Weathering the storm

Climate change is amplifying the impact of difficult weather, and hence delays in busy airspace – but German air traffic controllers have found a way to make better use of existing forecasts to keep capacity high

AIMEE TURNER LONDON

Weather consistently generates up to one-third of all air traffic management delays across the European network, according to the Eurocontrol Network Manager, whose recent statistics indicate an 80% increase in minutes of weather delay since 2013. In addition, weather events are becoming more unpredictable in their timing and intensity. Thunderstorms have become more static, larger and higher, making them increasingly difficult to fly around, while turbulence and sudden strong winds around airports are making flying increasingly uncomfortable for passengers.

The result is that air traffic management professionals in some of the busiest airspace in the world are facing increasing difficulty in balancing demand and capacity in the face of intensifying weather systems as a result of climate change.

PROBLEMATIC LANDSCAPE

Dealing with bad weather is nothing new for air traffic control (ATC). All operational units, such as towers, approach control or en route control are well accustomed to handling such labour-intensive situations. What is becoming clear, however, is that with the increased number and severity of phenomena because of evident climate change effects – combined with ever more aircraft transiting an already congested continent – those charged with ensuring the safety of airspace are faced with a new, more problematic landscape.

On the positive side, climate change will probably mean less snow for western Europe, although meteorological experts still cannot guess just how the region's typical fog, wind and rain patterns may evolve to become the "new normal".

Convective activity is becoming the main problem during the summer months, however. Storms are building more quickly and joining up so that their cross-border impact becomes more significant. Throughout June 2017, and especially in July of that year, it was not uncommon for the European network to be subject to around 100 regulations on any one day caused by severe weather.

Many of these regulations duplicated each other, meaning that flights could be subject to five or six different measures, making it almost impossible for them to be re-routed.

Winter weather is also changing and although it does not significantly affect en route airspace, it still remains a problem for a large number of airports – with one weather front simultaneously affecting a whole chain of terminal manoeuvring areas, the controlled airspace that surrounds a major airport where there will be a high volume of traffic.

Together with FABEC, grouping ATC organisations in neighbouring countries, German air traffic controller DFS is working to optimise operations at the local level and aiming to have a critical effect on the stability of the European network as a whole.

FINE TUNING

One solution that has been developed by DFS at its Langen area control centre seeks to finesse weather forecasting for Frankfurt operations to help reduce the impact of extreme weather events as far as is possible.

Frankfurt ATC must work around challenges impacting the whole continent

Fraport

Handling an average of 1,500 flights per day, Frankfurt is in normal times Europe's busiest international airport

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With more direct routes than any other airport in the world, Frankfurt airport plays a critical role in connecting passengers travelling through Europe; it usually handles an average of 1,500 flights per day, more than any other international European airport.

A total of 137 intercontinental destinations are served via the Frankfurt hub, underscoring its role as a leading node in the global air transportation system. Developing routine and seamless operational practices that optimise the use of airways, arrival and departure routes, as well as runways, in the face of increasingly severe weather is therefore a priority.

The most significant impact of a thunderstorm is the fact that it will reduce the actual airspace – limiting the physical boundaries within which an aircraft can operate. During heavy thunderstorms, unplanned, ad hoc diversions into adjacent sectors will most probably lead to a concentration of traffic there, increasing congestion and therefore airspace complexity.

These unplanned scenarios have an immediate impact on controller workload and timely decisions have to be made, with ATC supervisors most often having to err on the side of caution.

Also, as there are very few ways of understanding how a forecast thunderstorm will develop, air traffic controllers are forced into reactive mode, their actions guided by the weather. To prevent controller workload from becoming excessive, operations also have to be regulated to maintain safety and it is this which leads to vital capacity being lost and recovery times being unnecessarily long.

> "It is not rocket science – simply a better human-machine interface [that] leads to better understanding"
> **Armin Beirle**
> Head, Langen area control centre

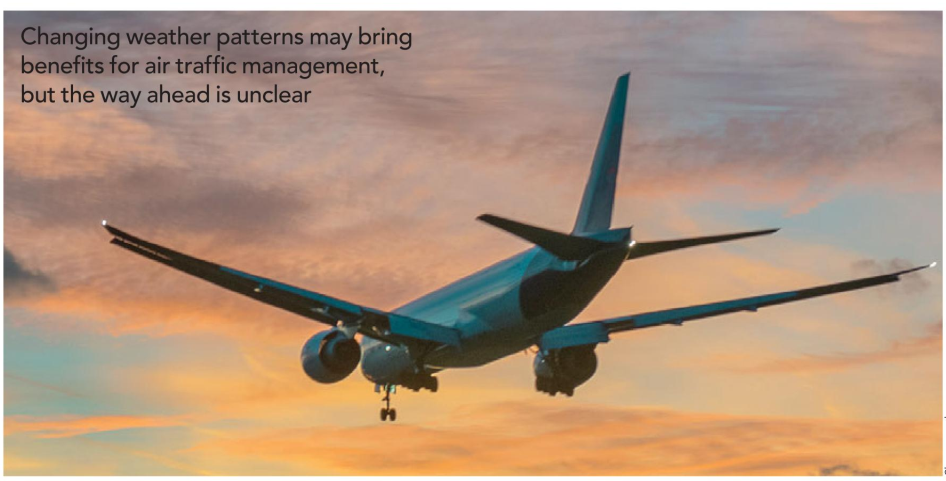
Workload complexity increases too for pilots, reflected in the proliferation of radio exchanges, which also puts available frequencies under pressure, especially at an airport with a complex parallel runway system such as Frankfurt. Add the fact that any electrical storm warning within 2.7nm (5km) of the major German airport will trigger a freeze on all ground handling operations, and the implications of worsening and persistent storms soon become clear.

BEST LAID PLANS

That decision is taken by the airport, although if there is a thunderstorm forecast, there will be much negotiation at management and operations level, meaning all stakeholders will be prepared. For airlines, that means reducing flights in the pre-tactical stage. For ATC, that will similarly mean taking pre-tactical decisions on flow measures, with help from German meteorological service DWD.

An example from one day in 2018 illustrates the concept. A thunderstorm was forecast to affect Frankfurt airport operations from 13:30 UTC. At 10:00, the supervisor at Langen decided to regulate arrivals between 12:15 and 17:00 from a starting rate of 42 aircraft per hour; based on the forecast, that rate would drop to 20 per hour at 13:00, then increase to 35 per hour at 14:30, 45 per hour at 15:30 and 60 per hour at 16:30, before reverting to unregulated status at 19:00.

As predicted, the approaching storm front came in from the direction of Luxembourg at 11:00 and moved eastwards into Langen's »



Changing weather patterns may bring benefits for air traffic management, but the way ahead is unclear

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» western sectors. But the plan for a smooth "staggered regulation" soon fell foul of meteorological reality.

In this case, all the approaches into Frankfurt were regulated, regardless of whether or not they were directly affected by the bad weather – reflecting the difficulty of maintaining a precise view of dynamic weather. Keeping a real-time view of the weather is notoriously difficult in the Frankfurt area, where storm fronts develop and dissipate swiftly.

So DFS asked how the rules could be adapted so those specific approaches into Frankfurt that are not affected by developing weather fronts would not be unnecessarily regulated. To consider alternative methods of air space management, a workshop was convened earlier this year by DFS to discuss this topic, together with DWD experts and members of Frankfurt's airline community.

Using the colour MET images familiar to controllers from briefings about forecast weather impacts, participants could see how DWD forecasts might allow for differential regulation of sectors around Frankfurt. Indeed, by dividing airspace sectors into smaller segments and generating a weather picture for each, DFS found it could better support decisions taken by its supervisors.

Of course, should ground services be ordered to discontinue, a "zero regulation" situation will always prevail. But with better forecasting, regulations can be applied to just one part of the airspace and approach flows managed more precisely.

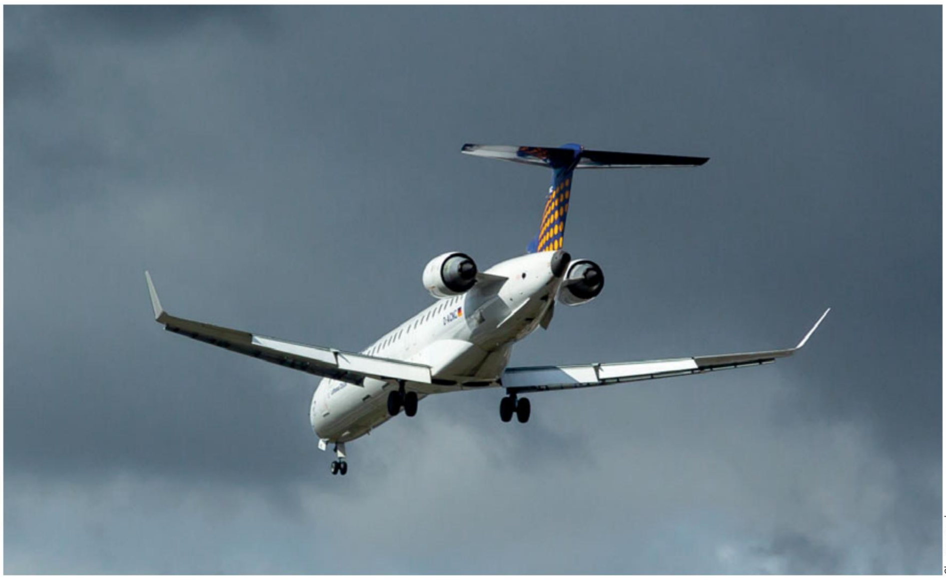
Langen area control centre head Armin Beirle explains that the development of a segmented weather forecast, rather than an area forecast, required no new MET technology. Instead, it was a case of using existing tools more efficiently: "It is not rocket science – simply a better human-machine interface [that] leads to better understanding."

The airline community was involved from an early stage and there were benefits from a segmented approach to regulation. Raimund Muller, Lufthansa chief pilot and an Airbus A380 captain, says: "From an airline perspective, the close co-operation and integration of weather experts into an airline operation centre has created value. It helps in steering our operation in terms of better decision-making, particularly on a short-term basis in tactical operation optimisation."

> "The close co-operation and integration of weather experts into an airline operation centre has created value"
> **Raimund Muller**
> Chief pilot, Lufthansa

The advantage of this method is that only those flights that are actually affected by the weather will be regulated. The rest remain without regulation and thus without delay. The trade-off can be that those flights that do pass through the quadrants with thunderstorms will probably suffer greater delays, and potentially more diversions.

Here, Beirle points out that giving airlines that visibility over ATC decision-making also has an overall positive impact on the environment, as departing aircraft can delay starting their engines on the ground and then fly a more direct route to their destination. The method – which required no regulatory approval – has now been introduced at DFS's other busy hubs such as Cologne, Dusseldorf and Munich. ■



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Thunderstorms have grown larger and more static, making them more difficult to fly around

RESEARCH **DAN THISDELL** LONDON

Altitude changes could mitigate impact of contrails

Strategies for reducing aviation's climate change impact tend to focus on engine technologies to improve fuel economy and air traffic control schemes to guide flights on more direct routes and minimise time spent in holding patterns. In both cases, the objective is to reduce fuel consumption – and hence carbon dioxide (CO_2) emissions. But could there be a way to decrease the global warming impact of aviation even at the cost of a small increase in fuel consumption?

Perhaps counter-intuitively, the answer may be "yes" – by making small changes to cruise altitude that could reduce contrail formation. And the net benefit would increase with wider use of engine technology that reduces the emissions of black carbon, which seeds the formation of contrail ice particles.

Under some conditions, contrails – the fine-line clouds that form in jet exhaust under certain atmospheric conditions – can reflect sunlight back to space and have a cooling effect, but otherwise contribute to warming by reflecting back downwards heat rising from the ground, which would otherwise be dissipated into space. On balance, this climate forcing of contrails and their related induced-cirrus clouds is thought to be comparable to the cumulative impacts of aviation CO_2 emissions.

So, working with Japanese airspace data, researchers at the Centre for Transport Studies at Imperial College London and Germany's DLR aerospace research institute in Oberpfaffenhofen looked at how raising or lowering cruise altitude, to avoid contrail-forming conditions, might affect the climate impact of aircraft and of the broader cirrus clouds to which they contribute.

Roger Teoh, Ulrich Schumann, Arnab Majumdar and Marc Stettler conclude that "a small-scale strategy of selectively diverting" just 1.7% of flights could reduce the net warming effect of contrails by nearly 60%, while increasing CO_2 emissions by barely 0.1%. Or, they found, "a low-risk strategy of diverting flights only if there is no fuel penalty" would still cut contrail warming effects by one-fifth.

Published in February by the American Chemical Society's *Environmental Science and Technology* journal, the authors note that "modern aircraft are designed with vertical altitude flexibilities of up to 3,000ft at the expense of a few per cent fuel penalty" – so, under the right conditions, directing an aircraft to fly a couple of thousand feet higher or lower could reduce a flight's environmental impact. ■

METEOROLOGY AIMEE TURNER LONDON

Wind of change forecast to drive greater turbulence on transatlantic services

In February 2020, a British Airways (BA) Boeing 747-400 set a new subsonic speed record for the New York-London route. Was that flight merely a statistical fluke or an indicator that climate change is leading to a far more powerful transatlantic jet stream?

Driven by Storm Ciara, the 22-year-old 747 completed the sector from New York John F Kennedy airport to London Heathrow in 4h 56min on 8-9 February, some 1h 20min faster than scheduled. A Virgin Atlantic Airbus A350-1000 that was following behind was only 1min slower than the BA flight.

To put that into context, the absolute New York-London record was set by a BA Concorde in February 1996, when it completed the sector in a record 2h 52min 59s with a cruise speed of Mach 2 – but that, of course, was a supersonic aircraft.

So, will record-breaking flight times increase over the Atlantic because of the atmospheric jet stream strengthening at cruising altitudes in response to climate change? Records normally grow harder to break as time goes by, but as Paul Williams, a professor of atmospheric science at the University of Reading's meteorology department, points out, the subsonic eastbound transatlantic flight time record has been broken a lot recently – three times in the past five years.

Williams has studied climate change impacts on aviation in some depth. In addition to examining potential climate change impacts such as intensified turbulence and increased take-off weight, he has also studied the theoretical effect on flight routes and journey times.

CHANGING CONDITIONS

By feeding synthetic atmospheric wind fields generated from climate model simulations into a routing algorithm typically used by flight planners, Williams wanted to find out what happened to transatlantic flights between London and New York if the atmospheric concentration of carbon dioxide (CO_2) was doubled.

He found that a strengthening of the prevailing jet stream winds caused eastbound flights to significantly shorten, with westbound flights significantly lengthening; flights were twice as likely to take under 5h 20min and over 7h 00min respectively. Unfortunately, the impact on each direction does not cancel each other out but, rather, increases round trip journey times.

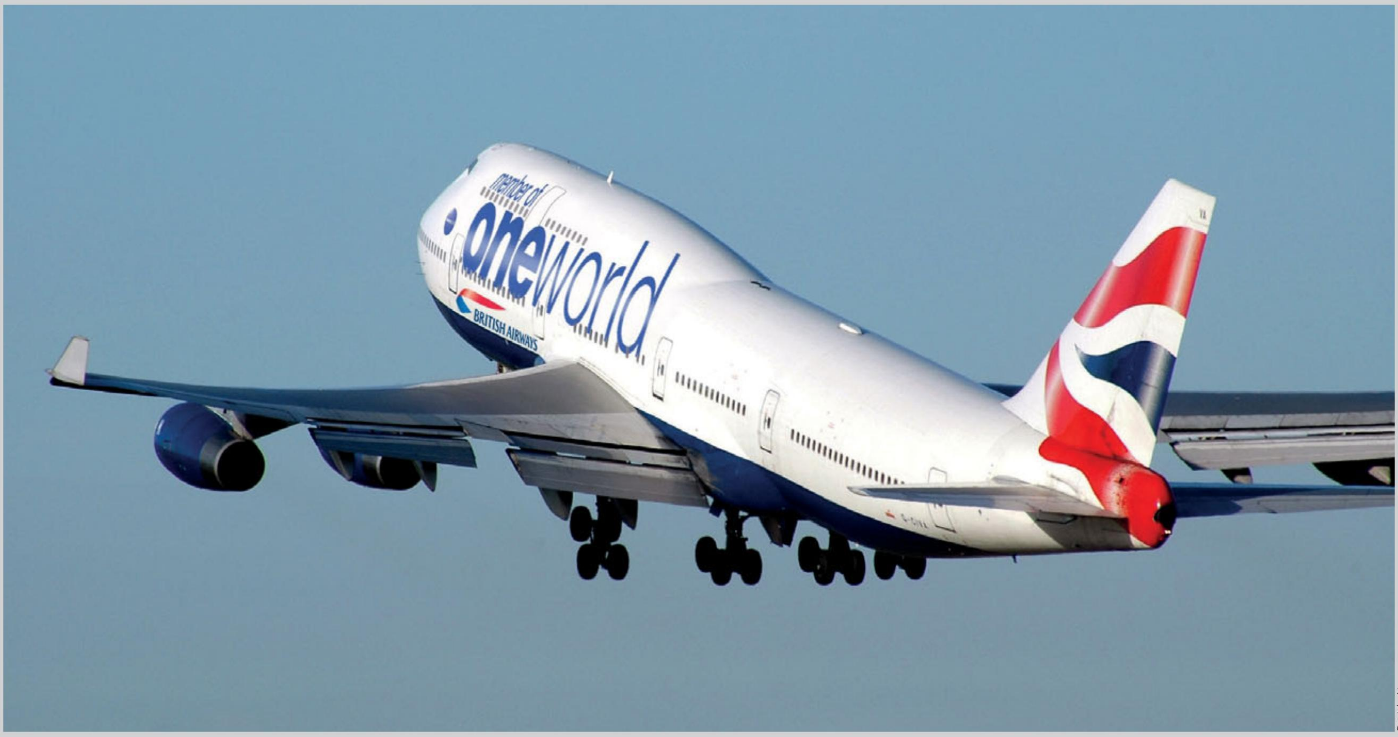
"Even assuming no future growth in aviation," says Williams, "the extrapolation of our results to all transatlantic traffic suggests that aircraft will collectively be airborne for an extra 2,000h each year, burning an extra 7.2 million USgal (27.3 million litres) of jet fuel and emitting an extra 70 million kg [154 million lb] of CO_2."

While Williams says it is too early to say whether the February record-breaking times will become commonplace or remain a statistical fluke, he adds a caveat: "What we can say, however, is that the jet stream is already a lot more sheared than when satellites started observing it 40 years ago."

If so, pilots should expect a lot more clear-air turbulence (CAT) in future. Williams's work indicates that at cruising altitudes on transatlantic flights in winter, the diagnostics show a 59%, 94% and 149% increase in the prevalence of light, moderate and severe CAT, respectively, with similar results on other routes and other seasons.

> "The jet stream is already a lot more sheared than when satellites started observing it 40 years ago"
>
> **Paul Williams**
> Professor of atmospheric science, University of Reading

"We conclude that, all other things being equal, climate change will lead to bumpier flights later this century," he says. "Flightpaths may become more convoluted to avoid stronger and more frequent patches of turbulence, in which case journey times will lengthen and jet fuel consumption will increase." ■



British Airways

Flag carrier set a subsonic speed record in February, with a 747-400 flying from New York to London in 4h 56min – helped by Storm Ciara