EUMETNET Information Paper to EASA Conference on "Weather Information to Pilots"

1. Introduction

EIG EUMETNET (EUMETNET) is a grouping of 31 European National Meteorological Services (NMS) that provides a framework to organise co-operative programmes between its Members, in various fields of meteorological activities. These activities include observing systems, data processing, coordination of forecasting products and techniques, research and development and training. Most of the NMSs are Aviation MET Service Providers (METSP) certified in the framework of the Single European Sky (SES) Air Navigation Service Provision Regulation. Furthermore, EUMETNET is leading the consortium contracted by EUROCONTROL on behalf of the SESAR Joint Undertaking (SJU) to develop Work Package 11.02 (WP11.02) Meteorological Services of the SES ATM Research (SESAR) Programme. EUMETNET is also directly engaged in the preparation of the SESAR2020 Programme and SESAR Deployment Manager.

Of particular importance, EUMETNET acts as a central point of focus in coordination of European NMS', on matters impacting European Aviation Meteorological Infrastructure, particularly related to SESAR research and deployment activities. This collaborative approach facilitates synchronisation among all 31 EUMETNET Member States.

This paper outlines various SESAR projects EUMETNET have undertaken, but more importantly focuses on the considerations for future development of aeronautical meteorological (MET) information to the cockpit, the data link aspect of this, and what it means for MET information to become an integral part of the cockpit system.

2. Overview of EUMETNET Activities in SESAR

As the federating leader for all MET activities in SESAR and in particular, responsible for a dedicated work package on MET and Information Systems, EUMETNET has a key role in addressing the critical dependency between weather, the environment, and European Aviation stakeholders.

EUMETNET's contributing partners to SESAR ensure consistency and coordination of the MET architecture, systems and services, utilised by all SESAR projects; as well as developing new capabilities in weather forecasting such as consolidated forecast of icing, turbulence and convection, as well as assisting with trajectory prediction, forecasting winter weather impacts and development of 3D weather radar. These development activities give the opportunity to properly integrate MET information throughout the operational concepts developed and prototypes by the SESAR Programme in order to

enhance the success of the final outcomes of the SESAR Programme and ensuing successful operational implementation of the future air transport system.

3. ‘Weather in the cockpit’ in SESAR and SESAR Demo projects

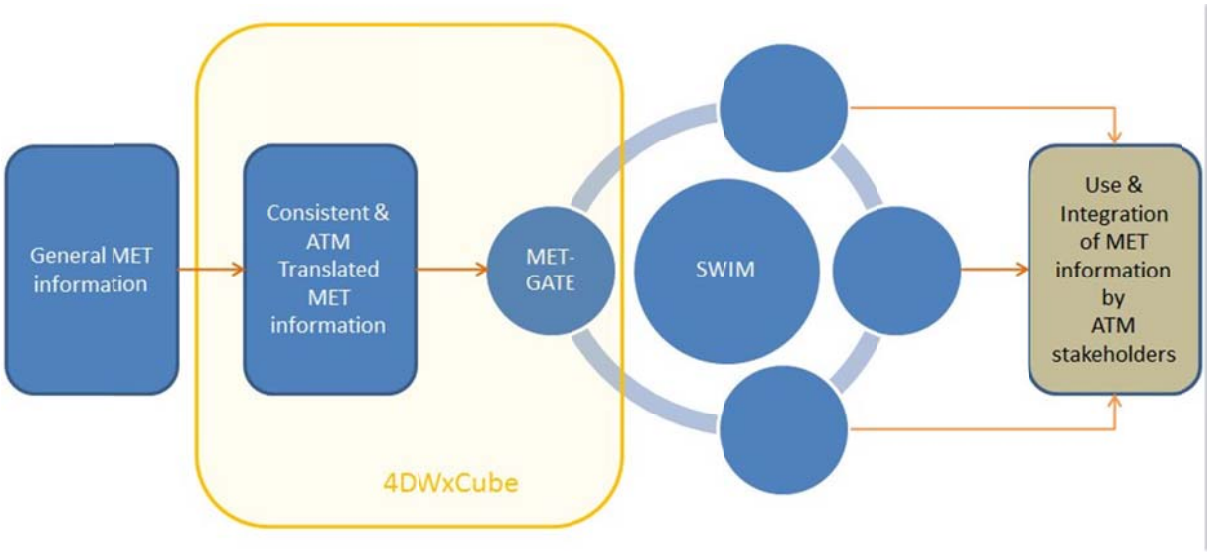
A key outcome of SESAR for WP11.02 is to ensure that consistent and timely MET information is available to all aviation stakeholders across Europe and extending out to the rest of global aviation. A number of demonstration projects and exercises within the SESAR Programme are used to validate the potential for new and emerging MET capabilities from WP 11.02. These demonstration projects include topics such as Free Routeing, Trajectory Prediction, Short-Term ATFCM (Air Traffic Flow and Capacity Management) Measures, and Winter Operations. Each requires a different type of MET forecast though all preferably need to have consistent MET information (by consistent, we mean that all stakeholders can base their operational decisions on the same MET information, thereby improving network predictability i.e. common situational awareness).

When taking into account what MET information could be useful in the cockpit it is useful to consider what information is already available and being developed for the future. The current demonstration projects in SESAR do not have a specific cockpit-focus but most of the information being used does have an element that would be of use to a pilot to ensure that they have a consistent understanding of the weather compared to ATC, the airport and their Operations Centre. Of specific relevance is the SESAR Validation Project VP700 (and an associated demonstration project TOPLINK, see next paragraph) which makes use of nowcast turbulence, icing, and convection for use in capacity management of the network. While in practice these forecasts will be mainly used by ATC to manage air traffic flow particularly in areas that may be impacted by adverse weather and high density flow, it will also be used for the cockpit to assist the pilot determining a safe route deviation and to ensure common situational awareness.

The TOPMET project was an early demonstration of the benefit of having consistent, relevant and up-to-date MET information available to ground and airspace users. The demonstration involved flight trials by Brussels Airlines and ATM operations involving DSNA. The demonstration showed improved resilience of ATM operations to weather hazards, leading to an improved flight safety; and more accurate information to inform flight planning, leading to improved flight efficiency and improved airspace capacity. MET information used in the cockpit, was made available on EFB (Thales tablet tool) at departure (it did not involve inflight updates), and live updates of the same information was made available to flight dispatchers that in turn could inform the pilot by voice communication or ACARS. MET information which was demonstrated included the observation and forecast of convection, lightning, thunderstorms, icing and turbulence (geographical coverage depended on the products). Unfortunately, high resolution Wind & Temperature data could not be used by the existing ATM & Aviation systems (aircraft FMS, ATM & AOC decision aids). A summary of TOPMET is included as an Annex to this paper. In addition there is a follow on demonstration project called TOPLINK which will take place in early 2016 which aims to include real-time updates to the pilot in-flight.

In the concept developed and prototyped by SESAR, consolidated weather forecasts and observations will be provided in a SWIM enabled format through the MET-GATE (part of the 4DWxCube) and by applying SWIM data-exchange principles. The main role of the MET-GATE is to supply MET information by performing relevant MET data management actions such as the retrieval from multiple distributed MET information sources, sub-setting, sub-gridding, thresholding, reformatting and aggregating of MET information, necessary to fulfil the needs of the ATM stakeholders. In other words, the MET-GATE is the SWIM-compliant one stop shop for MET information. It is an access portal enhanced with several smart functionalities.

The 4DWxCube can be viewed as a virtual repository of shared MET information, produced by multiple METSPs, from a variety of locations that provide ATM stakeholders with consistent and translated MET information via a dedicated SWIM node. The relation between the 4DWxCube, the MET-GATE and SWIM is visualised below.



The idea of this is that MET information from many METSP can be consolidated and translated to a format and an information service that is suitable for anyone who requires it whether that be an airline, flight planer, air traffic control or a pilot as each of these players have a common situational awareness that reflects reality even if they digest it in a different way. The way that the information is delivered to each user would be carefully translated to ensure that the detail and time scales that the ATC, FMP or pilot requires are suitable for their needs.

4. ‘Weather in the cockpit’ considerations

The concept of ‘weather in the cockpit’ has been around for many years and now as technology advances and sources of general meteorological information in the public domain, there is enhanced enthusiasm for pilots to be able to access the same information they could on the ground or as a private person. However the practicalities of these solutions need to be adequately assessed from an information, technical and safety perspective.

With new communications technologies, it may be entirely possible to send every piece of MET information to the pilot, in the same way you might access information at home via the internet. There is the risk that the pilot will be overloaded with irrelevant, conflicting or even malicious information. The bottleneck is no longer the bandwidth of the communication channel, but the available attention span of the pilot:

- Consider whether we expect pilots to become expert meteorologists, able to interpret large volumes of complex MET information; to determine what is relevant to that flight; and then decide the most appropriate course of action. In this scenario, each pilot will react differently, thereby worsening the network efficiency. In addition, it diverts pilot attention from the primary task of flying the aircraft.
- Secondly consider the implications of allowing non-regulated or information of unknown origin onto the flight deck for the purpose of inflight decision making.

We should be very clear and sensible about what MET information is actually needed in the cockpit. The requirements will be different between airline operators and between aircraft type, and this needs to be recognised. Should these requirements be specified by airlines, by pilots; how is a consensus reached? Does the AOC (or for some airlines dedicated dispatchers or flight-followers) have a role to play in determining what information is relevant and should be transmitted to the cockpit to enable them all to share the same situational awareness? In addition to this, how much training is required to assist the pilot in making a decision based on the MET information provided?

Most MET information that would be of use in-flight could or should be automatically ingested to an FMS or secondary system without any pilot interaction. For example updated forecasts of wind/temp could be handled automatically by planning systems. However details on thunderstorm or turbulence proximity would benefit the pilot if they used an alarm or visualised the information and so enable the pilot to prepare adequately for the upcoming event. This may be suitable during low workload phases of flight, but during climb or decent the workload for the pilot is already high and trigger point for a warning needs to be carefully considered to ensure that there is no false alarms diverting pilot attention at these critical times.

The forecast detail required comes in two facets: the first being the provision of a cut down level of information compared with ATC to ensure consistent information but only the minimum that is required, this could be provided direct to the FMS or electronic flight bag. The other is what information

is actually essential to a pilot to ensure safe and efficient flight? On board radar gives a level of understanding of what is immediately ahead of the aircraft and thus relevant, but a visual image of satellite or a convection nowcast will be able to assist a pilot's decision on any avoidance measures by providing a wider outlook of how their aircraft will be affected by the weather it will fly though-or not, depending on the severity of the phenomenon.

As with all new technology the safety implication of the provision of the MET information and the changes in technology are a key consideration, as is the cost of providing these services. Currently the ICAO specified MET information is part of a cost-recovery scheme and predominantly covered by the en-route charges or terminal charges, but this additional information for the cockpit may or may not be regulated and who has access to that supplementary information could be split by the affluence of the airline. Consequently the behaviour of different users may diverge if different levels of access to information is certified which could add extra stress to ATC/ACM as the pilots react to the differing levels of MET information.

All these questions need to be carefully considered by the aviation community at large.

5. Plans for weather in the cockpit in SESAR2020 & EUMETNET's role

The driver for 'weather in the cockpit' comes as much from the meteorological community as it does from those in the cockpit and their management hierarchy. The focus of EUMETNET's SESAR2020 involvement is to ensure that 'weather communication' to all the stakeholders is consistent and understandable. This will enable to the Pilot to have tailored and consistent radar information that is the same as the ATC/FOC data source though it may be cut down and simplified to reduce bandwidth and unnecessary detail that the pilot may not have time to consider its implications on the aircraft.

Looking to the future of MET information provision, SESAR2020 will build on the current programme and further develop MET information that can be cockpit ready which delivers consistent and relevant information to all stakeholders. Areas of focus in SESAR2020 would be on topics such as:

- up-linking ground weather radar to give a wider spatial assessment of the thunderstorm risk to a pilots intended flight path
- provision of nowcast details as well as tactical to strategic time frame forecasts that would be of benefit to medium and long haul flights
- down-linking the aircraft observations (temperature, pressure, humidity (where available), winds etc.) which can be directed to other aircraft in the vicinity and for the use in numerical weather prediction and assimilating into nowcast forecasts.

The SESAR concepts phase has been about gathering requirements and for all the players in the aviation community. In this exercise it has become clear that each stakeholder has different requirements and levels of knowledge to be able to handle that MET information in a robust way. The level of detail

required in the cockpit would vary from airline to airline, pilot to pilot, and possibly stage of flight. It is clearly recognised that there is no desire for information overload which could easily happen in an operational environment. Nor is there the desire to upload MET information for the sake of uploading everything that is available. The key is in uploading the right decision support information at the right time and for the right place to help improve efficiency across the whole network.

Flight trajectories optimised thanks to a new generation of meteorological services

Over the summer, Thales, Brussels Airlines, DSNA (French Air Navigation Service Provider) and three members of EIG EUMETNET (Météo-France, Met Office, DWD) have been testing, in the context of SESAR R&I Programme, a new generation of meteorological services for aviation. As a result, in the near future, three-dimensional customised meteorological information will be available in real time in cockpits through the use of touch pads. This technology will complement existing images obtained from airborne weather radars and traditional meteorological reports that a pilot receives before take-off. With more precise observations and forecasts, enabling the provision of a shared simultaneous global picture to all flight stakeholders (pilots, ground crews and air traffic controllers), the trajectory of the aircraft will be optimised against weather phenomena throughout the entire flight, from take-off to landing.

A crucial meteorology for aviation...

The SESAR R&I Programme has been working on using the most innovative meteorological products to drive improvements in the management of European air traffic. To achieve the objectives set by the European Commission, a consortium of European national meteorological services, members of EIG EUMETNET, and aeronautical industries are combining their expertise within the framework of SESAR to develop the "new generation" of meteorological services for aviation. These are a set of harmonised, standardised, cross-border meteorological services shared by all flight stakeholders and made available in real time, and are designed to support ATM and aviation decision-making systems.

...New generation meteorological services already operational in aviation

During the months of July and August 2014, these new services were tested under real flight conditions as part of a SESAR demonstration project called TOPMET, coordinated by THALES. This project consists of ANSP (DSNA), Brussels Airlines and Met Service Providers (EUMETNET EIG, Météo-France, DWD, Met Office UK).

TOPMET key figures

- More than 10 Brussels Airlines operational staff (pilots and ground Network Managers received training on the new tools and participated in the tests.
- 3 aircraft categories were involved in the tests:
  - Long-haul air carriers: A330;
  - Medium-haul air carriers: A319-320;
  - Regional air carriers: AVRO.
- The tests were run over most Brussels Airlines routes (all over Europe and Africa).
- Tests were conducted over a two month period over July-August 2014.

Daniel Muller from Thales, project coordinator.

TOPMET involves experts from four European countries (Belgium, France, Germany and United Kingdom) and has supported the development and testing of new dedicated decision support tools, for pilots in the cockpit, for flight dispatchers on the ground in the Airline operational centre, and for Flow Management Positions in the Air Traffic Control Centre, clearly demonstrating the major contribution that these new meteorological technologies make to the future of aviation.

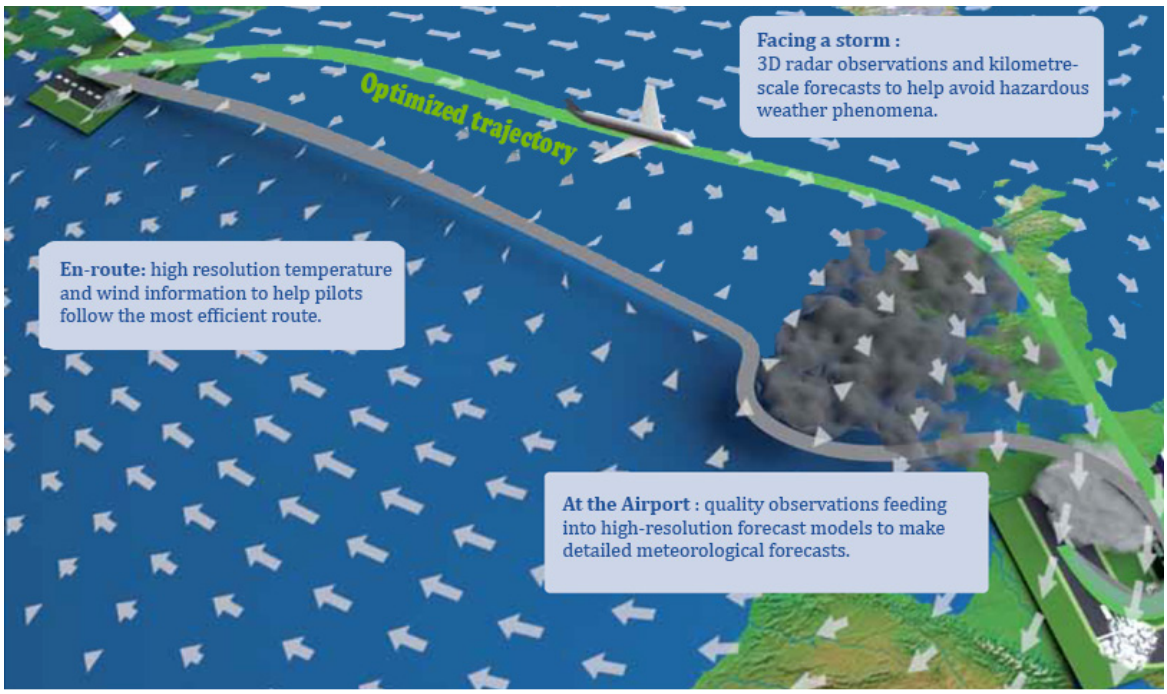
Jean-Marc Van Vynckt, captain Airbus A32F from Brussels Airlines.

Today, pilots and flight dispatchers mainly use "regulatory" weather information, standardised by the International Civil Aviation Organization (ICAO), and transmitted before take-off by the national weather services. This aeronautical MET information is therefore mainly used on the ground for flight preparation. Once in the cockpit, we have access to the MET images captured in real-time by the onboard weather radar, however the field of vision remains limited to a sector: typically 120° in front of the aircraft, over a range of not more than 150 nautical miles.Thanks to the new meteorological services developed under the framework of SESAR, we will share with flight dispatchers and air traffic controllers a real-time continuous overview of the situation, as well as forecasted over a horizon of 6 to 12 hours- most weather events (lightning, convection, icing, turbulence, volcanic ash, wind…) that could potentially impact the safety, efficiency, or even simply the comfort of the flight.

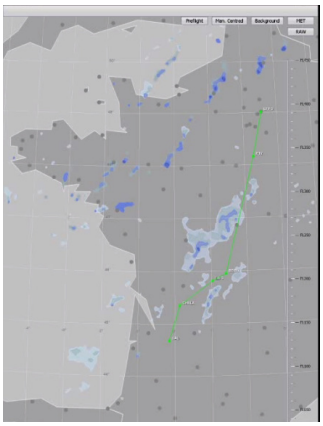
Philippe Kuhn from DSNA in Bordeaux.

The ultimate goal is to facilitate interaction between the pilot, the airline ground crew, and the air traffic controllers so that we can jointly agree on the best way to re-optimise the flight route during deteriorated weather conditions. The TOPMET trials have validated the prerequisites of this new Collaborative Decision Making process, enabling the identification of the most relevant MET information for the various stakeholders, how they can be processed to better support the decisions of each stakeholders, and the gains that can be obtained from operational usage.

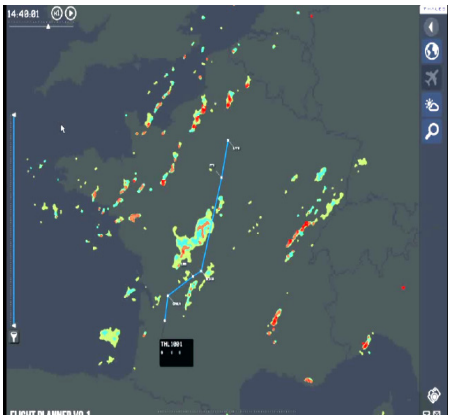
In turn, pilots will be able to better anticipate and handle such phenomena, and optimise their trajectory accordingly.



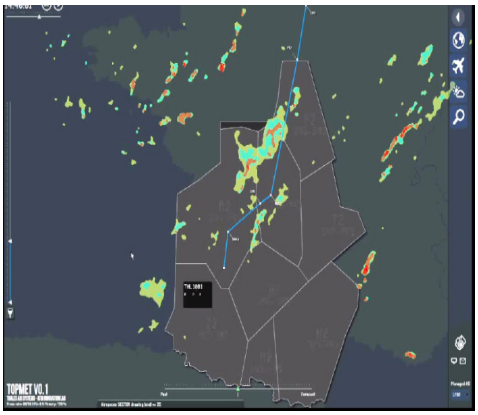
During the TOPMET exercises, common weather data was shared between Brussels Airlines' pilots and ground crew, and the air traffic controllers from the French Air Navigation Service Provider "Direction des Services de la Navigation Aérienne" (DSNA) in Bordeaux.



Pilot position



Airline Operational Centre position



Air Traffic Controller position

The "connected airplane" soon a reality

Throughout the summer, tests have been carried out on Brussels Airlines flights in order to gather information during relevant meteorological events. The data collected have now been analysed, and recommendations have been made for future evolutions of the experimental system. Plans are underway to further develop the concept and accelerate its operational deployment, particularly through a continued and permanent connectivity between the ground and the cockpit, thanks to satellite communications. The final target is to have new services operationally deployed for the benefit of aviation users within the coming two years. The "connected airplane" will soon become a reality, opening multiple perspectives beyond the sharing of meteorological data.

About SESAR

The Single European Sky ATM Research (SESAR) is the technological pillar of the European Single Sky. It aims to provide Europe with efficient air traffic management systems to modernise current systems. The SESAR Programme is the sister of the Air Traffic Management modernisation programme in the USA, called NextGen. In 2007, the SESAR Joint Undertaking was created to manage the definition and the implementation of the SESAR Research and Innovation Programme.

About EUMETNET EIG

EUMETNET EIG is a grouping of 31 national MET services for the coordination of pan-European MET activities for aviation.

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