SUPPORTING EUROPEAN AVIATION

Skyway magazine

EUROCONTROL

AUTUMN /WINTER 2019

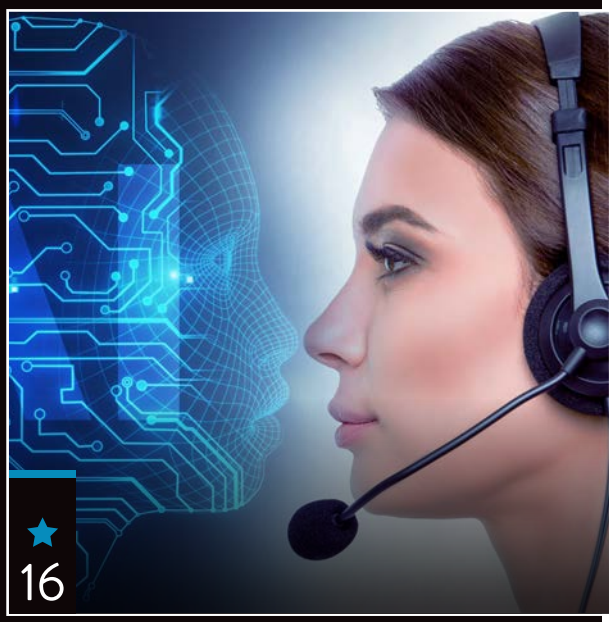
ARTIFICIAL INTELLIGENCE: A NEW ERA FOR AVIATION

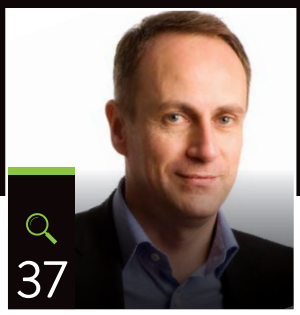
INSIGHTS FROM

PEKKA HENTTU, TANJA GROBOTEK AND IACOPO PRISSINOTTI

A NEW, BIG PUSH FOR MORE CONTINUOUS DESCENT OPERATIONS


ADB SAFEGATE
Boost airport performance
ALL THE RIGHT INFORMATION IN ONE PLACE MAKES IT EASY TO NAVIGATE THE AIRPORT.
THAT'S WHY OUR ONECONTROL SYSTEM PUTS ALL THE INFORMATION AIR TRAFFIC CONTROLLERS NEED ONTO A SINGLE SCREEN.
www.adbsafegate.com





DETAILS

Managing Editors
Lucia Pasquini, Catherine De Smedt

Editor
Philip Butterworth-Hayes

Advertising
Kay Rolland
101 rue de Sèvres
92100 Boulogne Billancourt – France
T: +33 609 133 510
E: kay.rolland@gmail.com

Design and Printing
EUROCONTROL

Contacts

Lucia Pasquini
Managing Editor
E: lucia.pasquini@eurocontrol.int
T: +32 2 729 34 20

Philip Butterworth-Hayes
Editor
E: Philip.Butterworth-Hayes@pmi-media.com
T: +44 1273 724 238

PMI Media Ltd
61 Davigdor Road, Hove, BN3 1RA, UK
www.pmi-media.com

EUROCONTROL
96, rue de la Fusee, 1130 Brussels, Belgium
www.eurocontrol.int

To receive a free copy of Skyway, please subscribe at www.eurocontrol.int/subscribe-to-our-products

Advertiser's index
Inside front cover – **ADB Safegate**
6 & 11/ENAIRE
15/ Indra
25-27/ Indra advertorial
44/Group EAD
50/Hensoldt
Outside back cover – **Aireon**

ATM's need for artificial intelligence

ATM is under great pressure at present. The drivers of the industry are safety, capacity, cost of the service, efficiency (direct routings at an optimal level) and the environment. The relative importance of these fluctuates over time – a few years ago, cost was the main influence on policy; now it is capacity, but with all the other drivers close behind and eager not to be forgotten.

At the same time traffic is increasing (11 million flights in 2018), extreme weather events are becoming more common and we also see airspace closures – typically on the fringes of Europe, or even further away (such as in Pakistan) but all having an impact on traffic flows in the European network, which itself is becoming more inter-connected and more inter-dependent. A staffing problem at one control centre, a thunderstorm or a blocked runway at a busy airport can create disturbances to traffic patterns hundreds of kilometres away, like ripples from a stone thrown in a lake.

And if by chance we have not one stone in our lake, but two or three at the same time, then the impact of those ripples becomes exponentially more difficult to predict.

For me, this is a good example of why we need to embrace artificial intelligence (AI) and to explore how it can help us in ATM. So this edition of Skyway has some very practical examples of what AI actually means for ATM. These include improving the accuracy and speed of existing tasks, such as processing 30,000 flight plans every day and minimising the need for human intervention. We also need to improve the predictability of traffic – looking outside our borders and also using new data flows from airports to find out where the network may become overloaded. For the future, we are moving towards a more interactive approach with aircraft trajectories being updated in real time to adapt to changes. It is closer than one might think and it will certainly mean a step forward in the capabilities of our systems to cope with the flood of data and to make intelligent decisions. This will be essential if we are to handle the levels of traffic predicted, as well as to cope with the new types of traffic, such as drones, that are on the horizon.

However, it isn't all about the technology. EUROCONTROL is a great believer that the kind of change needed to ensure successful uptake of AI should happen from the inside. As part of that, we have recently launched the European Aviation Artificial Intelligence High Level Group, bringing together representatives from both public and private sectors including EU bodies, international organisations in aviation and aviation industry representatives. Working together, the group is committed to develop a roadmap and practical recommendations to accelerate the uptake of AI in our sector and make sure that we can harness its potential for the good of our industry.

Eamonn Brennan
Director General of EUROCONTROL

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

ENAIRE

We are committed
to air navigation
sustainable mobility

NEWS
FROM THE AVIATION NETWORK

EU AVIATION STAKEHOLDERS SIGN JOINT DECLARATION ON THE FUTURE OF THE SINGLE EUROPEAN SKY

September 2019 - at the "Digital European Sky" conference, organised under the Finnish Presidency of the EU, representatives of 21 EU aviation and workers associations sign a joint declaration committing to a set of concrete actions to finally and fully implement the vision of a Single European Sky.

ICAO PUBLISHES ITS 2019 ENVIRONMENT REPORT

September 2019 - the ICAO Environmental Report consolidates all the progress that the international aviation community has made in environmental protection over the past three years, with a range of topical case studies, four of which – on ASBU environmental benefits, global horizontal flight efficiency, CCO/CDO operations and climate adaptation – have been authored/co-authored by EUROCONTROL's environmental experts.

EUROPEAN AVIATION RECEIVES BOOST FROM AIR TRAFFIC MANAGEMENT INDUSTRY

September 2019 - air navigation service provider members (ANSP) of the Civil Air Navigation Services Organisation (CANSO) and EUROCONTROL outline how innovation and partnership in the ATM industry have helped to tackle unprecedented levels of air traffic and improve environmental performance. Success was attributed to ANSPs working better together to redistribute traffic; taking a more Europe-wide rather than national approach to managing traffic; and gaining access to airspace normally reserved for military use.

GATWICK AIRPORT WELCOMES AI TECHNOLOGY TO ITS APRON

September 2019 - Gatwick has become one of the first airports in the world to reduce delays and improve on-time performance with the help of computer vision, directly on the apron. The apron AI technology, from Assaia, uses computer vision cameras pointing down to the stands on the apron to detect events that make up an aircraft turn-round process.

DOMUS TESTS DRONE OPERATIONS IN MANNED AIRSPACE

September 2019 - members of the DOMUS consortium led by ENAIRE complete a SESAR U-space demonstration to show unmanned aircraft can coexist in the same airspace as commercial and general aviation. The exercise doubles as a testing laboratory using a drone and a crewed aircraft.

UDPP SIMULATIONS SUGGEST COST OF DELAYS TO AIRLINES CAN BE LOWERED BY 40% IN CAPACITY CONSTRAINED SITUATIONS

September 2019 - User Driven Prioritisation Process (UDPP) trials at the EUROCONTROL Experimental Centre reveal that by offering airlines an additional set of information, they could optimise the position for a set of delayed flights within their margins, reducing the number of missed passenger connections and lowering the cost of delay by 40% in a capacity-constrained situation.

EUROCONTROL NETWORK MANAGER ANNUAL REPORT 2018: A YEAR OF RECORDS

September 2019 - As the Network Management Board Chair, Simon Hocquard, points out in the EUROCONTROL Network Manager (NM) 2018 Annual Report, 2018 was a year of records for the European aviation network, with traffic up 3.8% on 2017, more than 11 million flights for the first time, and a new busiest day on 7 September, which saw 37,101 flights. However, delays were more than double those in 2017 and three times more than the SES performance target.

BELGIUM INTRODUCES AUTOMATED UTM AIRSPACE AUTHORISATION AND MANAGEMENT SYSTEM

September 2019 - Belgium's air navigation service provider skeyes and the Belgian Civil Aviation Authority have released Droneguide PRO – a system which automates the administrative process for drone registration, flight approvals, dynamic airspace management and other UTM functions. It allows professional drone operators and pilots to access airspace via a web-based application.

NATS SUPPORTS NORTH SEA SAFE DRONE INITIATIVE

September 2019 - UK air navigation service provider NATS is supporting safe access in UK controlled airspace to commercial drone operators for Beyond Visual Line Of Sight (BVLOS) activities over the North Sea. In a partnership between NATS, the unmanned aircraft company FlyLogix and gas multinational Total, the North Sea drone initiative is developing and testing a concept for drone operations that will allow UAV operators to react within hours of an inspection request and enable routine BVLOS operations in the North Sea.

SESAR JU PARTNERS DEMONSTRATE URBAN AIR MOBILITY AT HELSINKI AIRPORT

August 2019 - partners in the SESAR JU Gulf of Finland (GOF) U-space project successfully complete a series of piloted air taxi flight trials at Helsinki International Airport. The flight trials demonstrate the feasibility of connecting conventional air traffic management (ATM) and unmanned traffic management (UTM) or U-space systems to enable urban air mobility.

FIRST WEB-BASED AIRPORT RADAR DISPLAY WORLDWIDE

August 2019 - Hamburg Airport becomes the first airport to operate the new web-based, cloud-enabled radar display PHOENIX WebInnovation from DFS Aviation Services. The radar and flight plan integrated system connects apron vehicles to an airside management network. Drivers can track all flight movements in real time and plan their routes accordingly.

FRANCE'S AIR NAVIGATION SERVICE JOINS THE INMARSAT AIR TRAFFIC MODERNISATION PROGRAMME

August 2019 - Inmarsat, the global mobile satellite communications service provider, announces that DSNA, France's air navigation services provider (ANSP), has signed an agreement to join a consortium of European ANSPs supporting the modernisation of air traffic management (ATM) over Europe through the Iris programme which enables secure, high-bandwidth, satellite-based datalink communications.

SWISS U-SPACE DEPLOYS NATIONAL FLIGHT INFORMATION MANAGEMENT SYSTEM FOR DRONES (FIMS) TO ENABLE A SAFE AND OPEN DRONE ECONOMY

August 2019 - Skyguide, the Swiss air navigation service provider and AirMap, the global airspace intelligence platform for drones, in partnership with the Swiss Federal Office of Civil Aviation (FOCA), announce that they have deployed the Swiss U-space flight information management system (FIMS) for drones.

OPEN DAY ENCOURAGES GIRLS TO PURSUE CAREERS IN AVIATION

August 2019 - NATS, the UK's air traffic control provider, opens its doors to 40 young women as part of a campaign to encourage girls into aviation and aerospace careers. The girls and young women, aged between 13-21, meet air traffic controllers and engineers, while enjoying a day of interactive talks, tours and activities aimed at helping them discover more about STEM (science, technology, maths and engineering) related careers.

LONDON HEATHROW GOES OPERATIONAL WITH INDRA'S LATEST GENERATION A-SMGCS

August 2019 - NATS' air traffic controllers at London Heathrow have started using Indra's latest generation system for Advanced Surface Movement Guidance and Control (A-SMGCS); InNOVA Ground. With the upgrade, the A-SMGCS and the tower displays have been merged into a single integrated system, improving operational efficiency and reducing the need for maintenance.

LAUNCH OF ADS-C PRE-OPERATIONAL DEMONSTRATION

July 2019 - Aircraft operated by easyJet have started exchanging Automatic Dependant Surveillance – Contract (ADS-C) data with air traffic controllers at EUROCONTROL's Maastricht Upper Area Control Centre (MUAC). Air France, British Airways, Iberia, Novair and Wizz Air will soon join the demonstration, which is managed under the SESAR2020 DIGITS project (Demonstration of ATM Improvements Generated by Initial Trajectory Sharing). Using ADS-C technology, aircraft log on to the MUAC system and automatically downlink flight management system information, which can be displayed on the controllers' screens.

EUROCONTROL THINK PAPERS

Using exclusive EUROCONTROL aviation data, EUROCONTROL's Aviation Intelligence Unit has embarked on a series of thought-provoking papers for industry leaders and policy-makers.

Four Think Papers are available to date:

- **Fuel tankering in European skies: economic benefits and environmental impact**
  This paper takes a look at "fuel tankering", the practice whereby some aircraft carry more fuel than required to reach their destination in order to reduce the need to refuel, or avoid refuelling altogether, at that destination.

- **Air traffic flow management (ATFM) regulations: a power for good**
  Flow management regulations are not popular but the mechanism is effective for making the network safer, more efficient and for minimising emissions. They are a key part of the EUROCONTROL Network Manager's flow management system, which is working to ensure traffic flows safely and as efficiently as possible. This Think Paper explores what ATFM regulations are, how they differ from the various reasons for delay as experienced by passengers and shows that their impact can be less than you might think.

- **Cybersecurity in aviation**
  At a time when the average cost of a cyber-attack is now estimated at $1 million the objective of "just" complying with new various cybersecurity regulations is now overcome by events. Our comprehensive penetration tests / ethical hacking on many ATM systems shows that most of them are vulnerable. The paper presents the cybersecurity threats we face and the actions we can take.

- **The aviation network – decarbonisation issues**
  Aviation is a major industry, supporting €2.7 trillion of the world's gross domestic product. Its environmental efficiency has improved, with fuel burn per hundred passenger kilometres falling to 3.4l/100km in 2017, down from 4.4l/100km in 2005. However, it did produce more than 900 million tonnes of CO_2 in 2018 and there is increasing pressure to decarbonise. The latest Think Paper looks at what is being done, including the use of market-based measures, such as the EU Emissions Trading System (EU-ETS) and how air traffic management can play its part.

Subscribe on EUROCONTROL's website to keep abreast of our latest Think Paper publications.

CIVIL AND MILITARY AIR TRAFFIC CONTROL IN BELGIUM TO BE MANAGED WITH A SINGLE AIR TRAFFIC MANAGEMENT SYSTEM

July 2019 - As from December 2019, the military air traffic controllers of the Belgian Ministry of Defence and the civil air traffic controllers at EUROCONTROL's Maastricht Upper Area Control Centre (MUAC) will all be using the upgraded MUAC air traffic management system – a concept known as the Shared ATS System (SAS2). Site acceptance testing – the last major milestone before the system goes live – has been successfully completed and a crewed aircraft.

ENAIRE, key to solving delays in Central Europe

Xavier Benavent, ENAIRE's Director of Operations and Chairman of EUROCONTROL's Network Directors of Operations Group (NDOP), had an important assignment for the summer of 2019 - to **reduce the level of delays and cancellations that occurred in 2018 all over Europe**.

From the beginning of the year NDOP has been working to manage this situation. Air navigation service provider (ANSP) operations managers alongside EUROCONTROL's Network Manager drew up an ambitious plan - as if they were a single ATM service provider - to address the excessive traffic load challenges that presented themselves in 2018 in Europe, in terms of delays and cancellations. As a result of this plan, an important series of measures were taken at the European network level in the summer of 2019, measures that Xavier Benavent says will continue to be developed in coming years. *"One of the main actions involved countries that did not experience severe capacity problems accepting additional flights that were initially planned to be routed through Central Europe,"* he says. *"These were diverted and routed through Spain, rather than busier countries such as France and Germany. A thousand flights were re-routed every day; traffic over central Europe was reduced and this summer has seen far fewer delays. It should be noted that traffic this summer has been much less affected by adverse weather - but we have ensured that the actions we have taken have been crucial in solving problems at the heart of Europe, thanks to the joint coordination process and, particularly, to the work of ENAIRE's professionals in their various departments".*

For Benavent, this way of doing things marks a turning point in the Single European Sky. *"This is the first summer that we have started working with a true network vision, something that the European Union (EU) Transport Committee wants to enhance by urging States to work as a single and better coordinated provider,"* he says. *"The EU, through the study commissioned by SESAR (the Airspace Architecture Study) and the report of the European Wise Persons Group, has issued a mandate to promote the evolution of the Single European Sky to 2035 through the work of air navigation service providers in two key areas: airspace & capacity and scalability & resilience".*

*"**Both areas lay out everything that we providers will have to do over the next 15 years under the SESAR framework**"*, says Xavier Benavent. *"All the projects that SESAR has developed, designed and started to validate are going to be implemented so that we can better face all the capacity challenges to come. At ENAIRE we have our Flight Plan 2025, which, through the Capacity and Efficiency Plan, lays out all the measures and projects we are going to carry out to improve and optimise the provision of the air navigation service in keeping with the goals of the study on airspace architecture, adapting capacity to demand in a completely dynamic way".*

DATA

FLIGHT SHARE BY MARKET SEGMENT

Total number of flights (January - June 2019)
(% growth on 2018)

Source: EUROCONTROL STATFOR

Traditional scheduled 2,819,000 (53.2%) **2.3%** ↑

Low-cost 1,604,000 (30.3%) **3.1%** ↑

-3.8% ↓ **Business aviation** 339,000 (6.4%)

1.2% ↑ **Charter** 186,000 (3.5%)

-5.2% ↓ **All-cargo** 156,000 (2.9%)

-1.7% ↓ **Other*** 198,000 (3.7%)

** Includes "Non Classified" and "Military"*

5,302,000
Total flights in ECAC

% growth on 2018 ↑ 1.7%

BUSIEST 10 AIRPORTS

Total Arrivals & Departures (January - June 2019)
(% growth on 2018)

		TOTAL NUMBER OF FLIGHTS IN 2019 (ROUNDED)	% GROWTH ON 2018
1	Frankfurt	252,000	2.1% ↑
2	Amsterdam Schiphol	248,000	0.0% ↔
3	Paris CDG	244,000	5.0% ↑
4	London Heathrow	237,000	0.8% ↑
5	Madrid Barajas	207,000	4.5% ↑
6	Munich	203,000	2.8% ↑
7	Barcelona	166,000	3.5% ↑
8	Rome Fiumicino	151,000	3.5% ↑
9	London Gatwick	139,000	2.3% ↑
10	Vienna	135,000	14.0% ↑

Top 5 airports per market segment[1]

Total arrivals & departures in January-June 2019
(% growth on 2018)

Traditional scheduled

1	**London Heathrow**	**224,000**	↑ 0.5%
2	Frankfurt	216,000	2.1%
3	Paris CDG	188,000	4.7%
4	Amsterdam Schiphol	176,000	1.0%
5	Munich	167,000	2.1%

Low-cost

1	**Barcelona**	**111,000**	↑ 3.7%
2	London Gatwick	92,000	0.0%
3	London Stansted	82,000	2.2%
4	Istanbul Gokcen	67,000	3.0%
5	Manchester	65,000	6.0%

Business aviation

1	**Paris Le Bourget**	**24,000**	↓ -8.2%
2	Geneva	15,000	-10.9%
3	Nice	14,000	-7.6%
4	Farnborough	13,000	0.1%
5	London Luton	13,000	-6.6%

Charter[2]

1	**Antalya**	**25,000**	↑ 22.7%
2	Sharm El Sheikh	10,000	53.6%
3	Hurghada	8,000	37.3%
4	Kiev Borispol	8,000	22.1%
5	Moscow Vnukovo	5,000	98.2%

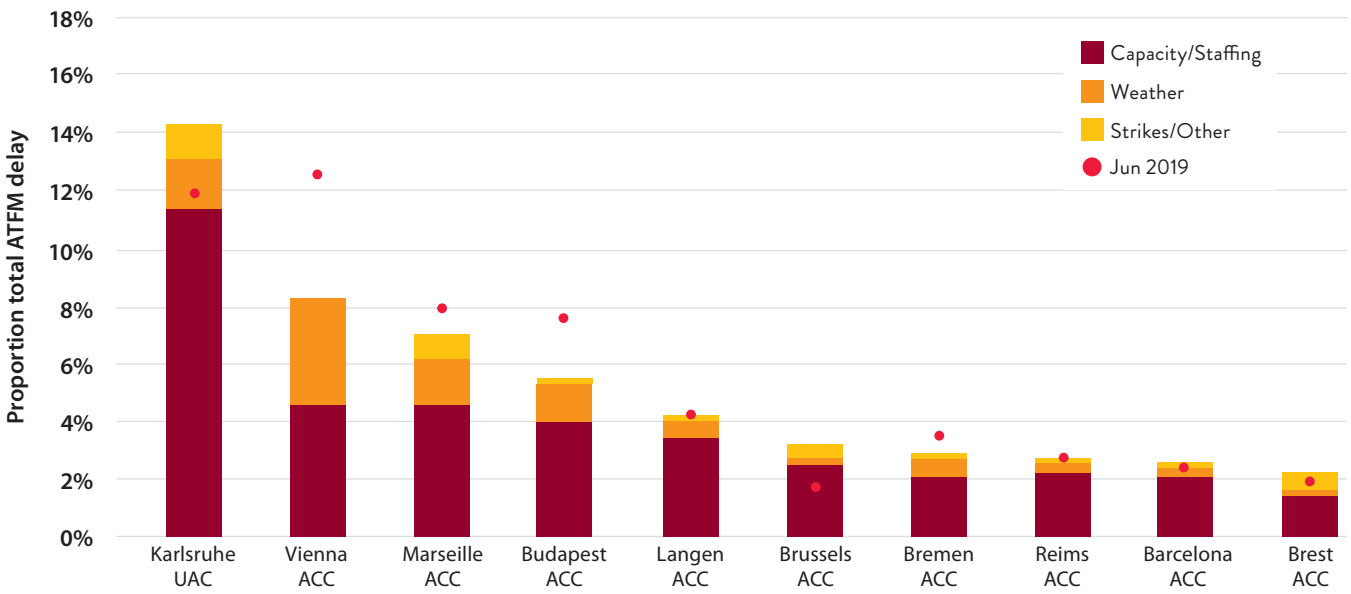
All-cargo

1	**Leipzig**	**23,000**	↑ 2.8%
2	Paris CDG	16,000	0.6%
3	Cologne Bonn	14,000	0.8%
4	East Midlands	13,000	-0.4%
5	Liege	13,000	-2.0%

[2] Helicopter flights were removed for this ranking and out of area airports include only European flights

EN-ROUTE ATFM DELAYS

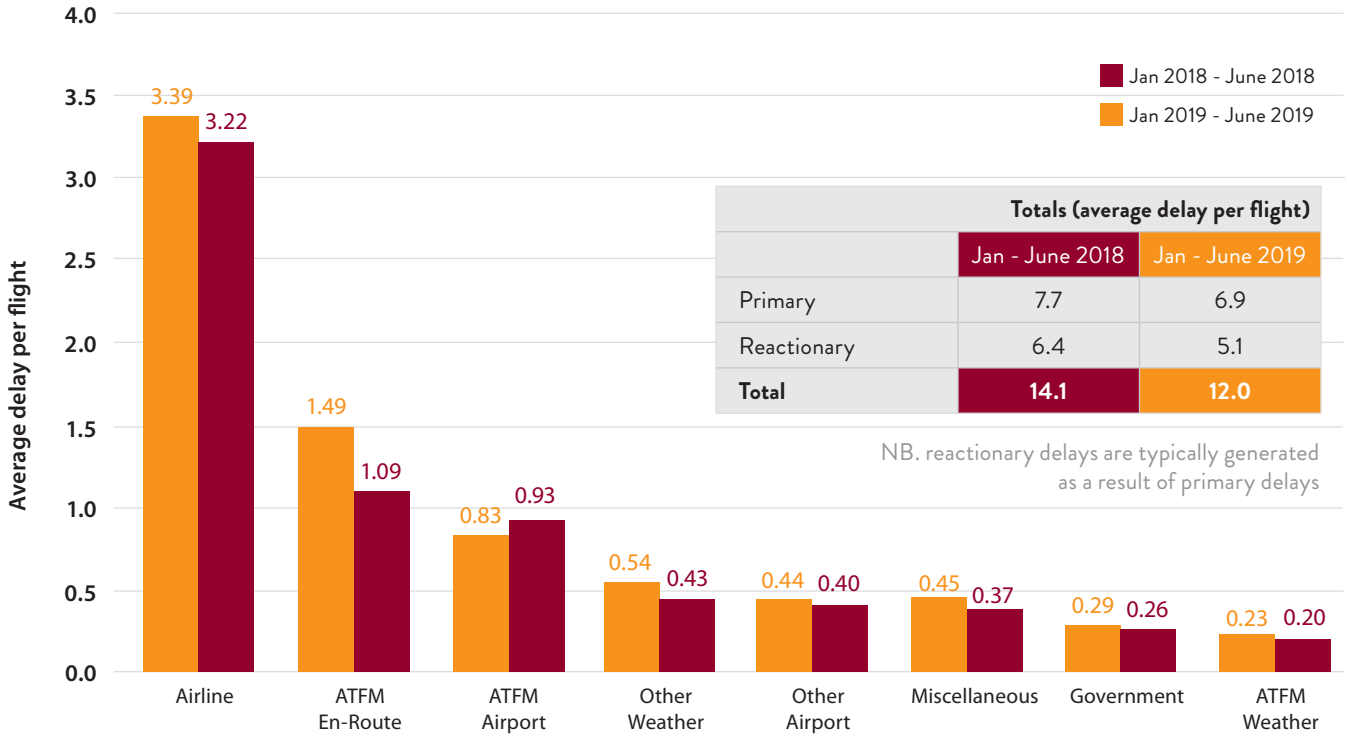
*Top 10 delay locations for January to June 2019**



* *Please note that the network measures this summer have resulted in the transfer of traffic from certain areas (with a shortage of capacity) to others. This graph should be read with this in mind.*

AIRLINE REPORTED PRIMARY DELAYS

*ON DEPARTURE**



Totals (average delay per flight)		
	Jan - June 2018	Jan - June 2019
Primary	7.7	6.9
Reactionary	6.4	5.1
Total	**14.1**	**12.0**

NB. reactionary delays are typically generated as a result of primary delays

* *For more information on the different types of delay in this graph, please refer to the CODA Digest https://www.eurocontrol.int/publication/all-causes-delay-and-cancellations-air-transport-europe-2018*

Creating Skies Together

indracompany.com

In ATM we connect people, places and skies, making everything work. We partner with our clients building the future together.

indra

WHY ARTIFICIAL INTELLIGENCE IS HIGHLY RELEVANT TO AIR TRAFFIC CONTROL

EUROCONTROL is at the forefront of introducing artificial intelligence into air traffic management, paving the way for new levels of predictability, safety and efficiency

Air traffic management stands to benefit significantly from artificial intelligence (AI) by virtue of its reliance on repetitive activity – which lends itself to analysis and machine learning. In addition, much of the complexity is embedded in the driving factors that deliver safe air traffic control: for example flight planning, flow management, safety assessments and conflict prediction. It is no surprise the industry is adopting the technology to enhance both planning and operational activities, and early trials by EUROCONTROL reveal gains of between 20-30% in terms of predictability and efficiency.

AI has been an integral part of the European Commission's Digital Single Market Strategy since 2017, supported by €1.5 billion co-funding under the Horizon 2020 programme from 2018 to 2020. This was followed by a roadmap and establishment of the European AI Alliance in 2018 to put Europe firmly on the path to becoming a leader in the AI revolution.

EUROCONTROL held an inaugural Forum on Aviation and AI in early 2019 which brought together key players and served as the launch point for a European AI Aviation Network. The activity is overseen by Directorate European Civil-Military Aviation (DECMA) Director Philippe Merlo: *"Our first role is to bring all the stakeholders together to enable an exchange of views. We want to define a roadmap with our stakeholders which defines our priorities and most important projects."*

EUROCONTROL is a facilitator in this process, with no vested interests, Merlo says, *"trusted for our neutrality and our expertise"*.

The process is part of a wider activity underway which sets out to deliver an integrated solution coordinated by the Commission. EUROCONTROL plays a central role at a technical level within the Commission's strategic initiative. Philippe Merlo points out the Agency already manages large quantities of ATM data in its role as Network Manager (NM) and this offers many opportunities for machine learning and AI. For example, the repository includes flight plans, radar tracks, meteorological data, safety incidents and special events, all of which can be interlinked to achieve a higher level of safety. With only a small percentage currently used, Merlo says the amount of relevant information extracted could increase dramatically with the help of AI: *"We believe we can develop conflict prediction tools and complexity assessment tools which can mitigate risky situations much earlier in a flight."* The activity will extend beyond safety and capacity to address environmental factors and cost efficiency.

An important first step towards achieving this level of connection is to complete implementation of the System Wide Information Management (SWIM) network as envisaged under Single European Sky (SES) legislation. This network interconnects all the ATM players – from airlines to airports and ANSPs – with seamless access and interchange of information between providers and users of ATM data and services. Simply sharing data in the first place brings huge benefit to operators in terms of better planning and collaborative decision making. "Once you have the data, you are in a position to take the second step and apply AI to analyse this large volume of data and identify opportunities to increase efficiency," says Philippe Merlo.

The first applications are air traffic control planning and flow management, where EUROCONTROL trials already show 30% improvement in trajectory prediction. Work to date looks at where safety can be improved, and delays reduced. Examples include the development of conflict and complexity prediction tools which can anticipate a risky situation based on past data, and can lead to mitigation much earlier in the flight. *"We already have tools which analyse trajectories automatically, can detect conflict risks and help air traffic controllers to avoid errors. Human errors are rare, thanks to controllers' training and skills, however, they remain the biggest safety risk in ATC, and this technology can trigger an alert and present what-if scenarios."* Philippe Merlo says environmental impact could be included in the future to expand the application to support optimised flight trajectories, and the agency is also investigating the airport environment where the technology could help to improve navigation around the airport surface.

Satellite navigation is another area where early research shows AI can add value. Satellite signals can be affected by atmospheric conditions which change with the seasonal equinox cycle. AI technology is being used to identify and isolate instances of ionosphere error to improve the prediction and likely impact of this phenomena.

Another promising area for the future digital environment is strengthening safeguards around cyber security. Philippe Merlo says AI can play a role in *"monitoring the flow of data between your own ATM system and that of your neighbours. It becomes easier to identify abnormal data flows, or messages coming from unknown sources, to show where there might be a security breach."*

Within the framework of SES ATM Research (SESAR), EUROCONTROL is applying AI to support the latest re-categorisation wake vortex separations applied to ensure safe separation between aircraft on approach.

The Agency has amassed a large database from re-categorisation research projects worldwide which is growing year on year. It includes trajectories from airports in Dubai, Singapore, Paris and London which are being used to determine the reliable safe vortex separation distance for different aircraft types.

The greater the volume of data, the better the outcome, especially when it comes to predicting flight profiles. EUROCONTROL currently exchanges flight data with the US Federal Aviation Administration (FAA) and service providers in the Middle East, and is in discussions with providers in Brazil, Japan, China and India. This will lead to the exchange of flight-plan data from the moment a flight departs, resulting in more accurate trajectory prediction.

EUROCONTROL is applying the same principle within Europe to improve information exchange across all airports. *"Today the large airports are well connected, but almost a third of the traffic departs from smaller airports so we need this data too,"* says Philippe Merlo. *"We have started a campaign to encourage these airports to connect to the network."* Sharing data with Network Manager will lead to improved trajectory predictions.

Air traffic management is a human-centric activity and software development is viewed with caution by experienced operators. Experience has taught them to rely on their own skills in case of failure and the digital environment presents new challenges. EUROCONTROL is investing in training programmes for existing staff to establish trust in the new technology, and has launched a recruitment effort directed towards attracting skilled AI operators.

Longer term, EUROCONTROL is engaging with the European Aviation Safety Agency (EASA) to develop an appropriate certification process. Philippe Merlo describes this as another kind of challenge: *"When you work with AI, you are dealing with probability. It provides a prediction, not a determined outcome. Is it possible to certify a probabilistic tool? I believe it is possible but this involves working closely with EASA."*

The digital environment also needs to be secured against cyber-attack. This is especially important as data access grows. Data sharing needs to be secure and reliable to deliver quality information across the network. AI projects tackle these issues in preliminary project phases, for example by selecting only appropriate data and removing unwanted data before any analysis takes place. *"We are very much in favour of open data policy,"* says Philippe Merlo. *"We are developing specific AI tools which can be used to clean data before it is used. In a similar development, AI can also be used to monitor cyber activity by analysing abnormal data flows, however small."*

He believes AI will change the role of the controller for the better. *"The main objective is to improve the efficiency of the working position. AI can give more priority to traffic management instead of tactically avoiding conflict. We've been working on this for 15 years, but thanks to AI we are now in a position to develop better advisory tools for the controller, and simplify the link between strategic and tactical air traffic management."* ■

Philippe Merlo
Director European Civil-Military Aviation,
EUROCONTROL

EUROCONTROL

In collaboration with

ACI EUROPE
AIRPORTS COUNCIL INTERNATIONAL

DIGITALLY CONNECTED AIRPORTS

MEETING THE CAPACITY DEMAND 2030

27 FEBRUARY 2020

EUROCONTROL's Brussels Headquarters

Participation is on invitation only.
For further information, please contact: airport2030.conference@eurocontrol.int
or visit: www.eurocontrol.int/event/apt2030-conf

EUROCONTROL CAN PLAY A KEY ROLE IN CONSOLIDATING AI DATA TO BENEFIT ALL STAKEHOLDERS

EUROCONTROL has taken the first steps to developing artificial intelligence (AI) solutions to predicting traffic loads – the next big step will be to start researching ways AI can be used to assist the controller.

For researchers at the EUROCONTROL Experimental Centre (EEC) in Brétigny-sur-Orge, the application of artificial intelligence to safety-critical air traffic control operations has always been a distant prospect. Until now.

"We have been working with AI for eight or nine years now," says Pierre Andribet, Head of Research and Development at the Agency. *"Three years ago we started a programme in cooperation with a number of universities to use AI for predicting controller workload and sector capacity, aircraft trajectories and runway capacity. Previously, the mathematical models on aircraft performance we used had clear limits and levels of uncertainty. When we applied the statistical approach of AI we had better results and saw the possibilities of moving quickly from exploratory research to deployment. Now, for the first time, we are starting to consider whether we could use AI for some safety-critical tasks – an area we have not been able to consider before. We think now is the time to start considering this, with the aim of producing the first tools within 10 years."*

So what has changed? Why are researchers only now starting to consider what kind of research will be required to move AI into the control room, with the ultimate promise of changing the nature of the controller's task from tactical air traffic control to airspace manager – something which has been an industry goal for decades?

There are three reasons why the time might now ripe for such exploratory research to start.

First, there is the work being undertaken elsewhere, by aircraft manufacturers for example, who have begun to look at how AI could be introduced into the cockpit.

"We are now starting to see other stakeholders looking at AI," says Pierre Andribet. *"We are seeing airlines starting to optimise their operations using AI while Airbus, in cooperation with universities such as the famous Montreal AI centre of excellence, is beginning to look at how AI could be introduced eventually into safety-critical zones of aircraft operations, such as single-pilot configurations. When I talk to manufacturers such as Airbus they say they are convinced many things are possible but it will take time.*

"Until now, these safety-critical zones have been a no-go zone for us but we should now start looking at how automation could eventually help the controller, perhaps during low traffic periods."

Initially new AI tools could help the controller at the planning stage; more accurate traffic-load predictions will mean Network Manager (NM) operators could start to reduce some of the buffers placed into the system as a result of uncertain predictions of traffic loads in a particular sector. *"The more we improve the prediction, the more we can relax the buffers while maintaining safety – you can only remove these buffers if you have clear evidence we are not touching safety,"* says Andribet.

Second, AI technology has evolved in terms of data management, tools, processing power and data manipulation while new skills have been developed in university research

centres. As the technology has matured, the comfort levels in the Agency with AI and machine-learning techniques have started to grow as the benefits of AI have become apparent. Over the last few years the Agency has looked at introducing AI techniques for more than traffic load forecasts. For example, it has also developed new tools to forecast the impact of the ionospheric effect – where global satellite navigation system signals slow down as they pass through the charged particles of the ionosphere, then through the water vapour in the troposphere – on navigation performance and improve predictability of the system's performance.

Third, there is a new understanding of AI that can be specifically applied to aviation to improve the performance of all stakeholders. And here, believes Pierre Andribet, data-sharing is the key.

"I think the development of AI in aviation is a question of synergies," he says. *"We have many data sets in aviation but we only use a small portion of the data and the benefits will be realised in proportion to the amount of data we can access. If we can find a way to federate data from airlines, manufacturers, NM, airports and air navigation service providers while protecting confidentiality, then the benefits for all stakeholders will be substantial. However, at the moment data is in many places. We have started to talk with partners to discuss how NM might in the future be able to share data collected on board aircraft and we are talking to airports, too. What we must demonstrate is that by sharing, all individual actors will benefit more."*

In May 2019 EUROCONTROL organised a multi-stakeholder AI event in Brussels to raise the aviation community's awareness of potential benefits of AI, and the need to start the process of data-sharing for AI advancement was loudly voiced. It is a role that EUROCONTROL is ideally placed to play, Pierre Andribet believes. The Agency is neutral, pan-European; it has a history of being able to find common solutions and is linked to all the major actors, including regulators and research agencies.

"We have started to launch a partnership network with aviation stakeholders to see what can be done – what we would like to do is create an innovation lab for AI using data federated among actors," says Andribet. *"Partnership is the key."*

But there will be many challenges to overcome before AI can deliver the potential network management benefits which experts believe are possible. It will take time to convince all stakeholders that data-sharing is really in their interests and that a framework has been put in place which achieves the right balance of protecting confidentiality while ensuring clear operational benefits. New levels of trust will have to be built among pilots and controllers that AI-based technologies will reduce workload, increase performance and enhance, rather than compromise, safety. A common understanding needs to be reached on cyber protection and data management. Universities must be brought into the aviation AI community in a systematic way, so people with the appropriate skills can appreciate the benefits of working in the aviation sector. Most importantly, regulators will also need to have access to AI knowledge and skilled personnel in a way which will allow them to make independent judgements on the safety of new AI technologies. Regulators are currently staffed by professionals with many decades' experience in aviation and aerospace; it will be impossible to simply employ AI technologists directly from universities and research centres.

Then there is the question of global competition. There are no Googles, Facebooks, Microsofts or Amazons based in Europe, attracting skilled technologists into the private sector straight from university. China is starting to invest heavily in AI.

But Pierre Andribet is optimistic that Europe has a key role to play in this area, despite global competition.

"Most of the AI tools we are using are public and widely used and I don't think Europe is lagging behind in terms of skills and education; I know it is a priority of the European Commission to develop even more new technical universities. It is true we are not filing as many patents as in the USA but we are developing the schools and aviation is an attractive employer. I am confident we have the capacity to retain the skills – but we will need access to volumes of data and if we cannot accelerate this access, we cannot develop.

"AI is embedded in our work now; it figures in at least 15 research programmes," he says. *"It will be a necessary tool in many aspects and used in almost all our different areas of research. The goal is not to build a team dedicated to AI, but to have teams dedicated to managing data, with people using AI technologies in many domains – NM, ATC, airports and even communications, navigation and surveillance (CNS) technology research. The key issue is to bridge the gap between the people who know their domain and the people who know AI. But we need to act now, we can't wait for five years."* ■

Pierre Andribet
Head of Research and Development,
EUROCONTROL

IMPROVING FORECAST ACCURACY THROUGH THE INTELLIGENT APPLICATION OF AI

New machine-learning techniques need to be applied very carefully if we are to improve forecasting accuracy at a time of increasing air traffic volatility.

In the world of air traffic forecasting there is a race underway. On one side the industry is becoming less predictable, more prone to sudden swings in industrial, economic and environmental turbulence. On the other, our understanding of the key patterns which provide indications of future demand is improving. New artificial intelligence (AI) techniques and associated improvements in the understanding of air traffic dynamics mean that, despite increased volatility, our ability to improve the accuracy of forecasts is making small but almost constant improvements.

"We're always on the lookout for new techniques that are going to improve the forecast, but techniques are not the whole picture," says Dr David Marsh, Head of the Forecast and Network Intelligence Unit at EUROCONTROL. *"It is a combination of techniques, data and collaboration with local experts; and it's these three working together that is really making a difference.*

"With an economic forecast you are predicting what the outcome will be from the interaction of millions of people and thousands upon thousands of enterprises. When we're forecasting air traffic movements in Europe, we're dealing with relatively small numbers of countries, airports, aircraft operators and aircraft types – which means that one event or one decision by a carrier can significantly change the traffic in several countries. So it's almost something that's not statistical."

For the last few years AI has given EUROCONTROL a set of highly capable new tools in their predictive analysis toolbox – but applying these tools in a way which generates real improvements in forecasting accuracy is a highly complex task. For example, one of the most popular AI-based analytical forecasting tools is XGBoost, an ensemble learning method, relying on a powerful algorithm with scalability that drives fast learning through parallel and distributed computing and offers efficient memory usage. EUROCONTROL tried applying this technique to improve overflight trend forecasts – but the results were disappointing.

"There's an important lesson here: with AI and data science you have to be prepared to try something and recognise that it's not working and stop until you've got a better idea or new data comes along or there are some other techniques that you can try," says David Marsh. *"Because not every AI project is successful and if you're going to innovate, then some of the time it's not going to work. Time and again in forecasting we find that we come up with a good method which seems to work in a small example, but when we apply it across the network it improves predictions in 51% of States but produces worse results for the rest; worse still, you can't tell in advance which State will be better and which worse. Unless there is a proven, consistent improvement we cannot adopt it."*

But when AI does work, the results can be impressive.

"The forecasting system is based on a wide number of different components," says Dr Claire Leleu, Forecasting Manager in EUROCONTROL's Statistics and Forecast (STATFOR) department. *"We isolate the trends, the relationships between the different factors into components, and ultimately improve the quality and performance of the final forecast. For example, we have put a great deal of effort into forecasting zone pair flows, to determine exactly how many more flights there will be between one zone and another at some time in the future. We have contracted a company to use new machine-learning techniques to help us with this. They have brought more input into the calculations than just the core gross domestic product (GDP) data we were using and the results have been very positive."*

EUROCONTROL tested this new AI approach on seven traffic flows across the North Atlantic. The data provided was weekly traffic records stretching back to 2010. On these pairs, the machine-learning process reduced the median absolute error, by between 8.5% to even 71% for some pairs compared to the STATFOR median absolute error, for a specific year.

According to David Marsh: *"They adopted a classic AI machine-learning approach, which analyses thousands of different types of exogeneous data, more than any analyst could make sense of. The machine-learning system selects the most relevant data sets, producing something more accurate than if the forecast was based on core GDP data. As a result we are re-engineering, restructuring the way we undertake our forecasts to exploit this."*

> "You have to have good data, good techniques and good collaborators who know the local situation to produce the most accurate forecasts."

But relying too much on machine learning can be a dangerous business, EUROCONTROL has found. EUROCONTROL has been using a highly automated, long-established machine-learning system for many years, implementing the Autoregressive Integrated Moving Average forecasting approach (ARIMA). But even after the input data has been validated and checked the system can still generate what forecasters call "monsters" – a few results out of the 10,000 generated which are absurdly extreme. At the moment, cleaning up the monsters is a human-based activity; they have trained an automated system to spot absurdities, but defeating them is not easy.

This is where EUROCONTROL has developed a specialist expertise – identifying the most effective mix of AI and other modelling techniques then balancing this with expert, human analysis. The Agency does not create new statistical modelling techniques, but it does combine them in novel ways into a framework which is unique. As a result, the forecasts produced by STATFOR are both continuously improving and consistently more accurate than comparative industry performance. At the moment, it seems, STATFOR is slightly ahead of the industry's volatility challenge.

"We believe that you have to have good data, good techniques and good collaborators who know the local situation to produce the most accurate forecasts," says David Marsh. "AI would struggle to synthesise the information we get from local experts across Europe."

"Maybe not everything should be AI," says Claire Leleu. *"At the moment we can control everything in our toolbox; we know that if we have this input and press the button we will get a certain output which is linked to what we already know. But with the quantity of data you can inject into your systems with AI, that will no longer be possible. Having said that we do need to benefit from these new techniques when it comes to the problem of volatility. Routes can change for many reasons and the explanations are not necessarily clear, but it's very important to be able to figure out what's behind the volatility."*

As turbulence within the European air travel market is predicted to grow over the coming years, the importance of identifying and exploiting new AI techniques – and then learning how best to apply them – will also increase.

"It's perhaps easier to find reasons as to why things have happened than to project them forwards, but one of the lessons from the high-volume input study that we have done recently is to look at how additional sources of information – trade, holiday patterns, migration patterns or population structure – could perhaps make volatility more understandable," says David Marsh. *"Then the challenge will be to project those things forward so we will be able to explain this particular increase in tourism in terms of a change in the exchange rate. That's good, but how do I forecast that exchange rate going forwards?"*

While more data will be required to understand the nature of volatility, it is not the volume that will help but the quality and relevance. The key will be to take increasing amounts of data and reduce it to some underlying trends that will generate a base forecast.

"We're constantly aware of it. In terms of the volume of data, there's a basic discipline we have to teach analysts when they arrive in STATFOR which is beware of launching analysis on the data," says David Marsh. "You have to reduce the sample first, otherwise you will just clog up the analysis framework."

"There's a lot of evidence that, if you can forecast in two or three different ways from different data and then you combine the output, you get something which is more robust and more accurate," says Claire Leleu. *"That's exactly what we do in STATFOR. We have this panel approach that we use in the forecast, and I think any AI will need to be part of a panel. Maybe it will be a panel of different AIs, but that's the way to defeat the monsters and improve the overall system."*

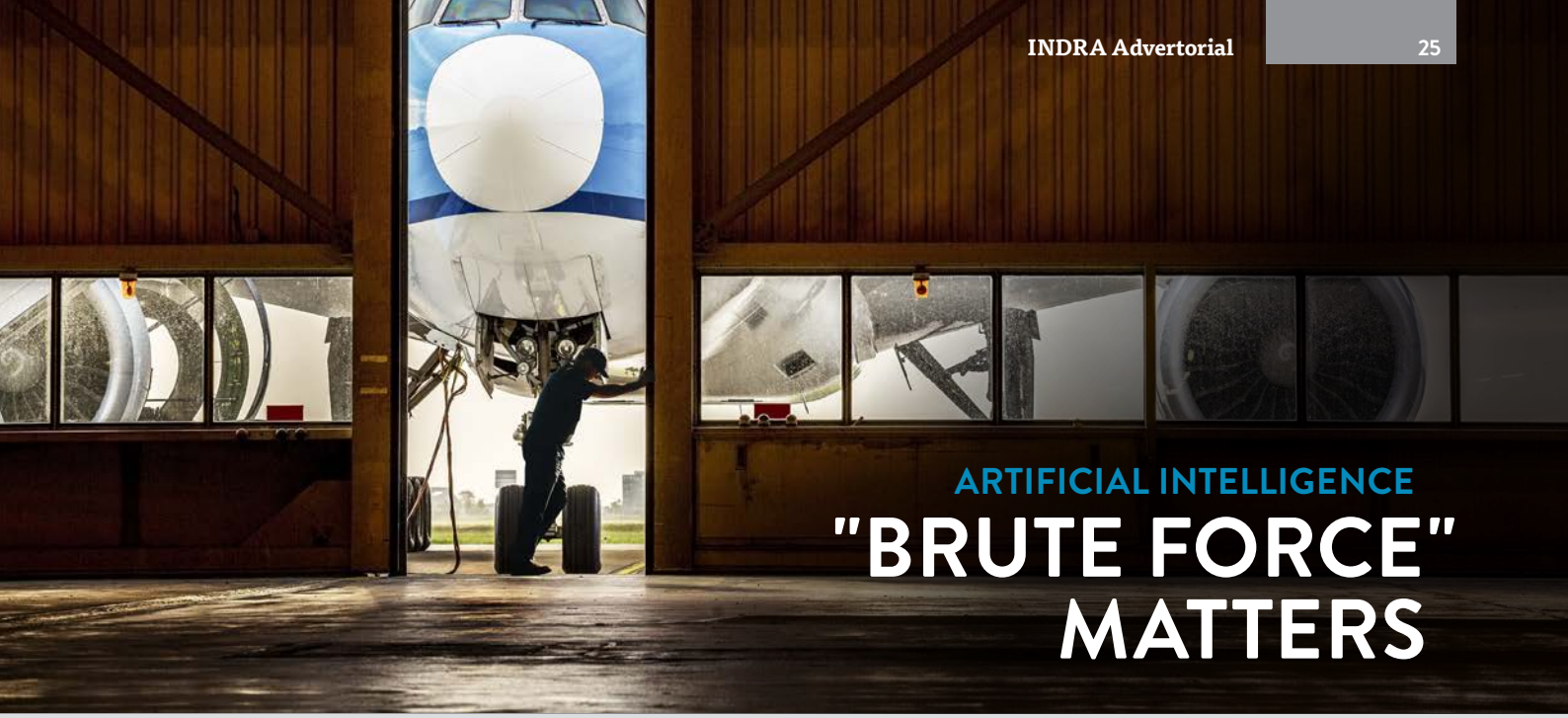
RESULTS FOR 2018 SHOW CONTINUOUS TREND FOR MORE ACCURATE FORECASTS

For all seven-year forecasts produced since 1990 by STATFOR the median error is 0.5%, so forecasts have been just slightly low. The corresponding Median Absolute Error per year is just below 3% and the mean relative performance (when compared to a same-as-last-year-growth forecast) is 1.81 which means that STATFOR forecasts have been 81% more accurate than the benchmark.

In 2018 the median error per year was small, at 1.1%, and the median absolute error per year was 2.1%, one of the lowest errors ever recorded by STATFOR. The 2018 forecast was 104% more accurate than the same-as-last-year growth baseline. ■

Dr David Marsh
Head of the Forecasts and Network Intelligence Unit,
EUROCONTROL

Dr Claire Leleu
Forecasting Manager,
EUROCONTROL



ARTIFICIAL INTELLIGENCE

"BRUTE FORCE" MATTERS

Artificial intelligence (AI) has the power to transform and revolutionize almost any industry in the world; almost no one denies that statement nowadays. While there is a massive hype around AI, it is also important to highlight that some impressive applications such as self-driving vehicles, virtual assistants or agents dominating complex videogames, have been developed in the last few years proving not only the power of AI, but also that the development of the discipline will not stop again.

On the most lucrative side of the technology, internet giants such as Google, Facebook or Netflix have developed applications that are generating literally billions of dollars by leveraging on recommender systems. Other than making money, those companies must also be credited for being able of developing systems for other purposes, such as natural language processing or computer vision, achieving unthinkable levels of performance and pulling the entire AI discipline forward. Similar achievements cannot be found easily in other industries, companies or research centers and one of the key reasons for that is "brute force". When developing AI systems, "brute force" in terms of money, talent and data matters, and it matters a lot.

As an example of "brute force" in terms of money, it has recently been published that Apple's R&D budget is almost equal to the total R&D funds of Spain from private and public sectors combined. In terms of AI talent, Internet Giants have the equivalent budget of an entire continent. Other than thousands of world-class engineers from the best technical universities in the world, almost all top researchers of the AI field work for those companies. In terms of data, the distance to the rest of the world is even larger. It was recently published that Waymo, Google's self driving car company, has self-driven more than 8 million miles, which is roughly four times more distance than all other competitors combined. On another example, Facebook computer vision systems are trained with a database of more than 3.5 billion images fathered from Facebook, Instagram and other sites.

Most industries cannot easily reach that kind of scale and therefore results of AI systems cannot be expected to be so impressive, despite of AI being a perfect fit for solving some of the most critical challenges of those businesses, as it is the case of the banking, telco or health industries.

In **aviation**, the situation is a little bit more complicated. On one hand, the industry is facing huge challenges in terms of increase in flight volume and strengthening efficiency, safety and environmental requirements. On the other hand, despite of being AI one of the key technologies that can definitely help to overcome those challenges, and despite of being the industry very familiar with automation systems since at least the 50's, there is still a lot of room for improvement in terms of deployment of large-scale AI applications.

Should the aviation industry want to leverage on AI technologies in order to overcome its main business challenges, one feasible approach could be designing a path as parallel as possible to the one followed by the internet giants, which will require to analyze three areas very carefully.

First area is volume; compared to the internet industry, players in the aviation industry are not so large in terms of availability of resources to be allocated in AI initiatives and data is not so abundant. Probably, no individual stakeholder in the industry has the available resources needed to develop large scale AI applications that can transform the industry significantly. Secondly, and much more importantly, in aviation there are very strong constraints in terms of regulation and safety requirements of IT systems. New techniques have to be develop for assessing AI systems before they can be integrated in a real operational environment. Third area is standards and homogeneity; systems must be homogenous so information and results can be shared among many stakeholders involved in aviation operations.

In order to advance in those three areas, it could be a good idea to coordinate joint efforts at European scale from a sort of "central AI organization". For this purpose, either one of the current European entities in the aviation industry could take the lead or a new entity could be created. In any case, should Europe want to become a serious player in applying AI for transforming the aviation industry, as many human, technical and material resources as possible should be allocated in that organization in order to boost at least three working lines.

1) Evangelize and disseminate knowledge

Not only knowledge about AI techniques and applications but also about a concepts that constraint the development and integration of AI applications in the industry. As an example, there is currently a debate regarding the certification of non-deterministic software. Many people think that machine-learning systems are non-deterministic while the reality is a little bit different. It is true that the training process could be non-deterministic, basically due to random initialization of parameters, random selection of examples in training or the use of techniques that involve randomness such as drop out regularization in neural networks. However, it is important to highlight that, when training is finished and the system is "frozen", and therefore parameters do not change anymore, most machine learning systems, not to say all of them, are absolutely deterministic in the inference phase.

Transparency or "explainability" of machine learning systems is another good example. Some techniques, and usually the most powerful ones, are just not explainable in the sense of being able to fully understand every detail of why given a certain input the system generates a certain output or, even more importantly, why given two "very similar" inputs, the system generates totally different outputs. There are many reasons for this such as high dimensional inputs, which increases the complexity of understanding relations among features in the input vector; encoding mechanisms which usually converts a high dimensional vector of "natural features" into a low dimensional vector of "synthetic features" by a transformation that depends on the specific training data; and finally, computational flow in some architectures such as deep convolutional neural networks or recurrent neural networks, is so complex that backtracking calculations for deciphering computational flow is almost impossible.

In both cases, clarifying those issues is critical for the development of AI applications in aviation. The industry needs to feel comfortable with modern AI systems and their idiosyncrasy in order to gain user, regulator and any other stakeholder acceptance for stimulating the deployment of large-scale systems.

2) Develop standards

Defining operational performance standards is a critical task for the development of AI applications in any environment subject to strong safety requirements. The usual is starting by defining a baseline that can be used as a benchmark of performance and, given that most tasks and processes are currently executed by people, the usual is measuring human performance in a certain task and take it as the benchmark. There is a popular rule of thumb in AI that claims that, on average, human performance in any "cognitive" task, ranges between 93% to 98%. Even for something as simple as distinguishing pictures of dogs and cats, people use to make errors because of being tired, distracted or bored, or being pictures very blurry, or having a bad visual angle or whatever other reason.

The main idea is that statistic-based AI systems will always make some mistakes, the same way humans will always make some mistakes. Since we know how to live with that with humans, and handle errors when needed, there is no reason to think that we cannot do the same with AI systems.

In order to address this issue, the suggested organization should define operational performance standards for different use cases as well as the minimum performance required for an AI application operating in a certain real environment. The industry needs to be comfortable with statistical measures of performance and learn how to deal with cases in which AI systems do not perform so well.

In order to assure safety and reliability, all AI systems should be submitted to a central organization to execute an objective statistical test of performance in order to verify its generalization capabilities. For any AI system, it is critical to assess the "statistical significance" of the dataset used to train it, as well as performing other statistical tests in order to verify that data is not biased, incomplete or corrupted in any form, since its generalization capabilities, and therefore the reliability of the system performance when deployed in different operational environments, rely very heavily on the data used for training.

3) Boosting development of AI in the aviation industry

First by gathering data and putting it at disposal of the different companies, research centers or entities that aim to develop AI applications. As we said before, "brute force" matters, and big volumes of data are critical for developing high accurate AI applications. The more data the better and this is not just an opinion. The beauty of AI systems is that sometimes business decisions are driven by mathematical results. In the case of AI, it is important to keep in mind the Vapnik–Chervonenkis inequality. It illustrates the relation among the amount of data, the power of the AI technique, in the sense of the complexity of the pattern the system can learn, and the generalization capability of the system. It states that the more data, the more powerful system can be used for a problem and the better generalization can be achieved. Therefore, gathering huge amounts of

11:14:21

OPERATIONAL PERFORMANCE STANDARDS OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN IRTOS 2.0

As an example, IRTOS 2.0., the second generation of Indra's remote digital tower platform, to be released in early 2020, is being enhanced with several advanced computer vision applications that will not only support and enhance tower control operations by displaying augmented reality on panorama screen, but also will perform other inspection, detection and surveillance processes autonomously, raising alarms and notifying controllers when needed. Since neither high rates of false negative alarms that can imply missing relevant targets, not high rates of false positive alarms that can annoy or distract controllers, are tolerated in the aviation industry, we had to define a very ambitious performance rate for all those applications. In particular, our target is achieving an accuracy rate (average precision including detection and classification among all categories of objects and / or events to be identified) higher than 90% for any application in any deployment scenario.

For being able to achieve such a high performance rate, our applications have to be based on state of the art "more than 100 layers deep" convolutional neural network architectures, that are being trained with literally thousands of hours of video recordings of airport operations.

The goal of the AI based set of computer vision applications of IRTOS 2.0. is two-fold. First, we want to deploy the best set of visual systems for enhancing and simplifying tower control operations, ranging from "basic" object detection and following systems to very advanced "event detection and verification" applications that can perform some processes autonomously. In order to make this possible, we think that 90% is the minimum acceptable performance rate that will enable industrialization and deployment in a real operational environment. Secondly, we also want to set the first operational performance standard in order to raise the bar for the whole industry and stimulate the improvement of visual systems in aviation.

data is a mandatory requirement, should high accurate AI applications for complex problems have to be developed. By gathering aviation data from many different stakeholders of the industry, huge databases at European level can be created for enabling the development of large scale applications with outstanding generalization performance. As in the case of ImageNet, MNIST, COCO or other datasets that had a crucial role in training AI systems in other industries, aviation databases should be shared with industry members and stakeholders in order to stimulate the development of AI applications.

Secondly, the industry could also benefit from additional sponsorship, managed from a central organization. Complementary to the initiatives currently undertaken by SESAR, such as those included in "Exploratory Research Call H2020-SESAR-2019-2" or in the" Initial Wave 2 Candidate SESAR Solutions" project calls, some additional funding could be raised to promote contests, which have been proven very beneficial to stimulate development of AI applications in other industries. As an example, most technological advances in self-driving cars and physical robots have been developed in the context of DARPA's contests. Deep learning took off after the impressive results of Geofrey Hinton's team in 2012 ImageNet contest. And so on and so forth. Funding research, demanding clear and objective and creating a healthy competitive spirit has been proven to work very well for boosting innovation.

In summary, should we want to develop large-scale artificial intelligence applications to address the main challenges of the aviation industry, we will have to combine our talent, resources and capabilities at European level. It is fair to say that we have all we need; we just have to show our determination to do it.

For further information, contact our expert:

indra

Rodrigo Garcia
Head of Artificial Intelligence, ATM business unit
rgsaiz@indra.es

SMART CONNECTIONS FOR SUSTAINABLE GROWTH

Pekka Henttu
Director General - Aviation,
at the Finnish Transport Safety Agency TraFi

As the President of the European Union, Finland is focusing on a proactive approach to safety, efficiency and sustainability.

Finland's presidency of the European Union (EU) began on 1 July, just 10 days after the European Council agreed the EU's strategic priorities. The new Presidency got underway at a significant time, not just for the EU but also for aviation – capacity constraints in the European sky are acute, environmental questions are more focused than ever. And at the time of writing, preparations for the International Civil Aviation Organization (ICAO) Assembly 40 were almost on short final.

Finland has four main policy elements on transport and communications: digital transport; services; transport automation; carbon-free transport and data economy. According to Finnish Minister of Transport and Communications, Sanna Marin, the four elements are closely linked.

"Data economy, digital transport services and transport automation offer opportunities for creating more efficient, safer and more comprehensive transport and communications services and for providing sustainable growth in the EU. To achieve the climate objectives of the Paris Agreement we need rapid emission reductions in the transport sector.

"The four themes are closely interconnected especially when digital transport services and automation are largely based on the more effective use of data. With the help of new technologies, we can also ensure significant emission reductions in the transport sector.

"We have chosen the motto 'Smart connections for sustainable growth' for our presidency in the transport and communications sector. This reflects not only the close connection of transport and communications services in the digital age, but also the future needs in developing networks. The EU's transport and communications policy should be smart and sustainable."

Today's performance of the air traffic management network does not serve airspace users or passengers in the way it should. Completion of the Single European Sky (SES) is a high-level priority for the Finnish Presidency of the Council. We support and want to promote the recommendations presented in the Airspace Architecture Study and the Wise Persons Group's report (see recommendations overleaf). We also emphasise the statement that safety, security and environmental elements have the highest priority when implementing the recommendations. When putting new technology into operation we should be ambitious by looking for a higher safety level than the existing one.

Trafi
Finnish Transport Safety Agency

To promote the activities that will improve the performance of European ATM, the European Commission and the Finnish Presidency of the Council organised the Digital European Sky High Level Conference on the Future of the Single European Sky, held in September this year. The commitment of the stakeholders and States for the agreed actions is vital to improve the performance of the network – each of us has to share responsibility.

The Finnish government´s climate goals are extremely ambitious. We also think that Europe has a unique opportunity to take the lead in sustainable solutions, and aviation is no exception. We have advanced technology in the aviation industry and sustainable aviation fuels. Proactive politics creates markets and business opportunities.

Aviation growth must be sustainable: this is not negotiable, and we are sure that consumer behavior will reflect that in the future. This also has to be reflected in European legislation and in global ICAO rules.

Stakeholder events organised with the Commission include a High-level Conference on the Future of Single European Sky (Brussels), Digital Transport Days (Helsinki) and a Data Economy Conference focusing on human-centric data economy with a competitive edge (Helsinki). These events are for strategic discussions in transport and communications – for cooperation and commitment to common goals.

Ahead of the ICAO Assembly (scheduled for between 24 September and 4 October 2019) Europe has prepared working papers to cover environmental and ATM issues. Indeed, global solutions are what aviation needs. On the other hand, we need to be careful that regional and global measures will not accumulate in an uncoordinated manner and create an unnecessary burden for our operators. The importance of cooperation between legislators and industry is becoming increasingly important. The commitment for each of us to own our responsibilities is stronger than ever before. That is the key issue for the future of aviation. ▶

WISE PERSONS GROUP ON AIR TRAFFIC CONTROL DELIVERS 10 RECOMMENDATIONS

The European Commission's DG MOVE established a "Wise Persons Group" on the future of the Single European Sky (SES) to produce recommendations for the direction that European ATM should take, to deliver better performance and better services while taking into account the continuous growth of air traffic. In April 2019 the group delivered its 10 recommendations.

1

Recommendation 1:
Confirm and strengthen EUROCONTROL's Network Manager (NM) role by providing it with the necessary executive powers to manage the ATM network, including managing European capacity and infrastructure based on standardised technology, while ensuring a clear division of responsibilities between the NM and ANSPs.

2

Recommendation 2:
Fully integrate airports into the network on the basis of linking the Network Operations Plan (NOP) and Airport Operations Plan (AOP), using extensive collaborative decision making (CDM).

3

Recommendation 3:
Implement a Digital European Sky based on an agreed roadmap building on the recommendations described in the Airspace Architecture Study (AAS), managed by the infrastructure manager, ensuring resilience of the system.

4

Recommendation 4:
Create a new market for ATM data service providers as recommended by AAS.

5

Recommendation 5:
Use the performance and charging scheme to support the digitalisation of air traffic services, and public funding to support deployment only where necessary from a network perspective.

6

Recommendation 6:
Facilitate the transition towards the Digital European Sky by reviewing current licensing and training requirements for ATCOs, with full involvement of staff representatives.

7

Recommendation 7:
Simplify and strengthen economic regulation while relying on a market-driven approach wherever possible.

8

Recommendation 8:
Establish a strong, independent and technically competent economic regulator at European level.

9

Recommendation 9:
Establish a seamless European (Upper) Airspace System including a common route charge.

10

Recommendation 10:
Encourage airports to procure tower services through competitive tender or contract, where operationally feasible and positively impacting users.

AEROSPACE NEEDS A WIDER VISION TO FIND AI SOLUTIONS

Philippe Mouttou
AI4EU's External Liaison Manager
Thales

Patrick Gatellier
AI4EU Project Coordinator
Thales

For ATM stakeholders needing to develop their understanding of the ATM network to master complexity, enhance predictability and increase resilience and agility, Artificial Intelligence (AI) is emerging as a key enabler with far-reaching effects.

European aviation is facing major challenges in the coming years, as continuous traffic growth and structural airspace and airport capacity issues call for disruptive approaches to reshape today's business models and operations.

While AI is still in its infancy with the first applications taking place outside safety-critical operations, AI developments look set to respond to these aviation-specific challenges, for example certification and smart, human-machine partnerships. Furthermore, the European Commission's (EC's) Digital Single Market Strategy launched in 2018 aims to bring digital innovation to multiple markets, including airspace management.

One of the Commission's priorities is to share AI knowledge and resources across a much wider audience than currently is the case. For this reason it launched the Artificial Intelligence for Europe (AI4EU) project to establish an AI on-demand-platform to facilitate access to AI capabilities to all business areas in all countries of the European Union (EU). This virtual platform enables small- and medium-sized enterprises (SMEs) to become active members of the European AI community and to access AI resources and use them as part of their transition to a digital environment. The EC awarded a €20-million, three-year contract to a Thales-led consortium to develop the platform in January 2019.

Thales Project Coordinator Patrick Gatellier says the purpose of the project is to reduce fragmentation within the AI community and democratise access to AI. *"We aim to improve and strengthen collaboration between different stakeholders. We are not inventing anything, but the platform enables people to connect and work together towards any proposed goal within ad-hoc and on-demand groups."* Companies are also able to search and find all their AI components from this single source.

The consortium includes 80 partners and spans 21 countries. Over the course of the programme, about €3 million of the €20-million total budget will be released to SMEs for research and development activity, selected via three separate open calls.

The digital platform aims to serve three main functions. The first of these is to provide access to relevant information from people already in AI, whether in research, technology, start-ups or venture capital. This activity supports a number of other Commission-funded AI activities which are running in parallel, including the Digital Innovation Hub network launched in 2018 which in addition to industry spans agriculture and health. *"These hubs get all their AI elements from the AI4EU platform,"* says Gatellier. *"The purpose is to bring together all those involved in each topic to make them grow, become more innovative and more collaborative."* ▶

The second function is to provide a repository for AI assets. Whether computer components, data sets or algorithms, users can visit the platform to source capabilities and tools to support their individual AI requirements.

Finally, the platform provides an experimentation facility. It allows users to develop AI applications based on resources provided by the platform in an accessible way. *"Today, you have to be an expert in AI to do this. We want to make this easier for users who are not experts, who wish to experiment with what AI can offer them," adds Gatellier.*

AI4EU's External Liaison Manager Philippe Mouttou explains that regulation will play a key role in managing the usage of AI in the human-centric and safety-critical sector that is particular to aviation. *"For example you have to be sure, when the system says it is okay to increase capacity, this remains within the capability of the operator as agreed by the regulatory authority. There needs to be agreement on the limits of any autonomous system."* For this reason, regulatory aspects need to be considered from an early stage. *"The idea is to make sure all the entities talk together from the outset. If you think through the regulation, it drives the technical acceptability."*

The long-term aim is for the platform to be a portal to the AI universe in Europe. This not only includes technology, but regulation and knowledge management. The Commission has committed to continue funding AI projects at least until 2027, for example releasing further grants in July 2019 to support AI research in various domains. Establishing Europe's AI capability is the first step towards leading worldwide development.

With the start of the AI4EU platform, aviation and other industries have the opportunity to leverage cooperation opportunities with the AI community and explore ways in which AI can benefit the passenger and the European economy. Managing the sizeable human factor element is fundamental to progressing AI in aviation in support of those operations.

As a follow-up to the High-Level Conference on Aviation and AI held at EUROCONTROL's headquarters in May 2019, EUROCONTROL is engaging with member states and other stakeholders to prepare aviation for the upcoming transformations and to harness the potential of AI. Mouttou expects EUROCONTROL to establish a domain application on the platform and start accessing the resources available, or push AI4EU to modify those resources.

In this context, Pierre Andribet, Head of Research and Development has been nominated as EUROCONTROL's representative on the AI4EU industrial committee. The role of the committee will focus on three tasks:

- influence the content and nature of the AI4EU platform development and scale-up;
- participate actively in the definition of the open calls and pilots that will put the platform to the test. The open calls are the tools used by the platform to select promising start-ups around critical AI domains for the future of the European industry. Pilot projects are projects gathering the best of European research and industry to solve AI problems currently impeding the development of products or services;
- interact with the scientific community to understand and define with them the challenges that European research will need to address in the future and provide input from industry to the European Strategic Research and Innovation Agenda (SRIA).

"For aviation, and in particular air traffic management, to become one of the pilot projects of AI4EU would be a unique opportunity to leverage cooperation opportunities with the AI community," says Philippe Merlo, Director European Civil Military Aviation at EUROCONTROL.

During the three years of the programme, EUROCONTROL has identified several focus areas which are relevant to airspace management. The first of these is to *"build confidence that the generic AI services of the platform can deliver significant performance benefits compared to other technologies,"* says Merlo. This is accompanied by validation of specific AI-based solutions relevant to aviation and airspace management. Thirdly, the agency plans to promote the use of the AI-on-demand platform in the Single European Sky ATM Research (SESAR) ATM modernisation programme and accelerate the adoption of AI-based solutions. Discussions on the next steps are underway. ■

KEY PRIORITIES AND TIMESCALES FOR ARTIFICIAL INTELLIGENCE TO HELP IMPROVE AVIATION PERFORMANCE

Françoise Soulié-Fogelman
Scientific advisor at Hub France AI – which aims to develop a French initiative in the field of artificial intelligence –' believes there are five priority areas where AI can benefit aviation.

Aviation has many assets that are a good fit for AI: a significant collection of large datasets, with the technical infrastructure and expertise to handle them; sophisticated simulators of many systems (which can be used as digital twins) and a strong culture of safety, with proven procedures for safety-critical applications – many aviation applications are safety-critical.

Opportunities for developing useful, well-functioning AI applications exist in nearly all domains: traffic prediction, airport passenger flow prediction, trajectory optimisation, runway occupancy and taxi time prediction, speech recognition, etc. Because of this potential, aviation companies such as Boeing are already investing heavily in AI.

But aviation is constrained by stringent limitations of resources in terms of airports and staff, while managing an ever-growing number of air passengers, currently an increase of 7% year on year. To sustain its development, aviation must find ways of optimising existing solutions and AI can play a significant part here.

There are, however, several challenges in bringing AI to aviation. Although there is an abundance of data there is no common, open infrastructure for global aviation data-sharing. To fully profit from AI, there would have to be a systematic effort to procure large, clean datasets.

- AI has not been part of the training of aviation engineers. Their expertise in AI is limited, their connection with the academic world is scarce and this talent-gap strongly limits the deployment of AI in aviation. Also, because most people have no expertise in AI, they might not trust AI and could have difficulty finding their role when working in coordination with an AI-based solution. Deployment of AI will thus have to include a significant effort in change management.

- Aviation widely uses simulators, notably for training. Such simulators could be used as digital twins to complement data sources. Think, for example, of a simulator used to generate 20 years of flight data. Such data could be very useful in developing new AI-based models or even maybe new certification procedures. But this still requires research and development.

As we have seen before, many areas in aviation are safety-critical and standard procedures have been devised and put in place to handle any safety risk. If aviation wants to benefit from AI without the risks, a first step is to isolate the applications where safety is not an issue and deploy AI there to gain knowledge and reap exploitation benefits. Meanwhile, work is starting on safety-certified AI, and this will take time: running autonomous AI-air traffic control operations will not happen in the near future.

AI can indeed bring significant benefits to aviation, but a lot of work must be done to reap the benefits, while limiting risk. Here are my recommendations, with timescales included.

AI is completely dependent upon data so massive efforts must be made here. A common cross-border European infrastructure must be deployed (within one to five years), with agreed standards and meta-data, collection modes and granularities, allowing all stakeholders to develop and share their applications.

To successfully deploy AI, aviation needs trained staff who understand the issues and development process and can interact with experts both in academia and in specialised consulting companies. Extensive training programmes need to be put in place at all levels (one to three years). Each time an AI application is developed, a parallel process needs to be deployed to explain and manage the change in procedures and work, so that staff feel confident working with AI-based solutions.

Simulators are a strong asset, but they were not developed to be incorporated into an AI-based system. It might be necessary to refine them in some learning algorithm-simulator loops, which need to be defined and tested (one to eight years).

A map of safety-critical/non-safety-critical applications needs to be made. In the non-safety-critical area, AI must be deployed rapidly and aggressively (two to five years) obtaining benefits and knowledge. A roadmap must be established to phase the deployment.

R&D programmes should be launched on safety-certified AI processes to evaluate the risks and start producing procedures for safety-critical applications. This effort will take time (five to ten years). But certified AI is the future of aviation.

ARTIFICIAL INTELLIGENCE IS A MACHINE PROCESS THAT CAN LEARN AND ACT IN AN "INTELLIGENT" WAY TO ASSIST A HUMAN

There are two different approaches to achieving the AI goal: Symbolic AI, the classical, logic-based school which emerged in the 1950s and led to Lisp (a high-level programming language) machines and the expert systems of the early eighties, and Machine Learning, or numeric AI which has enabled the development of the learning systems which are now at the core of the AI revolution.

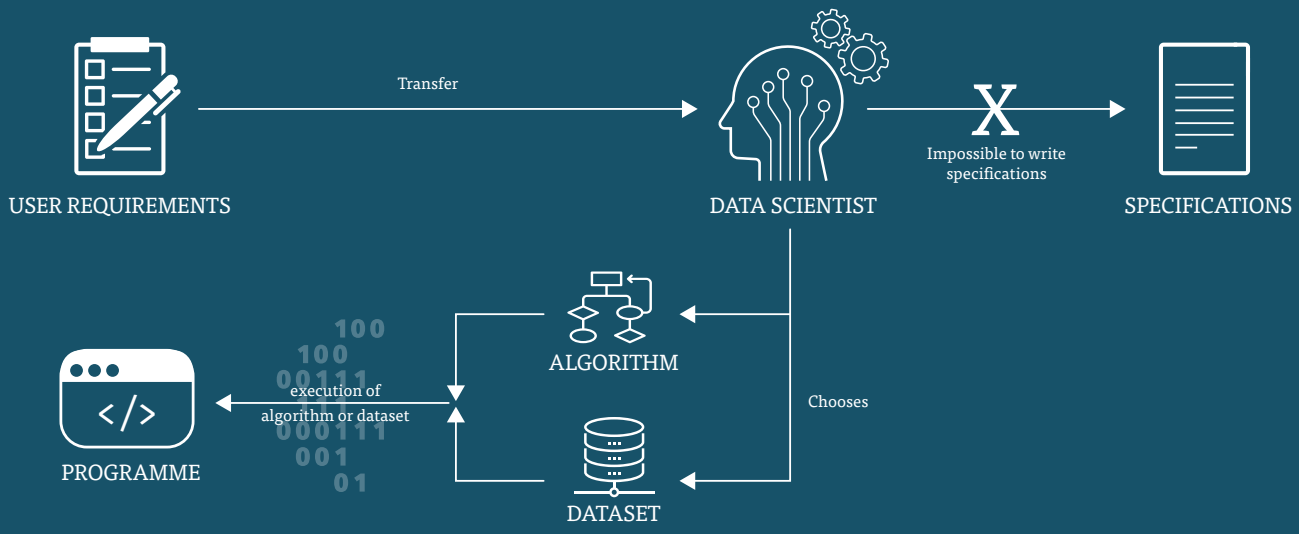
In Symbolic AI, programmers create rules for machines to follow; Machine Learning is about creating machines that can learn without an explicit technical specification of the task. The two approaches can be antagonistic.

Figure 1 (next page) shows how a software program is produced. In computer programming (and largely Symbolic AI), user requirements are described through specifications (functional and technical) which are translated by a programmer into a program – a sequence of instructions for the usual computer program, or “rules” in Symbolic AI. However, there are many cases where specifications are almost impossible to produce; for example, the requirements for face recognition are very simple, but we cannot translate these into a set of rules to perform the task. In this case, Machine Learning is used by running a learning algorithm (typically from an open source library such as scikitlearn for example) on a dataset appropriate for the problem to be solved. The result of this learning phase is a program which can now be used on inputs to produce outputs, just as is the case for the usual programming. ▶

SOFTWARE PRODUCTION

THROUGH COMPUTER PROGRAMMING

THROUGH MACHINE LEARNING



This fundamental difference has many consequences:

- **The importance of data:** The choice of the dataset, in terms of quality and quantity, is crucial for the performance of the resulting program or model, as it is usually called in Machine Learning (ML). Garbage in – garbage out is a common saying in the trade. Unfortunately, there is no scientific way to ensure that the chosen dataset is (the most) appropriate. In general, ML models get better performances with increasing amounts of data, so big data is very much needed. In many applications, large volumes cannot be obtained, and performances can then be quite poor. Small data research will therefore be very active in the near future, and various techniques are being investigated to this end: digital twins, as digital models of a physical system, may be used to produce synthetic data and complement real data; reinforcement learning is a technique which has been very successfully used in games, for example instead of using real moves in a game, the program plays against itself and learns the "good" moves; in this fashion a potentially infinite dataset is generated. The choice of the particular learning algorithm is not so critical: procedures for systematically evaluating and comparing algorithms can be put in place to ensure the chosen algorithm is adequate (although this can be computing-intensive).

- **Verification of correctness:** In computer programming, formal verification of software programs is a well-established approach for safety-critical applications. No such approach exists for Machine Learning at the present time: as a consequence, certification of AI remains an open issue, on which research is needed.

- **It should be noted that AI programs usually are probabilistic (the output is the estimated probability of the event of interest) and may need to be trained again to adapt to changing circumstances:** this is again an important difference from the classical software program. ■

REAL SAFETY AND CAPACITY GAINS AT HEATHROW FROM ARTIFICIAL INTELLIGENCE INITIATIVES

Andrew Taylor
Chief Solutions Officer, NATS

The introduction of an artificial intelligence (AI)-based airfield monitoring system, via the NATS Digital Tower Laboratory, at London/Heathrow could help the airport reclaim up to 20% of lost capacity caused by low cloud and reduced visibility.

Heathrow is the world's most capacity-constrained airport – delays and disruptions there caused by bad weather have a knock-on impact throughout the continent and beyond, so any improvement in the resilience of the airport during times of low visibility has a strategic value to the entire European network.

The airport is impacted by a lack of visibility 12 to 15 days of the year, when the top of the control tower disappears into low cloud, for example. Such events typically last for between 30 and 90 minutes; as Heathrow is working to about 99% of its capacity, that means an impacted hour will affect the schedule for the rest of the day. It also has a significant impact on the European network.

But AI could provide a surprisingly swift and significant uplift in the airport's resilience performance.

UK air navigation service provider (ANSP) NATS has been working on an AI programme within a purpose built Digital Tower Laboratory (see box overleaf), located inside the Heathrow control tower, a 87-metre structure which provides commanding views of the airport and surrounding landscape but which can also disappear into low cloud, even when the runways below are clear.

The lab is transforming the picture that controllers have on critical airside areas of the airport, improving safety and capacity while reducing workload in fair weather and foul.

The programme comprises a network of ultra HD 4K cameras integrated within an AI and machine-learning platform called AIMEE, developed by Canada-based Searidge Technologies. Aircraft and ground vehicles equipped with transponders are tracked by airport surveillance radar (ASR) and GPS location data. Radar data is received from four different radar heads, to give a maximum coverage of the airfield, while further tracking data is available from multilateration position identification. At the heart of the platform is Searidge's Hold-Line Surveillance System (HLSS), developed to ensure runway and taxiway operations can be safely monitored in International Civil Aviation Organization (ICAO) 'VIS 2' visibility conditions, when some or all of the manoeuvring area is no longer visible to controllers from the tower cab.

The enhanced view of the airfield area is displayed on a nine-screen video wall, each screen comprising a 55-inch ultra HD (4K) display, with ground vehicles and aircraft identified by real-time smooth labelling. ▶

The AIMEE platform interprets the images, tracks the aircraft and then informs the controller when the aircraft has successfully cleared the runway and its associated protected areas. The controller then makes the decision on whether or not to clear the next arrival.

"For the controllers it's a sharp contrast to the real-world view they have from the control tower – they come downstairs and they have this ultra-high-definition image, really sharp and with that extra layer of data over the top of it," says Andy Taylor, Chief Solutions Officer at NATS. *"Then at night time the low-light performance of the 4K cameras is better than the human eye so you can actually see the colours of the aircraft paint scheme and paint markings on the runway which you can't see from the control tower. That positive effect means you instantly have an engagement to the technology."*

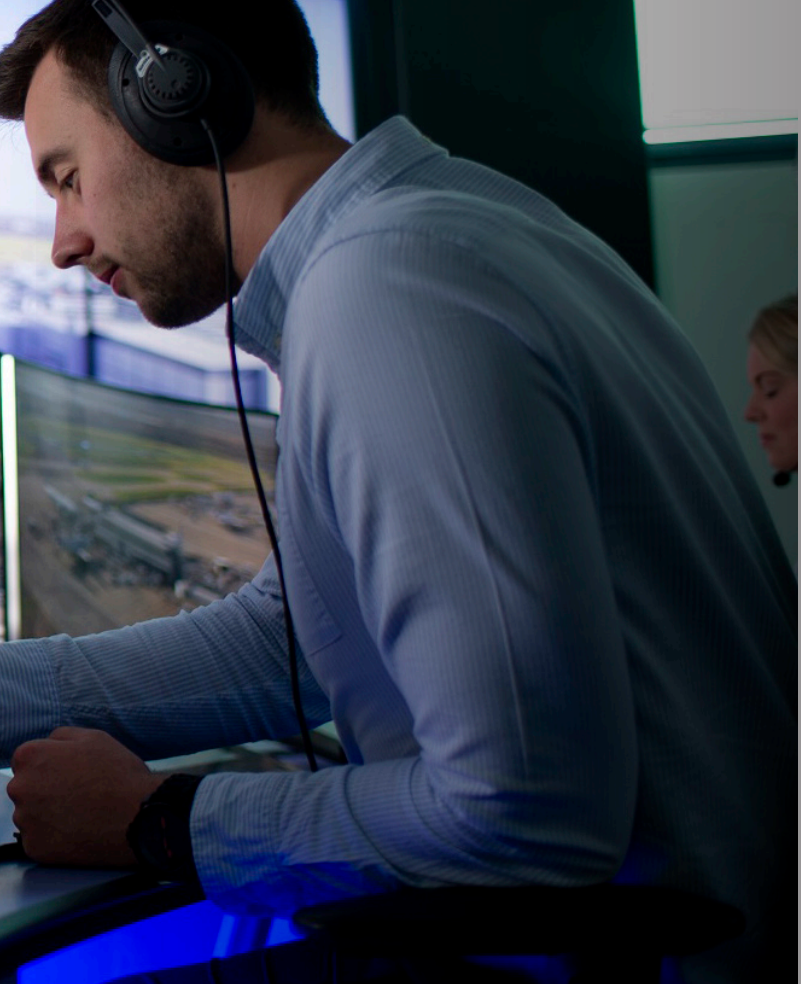
One key element of the AI-based system is the software which smooths the update rates – the ASR/GPS and multilateration-derived labels have a one-second update rate while the 4K cameras run at 25 Hertz, or 25 frames per second, so the software has been developed to ensure the labelling sticks with the target aircraft despite the differences in update rates.

But implementing any new technology at such a busy hub – especially a new technology which pushes the boundaries of human/machine interactions – is an extraordinarily complex task. There is no quiet period in which to slowly introduce the new system and the controllers need to receive exactly the right amount of information at the right time – which has meant NATS has had to undertake some innovative, lateral thinking to bring the lab into operation.

"We don't see that building a typical tower is necessary when you have the digital capabilities that you can bring together now"

"If you want to be able to deploy these systems in a rapid, sequential way then it needs to be done in a very intuitive manner so the controllers will be able to easily interact with it," says Taylor. *"We did not want something that required a huge amount of training and was a sudden change to work practices. We wanted something to enhance their current experience and reduce workload."*

In a conventional ATM equipment procurement programme an engineering-focused requirement spec is developed, a tender is sent out to industry, replies are compared, and the new solution is tested and then put through a site-acceptance process. But with the digital lab, Searidge engineers sit directly alongside the end users and the product evolves according to the input of the controllers. So, for example, cameras were placed near the runway exits in such a way as to avoid an aircraft obscuring the view of an exit. But controllers did not need or want to see individual footage of each runway-exit camera. So the engineers developed a system



which provides live prompts to the controller when an event occurs – such as the aircraft tail clearing the runway. That is what the controllers monitor every day in fine weather and that is what the AI and camera network has been configured to deliver in all weather conditions.

NATS, Searidge and the UK Civil Aviation Authority (CAA) have also set up an innovation team to help develop a new regulatory framework to assist in developing appropriate standards for such AI airport operations technologies and procedures, and to validate the results of the initial test phase.

"The AI model can operate day or night and that's part of what the validation process is showing: that the performance regardless of whether it's day or night conditions is equally good," says Andy Taylor. *"So potentially we will have benefits in reduced workload as the system will undertake much of the monitoring work as it scans the entire airfield constantly, providing feedback 25 times faster than the most up-to-date, multilateration, ground-movement radar."*

According to Taylor the controllers' reaction to the new system has been enthusiastic. *"When they see the Heathrow operation running live, in the lab downstairs, and can compare and contrast it exactly to what they've just seen from inside the control tower, it is a powerful contrast. We're getting great feedback and they're engaged."*

For NATS, the AI digital tower lab journey is just starting. Once the technology has been validated the ANSP will start looking at using the system for both main and contingency operations at Heathrow.

"We don't see that building a typical tower is necessary when you have the digital capabilities that you can bring together now," says Taylor. *"At Heathrow we have had a contingency facility in place for over 10 years, but it has no windows and no camera surveillance which means it has a 20% less capable operation than the main tower. What we would like to do is upgrade that facility and make it 100% capable. In fact with the cameras and integrated AI system we are developing here there is the possibility of having a contingency system which has more capability than the current, conventional tower. That's true not just for Heathrow but any airport tower."*

NATS has already begun work on planning the next applications of the digital tower lab, developing new capabilities – many focused on developing human-machine interface applications – based on a long list of operational constraints that impact airports around the world. The work is developing on an application-based approach, says Andy Taylor, which is helping to change the long-term asset cycle approach to capability upgrades, one individual system at a time, to one closer to an open ecosystem approach more like a smart phone than a traditional ATM systems procurement strategy.

"NATS looks at the challenge of airport capacity in the same way as EUROCONTROL – in the current growth market airports are a considerable potential constraint to the network so we have to do whatever we can to make our airport operations as efficient as possible," says Taylor. *"I think we have to get as much efficiency out of what we currently have while optimising any future investment in aviation capacity by ANSPs, airports and governments. We're all in this together and we all have to play our part."* ■

THE DIGITAL TOWER LABORATORY TIMELINE

Work on the NATS Digital Tower Laboratory at Heathrow Airport began in 2018. From January to March 2019 the programme started with a series of real-time, non-operational data collection/validation trials which involved the monitoring of more than 50,000 arriving aircraft to ensure the accuracy of the system, with the results of the project presented to the Civil Aviation Authority (CAA). This will be followed by a deployment phase, which will see added cameras around the airfield and integration of the data output on controller's screens.

AI IS NOT ABOUT REPLACING HUMANS – IT'S ABOUT MAKING THEM MORE EFFICIENT

John Hurley
Chief Technology Officer, Ryanair

For us, machine learning is the future.

Ryanair is unique in the sense that we have a unique customer challenge, a unique sales model and a unique operating model – a true low-cost carrier that operates over 2,100 routes, from over 236 airports, over 40 countries, all served by the same aircraft type. To make this work we have to be in a state of continuous innovation and at our scale, machine learning is vital.

For example, we need to know our customers, their journeys, their needs and how to best engage them. We need to know how to inspire them, how to achieve real-time personalisation and offer each customer the right product using the correct channel with the right message at the right time. Machine learning is helping us do that.

It has helped our marketing colleagues make more targeted offers with a smaller budget, while at the same time improving the customer experience. These technologies are not exclusive to Ryanair; I expect over the next few years these kinds of AI systems will become standard across the airline sector and with that, standards will rise and quality will improve. The end user's expectations will rise in line with these improvements and those airlines that don't embrace AI will be left behind.

Artificial intelligence (AI) is not all about customer experience but also helps support our employees, improving efficiency and thereby improving the overall product quality. We have known for some time that we could improve our Customer Service offering. Many of our customers ask the same questions at large volumes on a daily basis and we are now using artificial intelligence to interpret these questions, allowing us to offer the correct response in real time in the relevant language. We had been spending vast amounts of time manually replying to these queries but now our agents are monitoring bot conversations and only contributing if they feel there is a need. This allows our agents to focus on more complex requests in turn providing a much better service for our customers and greater job satisfaction for agents. Now we are answering more than 25K conversations per day (a conversation can contain multiple queries and requests to complete) across six languages (English, German, French, Italian, Spanish and Polish).

Intelligence gathered in this manner shows that the vast majority of customer queries are similar, we can now give consistent, automated responses to a wide range of queries as a result. Our customer-operation service managers can now see the bigger picture sooner on what is happening in the customer's context, they can also see various trends and react to them there and then. This data can then be provided to our copywriters in a shorter feedback loop leading to improved product detail FAQs and removing confusion at origin.

The bots have been there for nine months and all of our machine learning is recent – we are using Amazon's Lex framework to understand the questions and Sagemaker to return recommendations. Commercially available AI products are used, but we have personalised the responses. The next six months will see more advanced end-user

"Artificial intelligence is not all about customer experience but also helps support our employees, improving efficiency and thereby improving the overall product quality"

experiences appear on our website, mobile app and email channels.

As a low-cost airline, it will come as no surprise that Ryanair has a number of key projects focused on operational efficiency. AI affords us new methods, to not only look at large volumes of data but to find patterns within it and give recommendations based on the resultant information discovered. When you have over 475 aircraft in the fleet, a small change has the potential for large gains in operational performance and improvements to our bottom line. To that end, we plan to use AI to improve our turnaround times to optimise flight plans and further reduce operating costs. I believe there are probably patterns which we have not even started to detect yet that will further improve efficiency in the future.

AI is about exploiting the data available and we have vast quantities of operational data in Ryanair. Using the data we can identify cost savings to be made and improve future decision making. For example, we have eleven different engine configurations; while humans are very efficient at deciding which aircraft configuration type should be used on a particular single route, it is impossible for anyone to look at the pattern of flights for the entire day and see whether an aircraft is optimised for all its routes across the whole day. Our in-house developed AI tools can do this. They can make recommendations to our flight operations staff who then decide on whether or not to accept the recommendation. Using AI tools to optimise aircraft allocation saves millions every year.

Predictive maintenance will be the next operational area we will target, recommending the airports where we need to carry a stock of spare parts and optimising the location of both parts and engineers to see if we can introduce more predictability into our maintenance operations.

We want to share this data across the organisation and feed other data sets into it – such as the system wide information management (SWIM) protocol, which we see as a step in the right direction towards improving integration of operations and of course, Ryanair's singular mission – safety.

All of our machine-learning tools are cloud based. Cloud hosting gives the scale and reliability we need – while at the same time providing greater security to protect our data. For us, AI is about supporting small, frequent, continuous improvements. Our AI teams are focused on finding small solutions and removing the bottlenecks.

One advantage we have with attracting talent is that our projects are all very exciting. You work on something interesting very, very quickly and that does attract people to our unique business model.

Like every other European business, we need to find the best talent wherever possible to help with the data transformation of our company. We have offices spread across Europe in Ireland, Spain and Poland collaborating with excellent universities regionally who can help us maintain a good supply of talented scientists to further Ryanair's data driven ambitions. ■

INTELLIGENT STEPS FOR THE FUTURE

Tanja Grobotek
Europe Affairs Director at the
Civil Air Navigation Services Organisation (CANSO)

Artificial intelligence (AI) – and its machine learning applications in particular – has captured the attention of many leaders and researchers worldwide for its potential to enhance the performance of different industries, including the aviation sector.

It is an area of computer science that includes highly advanced computational methods that mimic the way the human brain works, and is a powerful technology that can find patterns in massive unstructured data sets and improve its own performance as more data becomes available.

Today, typical AI capabilities include speech, image and video recognition, smart automation, advanced simulation, as well as complex analytics and predictions.

The application of AI in the aviation field can help to overcome the current challenges of capacity, environment, connectivity and security.

As highlighted in CANSO Europe Vision 2035, CANSO believes it is paramount to find a clear journey towards system-centric technology, increased automation, service-oriented architecture, virtualisation and interoperability to transform air traffic management (ATM) performance. Digital transformation of the aviation industry enables data-driven technologies like AI which form a critical part of the high-performance ATM systems of the future.

CANSO is focused on building a stronger future today – and some member air navigation service providers (ANSPs) are already actively harnessing the power of AI to improve current processes, and create new ATM applications.

For example, DSNA in France is developing new AI tools to advance operational solutions to deploy the optimal configuration of sectors, and thus to optimise capacity with available resources. European airspace is divided into several elementary blocks of airspace which allow modularity and flexibility in building the different airspace configurations to meet expected and effective traffic flows. In the case of France, its airspace is composed of 168 elementary sectors.

In the tactical phase, Supervisors and Flow Management Positions (FMPs) analyse, on a continuous basis, traffic demand and available capacity from the analysis of the operational

air traffic control centre (ACC) data, including resources, technical availability, unexpected events and environmental data (weather, military activity). With their expertise, they manually determine the most adequate sector configurations. Without automation, identifying the sequence of adequate ACC sector configurations according to traffic flows and associated workload is time-consuming. And only solutions from predefined catalogues are routinely used, limiting the possibilities.

DSNA is therefore using innovative techniques, offering dynamicity, optimisation and time-saving in capacity management and ACC sector configuration. In order to maximise the benefits of airspace modularity while optimising resources, automated functions have been developed to support Supervisor and FMP decision-making. A new AI tool is able to optimise airspace solutions in case of high workload and unforeseen events which could require quick decisions for airspace re-organisation. It also provides additional means in the Air Traffic Flow Control Management (ATFCM) toolkit using dynamic sector configurations to facilitate users' preferred routings.

In the UK, NATS is using AI to measure air traffic characteristics (for example, high traffic volume, weather conditions) and predict the likelihood of potential safety events, like runway exit points for example. This will enable strategic corrective actions to avoid them. NATS is also exploring how AI could be used to help reduce flight delays. A project is now underway, within NATS' bespoke Digital Tower Laboratory at Heathrow Airport, to test whether a combination of ultra HD 4K cameras along with state-of-the-art AI and machine-learning technology can be used to help improve the airport's landing capacity in times of low visibility and improve punctuality (see NATS article in this issue). Non-operational trials are now underway to understand the feasibility of introducing the technology into service as early as this year.

The safe and fair integration of drones, or unmanned air systems (UAS), into the aviation system will be a major change project not only for ANSPs but also for the industry as a whole. The evolution of ATM for commercial drone systems relies on greater digitalisation, automation and pace compared to conventional air traffic management evolution.

AI is seen by many UAS operators and manufacturers as an essential prerequisite for communication between drones. In the event of irregularities, they must be able to keep drones on track and react to changes in milliseconds, and adapt their own flight routes according to the information provided by other drones.

In the longer term, one of the most promising benefits of AI is reducing human stress by supporting controller decision-making, which will improve operational capability, the consistency of delivery and will enhance safety.

Other AI applications being explored by ANSPs include enhanced ATCO training and simulations, improved predictive maintenance of air traffic management/communications, navigation and surveillance (ATM/CNS) systems and better trajectory prediction.

There are many other tasks that could be performed more efficiently by machines in advanced ATM systems, supported by big data and AI rather than human operators. However, there are several key aspects that need to be addressed first.

It is difficult to assess, validate and certify the AI systems, especially if they evolve in time, in particular for low occurrence (for example, safety) events. And for non-safety critical operations, certification needs to be less stringent than for safety-critical operations. This means that regulations need to be performance-based, and based on the nature of each AI solution.

Going forward, as ATM systems modernise and the use of advanced technologies increases, it will be essential to assess the impact on human operators (controllers, pilots, engineers and so on) and organisational aspects. ANSPs will therefore need to assess the role of the human in the future ATM system, training needs, user acceptance and regulatory changes (liability).

Finally, as it was reported at EUROCONTROL's recent Artificial Intelligence in Aviation event, less than 10% of the data produced by the industry in Europe is actually used. As machine-learning algorithms that make predictions have to be trained using historical datasets, it is essential to define clear data governance to ensure availability and integrity of data in order to optimise its use for more efficient and effective air transport.

For its part, CANSO is committed to working closely with all stakeholders and regulators to address the above issues, sharing best practice and ensuring that the ATM industry is fit for the future.

CANSO has recently launched a strategic technology initiative, identifying and assessing emerging technologies for potential impact and benefit for ATM. This will provide an important venue for collaboration and information among CANSO's global ATM network of air navigation services providers and suppliers to the industry, allowing key players to share information on new ATM technology and other related technologies and encouraging adoption and implementation.

The ATM industry has always been at the forefront of safe and efficient innovation and AI holds huge potential to develop and enhance the industry's capabilities, from increasing capacity and optimising traffic flow, to safely integrating a diverse range of airspace users. The challenge ahead will be how the industry can embrace the technologies available, learn from each other and unlock its full potential. ■

To find out more about CANSO and how the ATM industry is working together to champion new technologies, visit: www.canso.org

STATE LIAISON OFFICERS PROVIDE A VITAL BRIDGE BETWEEN STATES AND THE AGENCY

Now in its seventh year of bringing State representatives together at EUROCONTROL to strengthen coordination and help improve European aviation performance, the State Liaison Office has become a well-established mechanism, supporting Agency decision-making and providing that vital link between the Agency and its Member States.

The EUROCONTROL State Liaison Office was set up in 2012 to strengthen the Agency's links with Member States (and later also including the Comprehensive Agreement States) by providing a strong two-way feedback channel. Its role has evolved over recent years and over the past 18 months; this multicultural corner of the Brussels headquarters has focused on delivering constructive input across all areas of decision-making.

State Liaison Officer (SLO) for Spain, Itziar Lopez, says having so many different cultures and nationalities working together can be a challenge: *"Our interests are not always the same, but we help each other."* The range of backgrounds – including engineers, lawyers and air traffic controllers – brings a wealth of knowledge to day-to-day activities.

Maintaining this close working relationship is the responsibility of Deniz Aktug, Senior Advisor to the EUROCONTROL Director General (DG). Aktug works in the Private Office of the DG (DG/PO) and is responsible for the strategic coordination of the State Liaison Office. She also ensures that the SLOs are kept in the loop about key developments, and facilitates the officers' communication with the Director General.

"At times EUROCONTROL's complexity can be rather daunting, so the SLOs need a bit of guidance to find their way around various workshops, technical and policy forums, and most importantly contribute to bi-annual meetings of the Provisional Council/ Permanent Commission (PC/CN). This is the highest decision-making body, attended by the Director Generals of all 41 Member States and two Comprehensive Agreement States, and we seek to ensure clarification and coordination ahead of the meetings," Aktug says.

State Liaison Officers and EUROCONTROL contacts as of 13 June 2019

SLOs play a vital role in supporting decision-making by the Agency. While not all members of EUROCONTROL are European Union members, the Agency is tasked by the European Commission to deliver certain functions in accordance with the European law, while keeping a pan-European perspective. For example, in May 2019, the Commission reappointed EUROCONTROL as Network Manager (NM) for the air traffic management (ATM) network functions of the Single European Sky (SES) for the period 2020-2029. The SLOs contributed to the acceptance of this appointment in EUROCONTROL's Permanent Commission. They also contributed to the new Network Functions Implementing Regulation (NF-IR) which was adopted by the Commission in January 2019.

Who appoints the SLOs?

Each SLO is appointed by their national government to EUROCONTROL's Brussels headquarters to provide a link between their state and the Agency. The current composition of the State Liaison Office includes peripheral and non-EU states. *"Having one person here, fully dedicated to EUROCONTROL, shows the importance EUROCONTROL attaches to Spain, and enables Spain to deepen its knowledge of EUROCONTROL's daily affairs,"* says Lopez. *"The Spanish delegation can be represented in every EUROCONTROL meeting, and in other European institutions, and is more aware of the needs of other Member States,"* she adds. The SLO model is particularly attractive for more remote States or new members of the Agency, providing clear benefits via enhanced communications.

SLO accommodation, travel and medical insurance costs are covered by EUROCONTROL during their time in Brussels. They are entitled to about six weeks of teleworking from their own country, which helps to build understanding and information exchange between the two organisations, and they use their Brussels base to travel to meetings in other locations to gain insight into strategic and operational issues. This established administrative framework is managed by George Ranga in the Directorate European Civil-Military Aviation (DECMA), who ensures SLO operations remain within budget. *"We see them as colleagues on mission to EUROCONTROL. They are the direct representatives of our stakeholders and act as a sounding board for our management decisions. They contribute greatly to our in-house meetings,"* he says.

Building bridges

Morocco and Israel, EUROCONTROL's two Comprehensive Agreement States, are also represented in the current State Liaison Office. Morocco became EUROCONTROL's first Comprehensive Agreement State in 2016, when it committed to fully integrating with EUROCONTROL's working structure, and benefiting from the Agency's wide range of services.

"WE WANT TO BUILD BRIDGES. WE ACTIVELY ENGAGE WITH THE SLOs SO WE HAVE A SOLID, DYNAMIC AND SINCERE RELATIONSHIP"

"My role helps to strengthen our links with EUROCONTROL," explains Marouan El Benhaoui, Morocco's SLO. *"Not only do I have access to everything that is going on, but also Morocco is able to respond better as a result of this two-way channel."* In place of searching for relevant contacts or waiting for information, an SLO can identify appropriate contacts or set up meetings. *"I facilitate and accelerate this exchange of information,"* he adds.

Nicolaos Lyrakides is seconded on behalf of the Department of Civil Aviation (DCA) for Cyprus, having previously held posts as Air Transport and Communications Counsellor in the EU and Vice-President for Europe of the International Federation of Air Traffic Control Associations (IFATCA) (he formerly worked as an air traffic controller supervisor). *"A country like mine has limited resources, yet we all face the same challenges when it comes to European airspace capacity and performance,"* he says. He attends multiple meetings and workshops, and relays information to and from his Cypriot colleagues. *"I am a focal point for aviation matters here, be they related to EUROCONTROL, SES ATM Research (SESAR) or the European Commission. I am a member of the European Union Aviation Safety Agency management board and I can head the Cypriot delegation if required, as was the case at the most recent Provisional Council meeting."*

SLOs are also encouraged to interact with other European organisations as part of their day-to-day activities. To expand the lines of communication, Deniz Aktug organises presentations and visits to other institutions including the European Commission's DG for Transport and Mobility (DG MOVE), the European Parliament, SESAR bodies and stakeholder associations. *"We want to build bridges,"* she explains. *"We actively engage with the SLOs so we have a solid, dynamic and sincere relationship."* Building collaboration and trust across all Member States and stakeholders is a feature of the open-door policy introduced by Director General Eamonn Brennan.

It helps that EUROCONTROL is a technical organisation rather than a political one, one whose focus is directed towards supporting technical and operational capabilities necessary to deliver the Single European Sky. *"Unanimity is impossible across all States represented, but if you listen to the other side and hear their concerns, you make better decisions in the end,"* says Nicolaos Lyrakides. *"We are taking decisions for European aviation in general."*

Lyrakides, with the support of all SLOs, has set up an information-sharing platform that allows officers to post workshop notes, relevant articles, committee reports and topical content.

Tangible results

The SLOs also intervene to find solutions in the interest of the wider network. *"We requested EUROCONTROL support for analysing the causes that made the summer of 2018 so complicated in the Barcelona area,"* says Itziar Lopez. *"The project, among other recommendations, called for close collaboration between neighbouring States."* The Agency assists with cross-border events, for example through air traffic flow management, and can help reduce the impact of industrial action. *"EUROCONTROL is my full-time duty, where acquiring expert knowledge in a variety of areas, strong international relations and the colleagues' network are key pillars of my activities in Brussels,"* she adds.

Other notable successes with SLO participation include securing agreement to reopen Kosovo airspace, and accelerating the introduction of cross-border Free Route Airspace and the expansion of civil-military coordination.

Being physically present in Brussels also means that the SLOs are able to represent their country at short notice in important meetings – as was the case earlier this year for Nicolaos Lyrakides, who represented the Cyprus DCA at an ad hoc meeting following the second fatal crash of the B737 MAX 8 airliner. *"We assist our capital or the Agency if they want a quick response,"* he says.

Support at local level

The lines of communication are two-way, and serve to bring States closer to Brussels, and to provide first-hand experience and knowledge of EUROCONTROL activities and services to peripheral countries. SLOs can also observe how other States benefit from Agency activities, and can pursue similar opportunities in compliance with the Support to States policy.

To take advantage of the professional development aspects of being an SLO, several States including Georgia, Armenia and Morocco choose to rotate their representatives every few months. This also ensures that staff resources are only seconded for short periods with minimal impact on a small team.

EUROCONTROL is building on the existing foundation of Support to States (STS) activities by the implementation of a new STS Policy. Accordingly, resources are allocated to a number of areas including simulations, workshops, training, safety, operational procedures and equipment.

Within the scope of a recent agreement, for example, Moroccan and EUROCONTROL experts have started work on a number of projects aimed at enhancing safety and capacity in Moroccan airspace. These include safety management improvement, finalisation of the Morocco Local Single Sky ImPlementation (LSSIP) Document 2018, adoption of the performance-based approach, implementation of Free Route Airspace in all Casablanca flight information regions, implementation of airport collaborative decision-making at Casablanca and Marrakech airports, a high-level workshop on the flexible use of airspace and further roll-out of the concept, training for controllers and engineers, and safety and cyber-security workshops.

The SLOs and their EUROCONTROL coordinating counterparts in DG/PO and DECMA look forward to building on the effective and fruitful relationship they have established together. Plans are in the making for upcoming strategic discussions, including the future of SES and the evolving role of EUROCONTROL. ■

"US AND EUROPEAN ATM PERFORMANCE COMPARISONS PROVIDE VALID AND USEFUL BENCHMARKS"

John Gulding

System Product and Development Manager, ATO Office of Performance Analysis, US Federal Aviation Administration (FAA)

John Gulding, Manager, System Product and Development, ATO Office of Performance Analysis at the US Federal Aviation Administration (FAA), discusses how recent work to compare air traffic management performance across the Atlantic is helping the USA and Europe better understand the impact of demand, weather and other constraints on ATM service provision

The joint ATM operational performance comparisons between the USA and Europe are now well established, can you give a high level view of the main aims of this work?

For the USA, the joint work with Europe gives the FAA an opportunity to track performance trends over time with a similar European system subject to similar constraints. The questions asked by regulators and stakeholders on ATM delay and efficiency are also very similar in both regions and joint reporting gives us the opportunity to test our ideas on measuring constraints or improvements and take advantage of lessons learned. We can see the impact of demand, weather and policies such as schedule limitations on performance over time.

Given the number of differences between the two systems (the level of general and business aviation flights in the USA, financing of ATM services, the fragmented nature of Europe and so on) how have you concluded which areas of performance comparisons can be truly useful?

Yes, even though there are differences in the system, the questions asked by stakeholders and management on improving efficiency often match, which many times lead to nearly identical performance measures. Furthermore, FAA Systems Operations and EUROCONTROL are organised in a comparable way, especially concerning their mutual Network Manager and Performance Analysis functions. Even though Europe operates with more air navigation service providers (ANSPs) and airports under International Air Transport Association (IATA) schedule limitations, the concept of providing stability through Air Traffic Flow Management (ATFM) is the same.

Going back to the first joint report, a considerable amount of time was spent becoming familiar with the data sources

available to both groups. Both the USA and Europe have comprehensive flight level data sets that allow for a broad array of delay measures and flight efficiency measures using trajectory data.

Given the similarities in the Network Manager role and the similarities in the underlying data sources, we feel the benchmark comparisons are valid and useful.

What are your main conclusions?

For the USA, delay inefficiencies continue to be largely attributable to our Northeast Corridor and airports with high capacity variation during bad weather. We also see the effects of runway construction over time. When compared to Europe, ATFM delay/flight is far higher on average at several key facilities that are either IATA Level Two or Three. Whether the delays are mitigated through schedule limitations as seen in Europe or other investment will continue to be a key focus area for US aviation.

How are the results used for improving ATM performance in the USA, such as setting priorities, targeting of specific areas, the FAA's continuous performance improvement process (PERTI) and future investments?

From the recent report, we are able to see that there is still much more to be done to improve efficiency in the US Northeast corridor. As noted in the report, this is due to several factors including the change in scheduling practice at a major airport. The FAA has also increased its resources for pre-tactical planning which is part of our PERTI initiative. Many of the data mining tools made available to PERTI that assess historical performance during Traffic Management Initiatives utilise the performance work developed jointly with Europe. This reporting and use of ATFM delay data ▶

FAA/ATO (CONUS) Area

10.4	MILLION KM^2
1	SERVICE PROVIDER
26	STAND ALONE APPROACH CONTROL FACILITIES
20	EN-ROUTE FACILITIES
517	AIRPORTS WITH ATC SERVICES
41 874	AVERAGE DAILY FLIGHTS
31 647	TOTAL STAFF

EUROCONTROL Area

11.5	MILLION KM^2
37	SERVICE PROVIDERS
16	STAND ALONE APPROACH CONTROL FACILITIES
62	EN-ROUTE FACILITIES
406	AIRPORTS WITH ATC SERVICES
28 475	AVERAGE DAILY FLIGHTS
55 130	TOTAL STAFF

has improved significantly over the last two reports and we expect this will continue as we get more sophisticated in our ability to assess Traffic Management Initiatives (TMIs).

Apart from the core ATM performance metrics - safety, delays, cost and environmental footprint, have you been able to compare other areas such as controller productivity and deployment of advanced systems?

Controller productivity is assessed in a separate joint FAA/Europe analysis dedicated to metrics that track cost and controller productivity with metrics such as flight hours per controller and cost per flight hour. Like the Operations report, I think it can be very useful to both groups in tracking how both systems are evolving over time.

Do you think that other world regions could also benefit from the joint work?

Yes, I think the report shows a wide array of metrics that can be used to assess system performance. They range from metrics that only require surface times such as Wheels-On and Wheels-Off at runways to metrics that utilise radar trajectories or systems that assign delay to flights as part of Air Traffic Flow Management. Currently EUROCONTROL and the FAA are working with the International Civil Aviation Organization (ICAO) to improve guidance on using Performance Measures for States. We are also both actively engaged in joint performance reporting for the Asia-Pacific region. ■

PEOPLE ARE THE FUTURE OF AVIATION

Iacopo Prissinotti

Director Network Management, EUROCONTROL

Iacopo Prissinotti took over from Joe Sultana as Director Network Management (DNM) in July 2019. The next few months will see major changes to DNM as new long-term operational, technical and institutional strategies are put into place.

What are your key priorities now and for the next few years?

Firstly, we had to make sure this summer's traffic loads were managed as smoothly as possible, which has meant continuing the excellent preparatory work made by Joe and the team by boosting our performance with many micro actions.

The second priority has been to prepare for the future, working on an analysis of traffic forecasts and deciding what we will need to do in terms of organisation, processes and procedures. This means putting in place change management practices, contributing to helping our people understand how central our role is in supporting European aviation.

As the Network Manager, we have an incredible task ahead of us and, with the 10-year mandate, we now have the requisite stability to accomplish it.

We need to implement new operational concepts. A new technological and investment strategy will be discussed at the next Provisional Council in November.

This is a time of change. Change is needed and the changes we are making are positive and will benefit EUROCONTROL and the wide European ATM; so no one should be afraid.

EUROCONTROL's Network Manager plays a crucial role in delivering the future of aviation – and people are key in this endeavour. We need to engage with and involve all operational stakeholders. This is a fundamental objective and one which will allow the best decisions to be made. Together, we will create an agile and scalable network for the future – one in which States will also play a crucial role in ensuring its success.

What needs to be done to improve information flows between NM and aircraft operators to improve the predictability of imminent traffic loads?

We have to go back to answering some essential questions: what are the business needs and what kind of exchange is required for what type of business service? To this end, we are reviewing NM's operational role and how best to support stakeholders in their operations. This will mean, for instance, doing more tactical flow management, carrying out better planning in the 48 hours before operations – especially in receiving information from the airlines on last-minute changes – and better managing tactical flows. Of course, as I said, an essential element in succeeding in this is creating a network effective decision-making processes with all operational stakeholders.

A more robust technical capability is needed in terms of exchange processes and procedures around collaborative decision-making. This means examining how we package the data – increasingly through system-wide information management (SWIM) protocols – and through business-to-business (B2B) capabilities to improve the way the human machine interface (HMI) is designed. We need to improve how information is presented and not just packaged.

We need to take a fresh look at what type of data NM should be providing and what type of data it should be receiving. We will start new conversations with airlines about confidentiality with a view to getting the crucial data we need from 48 to 24 hours before operations. This is an area where data is critical if we are to improve forecasting and the predictability of operations.

Over the next few years, we will be able to downlink 4D trajectories; we will also be receiving more information from the flight data processing systems, such as trajectory predictions. Coupled with enhanced surveillance capability, this would give us – in real time – more precise and accurate information on where aircraft are and where they will be.

I want to move towards more tactical flow management so as to be able to predict with more accuracy where the network constraints are. Today, we apply regulations in real time on predicted operations which are sometimes different from what was forecast. With more accurate information, we will dramatically reduce the volatility of the real-time situation and improve predictability, increasing the capacity and efficiency of the European network.

How will emerging technologies – artificial intelligence (AI), automatic dependent surveillance – broadcast (ADS-B), datalink and so on – transform the NM's capabilities and roles?

We have already started applying AI techniques to the NM's systems and this is going to increase further – both for operational data and statistics. Relying more on statistical information in the operations room, based on a combination of information on weather and traffic levels, as well as applying AI algorithms and statistical analysis, would definitely give us a better picture of what is going to happen in the network.

AI also poses some very interesting challenges: an incident due to an autonomous system is naturally much less acceptable than one caused by human error. This is why we in NM will keep our high safety standards and rely on our people to implement secure processes.

We have started to look at satellite-based ADS-B data as we need to have a broader and more accurate surveillance picture beyond the 41 States. It will be very important to receive better predictions of North Atlantic flows and integrate these with capacity management in Europe.

Other operational concepts and technologies will be rolled out and, as part of this process, we need to reinforce the importance of the Network Directors of Operations Meetings in moving towards implementing the first five-year programme of the Airspace Architecture Study. This will mean that airspace reconfiguration and operational excellence improvements will be coordinated promptly and affectively by airlines and ANSPs.

Are there any stakeholder groups where we need to develop better information flows?

B2B is already a success and growing incrementally. The tool is there and it needs to evolve. Priority will be on making sure the legacy carriers provide us with the necessary data at least 24 hours before operations. Information flows from airports will also need to be improved and centrally consolidated.

It's also important to ensure that we have better data from business aviation organisations – it's not the quantity that is the issue here, it's the fact that business aviation operates from smaller airports and their trajectories can be quite complex. All this makes network operations more intricate.

How do you think NM's role will evolve in helping ANSPs meet their performance targets?

First of all, we need trust: trust in relationships and trust in processes. To build trust, you need effective and timely decision-making processes with the right level of accountability. This a prime focus for us. We are all operational stakeholders and we need to work together. We have already kicked off some actions in this area. For instance, we have reinforced the importance of tactical actions in the coordination cell, where Network Directors of Operations meet and where the collaborative decision-making (CDM) process can be enhanced. The implementation of the Airspace Architecture Plan will also lead to more in-depth collaboration.

To meet the ambitious targets of capacity and scalability, we need to develop and implement a robust operational excellence programme. This is more than just "best practice" – it means deciding together on the best level of performance we should have and setting common standards.

Airspace reorganisation and operational excellence together make a very good platform for decision-making. Once we have that, we should have done a good job in building trust with ANSPs.

What is being done to improve information on traffic demand predictions from areas outside Europe, such as North America and the Middle East?

We already have departure information from these areas from airlines and ANSPs, giving us a reasonable level of predictability. But we cannot always be sure about the quality of the data or its update rate, for example, and if we suddenly need real-time data, it's not there.

Real-time surveillance data will give us much more precise predictability to ensure we can move traffic patterns in a more agile and efficient way. If we have these updates, we can relax the constraints we have to impose in the planning phase. We often identify areas of predicted congestion but circumstances, such as weather, can change and these areas shift, which can lead to ANSPs suddenly having to manage more traffic in unexpected ways.

How different will NM be in 2024 from now in terms of services it offers, improvements in demand-capacity balancing and relationship with tactical ATC?

NM needs to take a number of actions to improve the service it offers its customers.

Firstly, it needs to manage the airspace density and traffic flows on strategic and tactical levels. We will build an automated network and deliver very accurate forecasts. We will manage seamless ATC processes from planning to execution and achieve the right degree of network flexibility to manage volatility. Today, we focus mainly on capacity; we need to move towards scalability and punctuality.

So, the network needs to evolve and become more agile and scalable to meet the volatility challenge. It needs to be able to adapt to even more to fluctuations in traffic levels. We need to provide network balancing, depending on traffic density and real tactical flow management. If we see a cumulonimbus developing over Padua, for example, we need to re-plan a flight flying from Turkey to the UK until one hour before it is due to reach the area.

In order to achieve such ambitious performance targets, the Network Manager is developing a technological modernisation strategy – iNM – that will allow us to optimise and transform the European ATM business and achieve our ambitious objectives.

Secondly, we need to work with operational stakeholders to help drive the coordinated implementation of improved operational concepts and technologies. We can do so by pooling and integrating the expertise we have here with operational stakeholders, creating synergies and fostering change.

The last three pillars are more technical – supporting infrastructure improvements, to make sure technical data and communications, navigation and surveillance (CNS) equipment programmes are properly coordinated. A full, holistic monitoring of the network operational performance enablers on both technical and operational levels is key.

Finally, we need to improve our crisis management capabilities; we are already doing this but there are always better ways we can work.

As the European Network Manager, we will continue to evolve and work hand-in-hand with our partners to develop solutions to meet current and future airspace and ground capacity needs. We will address performance challenges strategically, operationally and technically, for the benefit of the entire European aviation network. ■

NETWORK MANAGER INVESTS IN AI TO TURN DATA INTO BUSINESS VALUE

After a successful first phase of digital transformation 10 years ago, the Network Manager (NM) is now engaged in a second digital transformation phase by developing a new data centric system architecture and leveraging machine learning and AI techniques. This will allow for the introduction of intelligence and automation in real-time business processes, augmenting human capabilities and supporting informed decision-making.

As with most digital technologies, artificial intelligence (AI) is now widespread. Learning, reasoning, heuristic search and problem solving algorithms are found in a very wide range of applications. Most industrial and economic sectors are deploying these techniques in their engineering methods and products. Artists are experimenting with AI in their creative tools.

The Network Manager is planning a technology breakthrough and AI will be one of the most important enablers for the next generation system. AI already contributes to – and benefits from – an accelerated momentum of technology development, which is opening a wealth of opportunities in many different fields. AI technologies help medical professionals and benefit environmental protection and monitoring programmes, in agricultural projects and in the modelling and management of cities, infrastructures and industries. They contribute to safer and more efficient mobility and transport systems, offering effective tools for multi-modal and multi-lingual interaction and information querying.

The new NM's system architecture involves much more than just a technological upgrade of the system that performs the demand-and-capacity balancing within Europe's air traffic management (ATM) system – it will be a key enabler for the entire and profound digital transformation of the continent's ATM network, changing the way the European network is managed and the relationships between all aviation stakeholders. AI techniques will become the mediator between the users and this new digital world. The challenge will be to be able to accurately analyse and qualify the safety properties of components and systems to go above the current safety standards.

The first digital transformation of NM was already a catalyser for the ATM digital transformation. It allowed NM to make ATM data widely available via its business-to-business services (NM B2B), promoting interoperability based on open standards, which is a core goal of the Interoperability Strategy of NM, a goal aligned with the European Aviation Strategy and the Digital Single Market. The NM B2B services have stimulated creativity and innovation and have contributed to safer and more operational-efficient and cost-efficient services. They have also enabled new entrants to the market, creating jobs. They form the backbone required for the inter-regional data exchange that supports the global ATFM vision.

At the March 2019 World ATM Congress, the European Commission's Single European Sky (SES) recognised the contribution of NM's interoperability initiatives to the digital transformation of the ATM and granted the SES Innovation Award to the "Interoperability with the EUROCONTROL Network Manager" initiative. *"This initiative"*, highlights Idalina Mendes Videira, Network Strategy and Development expert, *"recognised the achievements of NM and its ten partners*[1] *– five air navigation service providers, three airports, one airline and a computerised flight plan service provider – in collaborating on a*

[1] DFS, DSNA, ENAIRE, MUAC, skyguide, Copenhagen Airport, Nice Airport, Schiphol Airport, Air France and RocketRoute

variety of digital data exchanges with NM. The interoperability initiative has to date delivered more than 100 services and connected to NM more than 200 systems from organisations worldwide, and demonstrated the tangible operational benefits of making ATM data digitally available."

The first phase of digital transformation capitalises on the Service-Oriented Architecture (SOA) technologies to redesign and open systems to achieve more levels of interoperability with customers. The NM's Technology Division is now moving into the second phase to ensure that the huge amount of data being store can be exploited. NM has several years of archived data, which has been used for post-ops reporting, but not leveraged for supporting real-time operations. The idea is to put some intelligence behind the unexploited data to help humans increase their capability to understand the dynamic traffic situation they face and make the right decisions. AI will be at the core of this project.

NM has been adding increasing levels of automation to its system architecture over the last few years. The introduction of data science techniques to analyse the processing of flight plans in 2017, has been allowing to further automate the process and is a fundamental reason for the leap in the number of flight plan transactions which NM is able to process automatically (see box "How AI has accelerated automated flight plan processing").

With the application of new AI processes, NM will be able to understand the effect of an event before it happens. So if there is a weather phenomenon forecast or a sudden runway closure, NM will know the impact of this on the network and calculate the best course of action to take.

The introduction of new machine learning capabilities within the NM's systems architecture will not just improve predictability, it will transform the way humans and machines work together to manage the network. Currently humans play the role of a stop-gap to fill the constraints of the system but this paradigm will need to be reversed so that the machine and the human can work in a complementary way. This means NM needs to understand better the issues of demand-and-capacity balancing through the actions of different actors. A complementary aspect, which will increase predictability, is the gathering of data from new sources. As an example, an experiment with ADS-B satellite information on aircraft positions before entering the European airspace demonstrated the increase of predictability of the system by up to 10%, which is a huge improvement.

NM is now receiving advanced information on flight operations in the USA from the Federal Aviation Administration (FAA) and Brazil using System Wide Information Management (SWIM). In the near future, more information could become available from flow control centres in the Middle East and Singapore.

The increase in predictability, resulting both from the use of AI and the use of additional sources of data, specially outside Europe, is expected to raise confidence in the system and to unleash unused capacity, which is currently kept in order to be able to deal with the high levels of uncertainty we have today.

As data is exchanged between stakeholders in increasingly automated ways, the door is open for new artificial intelligence capabilities to start changing the way all stakeholders in the system interact with each other at an operational level. ▶

The volume of data being processed by NM is rising

Challenges – High volume of data processing

	Peak days in 2018	
	Flights	38 000
Average 100 msg/sec	Msg In	400 000
	Msg Out	700 000
Peak >200msg/sec	CPR	7 million
	B2C/B2B requests	4.5 million
	B2B Pub/Sub	8 million

One order of magnitude needed for new NM system

System sizing (WW ready)	
Flights	300 000
Msg In	3 million
Msg Out	6 million
CPR	60 million
B2C/B2B requests	35 million
B2B Pub/Sub	100 million

"We are starting to see that airlines are looking again at the way they are undertaking their flight planning," according to Pierre Hanoune, IT Architecture and Strategy, within the NM Technology Division. *"In the past, much of the work has been outsourced to third-party flight plan service providers. But as aircraft operators have seen the benefits of interacting directly with the NM via the NM B2B services – in terms of ease of use and low cost – they are starting to undertake more automated communications directly. Having the NM data gives the airlines the network situational awareness, which allows them to move from the old paradigm of "file and forget" to being an active actor in the overall traffic optimisation. A key enabler for NM to accommodate theses increasing levels of data exchange is to migrate our system to public-service cloud-based data providers. This will give us the required scalability and elasticity to cope with growth."*

"To embrace the digital journey means that we have to manage changes at all levels, operational, technical and cultural. And it is not only the initiative of one party, we all need to work towards the same goals and this will mean a transformation of the way we work together. We will see new types of jobs, new opportunities and innovation labs (or digilabs) spreading out. These are not just to test the technology but more to establish a different human-machine interaction paradigm, in terms of user experience and, as well, to teach the machine and make it learn from our complex environment, which will be key to make AI technologies become a commodity in the European ATM network." ■

Idalina Mendes Videira
Network Strategy and Development Expert, EUROCONTROL

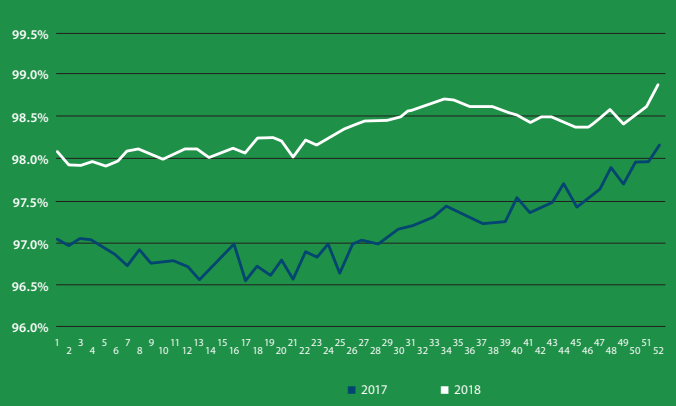
Pierre Hanoune
IT Architecture and Strategy, NM Technology Division, EUROCONTROL

HOW AI HAS ACCELERATED AUTOMATED FLIGHT PLAN PROCESSING

The past few years have seen NM working hard to increase the number of Flight Plans (FPL) that are automatically processed. Each time the system could not process a flight plan it required manual intervention by NM operations staff to analyse and act on the flight request – a time-consuming and expensive business. Evolving the automatic pass rate by traditional methods saw only a very small improvement – NM processed 96.32% of all FPLs automatically in 2014, rising to 96.79% in 2016. In 2017 data science techniques were introduced to identify specific and complex patterns that could be automated. By the final weeks of 2017, NM was recording automated processing rates of 98%; in the Summer 2019 it had risen to 99.5%. A 1.5% increase may not seem very much, but with more than 30,000 FPLs a day being processed it has meant a significant reduction of workload in the operations room.

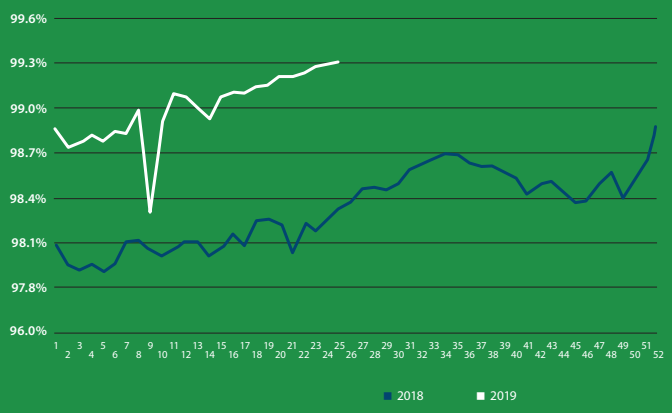
Comparison of the automatic flight plan processing rate between 2017 and 2018

Automatic processing rate – Weekly evolution



Comparison of the automatic flight plan processing rate between 2018 and 2019

Automatic processing rate – Weekly evolution



MAASTRICHT PIONEERS INTELLIGENT PLANNING

The Air Traffic Control to Air Traffic Management (ATC2ATM) programme is exploring new ways to improve the centre's productivity

The Maastricht Upper Area Control Centre (MUAC) is responsible for managing some of Europe's most complex airspace and started examining Artificial Intelligence (AI) tools in 2016, deploying its first intelligent automation solution in 2018. The air navigation service provider (ANSP) is now a pioneer in machine learning and plans to roll out further intelligent tools in the latter part of 2019.

AI is part of a wider programme at MUAC – called Air Traffic Control to Air Traffic Management (ATC2ATM) – which is exploring ways to improve the centre's productivity under the leadership of Robert Parys. Two projects within the programme are closely linked to AI and its use in the pre-tactical planning flight phase.

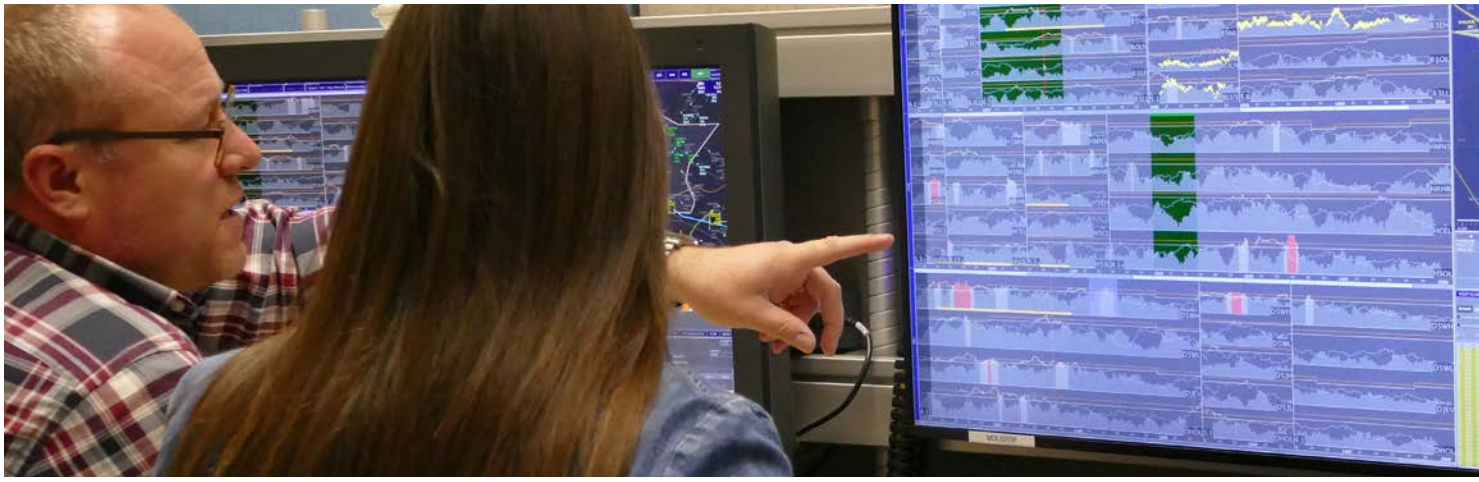
The Post-operations Analysis and Business Intelligence (PABI) project is well advanced with the establishment of a data warehouse which provides a framework for the development of intelligent tools. These tools essentially form a business intelligence layer on top of the data and allow operators to access specific information relating to previous flight history.

The post-operational analysis work initially involved a lot of manual input, but increasingly *"goes towards an integrated system and use of machine-learning algorithms,"* says Parys. *"Based on the previous day's situation, we build a plan for next year's equivalent day, taking into account as many parameters as possible."* This includes traffic predictions, available resources, traffic complexity, workload reported by controllers, regulations, events, weather, industrial action and so on. This is enabled by development of a Sector Opening Timetable Architect (SOTA) tool, used to determine sectors' workloads and consequently their opening times. *"As we learn, we catch more structured data and classify (score) the analysed day according to pre-defined categories. At some point we believe this process might be more or less automatic."*

"Based on the previous day's situation, we build a plan for next year's equivalent day, taking into account as many parameters as possible."

Robert Parys
Programme Manager,
EUROCONTROL MUAC

It is the wealth of information within Maastricht's data warehouse which contributes to better decision-making. The data collection covers not only the executed event, but also all the evolution of the predictions which occurred prior to now-time. By applying machine learning to this historical data, it is possible to identify influential factors and improve decisions next time. Project Manager Sebastian Wangnick explains: *"Controllers take sharper decisions when they know the certainty behind the data. Information at the point of decision-making is associated with a lot of uncertainty. The collection of all this historical data allows us to look much deeper into the sources of uncertainty."* The information includes all the updates, corrections and modifications that occur during the course of a flight. *"You have to compare what actually happened versus the optimum outcome in the context of the information presented when the decisions are made. Machine learning can help draw conclusions and improve our operations."* ▶



Traffic Prediction Improvements (TPI) is the second project employing AI. Several uncertainties hamper the accuracy of predicted flight trajectories, such as future air traffic controller clearances that will cause the flight to deviate from the original flight plan. By using modern AI algorithms these deviations can be predicted. MUAC launched the initial version of TPI in 2018, starting in the Brussels sector group where a large military area was affecting sector flight planning. The tool has proved very successful, leading to improved predictions for flights between specific city-pairs. For example, average lateral error halved between city-pairs: London Heathrow-Berlin Tegel; London Heathrow-Copenhagen; and Madrid Barajas-Frankfurt as a result of more accurate forecasts of the sector sequence.

The results can also be unexpected: for example, when predictions put flights close to sector boundaries, sometimes they are counted in unexpected sectors. In general, users prefer errors they are familiar with to unknown errors,even if the new errors are smaller overall. As a result, MUAC is rolling out the predicting tool one traffic flow at a time, once operators have sufficient confidence in the system.

4D trajectory prediction

In the next stage of the TPI project MUAC looks at trajectory prediction with the added dimensions of time and vertical movements. Rather than addressing specific elements of the prediction individually (e.g. route, entry point) and feeding it back to the Flight Data Processing system for the calculation of a predicted trajectory, the AI algorithm takes the full output of the existing Flight Data Processing system and transforms it into a more accurate forecast taking into account additional data. The AI technology combines elements from image transformation and language translation. The algorithm will be complemented by another machine learning algorithm that, for the predicted trajectory, predicts which sectors will control the flight based on how similar flights were controlled in the past.

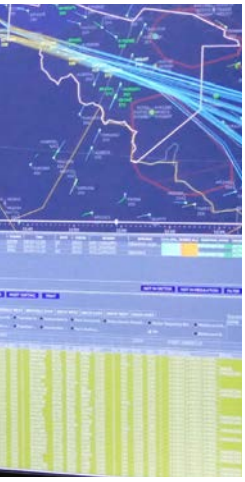
Sebastian Wangnick
Project Manager,
EUROCONTROL MUAC

"Controllers take sharper decisions when they know the certainty behind the data."

Project Manager Herbert Naessens says the 4D trajectory includes aircraft position, altitude and speed and already provides more accurate predictions. *"We have an advanced prototype we are considering for operational implementation,"* he says. Results to date show a benefit of more than 47% for horizontal accuracy, while the average accuracy of the vertical predicted trajectory improves more than 27%. The figures apply to flights not yet in the MUAC airspace, which often suffer from inaccurately predicted trajectories.

In the most recent development of the trajectory prediction tool, MUAC has added surveillance data to develop the tool into more of a real-time solution. *"When we have the surveillance data with the machine-learning prediction layer on top we see a 40% improvement in trajectory prediction accuracy both horizontally and vertically,"* says Naessens. These figures apply to flights in MUAC airspace. Existing deterministic prediction methods already adapt the prediction based on the observed position, and perform reasonably well horizontally. Nevertheless, machine learning can still improve upon them.

"The benefits are twofold," says Naessens. *"On one hand, the tool predicts traffic one or two hours in advance when and where a flight is going to enter a sector, providing the flow management position with the expected workload and allowing them to decide on optimal regulations. On the other hand, it looks at a shorter horizon of about 30 minutes and provides the Advanced ATFCM Planning Function (AAPF) with predicted clusters or bunching points."*



"User acceptance is really important. We have learned we need to be prudent."

Herbert Naessens
Project Manager,
EUROCONTROL MUAC

Implementation of the 4D trajectory prediction tool is anticipated in 2020, subject to the addition of auxiliary integration equipment and rigorous checks associated with safety-critical systems. *"User acceptance is really important,"* explains Naessens. *"We have learned we need to be prudent."*

Real-time benefits

Bringing together Air Traffic Flow Capacity Management (ATFCM) and ATC environment is another goal of ATC2ATM. MUAC began this process with the development of the integrated Flow Management Position (iFMP) in 2016 which provides a bridge between supervisors, flow managers and tactical controllers.

In a further development, MUAC plans to introduce a new connection between the iFMP and the tactical controller working positions that will enable messages to be exchanged directly between the two displays relating to specific flights. Robert Parys says a prototype will be introduced later this year followed by operational use in 2020, where *"traditionally these have been two different environments."*

MUAC is also working with the EUROCONTROL Experimental Centre to develop a prediction model focused on aircraft take-off times, a major cause of uncertainty when trying to predict sector loads. The research takes all the available information about a particular flight in the two to three hours before take-off. This includes any delays at the departure and arrival airports, sector traffic load, weather, active regulations and events, to come up with an estimate of when the flight will take off. The model considers multiple factors down to the airline and aircraft type to deliver a more accurate take-off time than is currently available. *"We take everything we can, for example data from the Network Manager, airports and ADS-B providers"* says Herbert Naessens.

Unlike earlier trajectory prediction activity which looked only at MUAC flights, this machine-learning tool is designed to work on all flights in Europe. Naessens hopes to have a prototype available by the end of 2019. *"We are not talking about experimental technology any longer. Machine learning is being implemented now and solutions are in use. They will simply become more technically advanced."*

Intelligent solutions

How to take this to the next level is the real challenge. Having developed a good understanding of where the traffic will be, the intelligent part will be to provide solutions. *"This will be our focus over the next couple of years,"* says Robert Parys, *"where the system will provide a couple of solutions the user can choose from. User selection will build confidence in the system and over time the system will learn preferred solutions, taking us from simply presenting lots of data to providing solutions."*

Among early initiatives, MUAC is looking at proposing solutions, rather than basic alerts, when clusters are predicted close to sector entry. Currently the planner checks the flights and decides on an action, such as a level or heading change, which can impact controller workload. The system would offer "hints" as to the optimum action. *"We are taking very small steps,"* adds Parys. *"The key here is trust."*

Outside the ATC2ATM, MUAC is also looking at enhanced automation support tools for controllers. *"A system running in the background calculating all the conflicts in the next 10-15 minutes can help to reduce the workload for the controller,"* says Parys. MUAC is building a prototype tool called ARGOS acting as an "electronic assistant" to the controller. It monitors flights and generates instructions and consequently datalink messages in certain situations, for example where there is no conflict and the only action necessary is "hello" and "goodbye". Parys says while there is a lot of technical development still to be done, there is more work on the communication side, *"explaining to people we are not aiming to replace them, just reduce their workload by automating routine tasks. Humans will have to stay at the centre of decision-making in the coming years."* ■

COLLABORATION WILL BE KEY TO REALISING THE FULL BENEFITS OF CONTINUOUS DESCENT OPERATIONS

Continuous descent operations offer the potential for major environmental and fuel-burn improvements – but implementation needs to be more coordinated and widespread throughout Europe.

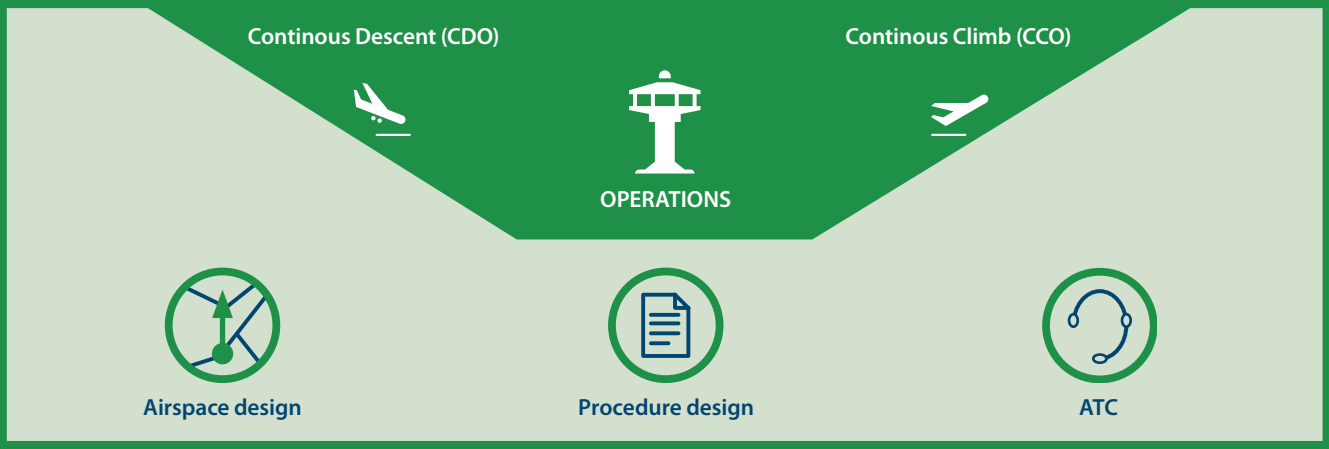
There is an initiative underway to optimise the operational environmental and fuel-burn benefits of continuous climb operations (CCO) and continuous descent operations (CDO) in Europe (see box). While CDO is a natural pilot technique, a relatively modest portion of the potential benefits – in fuel burn, noise and emissions reduction – are being realised. The task force set up under the aegis of EUROCONTROL in 2015 to agree on harmonised definitions of CDOs, metrics and parameters for measurement across the continent is addressing this by developing a high-level European CCO/CDO Action Plan to provide a renewed impetus to the programme. The Plan will outline the task force's view on what actions will be needed to make further gains in performance improvements, especially from CDO, and will give more detail on current barriers to further implementation and what can be done to overcome them. The Plan will, therefore, help every stakeholder to understand better the complexity of optimising CCO/CDO, highlighting potential best-practice solutions in European airspace.

"There have been many initiatives to increase the number of CCOs and CDOs at European airports, but just because an airport has published a CDO arrival procedure doesn't mean it is ever used or has enabled a performance improvement," says David Brain of EUROCONTROL's Environment Unit, and task force co-chair. Task force co-chair Marilyn Bastin of Belgian ANSP skeyes adds: *"Using harmonised parameters allows us to identify a large set of environmental improvements that could be achieved/*

CONTINUOUS CLIMB OPERATIONS (CCO) AND CONTINUOUS DESCENT OPERATIONS (CDO) DEFINITIONS AND BENEFITS

Continuous Climb Operations (CCO) and Continuous Descent Operations (CDO) allow arriving or departing aircraft to descend or climb continuously, to the greatest extent possible. Aircraft applying CCO procedures employ optimum climb engine thrust and climb speeds until reaching their cruising levels. With CDO, aircraft employ minimum engine thrust, ideally from top of descent and in a low drag configuration, prior to the final approach fix. Both are performed in compliance with published procedures and air traffic control (ATC) instructions. SESAR (the Single European Sky ATM Research programme) studies have concluded that a CDO flight compared to a non-CDO flight can reduce noise by 1-5dB.

In 2018, EUROCONTROL conducted a European Civil Aviation Conference (ECAC)-wide CCO and CDO analysis using 2017 traffic data, to estimate the potential network benefits of optimising the CCO and CDO in terms of fuel savings, emissions reduction and fuel costs. The study estimated that optimised CCO/CDO operations could provide fuel savings of up to 350,000 tonnes per year for airlines, equivalent to approximately €150 million in fuel savings; annual CO_2 savings would be greater than one million tonnes. The study also demonstrated that across Europe the potential fuel-saving benefits from CDO are in the region of 10 times greater than those from CCO. Therefore, while at certain airports the potential of individual benefits from optimising CCO may still be greater than those from CDO, at the European level the primary focus of vertical flight efficiency improvements for climb and descent profiles should concentrate on optimising the arrival profile, and from top of descent wherever possible.



retrieved from optimising CCO/CDO. We are now working on improving performance, and that means getting the airlines and the air navigation service providers (ANSPs) to come together and collaborate."

The task force is developing a tool kit which consists of the European CCO/CDO Action Plan; Monthly CCO/CDO performance tables for all airports / airlines in Europe, and a set of resources to support CCO/CDO implementation and optimisation to be available on the task force's web pages.

These resources will contain guidance material for implementation – for example support on CCO/CDO implementation, sharing best practices in airspace and procedure design that allow optimised CCO/CDO, support and guidelines for training on aircraft energy- and flight-performance management, International Civil Aviation Organization (ICAO) documentation on CCO/CDO and impact assessment guidelines for ATM changes – with advice on setting up cross-stakeholder meetings where CCO/CDO implementation can be discussed, as well as and support in stakeholder consultation.

Collaboration should involve airports, airlines, ANSPs, pilots, controllers and airspace designers developing a common approach to understanding and implementing CDOs and CCOs. It will be a complex task. Airlines will be the major beneficiaries, but their current focus on ATM issues is concentrated on the big issue of delay reduction and airspace capacity enhancement rather than operational refinements that can reduce fuel burn and thus emissions. Airports will also benefit – CDOs and CCOs can lower the noise footprint of descending and ascending aircraft – but their role in enabling the operation is peripheral. ANSPs and controllers will have to do much of the heavy lifting in implementing and enhancing the optimisation of CCO/CDO.

One of the first challenges will be to measure performance and define a harmonised definition of a CDO in a meaningful, standardised way across all stakeholders' groups within a

common set of parameters. Without this, CDO operations are not yet delivering the benefits they could.

"If you measure performance you improve performance," says Brain. *"We want to do it for all European airports and all airlines flying in Europe, subject to data availability, on a monthly basis with the best performing airports and airlines identified. But there are other aspects of performance as well. Some airlines have really good practices and we think these should be followed throughout the industry. However, CDO measurements at some airports are focused only on the last part of the descent operation. A CDO at London/Heathrow, for example, is pretty much standardised to optimise the noise footprint of arriving aircraft from 6,000 feet down to 2,500 feet, when the aircraft intercepts the ILS glideslope. But if you have a descent profile starting from top of descent (e.g. flight level 360) and you are focusing just on the last 3,000 feet or so down to glide slope interception, that is just one-tenth of the whole vertical profile. There are also big fuel savings to be counted if we optimise from top of descent, and this is really where I think it should be focused."*

The main challenge is to overcome the silo approach to adopting more environmentally responsible operations. Aircraft manufacturers do not have specific references to CDOs in their aircraft operating manuals. ANSPs do not always train their controllers to understand the impact of air traffic control (ATC) instructions on pilots and pilots do not always understand why controllers give them the instructions they do.

"Predictability is an important element here," says Brain. *"It sounds like an easy word, but it means different things to pilots and controllers. When pilots say they want predictability, they want to know what's going to happen to them en-route from the current location to the airport; they don't know if they are going to be vectored 100 miles out the way or receive instructions to level-off during descent. They need to be told as soon as they are on frequency what's going to happen and with appropriate information provided so they can plan an optimum descent profile. But from the point of view of controllers, predictability means they want to know what a pilot is likely to do if he or she has been given an instruction. For example, if the controller says "descend flight level 100", some pilots may do it immediately, others may do it after 10 or 15 seconds, others may use a lower or higher rate of descent. The controllers need to know that all pilots will do the same thing."*

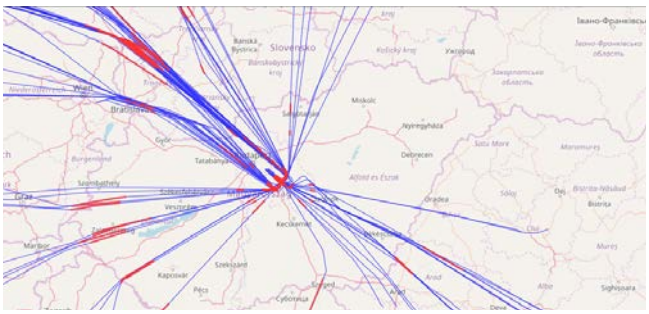
The task force is proposing some updates to controller training material on CCO/CDO and is developing a new controller refresher training module on aircraft energy management so that controllers and pilots can together manage optimum descent profiles even in complex airspace. It will require new levels of collaboration between controllers and pilots.

"We are promoting the work of Collaborative Environmental Management groups, where all operational stakeholders come together at an airport to identify how they can work together to promote environmental benefits, and CDO is one of them," says Brain. *"But more than that, we have seen that projects, for example in Germany, have been successful because the individual pilots and controllers working on a specific procedure have come together. So, it's a more generic collaboration initially, followed by a more focused approach by the actual operational actors working in collaboration with each other."*

CDO operations in complex airspace offer a particular challenge, especially when CDOs start in the airspace of one State and finish at an airport in another. The European CCO/CDO Action Plan will highlight some of the factors that might affect optimised CCO/CDO performance and they include the way airspace is designed and allocated in neighbouring States and air traffic control centres. Cross-border operations are already framed by Letters of Agreement (LoAs) – and cross-border CDOs will require a new, more flexible approach for these agreements.

"If you have a descending aircraft between two different sectors, the agreed transfer of control level between the two sectors may be flight level 320," says Brain. The flight level 320 will have been agreed based on the average flight profile of aircraft that cross this boundary, or it might be designed to keep the aircraft out of a neighbouring sector that has capacity issues. *"In either case, the higher sector will descend the aircraft to 320, and then transfer control to the lower sector, and the lower sector will then descend the aircraft further. But because of this procedure, it usually ends up that the aircraft remains in level flight at flight level 320 for a couple of minutes, burning much more fuel at non-optimal levels."* An example is shown below where the red lines indicate all level flight for arrivals to LHBP (Budapest).

"This is something we are addressing within the Route Network Development Sub-Group in EUROCONTROL, a group which comprises the airspace designers of each country. Any change to procedures will involve complex negotiations laid out in the LoA between ATC centres, but we are looking at route network design to see if these can accommodate any such changes to optimise CDOs. It will be very time-consuming and effort-intensive but studies have shown that there are benefits to be gained, even in the core of Europe. We just think a bit more flexibility will be required." ■



David Brain
EUROCONTROL's Environment Unit, and CDO Task Force Co-chair

DIGITAL SKY CHALLENGE

TAKE OFF TO ATHENS TO REINVENT AVIATION

ACI EUROPE AIRPORTS COUNCIL INTERNATIONAL

SESAR JOINT UNDERTAKING

ATHENS INTERNATIONAL AIRPORT ELEFTHERIOS VENIZELOS

DECEMBER 2-4 2019

ATHENS INTERNATIONAL AIRPORT

An unprecedented number of aviation partners are joining forces to bring you the Digital Sky Challenge: a 48-hour innovation sprint aiming to create new digital technologies that will help meet the future needs of the European aviation system in terms of capacity, safety, efficiency, and environmental impact.

We are looking for new digital solutions in these 3 key areas:

CHALLENGE 1
PASSENGER EXPERIENCE

How can we increase the reliability of flight delay information and improve the delivery of such information through better use of big data?

How can you help passengers find their way in airports, helping them to follow the fastest way to reach their boarding gate?

CHALLENGE 2
ENVIRONMENT

How big is the impact of extreme weather events on aircraft emissions and noise, looking at aircraft movements and data sources like weather and noise monitoring?

How far does your green creativity go for a multimodal mobility tool that informs passengers about emissions caused by mobility choices they take?

CHALLENGE 3
SAFETY

Based on safety data, can we determine how air traffic patterns influence the development of a safety incident?

How can safety events be predicted considering both aircraft and external factors?

IN COLLABORATION WITH

EASA European Union Aviation Safety Agency

AIRFRANCE

METSAFE

SITA

MÉTÉORAGE

innaxis

EUROCONTROL

LUFTHANSA GROUP

IATA

METEO FRANCE

OPENSKY Network

POWERED BY

BEMYAPP

FIND OUT MORE & REGISTER BY 15 OCTOBER AT WWW.DIGITALSKYCHALLENGE.EU