within the Met Office that are directly related to the NR23 activities and cost base:

a. Contribution to the National Capability and International Subscriptions, as managed within the Public Weather Service (PWS). This refers to the underpinning infrastructure which is fundamental to the provision of an accurate weather forecasting capability; and,

b. Aviation MET service delivery and development, which specifically refers to the delivery of aviation MET services, complimentary capability and development to enable improvements in the services provided.

National Capability and International Subscriptions

The Public Weather Service (PWS[6]) provides weather information and severe weather warnings helping the UK government, businesses, emergency responders and public to make informed decisions. This is a core function of the Met Office and relies on underlying capability and infrastructure in order to operate effectively. This underlying capability can be summarised as:

a. National Capability: this is infrastructure such as the UK radar network, UK weather observations, a UK and global Numerical Weather Prediction (NWP) or weather modelling capability, and core science research and development.

b. International Commitments: this describes the commitments from several States to support a shared capability. For the Met Office, this includes weather satellite programmes operated by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the UK contribution to the European Centre for Medium Range Weather Forecasting (ECMWF) and the UN body the World Meteorological Organisation (WMO) through which most of the cross-boundary sharing of observation data is determined.

Oversight of the PWS is provided by the Public Weather Service Customer Group (PWSCG[7]) 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 PWS output. 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.

It is also recognised that, in order to fulfil the UK's obligations for the provision of accurate MET information for aviation, there are shared requirements for this underlying capability. For that reason, there is a contribution from the en-route charge mechanism to support the UK's Met National Capability and International Subscriptions. The majority contribution to this cost is from the Department for Business, Energy and Industrial Strategy (BEIS) on behalf of UK Government, whilst the aviation contribution is equivalent to approximately 15.5%. It is proposed to continue with an equivalent level of contribution through NR23. It is noted that this is specific to how the UK arranges the cost recovery of core meteorological capability, including the funding of satellites, and this is addressed differently in other States.

[6] https://www.metoffice.gov.uk/about-us/what/pws

[7] https://www.metoffice.gov.uk/about-us/what/pws/pwscg/index

Figure 6 Summary of PWS National Capability

There is a continued commitment through NR23 to these capabilities within the UK (National Capability). Figure 6 summarises the infrastructure and activities associated with the National Capability. This ranges from the surface-based observations such as from ships and rainfall radar, through to the research and development activities to operate and continually improve the weather forecasting process. The infrastructure involved is continually evolving as new technologies become available.

Within the International Commitments, there are significant changes expected over the next few years, specifically with regards to the associated satellite programmes:

- In 2024, the next (3rd) generation EUMETSAT Meteosat geostationary satellite is due to start operating; and,
- In 2024, the next generation of EUMETSAT polar orbiting satellite is due to start operating.

Satellites form a significant part of the observation infrastructure, necessary for accurate weather prediction. In a recent study from the Met Office, it was estimated that the relative contribution of satellite observations to the global 24-hour forecast is 76% of the total observations input (see figure 7). As a note, accurate observations are the fundamental part of the weather forecasting process; these provide an understanding of what the atmosphere is doing now and the better the quality of the observations input, the less the error in the weather forecast evolution.

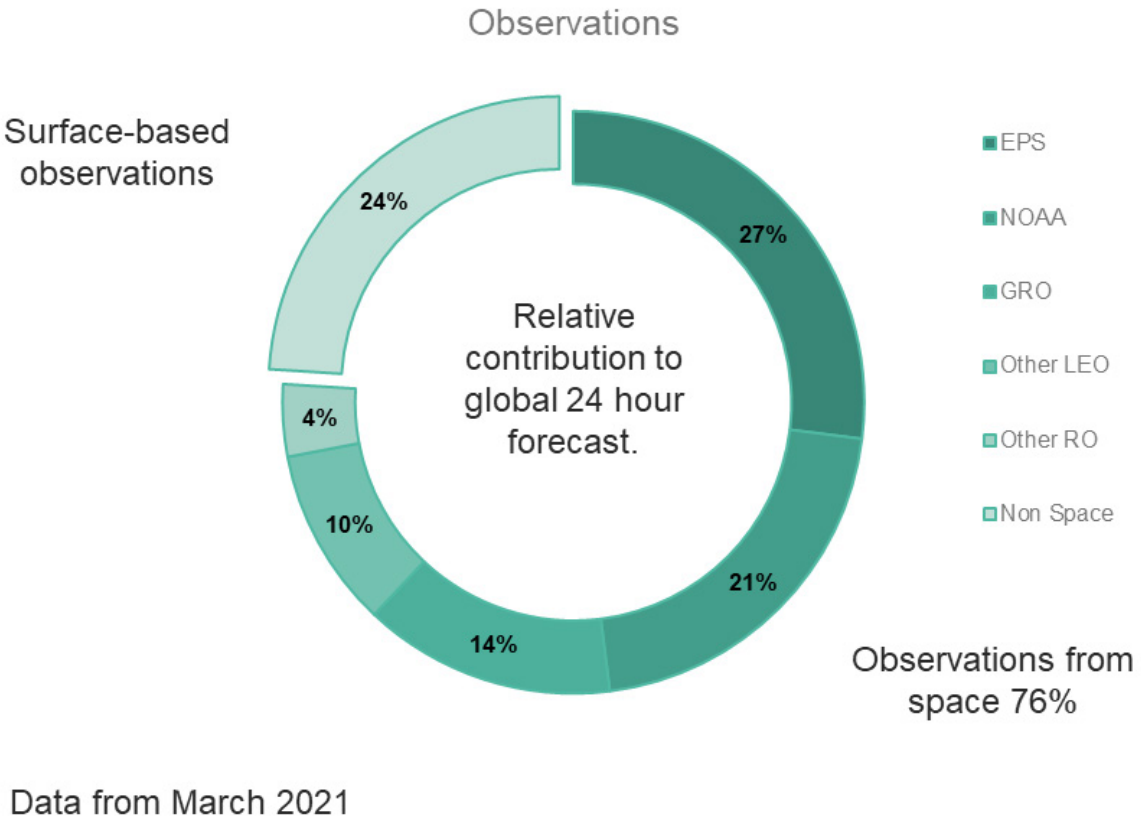

Figure 7 Relative contribution from different observations types to global 24-hour forecast. Source: Met Office

There have also been studies into the impacts of removing satellite observations from the weather forecasting process. In one such study where experiments were conducted to remove the satellite observations, known as 'data-denial' (Candy, Cotton and Eyre, 2021[8]), the observation types found to have by far the biggest impact on forecast accuracy were satellite based. Figure 8 shows two graphs from that study in which the forecast sensitivity to observation impact results by observation type show that the highest three impacts are associated with satellite-based observations (Hyperspectral IR and MW Sound-Ing relate to radiances sensitive to humidity and temperature; AMVs are wind vectors calculated from satellite instruments). In total, these three satellite-based observation types accounted for over 60% of relative total impact on forecast accuracy in both study periods.

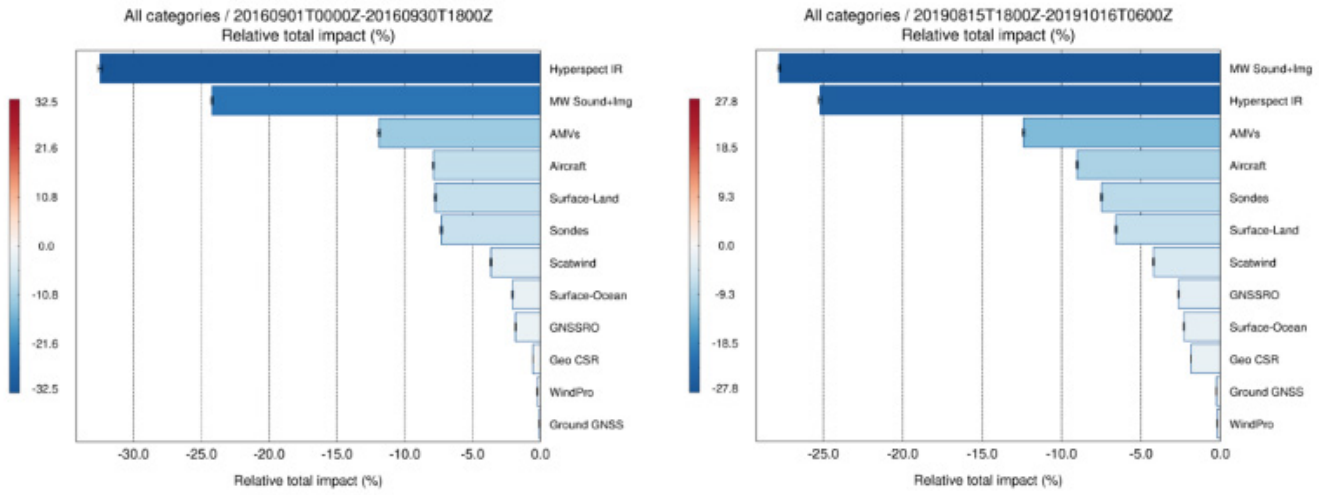

Figure 8 Forecast sensitivity to observation impact results by observation category for September 2016 (left panel) and period of 15th Aug 2019 to 16th Oct 2019 (right panel).

[8] frtr_641_2021p.pdf (metoffice.gov.uk)

It is this importance of the satellite meteorological capability to forecast accuracy that means the Met Office continues to work alongside UK government in joining and helping to progress the international satellite programme agreements.

Another anticipated continued investment is in the European Centre for Medium Range Weather Forecasting (ECMWF) which provides an independent and high-quality alternative source of weather forecast information. The ECMWF is a pan-European funded capability, with a focus on the 'ensemble' method of forecasting (utilising multiple runs of models to provide probabilities and a quantified assessment of the uncertainty in the weather forecast). Whilst this enables the Met Office to assess an alternative forecast to help determine the 'best' forecast, we are also increasingly able to incorporate ECMWF data where it is appropriate to provide the most relevant and accurate overall forecast output. ECMWF data is also the primary weather model source for Met Office forecasts beyond day five.

National Capability and International Commitments Cost Summary

A full description of the costs associated with the aviation contribution to the **National Capability and International Commitments** through NR23 is discussed in section 4. The following table presents a summary of these:

Cost (£,000)	NR23				
	2023	**2024**	**2025**	**2026**	**2027**
International Subscriptions (Inc Satellites)	£6,697	£10,715	£12,742	£12,742	£12,742
Other National Capability	£11,350	£11,350	£11,350	£11,350	£11,350
Total aviation NR23 contribution	**£18,047**	**£22,065**	**£24,092**	**£24,092**	**£24,092**

Aviation Service Delivery and Development

The main area of aviation-specific activity within the Met Office relates to the delivery of operational services and the development of new or improving capability.

Aviation Service Delivery

Providing information for safe flight is a fundamental purpose for the Met Office provision of aviation meteorological services. Increasingly and through NR23, we aim to develop these services to enable performance-based operations and act as an enabler for efficient and increasingly sustainable flying activities.

The service delivery aspects are stated within our designation agreement with CAA and primarily to meet our obligations as stated within ICAO Annex 3.

The delivery of these services utilises the team of specialist aviation meteorologists, a weather visualisation and forecast production system, and support by 24-hour IT teams, to enable a resilient and robust service.

The recent Covid-19 lockdown tested the model of in-person operations rooms, both from a government guidance and personal well-being perspective. We were able to respond by enabling most of our operational staff to work remotely through connectivity back to the Met Office and continuing to provide the services. Further to this, it has enabled a long-term increase in the flexibility of how we provide services, improving the resilience of the operation.

The main areas of operational delivery are:

a. TAFS, for 55 airfields across the UK

b. Airfield Warnings, for 108 airfields across the UK

c. GAMETs

d. Low level significant weather (F215 and F415)

e. Low level winds (F214, F414)

f. Forecast QNH

g. Met Watch Office (MWO) responsibilities: SIGMETs for London, Scottish and Shanwick Oceanic FIRs

h. Trend forecasts at LHR and MAN

i. Take-off data for LGW

j. London CTA helicopter forecasts

It is broadly anticipated the provision of these services will continue as a requirement through NR23, subject to any adjustments described with the Designation Agreement and which stem from changes within ICAO Annex 3.

World Area Forecast System (WAFS), as provided by the (Met Office) World Area Forecast Centre (WAFC) London

WAFS is a global service provided by the UK and US on behalf of ICAO. The UK element of the service is provided by WAFC London as hosted by the UK Met Office. WAFS provides a global dataset of weather data every six hours and is utilised globally in the flight planning process:

a. Wind and temperature information in 3 hourly time steps

b. Weather hazards (Turbulence Potential, cumulonimbus clouds and Icing Potential) information in 3 hourly timesteps

c. Significant Weather charts, one time step per issue, valid at T+24

d. The wind and temperature 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.

e. Turbulence (FL100, FL140, FL180, FL240, FL270, FL300, FL340, FL390, FL450), Icing (FL060, FL100, FL140, FL180, FL240, FL300) and Cumulonimbus is provided on a 0.25° horizontal grid.

In November 2020 the science behind the Turbulence and Icing datasets was upgraded, and forecasts are now provided in terms of an Eddy Dissipation Rate (EDR). These changes are described in Appendix 2.

The production of the UK element of WAFS is cost recovered within the UK en-route charging mechanism, whilst the global distribution of the information (and other OPMET data) is cost recovered through the ICAO SADIS agreement.

Anticipated developments to the WAFS are discussed later in this section under Aviation Development.

Volcanic Ash Advisory Centre London

The UK is designated by ICAO as a Volcanic Ash Advisory Centre (VAAC), known as VAAC London[9], and is operated by the Met Office. It is one of 9 VAACs around the world (see map in figure 9) with the responsibility for forecasting the volcanic plumes associated with eruptions that occur in Iceland and Jan Mayen.

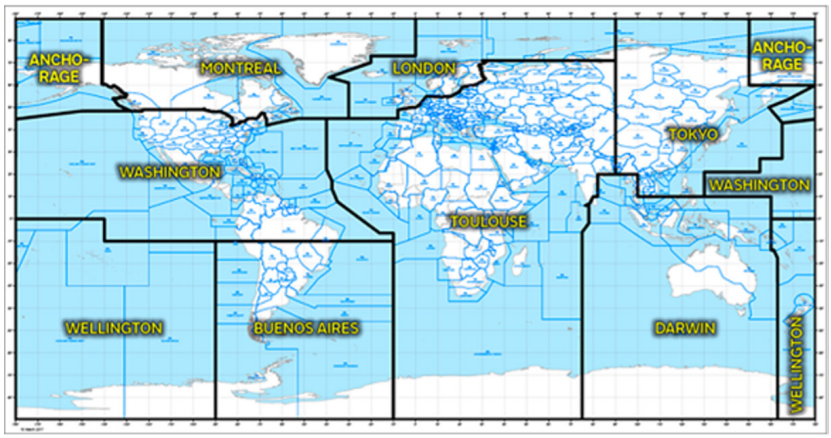

Figure 9 Map of VAACs and areas of responsibility.

In the event of an eruption, the London VAAC will provide Volcanic Ash Advisories (VAAs) and Volcanic Ash Graphics (VAGs) as detailed within ICAO Annex 3. In addition, the Met Office will also facilitate and provide input to daily briefings for aviation stakeholders during an impactful eruption. To facilitate the provision of VAAC services, the UK Met Office continually liaise with the Icelandic Met Office (IMO[10]) who act as the State Volcano Observatory (SVO) and provide the monitoring and alerting capability of the known volcanoes[11]. The VAAC capabilities are provided by a team of VAAC meteorologists, volcanic ash observation specialists and atmospheric dispersion scientists.

Anticipated developments to the London VAAC service are discussed later in this section under Aviation Development.

Space Weather aviation services

Met Office Space Weather Operations Centre (MOSWOC) is responsible for supporting the PECASUS Space Weather Centre (a pan-European Space Weather consortium), by monitoring and forecasting a global ICAO compliant space weather advisory service. The MOSWOC also serves as the nominated contingency location for PECASUS.

ICAO compliant Space Weather Advisories are issued for expected space weather phenomena that have an aviation impact pertaining to HF radio communications (HF COM), GNSS-based navigation and surveillance (GNSS), and radiation at aircraft altitudes (RADIATION). The MOSWOC maintains the ability to disseminate Space Weather Advisories to NATS Data Services so these advisories are accessible to area control centres, flight information centres and aerodrome meteorological offices.

[9] https://www.metoffice.gov.uk/services/transport/aviation/regulated/vaac/advisories

[10] https://en.vedur.is/earthquakes-and-volcanism/volcanic-eruptions/

[11] https://icelandicvolcanos.is//

Services to General Aviation

Pre-flight weather briefing products for general Aviation

To ensure that the UK General Aviation community have easy access to comprehensive pre-flight briefing information, to help ensure air safety during take-off, landing and en-route, the Met Office is responsible for the provision and dissemination of an extensive range of aviation weather products.

Specific products provided include UK low level significant weather forecasts in graphical and alphanumeric form (figure 10), 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.

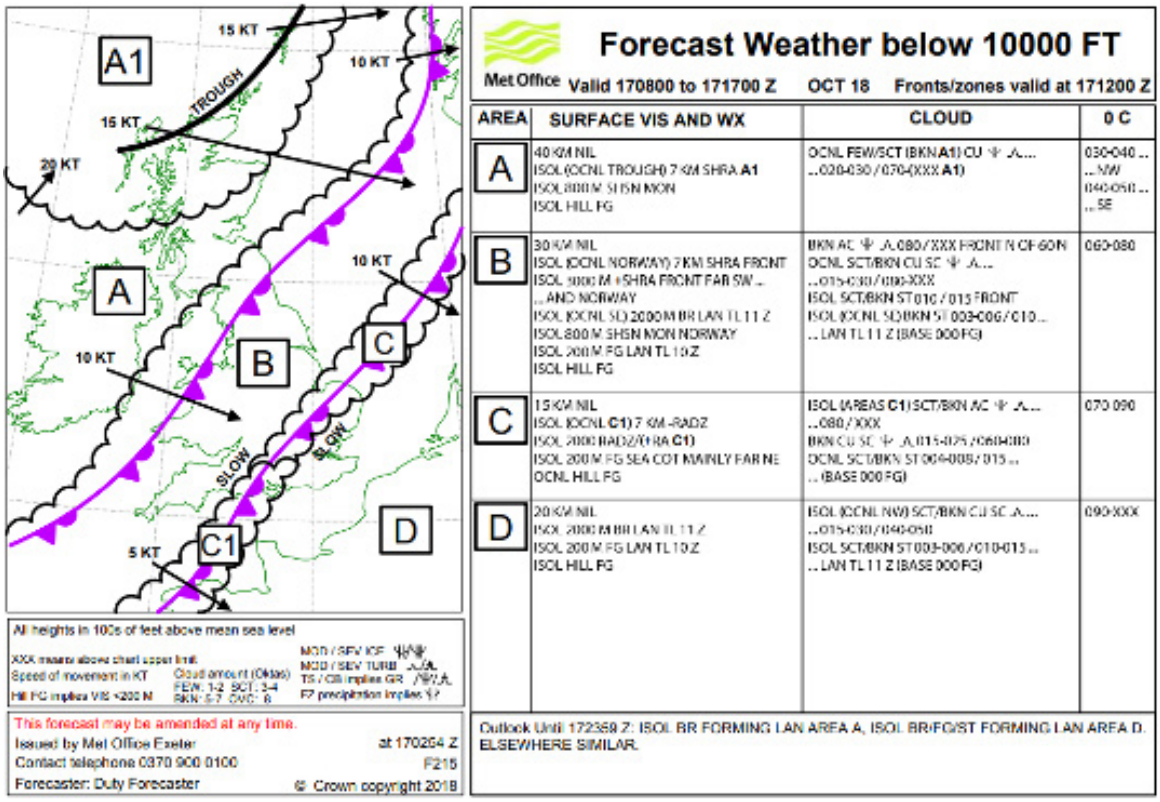

Figure 10 UK low level significant weather briefing chart

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 jet 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.

Other services available

To supplement the products on the Aviation Briefing Portal, aviators are welcome to contact the Met Office to speak with a forecaster directly should he/she wish to seek clarification or amplification on any part of the forecasts.

The Met Office also supports the work of CAA and Air Accident Investigations Branch teams through the provision of weather data, aftercasts and analysis.

Guidance and documentation for aviators

To assist pilots in making the most from the weather briefing products available, a range of resources are available on the Met Office website. The Met Office works closely with the CAA to ensure the information available is consistent with the requirements of pilots. Our Customer Centre is able to direct any GA enquiries to the appropriate experts for prompt response.

Stakeholder engagement activities

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. These include membership of the General Aviation Safety Council (GASCo), hosting weather safety seminars for GA, annual user forums, and attendance at popular events such as the Bristol Balloon Fiesta.

Future plans

The Met Office continues to work closely with the CAA to evolve and enhance the forecast provision to the UK general aviation community, with further enhancements planned for specific products and, more broadly, an API information service capability for use by general aviation flight planning software providers.

Services to NATS

NATS and the Met Office work closely in the management of airspace with respect to weather, and the handling of disruptive weather events. There are two main areas of service delivery of MET services to NATS:

1. Onsite team of meteorologists
2. MET Products and Data services to NATS

Onsite at NATS

Since 2017, the Met Office has provided a team of meteorologists at NATS Swanwick, providing information and advice 24 hours a day. Since its inception, this has been recognised as a valuable addition, enabling planning and supervisors to make enhanced decisions around airspace capacity; this has been particularly beneficial around disruptive weather events such as thunderstorms in the London TMA, widespread strong wind events and low visibility events at airfields.

The same team at NATS is also engaged in activities to provide information into Eurocontrol's Network Manager (NM), particularly the cross-border thunderstorm forecasting service. This is to ensure a consistent weather forecast is used by NM as is already used by NATS in the UK; approached in a similar way across Europe, this facilitates consistent decision making between States and NM, enabling improved performance for UK traffic through the Eurocontrol region.

Whilst it was intended to increase the complement of Met Office staffing at NATS to enable the shift pattern to match the NATS controllers, increase resilience and carry out development activity, this was slowed down during 2020 due to the impacts of Covid-19 on airspace capacity. Noting that UK and European traffic is expected to continue to increase, it is proposed to continue with the onsite team of meteorologists through NR23, providing a 24/7 capability and an ability to provide analysis and further service development activities.

MET Products and Data Services to NATS

A range of MET services are delivered to NATS and we have engaged for many years over the development of products and data services to meet NATS' requirements for managing the UK en-route and terminal airspace. Through NR23, it is anticipated that there will be a need to modify these services to take advantage of developing Met Office capability, and to transition towards SWIM-compliant data services.

Web visualisation services

In order to support the availability of information to aviation stakeholders, the Met Office provides three operational web visualisation services:

a. Network Weather Resilience[12]
b. Aviation Briefing Service[13]
c. HeliBrief®

Services to NATS:

Products

- FIR Winds
- SFC/3000ft LHR winds
- SFC/3000ft LCY winds
- Pre-tact forecasts (monthly forecasts)
- 6-day hazard forecast
- Daily proforma
- Telephone conferences
- TC Controllers Weather Self Briefs
- NM Cross Border Weather Advisory
- Disruptive Weather Forecast & WebEx Presentation
- 0330L Weather Brief to TC OS
- ACM Daily Network Review
- Local Area Forecast
- Sea State Forecast
- LVP Risk Matrix
- D0/D-1 UK Convection Forecasts
- Heathrow 48hr Wind Forecast Lightning Risk Warnings

Data feeds

- ITEC GRIB2 data
- Gated NAT Tracks (Optimum Routes)
- iFacts GRIB (hi res gridded winds)
- iFacts GRIB (planning)
- Forecast Precipitation & Lightning data
- UKPP datafeeds
- European ATDNet data
- Satellite cloud top imagery
- Radar/sferics data
- European Radar (1km/15min) data

[12] https://www.metoffice.gov.uk/services/transport/aviation/regulated/network-weather-resilience-nwr
[13] https://www.metoffice.gov.uk/services/transport/aviation/regulated/aviation-briefing-service-guidance

Launched in the summer of 2020, **Network Weather Resilience (NWR)** provides a portal whereby UK aviation stakeholders (ATM, airlines, airports) can access, free at point of use, the observed and forecast aviation weather services. The aim is to enable access to consistent weather information as provided under the Met Office designation from CAA, and in turn act as an enabler for the improved handling of network challenges in disruptive weather.

NWR currently provides an initial functionality, with TAFs and METARs displayed on a map (figure 11), a limited number of weather layers (figure 12) and some of the products used by NATS and Network Manager, such as CB/thunderstorm products and LVP forecasts.

Through NR23, it is intended to maintain the provision of NWR and update the service routinely to enable the visualisation of additional Met Office aviation weather data as it becomes available. These plans will be discussed further in the Development section of this consultation paper.

As the sole designated UK ANSP provider of aeronautical meteorological forecasts, the Met Office is required to provide a range of briefing products to support the activities of the UK General Aviation[14] and business jet communities. The Met Office discharges this responsibility through a range of products and services. These are made available through the **Aviation Briefing Service** (figure 13), a web portal available on registration. It is intended to maintain the provision of these products and services through a web portal during NR23. However, there is a requirement to transition the portal away from a legacy infrastructure, which is referenced further in the Development section of this consultation paper.

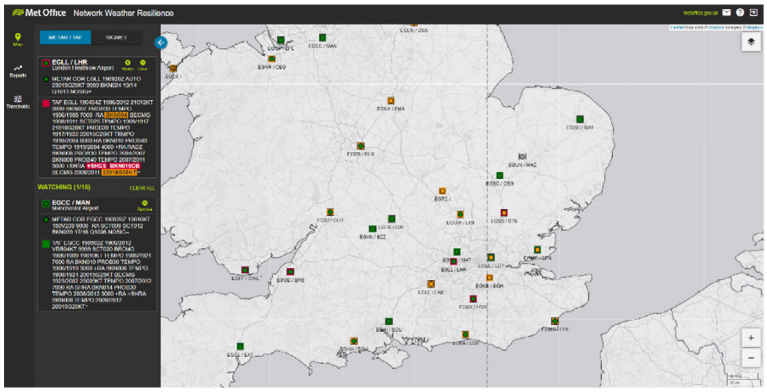

Figure 11 NWR showing TAF and METAR on a map

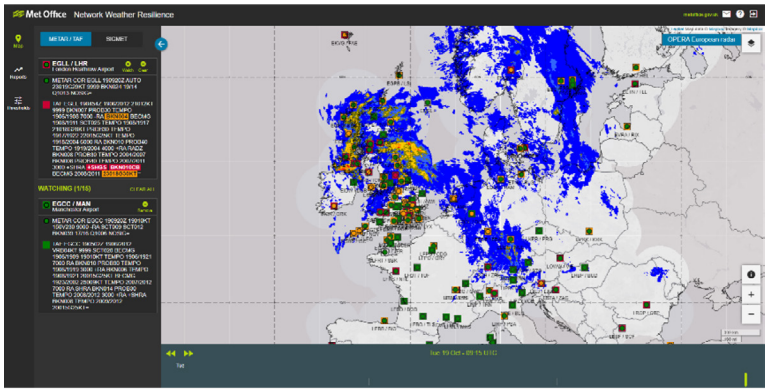

Figure 12 NWR showing rainfall radar overlay

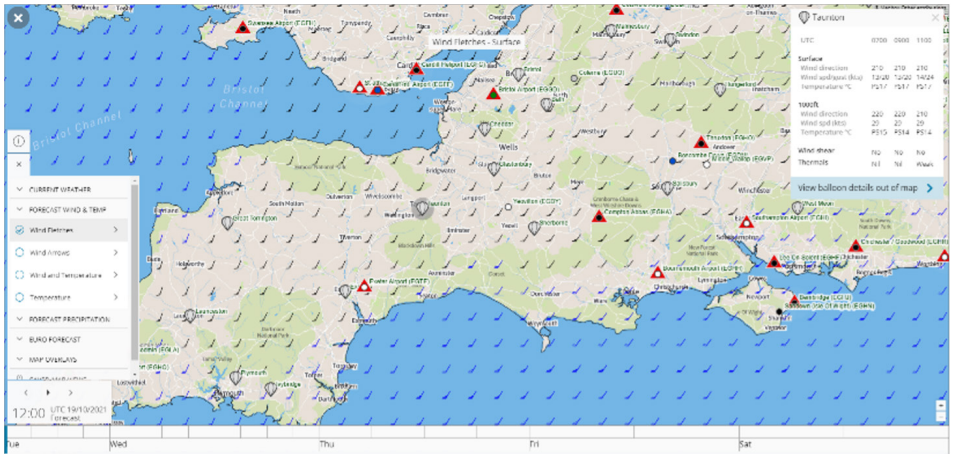

Figure 13 Aviation Briefing Service showing surface wind and airfield warnings information

[14] 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.

HeliBrief® is provided under contract with NATS and on behalf of the CAA (in accordance with ICAO Annex 3 SARPs), to facilitate the safe operation of helicopter operations to oil and gas platforms located on the North Sea, Irish Sea and NE Atlantic. A range of Annex 3 products, specific products for rotary aircraft and visualisation of observation and forecast data are provided.

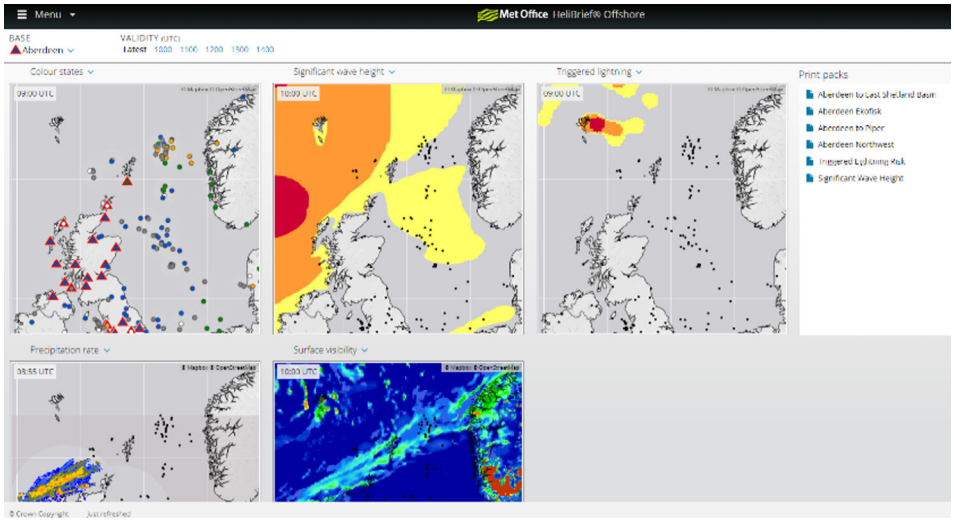

Figure 14 Helibrief showing a variety of useful weather parameters

A similar service is provided to UK emergency helicopter options, including UK Search & Rescue, National Police Air Service and Air Ambulance operations.

Other services to CAA & Agencies

The Met Office provides authoritative and impartial reports to the CAA and the Air Accidents Investigation Branch (AAIB), in support of air accident investigations and MET related Mandatory Occurrence Reports (MORs). We also provide ad-hoc climatological and statistical analysis in support of a range of CAA initiatives.

Aviation Service Delivery Cost Summary

The overall finances for the Met Office proposals for NR23 are discussed in section 4. However, as a summary, the expected cost base for the Aviation Service Delivery aspects are as follows:

Cost (£,000)	NR23				
	2023	2024	2025	2026	2027
Designation Agreement Services	£7,740	£7,547	£6,358	£6,2199	£6,044

[15] The charges for HeliBrief® are recovered from the North Sea round-trip charge and therefore do not contribute to the NR23 cost profile.

Aviation development

Developments to operational services

WAFS Upgrade 2024

Recent discussions within ICAO groups and agreement at the ICAO's Met Panel have led to a series of recommendations being progressed for changes to WAFS, for implementation in November 2024 (Amendment 81 of ICAO Annex 3). These changes represent a significant upgrade in WAFS capability and aim to improve safety and enable more efficient or sustainable flight operations:

- Increased horizontal resolution of the wind and temperature 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) (see figure 15)
- Vertical resolution increased to every 1000FT for all parameters (see figure 16)
- Increased temporal resolution, with hourly data from T+6 to T+24, 3-hourly timesteps from T+27 to T+48, then 6 hourly timesteps to T+120
- Next Generation Significant Weather (SIGWX) forecasts
    - 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)
    - Consolidation of the high and medium level SIGWX forecasts into a single SIGWX forecast spanning FL100 to FL600, with upgrades that will bring global coverage icing objects and the introduction of tropopause contours.
    - Introduction of a new IWXXM format

These upgrades will be implemented in November 2024 as SWIM-compliant services, along with the provision of both IWXXM and traditional alphanumeric format OPMET data sets (METAR, TAF, SIGMET, AIRMET, GAMET, Volcanic Ash Advisories, Topical Cyclone Advisories, Space Weather Advisories). More information on the WAFS upgrades is available on the Met Office website[16] including more detail about the forthcoming changes and a training presentation for the new hazard datasets.

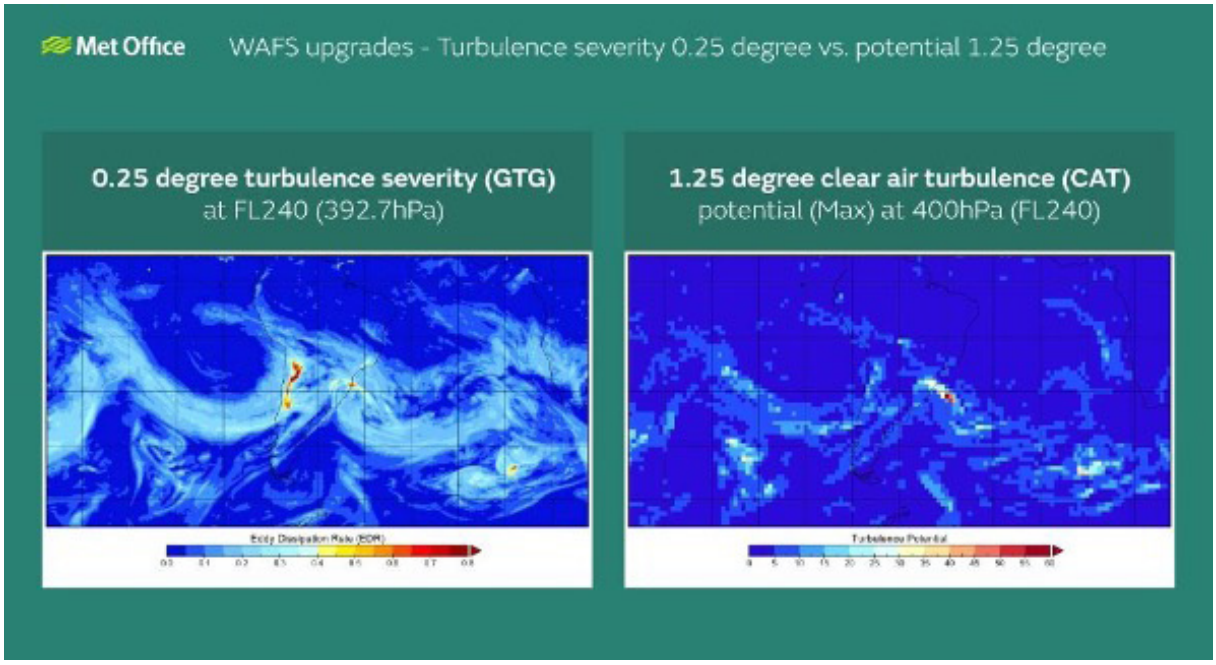

Figure 15 Example image showing the increased detail in the new 0.25-degree turbulence dataset (left) versus the standard 1.25-degree dataset (right).

[16] https://www.metoffice.gov.uk/services/transport/aviation/regulated/wafs-2023

We have commissioned a study to investigate the benefits of the forthcoming changes to the WAFS service. This was completed pre-COVID by Helios (now EGIS) and through reduced fuel burn, lower emissions (15-20% of total saving) and reduced crew and passenger injury, the savings for the global aviation industry are expected to total £792 million in 2025 and £1239 million per year by 2030 (noting these are pre-COVID figures).

WAFS Upgrade 2026

The WAFCs are also planning for additional upgrades to the WAFS data sets for November 2026 (Amendment 82 of ICAO Annex 3) to introduce probabilistic hazard forecasts. The underpinning capability to create these forecasts is already well advanced, and a period of consultation with aviation users is being carried out to determine exactly which probabilistic forecast information will be most useful.

Quantitative Volcanic Ash (QVA)

Whilst there is a continued need to deliver the current volcanic ash and VAAC capability through NR23, there are also significant developments driven by ICAO Annex 3 to upgrade the volcanic ash forecasting capability. This will initially be a recommended practice in November 2024 (with Amendment 81 to Annex 3).

These changes are described as Quantitative Volcanic Ash (QVA) and describe the globally consistent implementation of concentration information for 'significant' eruptions. Whilst the UK and France already provide concentration charts for eruptions (as described in the ICAO contingency plan for the EUR/NAT regions[17]), the forthcoming changes will provide a SWIM-compliant data service, with the forecast plume for specific concentration thresholds.

These changes are driven by the requirement for globally consistent information which enables the development of safety risk assessments which allow for some engine exposure to volcanic ash. Whilst the initial implementation is expected in November 2024, it is expected that these requirements will be iterated further with a potential uplift for implementation in November 2026.

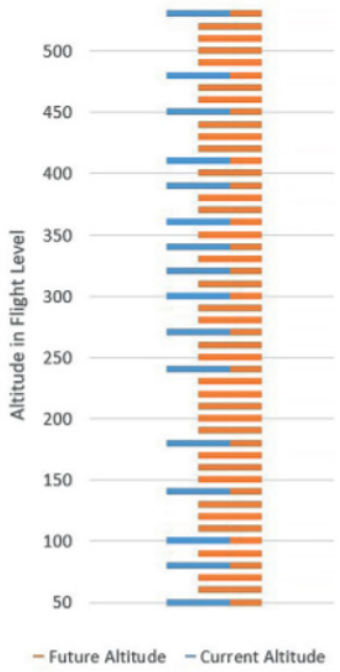

Figure 16 Illustration showing the currently available data levels (blue) versus the levels that will be available in November 2024 (orange)

QVA summary:

Gridded dataset of ash concentration values at 0.25 degree horizontal resolution and 5000FT vertical levels.

Frequency of exceedance probabilities for the following Volcanic Ash concentrations from surface to FL600:

- Very high: Equal to or above 10 mg/m3
- High: Equal to or above 5 and below 10 mg/m3
- Medium: Equal to or above 2 and below 5 mg/m3
- Low: Equal to or above 0.2 and below 2 mg/m3
- Very low: Below 0.2 mg/m3

Delivered as SWIM-compliant gridded data and IWXXM

[17] https://www.icao.int/EURNAT/Pages/METEOROLOGY/Volc_Ash_CPs.aspx

Aviation Data Services

A common requirement in the GANP, AMS and CP1 is the development and provision of SWIM compliant services. This links also to the developments of data services to meet the requirements set out for the next generation WAFS data, QVA data and that anticipated for UK traffic and developing ATM concepts. This is coupled with the changing nature of MET data; increasingly powerful supercomputer capability and higher resolution models mean that ever greater amounts of data are available and moving large global datasets around the world becomes un-viable. The Met Office has already begun to develop these SWIM-compliant services and the underlying systems that support them.

The first SWIM Services on offer are those resulting from the SESAR Deployment projects the Met Office has been involved in: a 3D Radar Service and a Harmonised Turbulence Service. These SWIM services have now been successfully deployed operationally, listed in the European SWIM Registry and available for use on an ongoing basis. (See Annex 2 for further detail).

Meanwhile, the current and ongoing phase of development focusses on delivering the Met Office Aviation Data Services (ADS) programme of work, which will make a wide variety of aviation specific data sets available to users through a series of core capabilities:

- Web Coverage Services will expose gridded data sets, and enable the end users to sub-set the data to select the levels, timesteps and area relevant to a specific application.
- Web Feature Services enable the retrieval of four-dimensional trajectory information and corridor information applicable to specific flight routes.
- Web Map Services will allow users to download georeferenced tile images that can be displayed on downstream systems.
- Provision of weather objects/features (for example jet streams, or areas enclosing hazardous weather).
- Provision of spot data.
- Provision of aviation specific charts and written forecasts.

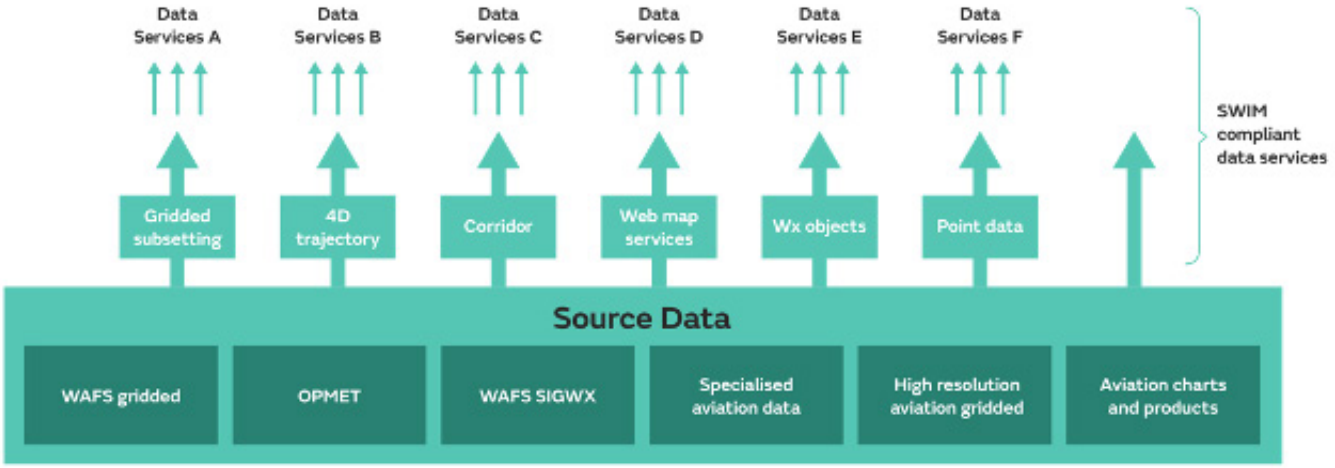

Figure 17 Illustration showing the variety of different source data and available formats for new aviation data services

These capabilities will be accessed via a series of APIs[18], all recorded within the Eurocontrol SWIM Registry[19], and adhering to the requirements listed in the Eurocontrol SWIM yellow profile. Two main types of API will be provided:

- Streaming API: enables a user to subscribe to a particular data feed, and whenever new data becomes available they will be notified and either provided with this data as a payload or directed to where to pick it up. Streaming will be available for most data types.
- Request-Reply API: enables ad-hoc requests for data to be made, and suits activities such as trajectory and corridor requests in which the route being flown changes each time.

The ADS capabilities will be applied to the WAFS data sets and released by November 2024 as a "SADIS API". This will be a family of three APIs which will enable the sub-setting of WAFS gridded data, the sub-setting of OPMET data (in both traditional alphanumeric and IWXXM formats), and the new multi-timestep SIGWX forecasts (which will be generated by the ADS weather objects/features capability). The SADIS API will be available to users located within the SADIS footprint, but can also be made available to other categories of users should this be required.

In November 2024, the new QVA forecasts will also be made available and the IWXXM objects will be created by ADS from the gridded QVA data.

The capability to provide data using Web Map Services, spot data, and access to the charts and other aviation forecasts will be enabled as allowed by the development schedule. Where relevant for specific services, higher resolution (10km) global gridded data sets will be added to the ADS "data store" as will 1.5km UK specific and other data.

As new web map data layers are made available, they will be connected to the Network Weather Resilience (NWR) platform so that users can see a visualisation of the new datasets.

During 2026 and 2027 it is anticipated that updated capabilities for WAFS and volcanic ash will be added. Additionally climatological/historical data sets may be added to support the design and planning of infrastructure, flight routes and airspace management and incident and accident investigations.

Web Visualisation Platforms

As referenced previously, the Met Office provides the web platforms of Network Weather Resilience (NWR), Aviation Briefing Service and HeliBrief to aviation stakeholders in the UK.

The NWR platform is a recent addition and is aimed at enabling access to consistent weather information for all UK aviation stakeholders. Whilst the functionality and available data layers is currently relatively limited, it is intended that NWR will continue to be developed through NR23 to enable the visualisation of the data services provided by the ADS programme.

There are several options for how much NWR is developed and this will depend on user requirements. One proposed option is to incorporate a site-specific airfield weather data visualisation. This would be designed to enable airlines to see improved detail of weather data at airports and also provide an opportunity to develop the provision of airfield warnings to be consistent with available data feeds, meeting one of the requirements set out in CP1. This development would need to be fully scoped and is dependent on the user requirement; once the data service is available, a likely cost* for visualisation through NWR is approximately £300-£500K.

Whilst NWR has been developed recently and benefits from sitting on a cloud-based platform, the Aviation Briefing Service and HeliBrief® are provided on older platforms which are viewed as legacy and in need of replacement. The re-development of these services will be approached through seeking opportunities for efficiencies between these services and, where possible, the development of a common service provision.

[18] Application Programming Interface

[19] https://eur-registry.swim.aero/services

The overall finances are discussed in more detail in section 4. However, the costs* of developing and life-cycling the IT infrastructure for the Aviation Data Services and Web Visualisation Platforms are as follows:

Cost (£,000)	2023	2024	2025	2026	2027
Aviation Data Services (ADS) and Web briefing	£2,812	£2,447	£2,250	£2,000	£2,000

These are based on the expected need for technical development 'squads' to work to deliver to external deadlines, as identified specific requirements through the GANP, CP1 and AMS analysis.

* The recommendations for specific development decisions will be reported to CAA, and airspace users will be updated and further engaged prior to the final decision(s). These updates will be provided through either specific communication or through the annual Met Office User Forum.

Volcanic Ash research, development and observations

Volcanic Ash provides an ongoing threat to UK aviation and, at the time of writing, there are three Icelandic volcanoes at colour state yellow indicating an elevated state of activity.

Further to the UK's VAAC responsibilities, a team of specialist atmospheric dispersion scientists maintain and develop the volcanic ash modelling and forecasting capabilities. This includes the assimilation of data from satellites, and continually improving the dispersion model used at the UK Met Office, known as NAME.

Whilst this is fundamental to the current provision of information in the event of a volcanic ash eruption, this team is also engaged in the development activity to deliver future services:

- QVA; the requirements for quantitative ash mean the development of the availability of a significantly increased amount of data and changes to the production process. In addition, this will also involve for the first time the use of 'ensemble' modelling within the volcanic ash forecasting process; this involves the use of multiple runs of a weather model to better quantify the uncertainty in the forecast evolution and therefore represents a significant step up in data volume and scientific complexity.

- Sulphur Dioxide, SO2, in the atmosphere: SO2 is known to be a potential hazard to both human health and aircraft and is present in the atmosphere due to both volcanic eruptions and industrial emissions. The atmospheric dispersion team have been engaged in research activity in relation to ICAO-led initiatives for understanding an ability to forecast volcanic related SO2 emissions. It is expected that there will be ongoing work in this area, with the potential for initial SO2 service development through the latter part of NR23.

Also in support of the UK VAAC responsibilities and to support UK aviation decision making, the Met Office has provided a series of additional volcanic-ash focussed observation capabilities:

- Met Office Civil Contingencies Aircraft (MOCCA); this aircraft was developed as an operational capability following the 2010 Eyjafjallajökull eruption which caused a large amount of disruption to aviation over Europe. MOCCA was fitted with precise scientific measuring equipment to monitor the presence of volcanic ash in the atmosphere over a wide geographical area. However, in efforts to reduce our costs base during 2020 following the onset of the Covid-19 pandemic,, the use of MOCCA was suspended and this remains the case today.

- A network of Volcanic Ash LIDARs; precise scientific instruments which can measure and quantify the vertical atmospheric concentrations of volcanic ash at site specific locations. This network remains operational with 9 sites around the UK and has been operating for 5 years.

Within NR23, it is proposed to renew the observations capability in specific support of measuring volcanic ash in the atmosphere. It is recommended to review the overall requirement and seek the most relevant and cost-effective option. This will include:

- A review of airborne capability. It is known that a crewed capability can be developed to provide a similar capability to MOCCA. However, given rapid developments in capability, it is recommended that we undertake further work to assess the potential for the use of RPAS (Remotely Piloted Aircraft System) to provide a wide areal coverage capability.

- For VA LIDAR, it is recognised that there is a need to upgrade the current equipment given the age and expected lifetime of the current instruments, and to increase resilience and reliability. Since the network was installed, new instruments have been developed and we are exploring options for how best to maintain and develop the network.

Based on these reviews and analysis of options, recommendations will be provided to CAA to agree the most effective strategy for maintaining and developing an observational capability in support of our volcanic ash forecasting responsibilities for aviation. Estimated figures have been included within the NR23 costs, based on a preferred VA LIDAR option and previous costs for developing and operating an airborne capability.

For the VA LIDAR, these costs* are estimated as:

- £400K per annum in 2023 and 2024 for installation and initial operations, then £200K per annum running costs thereafter.

For the airborne capability, these costs* are estimated as:

- £1,100K per annum in 2023 and 2024 for installation and initial operations, then £700K per annum operational costs thereafter.

* These cost estimates are subject to a thorough review of the relevant options to best meet the needs of supporting the volcanic ash forecasting capability. Resultant recommendations will be reported to CAA, and airspace users will be updated and further engaged prior to the final decision(s). These updates will be provided through either specific communication or through the annual Met Office User Forum.

Science Research and Development

To support developing ATM concepts, deliver continuous improvement to operational services and to ensure the full aviation benefit is derived from UK supercomputer investments, a range of aviation R&D activities is ongoing and are planned for the NR23 period.

The plans address all stages of the forecasting process and a wide range of meteorological conditions that impact the aviation industry. The activity is focussed on developments to enable improved accuracy and consistency, extensive verification, the provision of new probabilistic forecasts to communicate risk, and the development of new products to deliver information for new hazards and timescales. This is valid for both inter-continental traffic and UK-domestic and near continent air travel.

Our activities focus on two main themes:

i. Development of improved forecasts of **global en-route hazards**; working closely with colleagues in the US, much of this work relates to developing our WAFS provision. Recent work has delivered significant improvements and updated science in global icing and turbulence forecasting, which are available operationally. Increasingly, focus is turning to utilising the developing 'ensemble' modelling capability. The main areas of global focus are:

- Convection/Cumulonimbus (Cb)
- Turbulence
- In-flight icing
- High Altitude Ice Crystals (HAIC), see example image in figure 18, demonstrating a recently developed satellite product capability that forms an input to a nowcast product. Airspace user review and demonstration is the next phase of development.

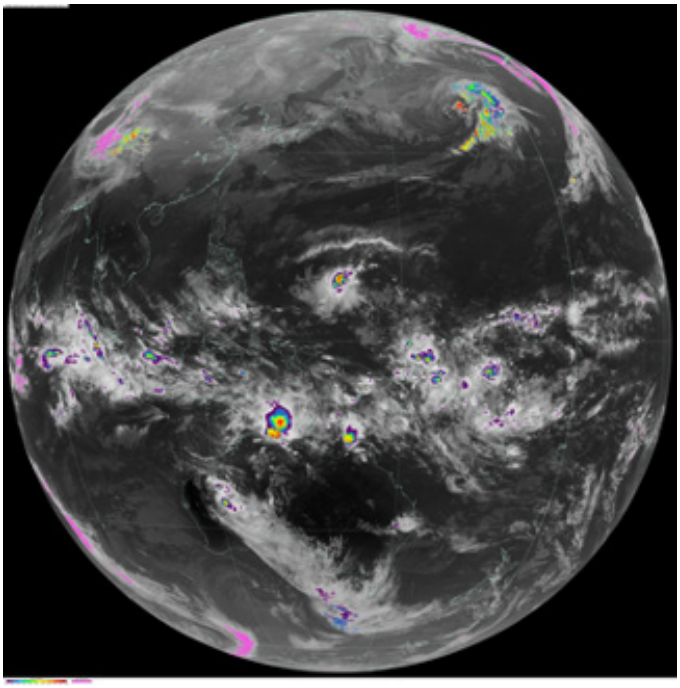

Figure 18 HAIC probability satellite product, developed by Met Office building on research at NASA's Langley Research Centre (Minnis et al)

ii. Improved understanding and forecasting of weather in UK airspace; the focus of research and development for UK weather is on both utilising very high-resolution weather modelling and 'ensemble' weather modelling to develop skill in terms of detail and better understanding uncertainty, such as in the forecasting of low visibility. New forecasting approaches such as the utilisation of machine learning are also being assessed. The work splits into four main sections:

- Convection in the UK
- Disruptive conditions at UK airports
- Improvements to TAF verification and forecasting
- Other topical studies (including addressing meteorological requirements for the safe operation and integration of Remotely Piloted Aircraft Systems (RPAS) operating in UK airspace).

One example area of research is a very high-resolution (100m) ensemble looking at low visibility prediction. Figure 19 shows this cutting-edge numerical weather prediction research and several weather model 'postage stamps' for the same timestep, indicating the likelihood of forecast outcomes. Even with just 10 hours forecast lead time there are a large range of possible outcomes for the test site (indicated by a black star).

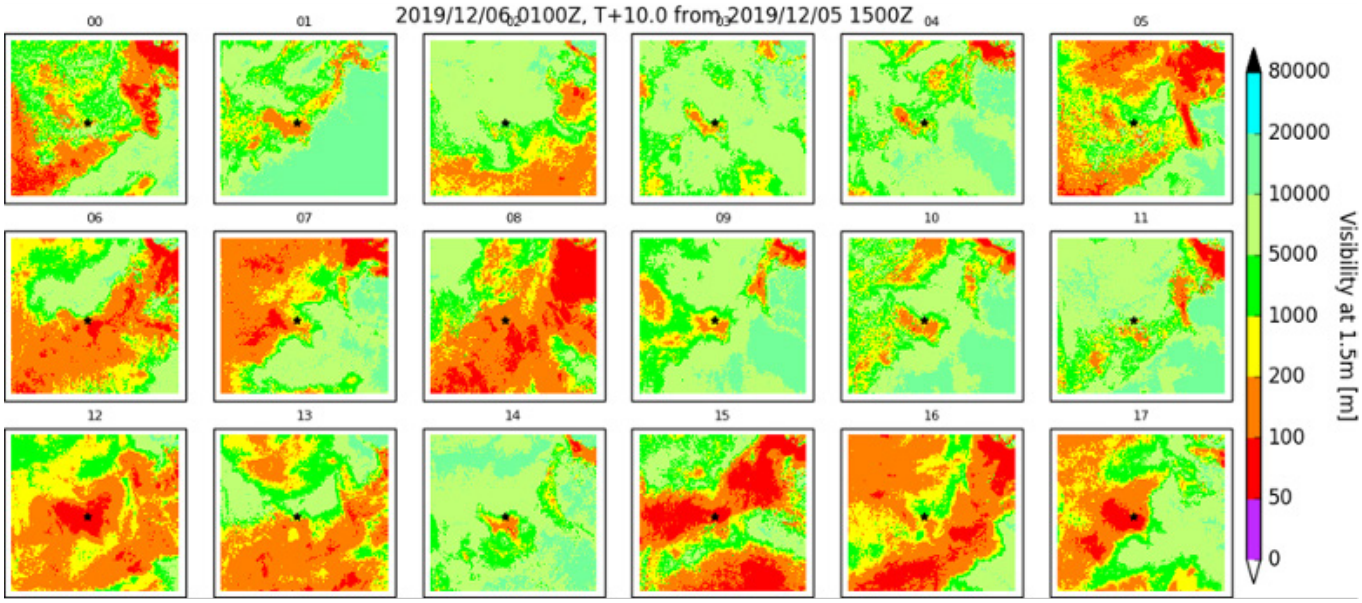

Figure 19 Example plot from very high-resolution ensemble weather modelling research, known as the SOFOG research, in conjunction with researchers at the French National Centre for Meteorological Research (CNRM).

The aviation science R&D activity plan will also be updated to utilise the UK investment in meteorological supercomputing capability. As referenced within section 1, the UK government recently announced a £1.2bn investment in Met Office supercomputing capability over the next 10 years. Compared to the current capability, this will increase computing capacity by six times for the initial five years and at least a further three times for the final five years. This enables some significant developments in weather modelling, such as:

- High resolution UK ensemble; providing detail on hazards and improved risk prediction
- Very high-resolution city scale models; focus on small scale processes such as low visibility prediction
- Relocatable sub-KM scale model; ability to deploy to a non-fixed geography to focus on specific hazards such as thunderstorms
- Improved modelling of complexity; new physics schemes necessary for improved prediction of cloud (and visibility) and aerosol interactions
- 5KM scale global deterministic; improved prediction of hazards and extremes and reduction of systematic errors
- 12KM and 14-day global ensemble model; improved risk and uncertainty predictions.

Aviation Service Development Cost Summary

The overall finances for the Met Office proposals for NR23 are discussed in section 4. However, as a summary, the anticipated cost base for the **Aviation Service Development** aspects are as follows:

Cost (£,000)	NR23				
	2023	**2024**	**2025**	**2026**	**2027**
Other Designation Met Services (service development)	£7,173	£6,965	£6,253	£6,087	£6,187

3. Performance Management

In order to monitor performance of the MET services and identify areas for improvement, several KPIs have been agreed with the CAA, which are summarised below. More detail is provided at Annex 3:

- TAF accuracy
- TAF timeliness
- TAF compliance
- Aerodrome warnings accuracy
- Timeliness of TREND forecasts
- SIGMET compliance
- Global Model performance: Wind & Temperature
- GRIB2 timeliness
- GRIB2 CB/Icing/ Turbulence timeliness
- Timeliness of BUFR data
- HeliBrief® Uptime
- LVP verification
- Airborne holding due to weather
- Number of unexpected/reactive weather regulations applied by NATS

National Aviation and WAFC London performance reports are also provided on the Met Office website.

Met Office performance is reviewed by the CAA every 3 months. The CAA also maintain Performance Based Oversight of the Met Office through annual auditing against elements of Regulation (EU) 2017/373 as retained (and amended in UK domestic law) under the European Union (Withdrawal) Act 2018.

Verification is also used to monitor performance of the PWS forecast accuracy: https://www.metoffice.gov.uk/about-us/what/accuracy-and-trust/accuracy-performance

4. Met Office Determined NR23 costs

The aviation contribution to the National Capability and International Subscriptions through NR23 is expected to be:

Cost (£,000)	NR23				
	2023	**2024**	**2025**	**2026**	**2027**
International Subscriptions (Inc Satellites)	£6,697	£10,715	£12,742	£12,742	£12,742
Other National Capability	£11,350	£11,350	£11,350	£11,350	£11,350
Total aviation NR23 contribution	**£18,047**	**£22,065**	**£24,092**	**£24,092**	**£24,092**

The overall contribution can be seen to increase, most notably in 2024 and 2025. This is driven by the International Commitments and specifically the satellite programmes described above. The specific satellite costs for PWS as a whole (BEIS and aviation) are shown in figure 20. These are subject to government agreements, as coordinated by the EUMETSAT organisation.

The shown annualised charge to PWS recovers the total cost of EUMETSAT programmes over their life. The currently operational satellite programmes have been extended beyond their originally anticipated lifetime; with the Meteosat 2nd generation extended by 6 years and the geostationary satellite extended by 2.5 years, meaning that the current cost base is artificially low.

There remains some uncertainty in the timing of these costs due to the normal adjustments and complications with satellite developments and launch dates, plus any possible additional impact from Covid-19 on the space industry and EUMETSAT.

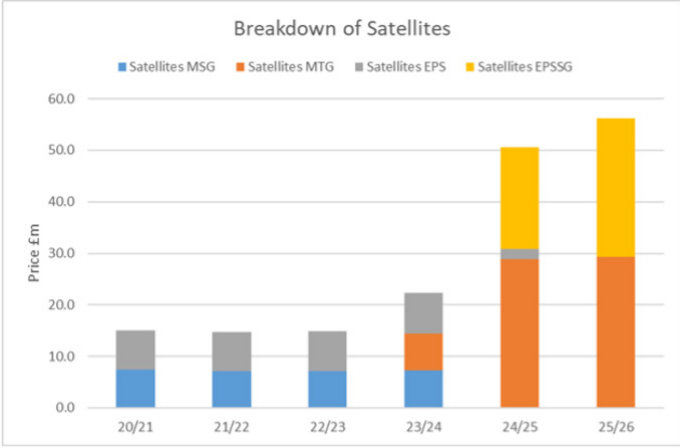

Figure 20 Summary of expected PWS meteorological satellite costs

The costs for **Aviation Service Delivery**, providing the operational capability to provide the services to meet our ICAO Annex 3 obligations, are as follows:

Cost (£,000)	NR23				
	2023	**2024**	**2025**	**2026**	**2027**
Designation Agreement Services	£7,740	£7,547	£6,358	£6,199	£6,044

For the designation agreement services a 2.5% efficiency is applied each year. This will be achieved through a series of projects within the Operational Delivery of the Met Office regarding the tools and systems used for forecast production.

It is also expected that there will be a significant reduction cost base from calendar year 2023 to 2024. This approximate £1M reduction per annum is due to the automation of the WAFS service and enabled by the Aviation Data Services development activity to provide the next generation of WAFS data by November 2024. The savings are achieved through headcount reductions in Met Office forecasting staff.

The costs for the Aviation Service Development area, which support our operational capability and provides service improvements, are as follows:

Cost (£,000)	NR23				
	2023	**2024**	**2025**	**2026**	**2027**
Insurance Premium	£10	£10	£10	£11	£11
NERL	£800	£800	£800	£800	£800
Volcanic Ash Operations and Development	£550	£550	£550	£550	£550
Volcanic Ash Lidar	£400	£400	£200	£200	£200
Volcanic Ash airborne monitoring capability	£1,100	£1,100	£700	£700	£700
Scientific R&D	£743	£743	£743	£743	£743
Verification	£32	£32	£33	£34	£34
Secondment	£80	£81	£83	£84	£86
SADIS	£32	£32	£33	£34	£34
Aviation Data Services (ADS) and Web briefing	£2,812	£2,447	£2,250	£2,000	£2,000
ADS operational costs	£554	£710	£791	£871	£969
Space weather	£60	£60	£60	£60	£60
Other Designation Met Services	**£7,173**	**£6,965**	**£6,253**	**£6,087**	**£6,187**

Notes about aviation service development areas of cost:

- Insurance Premium; this is a requirement for the Met Office to provide aviation services.
- NERL: this describes the commitment of the onsite team of meteorologists at NATS Swanwick and the associated system support for the provision of those services. With a steady staff headcount, the cost base is expected to remain stable.
- Volcanic Ash Lidar; this includes an initial investment in years 1 and 2 for an upgrade/replacement to the current equipment. For the remainder of NR23, an annual operational running cost applies.
- Volcanic Ash airborne monitoring capability; on the assumption of a commitment for a capability that can sample a wide geographical area, this includes the investment in a new capability in years 1 and 2 plus, combined with an ongoing running cost throughout the NR23 period.
- Scientific R&D; the ongoing programme of focussed aviation research and development activity to develop improved accuracy and application for aviation forecasting.
- Verification; an annual cost for staff and systems to monitor the accuracy of our aviation forecasting programmes.
- Secondment; the provision of a member of Met Office staff to the CAA in support of CAA's Met Authority function.
- SADIS; This is a data distribution system operated by the Met Office on behalf of ICAO. Whilst it distributes the 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%.

- Aviation Data Services and Web briefing; this represents the continued investment in capability for data services as described to meet milestones set-out within Annex 3, CP1 and expected requirements for AMS and services in support of NATS. In addition, this includes the ongoing development and provision of weather visualisation web services. The costs indicated represent the anticipated development resource requirement which is higher in earlier years aligned with the technical capability roadmap development planning.
- ADS operational costs; with increasing use of cloud based computing capability, there is a direct cost of the operational provision of data services, including processing, information availability and resilience. This represents an estimated profile of costs based on increased data usage.
- Space Weather; there is a contribution to the wider Met Office space weather operational and advisory capabilities, specifically in support of aviation activities. This includes the support of CAA in space weather advice and exercises, plus where relevant the assistance provided to airlines in their space weather planning.

Totals for NR23

The combined cost base for National Capability and International Subscriptions, Service Delivery and Service Development are as follows:

Cost (£,000)	NR23					
	2023	**2024**	**2025**	**2026**	**2027**	**Total**
Total Met Office NR23 cost	£32,960	£36,577	£36,703	£36,378	£36,323	£178,941

Once traffic forecasts become available for the NR23 period, a unit rate calculation will be included.

Additional recovery of payments

Due to the reduced traffic numbers, the Met Office was unable to recover £5,292K of Determined cost payments in 2020 and 2021. It is proposed to recover this evenly over the 5-year NR23 period. However, the Met Office also reduced its cost base in 2020 versus the Determined costs and is only intending to recover the actual costs for that year. Therefore, the difference between Determined and Actual of £1,213K will be re-paid by the Met Office in 2023.

5. Consultation questions

You can provide feedback on the following consultation questions via our feedback form:
https://response.questback.com/metoffice/NR23consultationfeedback

Q1. Are you in broad agreement with the plans set out within this Paper?

Q2. Technological & Science developments: The proposal outlines an investment in capability, which is expected to enable significant improvements in fuel efficiency and hazard avoidance, as highlighted in the GANP, CP1 and AMS. To what extent do the technological and science initiatives outlined in this Paper meet your future operational plans?

Q3. What assistance do you feel you may need from the Met Office in adapting systems to use our SWIM compliant API services, or is this something you may require in the future?

Q4. 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?

Q5. There are references to developing web-based visualisation capability and specifically NWR. Do you feel this continues to be a relevant and helpful direction of development?

Q6. Volcanic Ash Monitoring: there is a proposed continued investment in an environmental monitoring capability specifically in support of monitoring and predicting the impact of volcanic ash on UK aviation. To what extent would you consider this as a priority for investment of time and cost?

Q7. Aviation contribution to National Capability and International Commitments, including the weather satellite capability; do you feel you have enough information describing why this investment is relevant?

Q8. 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 NR23?

Q9. Are there any other comments or questions that you would like to raise in respect of the Met Office's NR23 proposals?

The Met Office is managing the form using Questback, details of which can be found here:
https://www.questback.com/uk/feedback

Outcomes of MET-consultation

Further to the consultation event held in November 2021 and subsequent discussions, a summary of the feedback on the NR23 proposals received by the the Met Office is as follows, along with subsequent actions:

- Overall support for the proposals outlined.
- For SWIM data services, it would be helpful for the Met Office to develop guidance material to assist in operational implementation. Action: The Met Office will develop guidance material and offer webinars to assist users.
- For web visualisation products, specifically NWR, there was general support for the direction outlined. In addition, it was suggested that a NWR user-group might be a useful way to help shape the direction and development priorities. Action: the Met Office will, in coordination with CAA, establish an NWR user-group.
- For Volcanic Ash observations, there was general support for a robust UK capability, although there was some doubt expressed in terms of value for money of a dedicated volcanic ash monitoring aircraft. Action: Met Office will monitor for further feedback during the NR23 consultation process and liaise with CAA to determine the most cost-effective option(s).

Other changes in this document

A few additional changes have been included in this Version 2 document, reflecting some additional feedback or new information becoming available since the original consultation paper dated November 2021. These are:

- the applicability date of ICAO Annex 3 AMD81 is now expected in November 2024, rather than the previously understood November 2023. The subsequent changes to the WAFS and QVA services have therefore been updated to state an implementation of November 2024.
- Linked to the above date change, the automation of WAFS SIGWX is now expected in November 2024, which means the automation of significant weather charts needs to also be delayed until that date. As a result, the headcount savings anticipated in November 2023 have now been transitioned to November 2024. In addition, some re-profiling of the Aviation Data Services work has led to a small upward adjustment in the anticipated annual development and operational data cost base.
- Further to an under-recovery of payments in 2020 and 2021, this cash recovery has now been added into the Met Office NR23 proposals, to be spread evenly over the 5-year period.

6. Annexes

Annex 1 – Regulatory Drivers

ICAO Global Air Navigation Plan (GANP)
There are specific requirements within the GANP for AMET (Advanced Met) that relate to the provision of meteorological observations products, forecast and warning products and climatological/historical products: https://www4.icao.int/ganpportal/ASBU?Threads=5 **Block 0:** The "as-is". https://www4.icao.int/ganpportal/ASBU?Threads=5&Blocks=B0 **Block 1:** Provision of meteorological data/products begins to move from traditional alphanumeric code forms to IWXXM. Dissemination of data via SWIM-compliant services to access the exact meteorological information required by users (in terms of geographical coverage, resolution etc). Meteorological information will support automated decision process or aids, involving meteorological information, meteorological information translation, ATM impact conversion and ATM decision support. Climatological information will support the design and planning of infrastructure, flight routes and airspace management while historical meteorological observations, forecasts, advisories and warnings in support of incident and accident investigations. https://www4.icao.int/ganpportal/ASBU?Threads=5&Blocks=B1 **Block 2:** Builds on block 1, and moves towards full integration of meteorological information in support of enhanced operational ground and air decision-making processes (impact assessments), particularly in the planning phase and near-term. Wider use of MET-SWIM services will support flexible airspace management, airborne re-routing, improved situational awareness, collaborative decision-making, including in terminal areas and at airports, dynamically optimized flight trajectory planning, ATM impact conversion and ATM decision support, hazard avoidance. https://www4.icao.int/ganpportal/ASBU?Threads=5&Blocks=B2 **Block 3:** Integrated meteorological information in support of enhanced operational ground and air decision-making processes, for all flight phases and corresponding air traffic management operations. https://www4.icao.int/ganpportal/ASBU?Threads=5&Blocks=B3 Increasing use of probabilistic forecasts and warnings will further help decision makers to apply their own operational constraints (i.e. business rules) to determine the risk to their operations. Meteorological information will be fully integrated into the SWIM environment.
Trajectory-based operations (**TBO**) and Free Route Trajectory Operations (**FRTO**): require accurate forecasts of temperature, wind and hazards in order to accurately determine the arrival time of aircraft at waypoints and airports. This includes continuous climb and continuous descent operations.
Network Operations (**NOPS**): Air Traffic Flow Management can be impacted by severe weather.
Surface Operations (**SURF**): meteorological information can assist with planning ground operations, and anticipation of when low visibility procedures or snow procedures may need to be invoked.
Remote Aerodrome Air Traffic Services (**RATS**): would benefit from fully connected meteorological information.
System Wide Information Management (**SWIM**) defines the way to manage the exchange of data through standardised information services exposed via a registry that allow the services to be integrated with downstream user systems.

European Common Project 1 (CP1)
ATM Functionality 5 (AF5) - System Wide Information Management (**SWIM**) - which specifies a functionality consisting of standards and infrastructure to enable the development, implementation and evolution of services for information exchange between stakeholders via interoperable services built on the same SWIM standards and delivered through an internet protocol. AF5 is broken down into 6 sub-ATM functionalities and corresponding Families, each with its own target deployment date; 3 of which directly impact the MET service provider:
5.1.1 Common SWIM PKI and cybersecurity, and **5.2.1. Stakeholders SWIM PKI and cybersecurity.** These specify the infrastructure components that must be utilised in the provision of SWIM compliant services - for MET this is ensuring that service offerings are built to the specification of the EUROCONTROL SWIM Yellow Profile and that the European SWIM registry is used for publishing information about the SWIM services available. The target deployment date for these components are 31 December 2024 for 5.1.1 and 31 December 2025 for 5.2.1 respectively.
5.4.1 Meteorological Information Exchange. This details which MET services should be digitalised to ensure a wide range of meteorological information can be made available for and usable by ATM systems and users during all phases of flight. The following four areas in which the Met Office will need to deploy SWIM services to meet the requirements laid out in the CP1 regulation are: ▪ Volcanic Ash Mass Concentration Information; ▪ Aerodrome Meteorological Information; ▪ En-Route and Approach Meteorological Information; and ▪ Network Meteorological Information. The target deployment date for these services is 31 December 2025.

CAA Airspace Modernisation Strategy
Initiative 3/9/10/11 (Airspace Management) The provision of probabilistic hazard forecasts (for CB, turbulence and in flight icing) and High Altitude Ice Crystal nowcasting, designed to enhance safety and increase airspace capacity, traffic flow predictability, aircraft navigational capabilities & resilience.
Initiative 3/9/10/11: Integration Characterises the environmental operating requirements of Remotely Powered Aircraft Systems (RPAS), as well as the high-resolution numerical weather prediction capabilities that could be applied for the identification of small-scale hazards needed to ensure their safe operation and integration into UK airspace.

Annex 2 - Aviation Data Services - Developments to date

World Area Forecast System (WAFS)

In November 2020 ICAO Annex 3, Amendment 79 introduced requirements for upgraded WAFS hazard data sets. This brought improvements to the icing and turbulence forecast data sets which had their algorithms upgraded and their horizontal resolution increased to 0.25°.

WAFS Turbulence Severity – The Graphical Turbulence Guidance (GTG) forecasting techniques[20], developed by the National Center for Atmospheric Research (NCAR) in the United States, has been adopted and provides forecasts of Clear Air Turbulence (CAT) and orographic turbulence in terms of Eddy Dissipation Rate. Eddy Dissipation Rate gives an aircraft independent measure of turbulence, which can be directly related to turbulence effects on different sizes of aircraft.

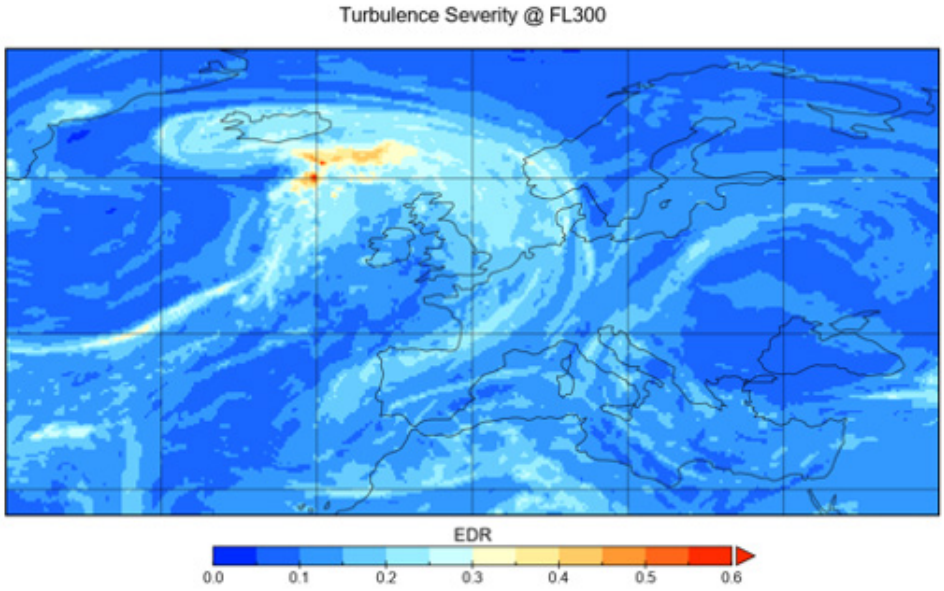

Figure 21 New Turbulence Severity forecast (CAT and orographic turbulence) at 0.25 degree horizontal resolution. Output in Eddy Dissipation Rate

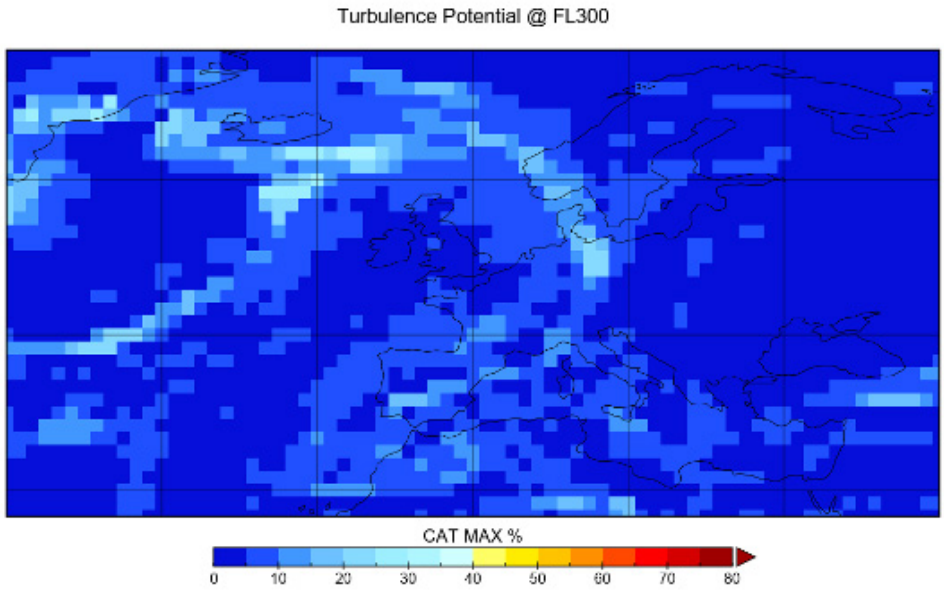

Figure 22 Old Turbulence Potential forecast (CAT only) at 1.25 degree horizontal resolution. Note: as well as the "max" a "mean" field is also provided

[20] https://journals.ametsoc.org/doi/full/10.1175/JAMC-D-16-0205.1

WAFS Icing Severity – the algorithms used have been upgraded and the type of output adjusted so that a categorical assessment of icing can be provided.

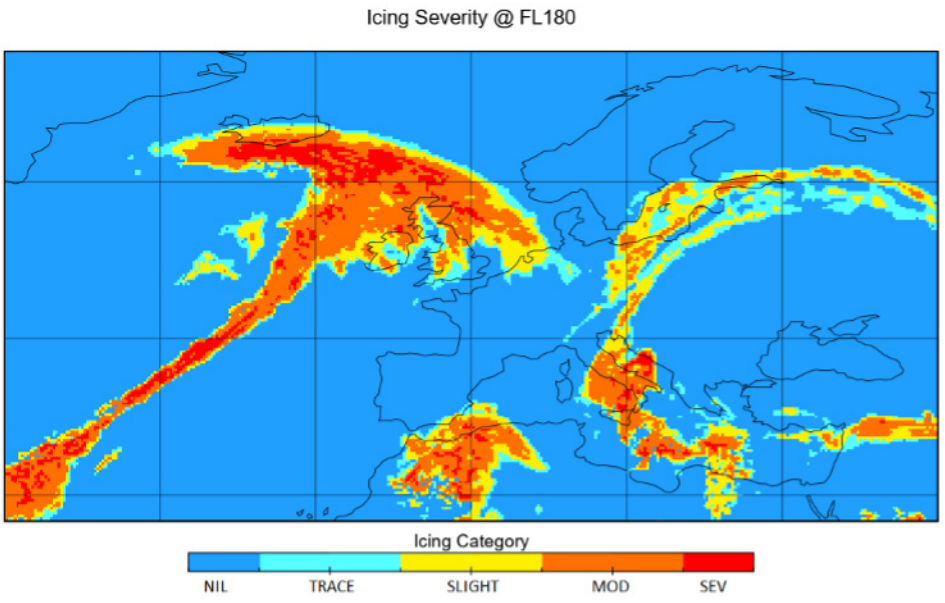

Figure 23 New Icing Severity at 0.25 degree horizontal resolution. Output as categories

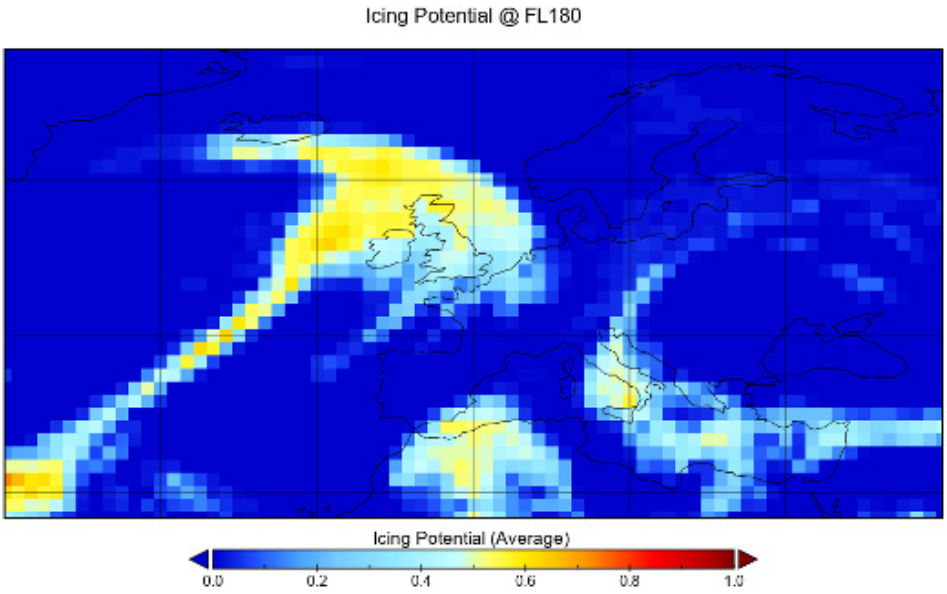

Figure 24 Old Icing Potential at 1.25 degree horizontal resolution. Note: as well as the "mean" a "max" field is also provided

WAFS Cumulonimbus – The cumulonimbus extent, base and top fields have not had any changes made to the science used in calculating them. The horizontal resolution has been upgraded to 0.25 degrees.

IWXXM data - ICAO Annex 3, Amendment 79 also introduced the requirement for the mandatory production of the METAR, SPECI, TAF, SIGMET, AIRMET, Volcanic Ash Advisory, Tropical Cyclone Advisory, and Space Weather Advisories in IWXXM format. SADIS was upgraded in November 2020 so that these new data sets could be made available to users.

SESAR Deployment

The Met Office has recently published its first SWIM Service offerings – a 3D Radar service and a Harmonised Turbulence service – as a result of the work completed as part of three of the SESAR Deployment Projects it has been contributing to (2015_067_AF5, 2015_068_AF5 and 2015_069_AF5).

The 3D Radar Service has been designed to give airlines, airports and air navigation service providers greater situational awareness and understanding of the convective weather activity that may impact their operations. It makes use of the hI-Resolution Mosaics for Aviation (IRMA) algorithm to preserve the height information present in each radar scan and use this to provide valuable detail on the vertical structure of convective weather. A variety of different products are on offer: not just horizontal reflectivity, but also maximum reflectivity and height of maximum reflectivity (see Figure 25), echo tops, and vertically integrated liquid – all valuable indicators of storm severity. The enhanced radar information on offer is more detailed than that available from traditional radar products, and the information will assist in tactical decision making, help enhance operational safety and lead to better airspace management during convective weather events.

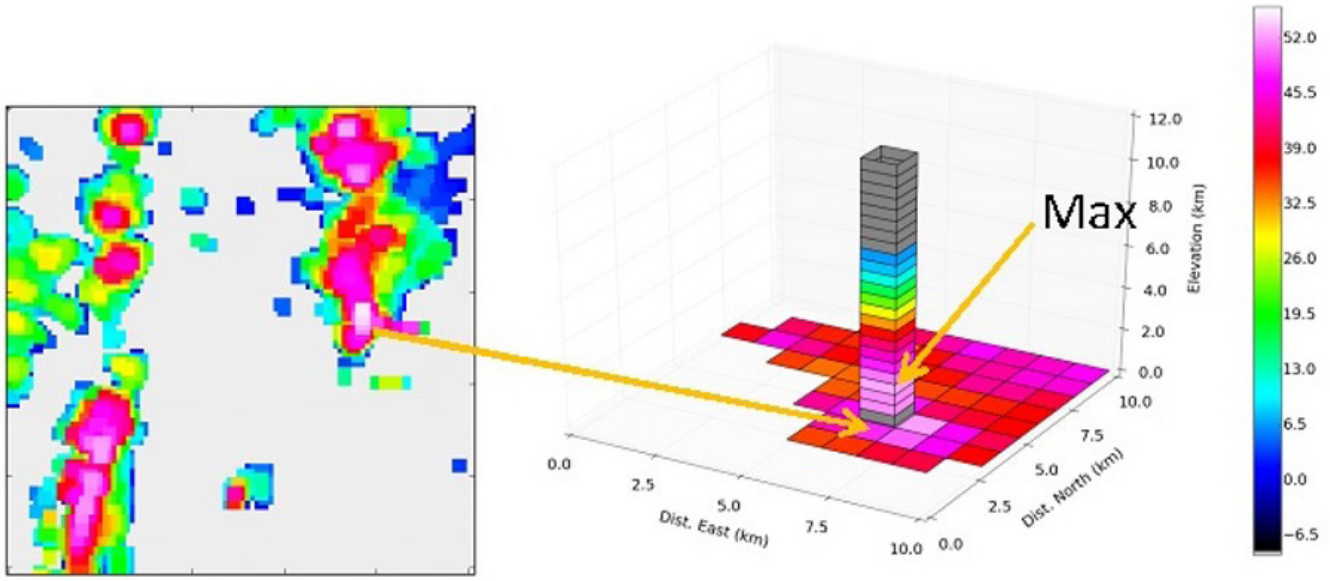

Figure 25 The maximum reflectivity parameter is the maximum reflectivity (dBZ) in a given column. The altitude level at which this was found then corresponds to the height of maximum reflectivity (m or FL).

The Harmonised Turbulence Service is part of a suite of Harmonised Weather Hazards Services that are being jointly provided by Deutscher Wetterdienst (DWD), Météo-France and the Met Office. Forecast products are being made available for icing, turbulence and convection, all well known aviation hazards. For each service, forecast data is taken from each of the participating national MET Service Providers and blended using a tailored weighting technique to ensure the harmonised output gives an optimal solution (see Figure 26). The resulting forecasts provide a synchronised, single view of these hazardous weather types across Europe, serving as a common reference for greater consistency and improved situational awareness which should support more consistent decision-making within the aviation community. The Met Office has led on the turbulence element; the service gives a harmonised view of turbulence that enables users to identify areas of light, moderate or severe turbulence over the European domain. In addition, the Met Office contributes to the icing and convection services that are being made available by DWD and Météo-France respectively.

Access to the datasets is via a SWIM compliant https: endpoint built on the AWS Cloud platform, ensuring the provision of a resilient and highly available service, with the ability to scale up and down in response to end user needs. The API service uses a request-reply system that only exposes the latest available data from each of the data processing components, guaranteeing that when the user makes a request, the reply consists of the most up-to-date information possible.

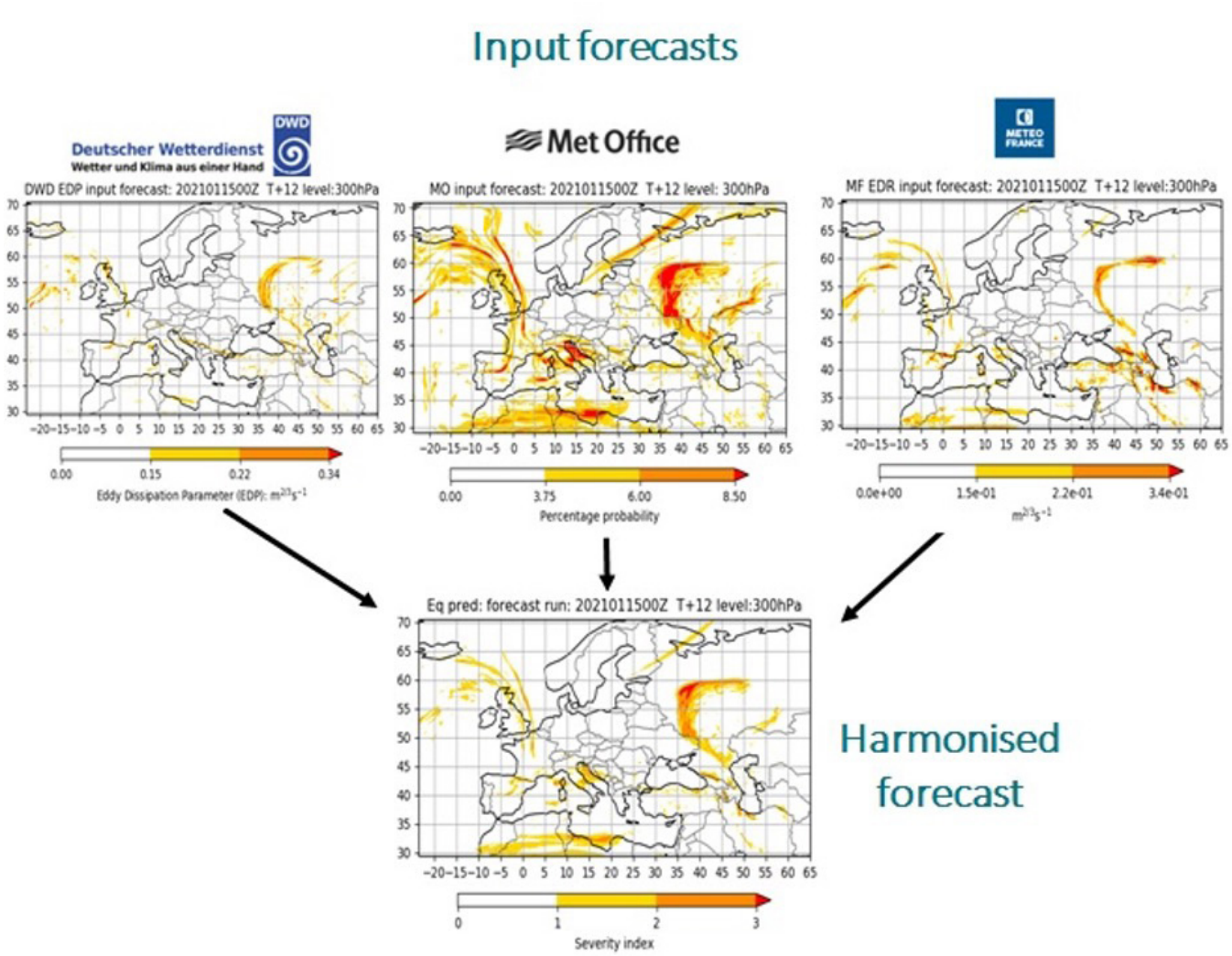

Figure 26 Visualisation of a model comparison of the turbulence forecast inputs from each contributing centre and the harmonised turbulence output. Model input from DWD, Met Office, Météo-France and the harmonised output solution (bottom centre)

Access to the datasets is via a SWIM compliant https: endpoint built on the AWS Cloud platform, ensuring the provision of a resilient and highly available service, with the ability to scale up and down in response to end user needs. The API service uses a request-reply system that only exposes the latest available data from each of the data processing components, guaranteeing that when the user makes a request, the reply consists of the most up-to-date information possible.

Further information regarding these Services and how to access them can be found in the SWIM Registry or via the dedicated webpages on the Met Office website here. Alternatively, please contact SESARServicesmanager@metoffice.gov.uk.

Annex 3 FY2021-22 CAA KPIs

Service	Description of verification and target	Report description (how we describe the measure to stakeholders in the monthly report)	Targets (RP3)
TAF accuracy	This is a measure of the performance of TAFs issued using a 36-month averaged Gerrity Skill Score	**Objective: 'to ensure airlines and pilots have accurate airport forecasts for planning purposes.'** The Met Office provides verification of TAFs for UK Civil airports against airport observations (METARs and AUTO METARs). The Gerrity Skill Score is in relation to the agreed performance measure for forecast Cloud Base and Visibility at airports in receipt of 9, 24 & 30 hr TAFs. The values obtained range from 0 to 1, where 1 indicates perfect forecasts, the value we aspire to. **Performance measure: At least 4 of the 6 sub-measures must be met for the KPI to be exceeded.**	4 of the 6 sub-measures meeting or exceeding: Cloud base 9hr Score 0.517 Cloud base 24hr Score 0.468 Cloud base 30hr Score 0.457 Visibility 9hr Score 0.426 Visibility 24hr Score 0.345 Visibility 30hr Score 0.366
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).	**Objective: 'to ensure airlines can access accurate global upper air model data for efficient air navigation.'** Accurate forecasting of upper wind and temperature is essential for safe and efficient international air transport. The CAA have agreed targets (shown below) with the Met Office for day 1 forecasts (T+24) taken from our 00 UTC and 12 UTC operational Global Model runs for results at 250hPa (which equates to FL340) over the Northern Hemisphere (90N-20N). Graphs display the accuracy of these two forecasts, with the smaller the error being the better value forecast to airline operators. **Performance measure: ≤ 2.85m/s for Wind and ≤ 0.56K for Temperature (based on 12-month mean values)**	By year end: 2.85m/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).		By year end: 0.56K
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.	**Objective: 'ensuring flight planning systems receive timely and reliable forecasts of en-route aviation hazards.'** As a World Area Forecast Centre (WAFC), significant weather charts to support global air travel are provided by the Met Office. The timely delivery of the data used to compile these charts is important for airlines' flight planning. Graphs show the number of occasions per month that a significant weather chart has been transmitted late, and from which model run it occurred from. **Performance measure: In no more than 3 instances per quarter (99.2%) should the transmission time of 7hrs 00mins be exceeded from any of the four model runs.**	99.2%

Service	Description of verification and target	Report description (how we describe the measure to stakeholders in the monthly report)	Targets (RP3)
Timeliness of TREND forecasts	Trends: appended and sent within 7 minute limit from the validity time of observation.	**Objective: 'to append landing forecasts to selected airport METARs in time for their global dissemination.'** 'Trends' are 2 hour 'landing forecasts' which get appended to METARs at selected UK airports. The target is to append a trend within 7 minutes of the validity time of the observation (nominally 3 minutes from receipt of the METAR). (Note: This measure excludes duplicate, untimely, automated and non-compliant METARs). Pie charts represent timeliness performance for six airports over the most recent four months, with a table showing the green area in the charts in percentage terms. **Performance measure: Trends appended to METARs at selected airports within 7 minutes of the validity time of the observation on ≥ 88% of occasions (based on a 12-month rolling mean).**	88%
TAF timeliness	Receipt into MetSwitch by HH-52, monthly.	**Objective: 'to ensure airlines and pilots have timely access to TAFs.'** Reliable provision of TAFs are important to airlines and pilots, to ensure they are fully briefed on the expected weather conditions at an airport upon arrival. Around 280 TAFs per day are issued by the Met Office, and the percentage of all these TAFs generated in time for inclusion into bulletins generated by NATS are measured (by HH-52 mins). Results from the most recent four months are shown. **Performance measure: At least 96.5% timely receipt of bulletins.**	96.5%
TAF compliance	From a sample of 18 TAFs per day, % classified as compliant (coding accuracy).	**Objective: 'to ensure TAFs are compliant with UK and international coding regulations and not likely to be rejected by flight planning systems.'** From a sample of 18 TAFs per day, a table shows the percentage of these which were classified as format compliant during the course of the last 4 months. **Performance measure: At least 98.5% of TAF sample fully compliant.**	98.5%
SIGMET compliance	For all issued SIGMETs, number deemed as compliant per month. Proposal to base the target on a rolling 12-month mean.	**Objective: 'to ensure SIGMETs are compliant with international coding regulations and not likely to be rejected by flight planning systems.'** Checking all issued SIGMETs for each month, a table shows the number of SIGMETs which were classified as compliant during the course of the last 4 months. **Performance measure: At least 98.5% of all SIGMETs compliant.**	98.5%
GRIB2 timeliness	The number of occasions that operational GRIB2 data sets are issued after T+4hrs 20mins, monthly score	**Objective: 'ensuring flight planning systems have timely and reliable forecasts of en-route wind, temperature and hazard data.'** A table shows the number of occasions that operational GRIB2 data sets being issued after T+4hrs20mins over the last 4 months. **Performance measure: ≤ 3 instances per quarter issued late.**	3 or less instances per quarter.

<table>
<tr><th>Service</th><th>Description of verification and target</th><th>Report description (how we describe the measure to stakeholders in the monthly report)</th><th>Targets (RP3)</th></tr>
<tr><td>GRIB2 CB/Icing/ Turbulence</td><td>The number of occasions that operational GRIB2 data sets are issued after T+4hrs 50mins, monthly score</td><td>Objective: ‘ensuring flight planning systems have timely and reliable forecasts of ‘blended*’ en-route aviation hazard data.’

A table shows the number of occasions of operational GRIB2 CB, Icing and Turbulence data sets being issued after T+5hrs00mins over the last 4 months.

Performance measure: ≤ 3 instances per quarter issued late.

*combined WAFC London & Washington hazard data</td><td>3 or less instances per quarter.</td></tr>
<tr><td>HeliBrief Uptime</td><td>Availability of offshore helicopter pre-flight briefing portal.</td><td>Objective: ‘to provide a reliable pre-flight weather briefing to support offshore helicopter operations.’

A table shows HeliBrief uptime (excluding planned maintenance) during the course of the last 3 months.

Performance measure: 99.6% HeliBrief availability per month (equivalent to 3hrs downtime per month).</td><td>99.6%</td></tr>
<tr><td colspan="4">The KPIs below will be presented as separate reports, and not in the monthly CAA KPI report</td></tr>
<tr><td>Aerodrome warnings</td><td>This is a measure of the value of the warnings service (expressed as ‘threat score’), defined as:</td><td>Objective: ‘to ensure airport operators have access to accurate warnings of impactful weather’

Performance Measure:

<table>
<tr><th>Warning type</th><th colspan="2">Enhanced</th><th colspan="2">Standard</th></tr>
<tr><td></td><td>False Alarm Ratio</td><td>Hit Rate</td><td>False Alarm Ratio</td><td>Hit Rate</td></tr>
<tr><td>Strong wind</td><td>≤0.4</td><td>≥0.8</td><td>≤0.4</td><td>≥0.8</td></tr>
<tr><td>Fog</td><td>≤0.55</td><td>≥0.6</td><td>≤0.75</td><td>≥0.4</td></tr>
<tr><td>Frost</td><td>≤0.6</td><td>≥0.75</td><td>≤0.65</td><td>≥0.75</td></tr>
</table>
Table 1</td><td>At least 9 out of 12 sub-measures in table 1 must be met</td></tr>
<tr><td>LVP verification</td><td>For D0 (issued at 0400L daily) LVP forecasts issued between Sep- Apr for Luton, Stansted, Gatwick, Bristol, Manchester & Heathrow</td><td>Objective: ‘to ensure ATS units are able to proactively manage airport capacity effectively through accurate advance forecasts of low visibility and cloud base’

LVP matrix tables summarise the frequency of LVP occurrence against forecast risk level for 6 airports, when issued at 0400L each day.

Performance measure: Frequency of forecast LVP occurrence within tolerance (shown as green) for at least 4 risk thresholds for each of the 6 airports.

Report presented by 30th June annually.</td><td>Frequency of forecast LVP occurrence within tolerance (green) for at least 4 risk thresholds for each of the 6 airports</td></tr>
<tr><td>Airborne holding due to weather</td><td>Linked to the input of meteorological services and advice at NATS; a target to contribute to the optimisation in airborne holding due to weather regulations (airport WA and en-route WE).</td><td>Objective: ‘to ensure airborne holding during weather regulations is optimised to support service performance, through advice provided by on site meteorologists’

Performance measure: Average airborne holding (mins) when weather regulations are in place will be monitored, and the number of occasions when holding >20 minutes (Estimated Approach Time) will be recorded.

Nb. If other variables/circumstances were in effect at the same time, which may have impacted holding, then that instance will be excluded.

Report presented by 30th June annually.</td><td>Occurrence of EATS <8 per year (due to weather)

Stretch target: Occurrence of EATS <2 per year (due to weather)</td></tr>
</table>

Service	Description of verification and target	Report description (how we describe the measure to stakeholders in the monthly report)	Targets (RP3)
Number of unexpected/ reactive weather regulations applied by NATS	Linked to the input of meteorological services and advice at NATS; a target to assess appropriate application of weather regulations applied to airports and en-route.	**Objective: 'to ensure NATS are applying weather regulations with sufficient notice to help provide stability to the network, through advice provided by on site meteorologists'** **Performance measure: Average lead time/application of weather regulations (for airports and/or en-route) will be recorded, with monthly, seasonal and annual results presented.** Report presented by 30th June annually.	90 minutes Stretch target: 120 minutes