At the core of the Engage KTN is the definition of various thematic challenges: new ideas suggested by the research community, not already included within the scope of an existing SESAR project. They are developed along with the ATM concepts roadmap and complementarily with some of the network's PhDs and theses.

Thematic challenge 3

Efficient provision and use of meteorological information in ATM

4th workshop write-up

Introduction

The fourth workshop of thematic challenge 3 took place as a Zoom meeting on 9th September 2021. The workshop was moderated by Tatjana Bolić from the University of Westminster and Luca Crecco from SESAR Joint Undertaking. There were 79 registered participants, out of which 63 attended, 54 for more than an hour. The focus was on panel and open discussions.

The workshop explored the MET&ENV topics requiring future research, development or community collaboration. The start was dedicated to the panel discussing the MET&ENV topics requiring future developments from the scientific or technical point of view, intertwining suggestions from the audience. The following panel discussed the paths and time need to cross from the basic research to implementation, and how these can be improved. We concluded the workshop with the participants being invited to help identify the elements needed in the future to facilitate the research (e.g. data sharing, common platform, etc.), collaboration and shortening the time of the innovation pipeline for MET and ENV topics. The discussion was based on a poll taken in advance of the workshop - what research infrastructure and future research can we already propose for SESAR 3, for example?

Programme

1030-1045 Welcome by SESAR Joint Undertaking and Engage KTN
Welcome by SJU and the introduction to the SESAR KTN, Engage, and the day's programme
Tatjana Bolić (University of Westminster), Luca Crecco (SESAR JU)

SESSION 1 MET&ENV research topics

1045-1100 ***Overview of MET and ENV topics being researched in SESAR 2020***
Tatjana Bolić (University of Westminster)

1100-1145 ***Panel 1: Future MET&ENV research***
Moderator: Tatjana Bolić (University of Westminster)
Panellists:

- *Alexander Baklanov - World Meteorological Organisation*
- *Sigrun Matthes – DLR (TBC)*
- *Rosalind Lapsley - EUROCONTROL*
- *Damian Rivas - University of Seville*
- *Lauren Donohue - EUMETNET*
- *Emmanuel Sunil - NLR*

1145-1200 ***Coffee break***

SESSION 2 From research to implementation

1200-1245 ***Panel 2: Paths and time to MET&ENV products deployment***
Moderator: Luca Crecco (SESAR JU)
Panellists:

- *Kamel Rebai - METSAFE*
- *Andre Weipert - Leonardo Germany*
- *Anton Muscat - metoffice London VAAC*
- *Philipe Lenne - SJU*
- *Chris Peregrine - NMOC*
- *Manuel Soler - UC3M*

1245-1345 **Lunch break**

SESSION 3	**Enabling fast innovation cycles**
1345-1430	**Discussion: research, development and deployment "infrastructure" needed in the future** *Moderators:* Tatjana Bolić (University of Westminster), Luca Crecco (SESAR JU)
1430-1445	***Wrap-up*** Tatjana Bolić (University of Westminster)

The programme is available for download on the Engage website engagektn.com/thematic-challenges.

Discussions

Session 1 - MET&ENV research topics

Overview of MET and ENV topics being researched in SESAR, presented by Tatjana Bolić. Evolution of MET and later ENV research in the SESAR research programme was presented. Current SRIA, does not contain explicitly directions for MET research, while some ENV matters are mentioned.

Panel 1: Future MET&ENV research

Introduction of expertise in the panel

Forecasting of severe weather events is a key challenge. Great progress has been made with volcanic ash and improvement of methods/models. Integrated atmospheric pollution (sand and dust) has seen great advances and in Europe is led by Barcelona Supercomputing Center. Issue of wildfires.

Atmosphere. Aviation is making a transition to the sustainable industry, and we need to join the expertise from different disciplines to work together – from ATM stakeholders to atmospheric scientists. The topic of climate is not easy, and we need an interface between the climate science, atmosphere and the ATM.

MET requirements for aviation. It is not easy to elicit the requirements for MET from the stakeholders, if it was easy, it would have been done already. A lot of this particular work is about informing and helping the stakeholders understand how MET can be used to improve their everyday work. There is the need for pro-active communication between experts in different fields (i.e. MET, ATM).

Analysis of aircraft trajectories, including the effects of meteorological uncertainty regarding FMP process and thunderstorms timeframe and trajectory-based operations.

Coordination between various MET services and other stakeholders (such as EUROCONTROL, EASA, EC). The fact of having many states in Europe makes the collaboration on the weather forecasts a bit more complex than in USA for example.

Aerospace engineering, drone integration into airspace, and impact of wind on the drones.

What are the future research needs in MET/ENV?

Forecasting **of extreme weather events** is one of the key issues for aviation. Previously the focus was more on regional (Europe) scale, but we need to move to mesoscale and world scales. Another point is to move from the standard methods of linear nowcasting to new methods. WMO works on similar projects. For volcanic ash there was great progress, after 2010/11. But we need the improvement of

methods in VAACs, regarding bettering the models and assimilation of observation data, for ash and SO_2, and source estimation. Forecasting and modelling of dust storms (Barcelona Supercomputing Center is the European centre for this) is constantly developed. Currently it is geared mostly to health issues but could benefit from more research for aviation. The impact of wildfires, and pollution on aviation should also be expanded.

We should focus on the **uncertainties** in various forecasts, and how to deal with them. There are many sources of uncertainty, especially when we are looking at the atmosphere – from observation, forecasting, etc. Then, in particular for the climate impact, there is still the uncertainty on how to measure different impacts (e.g. non-CO_2 impacts) and how the atmosphere is behaving. We need to see how to deal with these uncertainties. Dealing with uncertainties is something that ATM is used to, so we can build on this experience. For climate mitigation intentions, especially when we are talking about the climate-friendly trajectories, we need to find the solutions that are robust within the uncertainties. For this we need the joint multidisciplinary effort.

We are aware that aviation has been severely impacted by Covid. It was difficult to implement new ways of doing things, due to this impact. When we are looking at network impacts of weather, other factors should be included as well. Weather does not happen in isolation. For example, MET interacts with other ATM events (e.g. staff shortages in a sector). So, we cannot think just about the meteorology, but also how is this information used operationally. The real world is very complex, so when you combine the MET impact with other factors, it can easily lead to a bigger impact, so we need to look at the bigger picture. Wider thinking and engaging with industry partners are important. There have been plenty of projects, but the issue we always come against is – what do we do with these results next? **Engaging** with industry partners from early on is another aspect of getting and implementing these tools. If we give nice MET tools/products to ATCOs, what do we expect ATCOs to do? MET experts may interpret information differently from ATCOs. Focus of all stakeholders should be on **how the tool will be applied** in a real-world environment.

Forecasts for thunderstorms in 8h time horizon contain a lot of uncertainty that is not always easy to interpret by flow management position (FMP) controllers. They might require probabilistic nowcast. There are efforts towards a seamless forecast for use by these positions (8 hours ahead would be enough).

The need of engaging and working with the end-users. Often, we would hear from the users that they need more, better data but the user does not know how to use them. We talked about the deployment previously. In SESAR 1 weather cube was developed. SWIM registry includes new nowcasting products. There is almost **an education** piece that is missing for many of these tools. A gap that needs to be bridged between these different experts, information and how can this be useful to the end user. There is a gap between the available information and how it can be distilled down to be useable. For example, the convection affects the airline. MET service knows the height of it, but controller might just need to know if it will come into their airspace, whereas pilot might be happy to simply fly over it. How to make this multitude of data, observations usable to the users? Could AI and ML be used in these types of services/applications?

When talking about drones, we are just at the beginning of the investigation of the **weather impact on drone operations**. And here the focus is on smaller, light-weight ones that fly in the urban area. These are battery powered, so missions may be very different, and range can be affected by wind (from the safety and efficiency points of view). For example, if faced with the headwind, the range of the possible mission could be very much reduced. Drones come in all sizes, so it is difficult to give a figure on what strength of wind affects them. Drones are more sensitive to changes in the weather compared to aircraft. Suggested four challenges. One is related to measuring weather for drones (resolution and update rate of weather). For example, the wind gust of 15 m/s crashed our small drone, while the 5 m/s that was the mean wind in the same time period could have been easily

handled. Two, modelling the weather in the urban environment (urban weather is different compared to the open space one). Three, communicating weather information from the sources to the users. Here, there is the need for strong standards on how this information should be communicated. For example, in Europe we have U-space weather information service, and the WP13 in EASA are looking into how and who can be the provider for this type of information. As drone operators are less trained compared to ATCOs or pilots, these tools need to be extremely easy to use, and need to be extremely transparent on what is possible or not. Weather parameters needed for safe drone flight are: wind, precipitation and temperature. They all effect drone operations. Hopefully SESAR 3 will open a topic on this, as the weather could be a showstopper for this type of applications for small drones. **Engage KTN is a good platform** to draw different communities together (e.g. drone operators with weather forecasters).

Session 2 - From research to implementation

It is obvious that climate mitigation and reducing impact of aviation are fundamental, and there is direct link with MET product. We are building SESAR 3, and this is the point when to incorporate the lessons learned. There is the need to link MET product and **sustainability**, not only to stay at the link between the MET and delay and for example volcanic ash. There is a gap between R&D perspective and the operational world. We need to feedback the operational issues to R&D to fill this gap much quicker.

In agreement with this observation from an end-user perspective. There is a huge amount of data, and we need something to make sense/interpret the data, in an operational sense. A MET information 'sweet spot' needs to be found between too-simple and too-complicated! 2021 traffic is at 70%, so weather has not made such an impact, but some of the momentum has been lost. We often have a (cultural) problem of having the FMP position to engage in decision-making in advance. The trust into forecast if often missing, but we need to start planning in advance. Currently, we are firefighting when we are talking about weather, whereas we need to make decisions in advance. We need to get stability and predictability, through the use of all the tools we have at our disposal. There is the need to change from **reactive to proactive approach**.

Regarding the climate change – how aviation affects climate still needs further research. We need to bridge this by applying some sort of catalytic opportunities. There might be two ways of mitigating climate impacts – restrictions or market-based mechanisms. Restrictions could be given in terms of no-access zones. Market-based mechanisms imply rules that allow the system to somehow organises itself around the market rules. We still need to channel products, to translate MET forecast to climate-impact forecast that users can understand.

How to speed up the deployment? From industry point of view: impression that innovation pace of industry is faster than operational implementation (e.g. radar/Lidar). When we implement for example a new meteorological service, a wind product, there is a very complex chain of sensors to create a picture of wind information. The problem is that this example of service has been offered a fair number of years ago, but it is still not being used in operations. There is a chance to improve transition pace from generally validated MET product to tailored MET services (e.g. tailoring to the specific ATC needs). As mentioned earlier, there is the challenge in extracting **user requirements**. Another issue is to make it possible to move from general use to local/regional through more open system. Here, the data standards, policy and automation are needed. Automation should/will increase with availability of data. However, is this usable, transparent to the end-user? Barriers: we are suffering from individual KPIs (e.g. airports think about costs, ATC about safety). So, we end-up having a conflict between the innovation and cost, or between innovation and usability. The innovations should achieve a certain fitness of purpose and sometimes this goes at cross-purposes with the innovation pace. Requirements of different ATM stakeholders are different, which is in contrast of

common situational awareness. **Data sharing** is still not what it should be. Data sharing and standards are important for the future.

Regarding the discussion of requirements and prototyping: is the same language spoken between industry and innovation stakeholders? Sometimes we need a long time to come to the same level of comprehension. There are standards, e.g., windshear, glideslopes and they help. Note sometimes it is difficult to understand each other - the customers at different roles have different expectations. The system needs to have flexibility imbedded to allow for tailoring and adaptation, which needs iterations and time.

We are entering a data rich world, and there are demand from users for more data (e.g. for probability). For example, all volcanic ash advisory centres to offer volcanic ash concentration information to wider number of users. At the moment, this is provided to users in Europe, and it is beyond currently mandated ICAO's 'ash yes/no' information. All nine VAACs have now agreed to provide this information but on a much higher resolution (more altitude slices and time frequency and the probabilities). Just in this example, the amount of information is increasing significantly, so we might need to utilise MET advisors to understand the data and advise the users. There is the step change happening in the volcanic ash area. ICAO pathways are often very slow (which could be frustrating) but it is of paramount importance to agree on global regulations, to be applied by all stakeholders. We could all wish for speeding up the ICAO processes, but we should not circumvent them. Without globally agreed regulations we could easily slip into the 'wild west' of varied information, making it impossible to come to reasoned decisions!

Two en-route control centres deployed a tool within the three years, which was the goal of the centres. Small, agile teams included the ATCOs in the prototyping. When collecting requirements, needed to make it a more 'fun' process with ATCOs. The goal was to make it simple and focus on one problem, e.g. weather impact for next 24H. MET experts need to understand the difficulties faced by ATCOs interpreting the data, and ATCOs need to understand the information from MET. There is also **sociological/educational challenge**, especially linked to explaining the element of uncertainty. What is also interesting, the sensibility of controllers to the weather of one centre was completely different from the other one. There is also a need for "soft skills" of researchers/developers – sociology for example. There should be some level of regulation on data and services. However, is the **regulation** good for innovation? Often the regulation is blocking the fast pace of innovation.

Lots of data out there – AI usage in MET is slightly slower than other areas of aviation (e.g. capacity) – is AI and ML a way forward that would enable expediting the deployment?

We were told 30 years ago that: "machines would soon take over forecasting! Machines are getting faster, machine learning is being developed. There will come a time when there is no point having a person involved in the process." We are still not there.

In this case the group started to use AI and neutral networks – it works. It can work providing a better result temporally and for tailored products (e.g., for an airport). France MET service has an ML team, but there are barriers slowing down the pace. Product depends on **regulation**. ML not to substitute the MET person – will still need the MET expert. What we are applying the models on are complex, so we will still need experts involved int eh process.

Session 3 - Enabling fast innovation cycles

Room 1: Data and data infrastructure

Moderator: Tatjana Bolić

The discussion around data offered interesting views on what should be stopped, what should be started and what we should continue working on (see Figure 1 below).

The only point in the "stop doing" category refers to "losing" time on acquiring the data. Roughly 6-12 months of each project are spent on finding, acquiring and cleaning data.

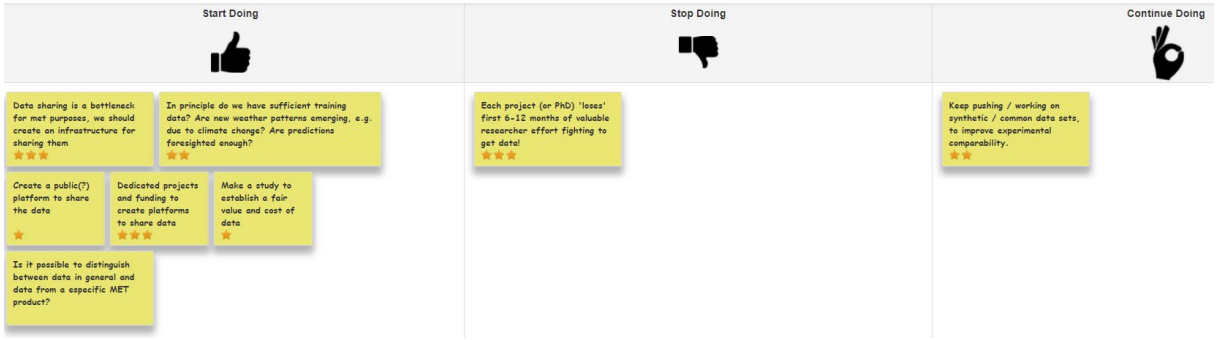

Figure 1: TC3 - brainstorming on data and data infrastructure

The discussion in the "start doing" category revolved around investigation of the requirements and costs for the data sharing platform, for research purposes. This is important as often in the MET the data is available through the local MET providers and makes obtaining European-level data complex. The two most voted ideas in this category can be summed up as: Maybe an infrastructure for data sharing is needed. It should be investigated what is the fair value and cost of data.

An important mention in the "continue doing" category is to continue requesting and working on either synthetic or common data sets, to improve the experimental comparability, which is currently lacking in the ATM domain.

Room 2: Research collaboration for faster deployment

Moderator: Luca Crecco

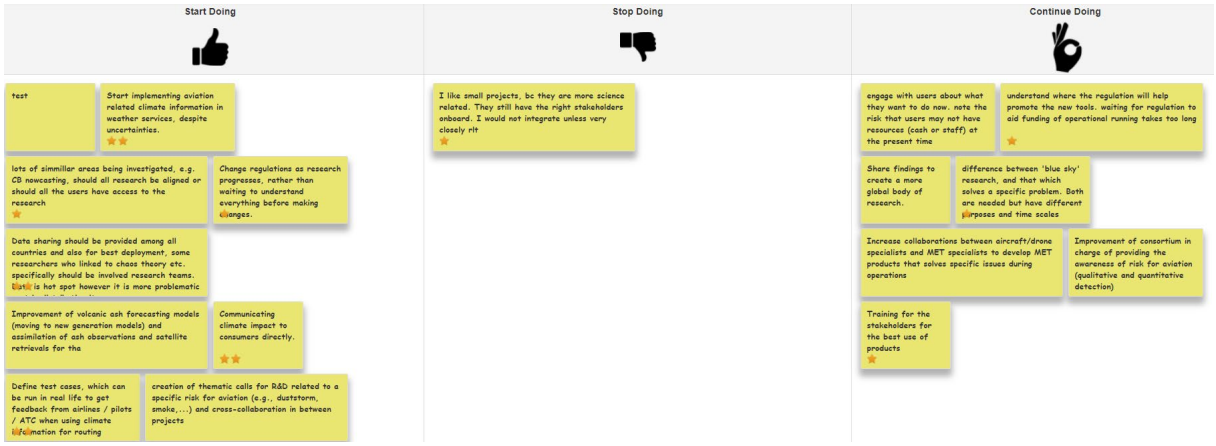

Figure 2: TC3 - brainstorming on research collaboration for faster deployment

The important thing in this area is that some research was performed, products defined, but until someone pays for them it is hard to get them out into the world. Regulation comes at the very end.

Change regulations as research progresses. We need to make sure everyone has an overview of what is going on; one person cannot do everything.

Data sharing is very important; distributing the data. Team members might help people to understand.

Volcanic ash forecasting now has much more comprehensive models. Sand and dust forecasting is well-researched in Europe, mainly for health concerns rather than aviation (e.g. engines). End-user has needs for such models, tools and services.

It is important to have reasons for changing regulations, e.g. body pushing for changes. Highlight airlines taking better routes. Public opinion is often overlooked.

Discussion

Moderators: Tatjana Bolić, Luca Crecco

Incentives for airlines to fly better trajectories? Identification of green trajectories, looking at the trade-off between the costs and benefits.

There are a couple of possibilities – test cases to get feedback; type of information provided, then we see the gaps.

We are receiving mixed messages from EC: EU Green Aviation offers incentives for green trajectories and on other side we have an amendment to Regulation 261 with a greater penalty on airlines for missed connections (in most instances encouraging accelerated fuel burn). There is a bit of conflict in terms of signalling, and it would be good to get some feedback from airlines on this.

Maybe we could use market dynamics. If we inform consumers about sustainability of individual flights so they can choose between them. To use competition principles to force airlines to become more sustainable. Big data could be used to make estimations on this. Some websites already give this type of information (like Skyscanner).

Recap of room 2 board: communicating climate impact to consumers directly is important. Early involvement of the regulator in research is encouraged (i.e. from the design phase). Involve all the stakeholders in the process. Recommendation to keep the existing research in the programme but try to consolidate various bits and pieces to move towards the services.

Recap of room 1 board: data is a bottleneck; difficult to obtain; cannot use same dataset in multiple projects. Maybe create public platform to share MET and ATM data to give easier access without having multiple agreements in place. Each PhD loses approx. 6-12 months trying to get the data. This is a recurring theme throughout different workshops. Keep pushing the work on synthetic datasets. Another negative impact is that we cannot really compare results between projects due to use of different data sources. EUMETNET access – can these be extended to cover more datasets?

The challenge of extending the access to data often depends on how it is paid for, in in the case of many MET data providers it is cost recovery. If it is cost-recovery, then there are very specific rules on how data can be used. IATA turbulence dataset is brilliant but expensive. It is important to know what type of data is of interest to researchers. The advice is to build relationship with local MET provider.

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