Weather Volatility

Adapting To The New Normal

Air Traffic Management

STRATEGY, TECHNOLOGY AND MANAGEMENT FOR THE WORLD'S MOST GLOBAL INDUS

FABCE AIRSPACE ALLIANCE

In 2017, the impact of adverse weather doubled in extent. For ATC, it is a question of capacity management at the end of the day. Early and precise predictions of size, location and probability are key enablers to plan our staff and the impacted traffic flows. Then, we would be in a position to provide the best service possible, and provide the system with the level of trust needed.

Gyula Hangyal FABCE / HungaroControl

Baltic FAB
A PART OF SINGLE EUROPEAN SKY

As an active air traffic controller, I am experiencing climate change as a fact in daily operations. Both the number and the impact of adverse weather phenomena is increasing. We have to do more – in training, in data sharing, in staffing. Simply put, we have to adapt our work to the changing environment.

Janusz Janiszewski
Baltic FAB / PANSA

danubefab
functional airspace block

We experienced two tornadoes in Romania for the first time in 2017. These weather changes require an holistic approach incorporating updated training modules, more flexible rostering schemes, improved weather data at the controller's working position and improved capacity management tools.

Alexandru Hozoc
DANUBE FAB / ROMATSA

FABEC

Harnessing Climate Change

Torrential rainfall, extreme thunderstorms, gale-force winds, and quantities of snow not seen for decades - climate change has reached Europe and is having a major impact on the air transport system.

European aviation is facing ever increasing delays caused by such weather events with the number of passengers suffering long delays, airport closures or flight cancellations set only to increase.

Europe's FABEC Functional Airspace Block has responded to these emerging weather patterns by combining new research from the World Meteorological Organisation (WMO) with practical air traffic management industry experience.

At the World ATM Congress held earlier this year in Madrid, the InterFAB panel on this topic was supported by the WMO and METAlliance as well as FABEC's partner Functional Airspace Blocks: Baltic FAB, DANUBE, DK-SE FAB and FABCE.

Their core message is that climate change is having – and will continue to have - a significant impact on aviation. Further, that impact is often more severe than expected and above all presents aviation with a unique set of system challenges, one that have rarely been encountered before at the same scale.

In this Special Report, two experts outline the consequences of climate change for the air traffic management industry. ATM

Variable Conditions

Dr Herbert Puempel of the World Meteorological Organisation outlines the issues that the ATM industry must address to understand the effects of climate change and variability

So what do we know; what do we expect? There are two methods of understanding climate change and variability. We can examine observed changes or look at model projections.

Most prominent in the public perception are the changes to the global mean near-surface air temperatures, which all climate relevant international agreements have considered. The current Paris Agreement seeks to limit this temperature increase to two degrees Celsius with an aspirational limit of 1.5 degrees. If these limits were exceeded, projections indicate that Arctic sea ice would largely disappear.

Areas of uncertainty remain, however. The atmospheric variables with the most effect on aviation and ATM are driven by smaller scales of atmospheric motion, i.e. fronts, rapidly developing cyclones and, most importantly, by thunderstorms and the effect of mountains and coasts.

These are the most difficult to predict even in the short range, as the forecast models used for aviation (e.g. the World Area Forecast System models) are global by nature and thus are best for the prediction of larger-scale phenomena down to typical low-pressure systems.

Risk management required

It is very important to understand that the large level of uncertainty in the prediction of regional and local trends of variables that affect aviation should never be an excuse for inaction. While we can be fairly certain of an increased impact, the extreme values to be reckoned with in a risk management system may exceed or be less than what models indicate.

For example, we know that a large percentage of annual rainfall in many regions of the world is caused either by tropical storms, or in the Mediterranean and other regions where high mountains border on warm seas, intense cyclogenesis. These regularly entail extreme events that affect aviation operations and require constructive measures (airports, access routes, aircraft design) as a primary means of risk management.

Such trends are unlikely to stabilise over time, as many extreme weather events depend on a complex mix of conditions to occur. This leads us naturally to recommend a 'least regrets' strategy, which would consider both the worst-case scenario, and the likelihood of its occurrence against the backdrop of the opportunity cost in a risk reduction strategy involving significant investment in design, hardening and maintenance of infrastructure and aircraft. ATM will face increasing difficulties balancing demand and capacity when the use of airways, arrival and departure routes as well as runways is restricted by severe weather.

We need close cooperation to identify and quantify risk. The facts and considerations presented above point to the need for a multi-disciplinary approach in adaptation and risk reduction in a changing climate. Designers, engineers, hydrologists, atmospheric scientists and social and medical scientists all need to address the highly complex and cross-disciplinary effects and events that are likely to occur in a more variable and sometimes hostile environment.

Unpredicted changes occur

One phenomenon that we have observed involves changed flow patterns at altitude. Model projections of global climate models that also consider the interaction between the oceans, biosphere and atmosphere, and in particular the hydrological cycle - evaporation, transport, and precipitation of water - indicate an increase in the energy available for storms and low-pressure systems.

In many regions, a poleward shift of the jet streams and in the last decade show a tendency to a larger amplitude, longer wavelength and slower movement of the large troughs and ridges in particular over the Northern Hemisphere. This is generally referred to as 'High Amplitude - Low Wavenumber' type of circulation. These changes favour extended periods of both hot and dry weather in the warm season, and unseasonal or protracted snowfall or icing episodes, again leading to significant delays and extra burden for ATM, flow control and aerodrome capacity planning.

The strengthening of the upper level jets and their northward displacement have been identified as a potential cause for a significant increase in aircraft turbulence e.g. over the North Atlantic.

Another phenomenon we see are rising sea levels. Although tendencies in different parts of the world are far from uniform, the melting of glacier ice in both mountainous regions and the Arctic (Greenland, Antarctica) will continue. This will lead to a sea level rise of probably around 40 cm by the end of the century. Thermal expansion of the oceans could contribute further to this rise. Many new airports have been built close to seashores and on tropical islands. Some of these airports may require significant protective action - sea walls, drainage pumps etc - to keep them in operation for the coming decades.

Storminess is increasing and less predictable

The next observed phenomenon is increased storminess. Higher levels of available potential energy from the atmosphere-ocean system are expected to lead to an increase in the frequency of occurrence and intensity, and to changes in their typical tracks and geographic distribution. These storms are likely to exacerbate the already critical situation of coastal airports, and have already led to critical situations where crosswinds are too strong which result in last-minute go-arounds.

Further changes can be seen in typical convective scenarios. The concurrent increase of temperature and humidity in the lower layers of the atmosphere, predicted for many regions, is beginning to manifest itself in a noticeable change in the genesis, development and life cycle of thunderstorms.

Recent European studies have indicated that, in particular, near mountain ranges and around the Mediterranean, Cumulonimbus tops are becoming higher - on average so far by about 2,000 feet. In addition, their development appears to be faster and more vigorous, and the lifecycle even of the hitherto less damaging air mass thunderstorms

found in unstable air masses independent of frontal regions, mountains or river/ lake basins have extended to several hours.

Their presence has also been found in the absence of a regime with winds changing from the surface to the higher levels, which has a negative impact on their predictability. Increased humidity also leads to higher ice content at altitude, leading to increased risk of turbine flameout.

Climate change affects regional – not global

Model projections predict highly regionalised changes in the future. All indications of current observational and modelling studies point towards a highly complex regional structure of the impacts of climate change and variability. An ICAO CAEP workshop in 2014 unanimously agreed that any adaptation measures should be based on detailed regionalised or even local studies and evidence.

The most critical changes are currently expected for the cryosphere, mountain regions, and small, low-lying islands as well as alluvial basins subject to a combination of severe tropical storms and run-off. ATM units, airport authorities and operators need to coordinate their responses to the identified threats and develop a coherent strategy of mitigation and risk reduction.

Another key question concerns the likelihood of early occurrences of these long-term projections. As mentioned above, the nature of climate change and super-imposed variability is subject to a combination with long-term oscillations - Southern Oscillation, El Nino, North Atlantic oscillation to name just a few. These are interacting with the Arctic sea ice cover, changes in vegetation and the release of greenhouse gases by human activity as well as changes in the deep ocean and the land biosphere. The resulting changes are non-linear and are likely to occur at an early stage. Some of the conditions are expected to be the 'new normal' at the end of the 21st century.

Our understanding of derived atmospheric parameters such as the occurrence of icing, turbulence, lightning and freezing/frozen precipitation affecting aviation is slowly improving. The small-scale nature of some of these processes, however, continues to pose a challenge to detailed predictions, and is subject to a large degree of uncertainty.

We need to address scenario-based analysis and validation. In order to better understand the incipient changes, a consideration of average conditions is not sufficient. Detailed studies of the weather situation with a traditionally high impact on aviation operations need to be identified; their frequency, intensity and characteristics need to be addressed in regionalised climate projections.

ATM specific issues and recommendations

One issue that needs to be dealt with is convection and blocking of airways. To be able to predict the expected accuracy and reliability of operational forecasts, scenario-based validation of forecast and climate model predictions are required.

Turbulence predictions need to be validated against aircraft data again for different scenarios ranging from clear air turbulence, mountain wave breaking and extreme turbulence in high shear/high stability regimes.

Runway choice and the prediction of crosswinds will require instantaneous detection, clear and real-time communication between automated systems as well as between pilots and air traffic controllers.

Aerodrome capacity issues in convective and winter weather need to be addressed based on in quantified, calibrated probabilistic information for informed collaborative decision making.

There is a need for increased cooperation between stakeholders in coping with adaptation. To achieve this, three measures must be taken. The first is to invest in meteorological infrastructure, competence and capability. Second, a there needs to be full exchange of aircraft-based, ground-based and remote sensor data. Third, research findings need to be transferred faster into operations and regulatory frameworks in view of increased variability and frequency of extremes. ATM

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A United Weather Front

German air navigation service provider DFS Deutsche Flugsicherung's **Wolfgang Bretl** argues that joint solutions can lead to better planning reliability

Dealing with bad weather is nothing new for air traffic control. All operational air traffic control units, such as towers, approach control or en-route control have always been confronted with such situations, which are among the most labour-intensive and critical situations.

What is new, however, is the increased number and severity of phenomena. Thunderstorms have become more static, larger and higher, making them increasingly difficult to fly around. This past winter, there were frequent cases of unexpected snowfall causing several airports to temporarily shut down. Turbulence and sudden strong winds around airports make flying increasingly uncomfortable for passengers and place new demands on safety.

Against this backdrop, the experts responsible for operations have developed concrete solutions at various levels over the past months and years in order to reduce the impact on passengers and aviation as far as possible. The safe conduct of flights always has priority.

The challenge is not so much the individual characteristics of each weather phenomenon as the interaction between them. In addition, sudden weather phenomena may cause planning to partially or completely erode. Air traffic controllers are forced to react to the weather and their work becomes reactive. When the ability to plan has been lost, capacity is also affected. Capacity values that can be easily achieved in fine weather can no longer be maintained and have to be reduced.

Airports: snow, winds and lightning

At airports, weather has a profound influence on take-offs and landings, as well as the handling of aircraft in the apron area. Air traffic cannot really avoid the weather at airports unless an alternative destination is chosen. From a geographical point of view, there are certain weather phenomena that are more frequent or even regular in certain regions of the world, while others are rather unlikely. That does not mean, however, that they are completely impossible.

In Central Europe, common weather phenomena at airports are precipitation in the form of snow, rain or hail, wind including severe storms and turbulence, lightning as a result of thunderstorms and, of course, a combination of these. How well an airport and local air traffic control are prepared for these phenomena depends primarily on how often these phenomena occur.

Experience has shown that airports in the Alps are much more efficient at dealing with snow, whereas airports near the coast, for example, are better prepared to deal with circulating winds. At these airports, operational processes are routine and the necessary infrastructure is available. Especially at large commercial airports, routine and thus smooth processes are of great interest to customers, i.e. airlines and their passengers. Priority is always given to safe traffic handling - and this applies above all in bad weather.

Cruising flight: detours and strong turbulence

When cruising, however, weather conditions are strongly dependent on where the aircraft is located in the airspace. Flight level and position determine the extent to which an aircraft is affected by weather conditions. Of course, different aircraft types are also equipped differently to handle the weather.

On en route flights, storms and thunderstorms in particular play the most important role of all weather phenomena. Large thunderstorm cells and contiguous thunderstorm fronts are impossible to fly through. Consequently, air traffic control must react quickly and flexibly with alternative routes. Long detours are possible and sometimes necessary. A Boeing 737 on its way from Prague to Zurich, for example, may have to fly north almost as far as the North Sea to avoid a massive front, before it can fly south again.

Icing conditions that occur during take-off and landing, but also during long-haul flights, can cause additional problems. Another weather-related influence on the course of the flight is turbulence. This can range from slight turbulence that makes the flight less comfortable for passengers to very severe turbulence that can cause large fluctuations in altitude over a very short period and even impair the safety of the flight.

Regardless of whether at the airport or while cruising, all operational solutions rely on communication and the ATS system, infrastructure, working procedures and flexibility.

More precise information makes planning easier

The exchange of information takes place at different levels and between different systems. The faster and more comprehensive the relevant information is exchanged, the better and more appropriate the response can be. This may conflict with the needs of the cockpit crew, who may need to stabilise the course of the flight, for example when experiencing severe turbulence or thunderstorms. Air traffic control requires specific information not only for each individual flight but also for planning further flights.

Communication means not only direct communication between controllers and pilots, but also between different air traffic control units. Automated processes and systems support this. For example, very advanced ATS systems enable air traffic controllers to systematically share changes in flight routes directly with others. During heavy thunderstorms, sectors are sometimes impacted by a flight that normally not have been affected. In such cases, the fast and precise data exchange of the trajectories ensures predictability - and thus safety and capacity.

Communication also entails the exchange of information on the ongoing development of certain weather phenomenon. The challenge here is the accuracy of the forecast and how it is communicated between the meteorological service and air traffic control. Ideally, weather advisors work directly in the control centres; which ensures comprehensive advice and assessment of the situation. Supervisors use this data to generate sector-related information. Colour images quickly and clearly provide information to controllers about the significance of the weather. At the interface to airports and airlines, data is exchanged systematically to optimise ground processes.

Solutions for airports

Certain weather phenomena are more likely to happen all over the world than others are. Frequently occurring phenomena, such as snow at airports near mountains, have a major impact on the infrastructure of an airport. Snowfall can significantly and rapidly reduce capacity. Runway closures to allow snow removal and de-icing of departing aircraft influence standard processes. Busy airports have streamlined these processes but they cause constraints nevertheless. Delays or even flight cancellations may result.

To ensure that everything runs smoothly, airports need to have a sufficient number of de-icing systems, ensure that these are always filled, have enough snow clearing

equipment as well as trained operating personnel. There are also regions where fog is prevalent. At airports with several runways, flexibility is ensured by carrying out visual measurements separately for different runways. Sometimes, there are large distances between runways and the CAT conditions may vary greatly. While CAT II/III conditions are present on one runway, a significantly better visibility/ceiling may exist on another.

In the case of independent parallel operations on two runways, the ground infrastructure influences the potential capacity. At Munich Airport, both runways are operated in "mixed mode" during normal operations. By repositioning the glide path transmitter and as a result reducing the ILS protection areas, single mode operation can now be used for CAT II/III. This allowed a significant increase in capacity.

New working procedures increase flexibility

Work procedures are directly related to the airspace structure, procedures between the various sectors and air traffic control units, as well as planning processes for staff scheduling. The focus here is on flexibility when dealing with difficult weather situations.

In case of thunderstorms, planned flight routes and profiles have to be changed. A more flexible allocation of standard departure routes (SID) for certain city connections is one way of using other sectors for departures that would have gone through sectors with thunderstorm cells and are therefore strongly regulated at the time of occurrence. A longer route usually results, but may actually have little impact on punctuality. However, the coordination workload for controllers increases.

In these situations, it is crucial that the weather forecast is precise. It is critical to adjust the flight plan as quickly as possible (< 30 minutes before ETD). This is possible at the airlines' operations centres, but these weather conditions are generally very labour-intensive and more standards need to be defined.

Another working method is the optimal distribution of approaches at airports with several runways. The CDM process (collaborative decision making) at Paris CDG Airport allows for the optimum use of the north and south runways by the upstream area control. This may result in longer routes but these can be compensated for by reducing holding times or departure delays.

The control centres of Vienna, Padua, Zurich, Karlsruhe and Munich have joined forces to prepare for the special weather situation in the Alps for summer 2018. This involves improving coordination processes, both procedurally and across the whole air navigation services system. High-descent areas enable aircraft approaching Munich Airport to descend at a later stage and thus better avoid the sometimes extremely high thunderstorm cells.

Strong winds, even if they are not side or tail winds, reduce the number of possible landings in the approach sequence, at least with standard radar separation. Time-Based Separation, as established at London Heathrow Airport, significantly shortens the possible distances without reducing safety.

Solving the crisis of bad weather together

Difficult weather situations are events that require special attention, both by airport operations and air traffic control. The safe conduct of all flights is the primary objective of all parties involved. The goal must also be to keep the required capacity stable. Standards that are agreed and practiced between the individual system partners help here. The following four points are of crucial importance:

- Safety first
- Communication – fast, targeted, comprehensive
- Processes – adhering to standards
- Consideration of local conditions

Difficult weather situations can develop into crisis-like situations, depending on their course and complexity. The performance of the overall system is directly related to the performance of the individual. This has to be worked out repeatedly on every new occasion. There is no single standard solution, but there are solutions. ATM

Wolfgang Bretl, is head of Munich Area Control Centre, DFS, and chairman FABEC Head of ACC Group we work together to keep the skies safe

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