The Future of Airports

A Vision of 2040 and 2070

Topic No. 3: Smart Airports at the Era of Information Technologies

White Paper

ENAC Alumni – Airport Think Tank

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Foreword

In February 2019, ENAC Alumni – the alumni association of the National University of Civil Aviation (ENAC) – organized a day of discussion and education on the current and future challenges in air transportation: **The State of the Air ("Les Etats de l'Air")**. This event, held at the headquarter of the French General Directorate for Civil Aviation (DGAC), was part of a broader effort to fulfill some of our primary missions toward our 24,000 members: to maintain their knowledge up to date, to provide them platforms where to express and exchange ideas, and to promote excellence in aviation & space.

In addition to master classes on Airports, Aircraft and Systems, Design & Certification, Airline Operations, Air Traffic Management, Aircraft Maintenance, Pilots & Flight Operations, Safety & Compliance, and Entrepreneurship, **the State of the Air** featured a series of roundtables bringing together key leaders of the industry in the sectors of air transportation, tourism and general aviation who presented their vision of the future.

Following the large success of the State of the Air, and considering the dedication and expertise of our alumni, it has been decided to take the momentum and invite our think tanks to launch projects on the future of aviation. These think tanks reflect the diversity and excellence of our alumni community: air traffic management, airline operations, airports, digital innovation, and sustainable development.

The Airport Think Tank chaired by Gaël Le Bris is one of the most active of our research groups. The Future of Airports is an important study that brings a significant value added to help us foresee future challenges and prepare our industry for the changes to come. The participants of The Future of Airports have provided remarkable work. The output of the working sessions and the research findings are being released as white papers and other practice-ready materials that will be shared and brought to decision makers and leaders of both the public and private sectors worldwide. I am confident that the outcome of this Think Tank will be a huge move forward for the promotion and recognition of the ENAC Alumni.

Marc Houalla, President of ENAC Alumni

Introduction

From March 2019 to April 2020, the Airport Think Tank of ENAC Alumni conducted a research project on the long-term future of the airport industry: "The Future of Airports". The project involved thought aviation leaders from diverse backgrounds and affiliations who looked at the trends and potentially disruptive changes, emerging transformational innovations, their impact on practice and their challenges for air transportation, and the needs in research, education, and policies for anticipating and facilitating these changes.

The future of airports cannot be envisioned without considering the future of our societies. At the 2040 and 2070 horizons of our study, we will count more fellow human beings than ever. Overall, we will be wealthier and more educated, and have a longer life expectancy. However, we will all face increased impacts from climate change that will put pressure on resources and communities, and might increase inequalities. We will have different social expectations. How can aviation address these new paradigms and continue to provide mobility?

First and foremost, we shall never forget that safety always comes first. As we are making air transportation increasingly automated and connected, we shall remember that our top priority must be to safeguard life, health, and property, and to promote the public welfare.

Human-induced climate change is the most formidable threat to our civilization. Transportation must become greener if we want to sustain the development of our societies without degrading our well-being and endangering public health at a horizon increasingly visible. Aviation shall keep pioneering green policies.

As aviation professionals, we are on the front line to tackle the fundamental issues arising and still continue to interconnect people and move freight. Aviation shall remain a world of opportunities and "create and preserve friendship and understanding among the nations and peoples of the world" as stated in the Convention of Chicago of 1947.

By 2040 and 2070, it is likely that unforeseeable groundbreaking technological innovations, scientific discoveries, and social and political changes will occur and deeply impact our world. When reading these pages, remember that we conducted our work and prepared these materials with our eyes of 2019.

We are all part of this future, and we can make a difference individually if we make ethical and sustainable decisions. Aviator and writer Antoine de Saint-Exupéry said that when it comes to the future, "it is not about foreseeing it, but about making it possible". Let's make a bright aviation future possible together.

Gaël Le Bris, Chair of the Airport Think Tank of ENAC Alumni

Topic No. 3: Smart Airports at the Era of Information Technologies

Smartphone Applications and Biometrics Enhance Passenger Experience

The information technology revolution in the passenger journey is already here. Passengers are exchanging data with and get personalized information from airlines and airports via their smartphones. From mobile applications, it is already possible to check-in for a flight and get an electronic boarding pass – that once were entirely relying on physical processes at the airport. Several airline applications now offer to perform more complex operations such as purchasing a ticket or changing flight instantly. Transactions can often be confirmed with the fingerprint. Airports too have their own applications. They can send pop-up alerts on flight status and remind the location of the parking spot. They are also supporting the new frequent flyer programs of airport operators – a new trend already available at Paris-Charles de Gaulle (CDG) and Paris-Orly (ORY), London-Heathrow (LHR), San Antonio International (SAT) or Singapore-Changi (SIN). They provide several services – some of them being real-time and georeferenced.

Passengers with their smartphone can interact with their environment when walking in the terminal. Bluetooth « beacons » and NFC tags share personalized commercials and special offers based on location and preferences. Miami International Airport (MIA) has installed more than 400 Bluetooth beacons in the terminal. These connected technologies provide georeferenced information and can facilitate the journey through large hub airports, improving accessibility to travelers with difficulties to find their way. These innovations, along with others such as augmented reality (AR), holograms and robots, are particularly relevant to enhance wayfinding for people with special needs – including a growing number of 60+ travelers. It is also of great help to passengers who do not read foreign languages available on the signage, providing electronic wayfinding in their mother tongue. For instance, the Paris Aéroport application provides contents in French, English, Spanish, Russian, Simplified Chinese, Cantonese, Japanese, Korean, German, Portuguese of Brazil, and Italian as well.

In return, these tools of the Internet of Things (IoT) provides the airport operator and other stakeholders with precious information on passenger flows. It is even possible to do so without a dedicated infrastructure. French startup Smart Flows has developed a flow metering solution based on public Wi-Fi connections and models calibrated depending on local habits.

Exiting the terminal is not the end of the journey for passengers. They use applications from the local transit agencies[a], taxi companies, and Transportation Network Companies (TNC) for the last miles to their destination. Airports are exploring options for connecting their applications to provide a unique portal of services and mobility to and from the airport. Such tools could compare transit times and costs, increasing transparency on price and competitivity between modes. At the 2040 horizon, these same tools might offer travelers the opportunity to pre-order an autonomous or connected vehicle (AV/CV), or an air taxi – the cost and accessibility of Urban Air Mobility (UAM) may be available to a larger public in some metropolitan areas as soon as 2025.

Airports and air carriers have deployed facial recognition to simplify the passenger journey. For instance, Delta Air Lines uses facial recognition devices at Hartsfield-Jackson Atlanta International Airport (ATL) to verify the identity at the gate when boarding international flights instead of scanning boarding pass and checking passports by hand. This expedites the process and minimizes the boarding time. By 2040, biometrics will be available at other steps of the journey from the curbside to the gate. Fingerprints and facial identity might be the future “keys” to your flight. In 2018, SITA presented a suite of solutions for check-in, bag drop-off, and boarding using the same biometric database. In the medium-term horizon,

[a] Transit agencies are implementing “tap-to-pay” solution to pay rides with a smartphone (e.g. Chicago, New York and Portland).

these solutions will reduce waiting times and will increase the automation of control and identification processes, along with other technologies such as the self-service bag drop-off kiosks. These kiosks already equip airports around the world and they might promote decentralized, accessible and easy drop-off services outside of the terminals (e.g. train stations, parking garage, curbside).

Crossing a border without having a passport checked by a border agent is a reality. For instance, the French PARAFE program launched in the years 2000 is available at Paris-Charles de Gaulle (CDG), Paris-Orly (ORY) and Marseille-Provence (MRS). Passengers from the European Union with a biometric passport can present this document at the entrance of a automatic gate, and then confirm their identity with fingerprinting and facial recognition. In the United States, the Global Entry program offers a similar service at 75 international airports – some outside the U.S. For passengers who did not subscribe to Global Entry, Mobile Passport Control (MPC) allows to perform the operations preceding the physical control of passports by an agent of the Customs & Border Patrol (CBP), from a smartphone. Screening is on the verge of significant changes as well. The U.S. Transportation Security Administration (TSA) is working with the industry on developing the next generation of checkpoints with expedited processes for the most trusted travelers (see Topic No. 4 on security).

Information and Intelligence Technologies are Revolutionizing Airport Operations

Building Information Modelling (BIM) is already widely used in terminal design and construction. Airport BIM is coming to the landside and airside for operations purposes as well. Continuing the digitalization of information initiated with Airport Geographical Information Systems (AGIS), ABIM will open a new perspective to asset management and airport operations. As Airport GIS was an important element in the implementation of Pavement Management Systems (PMS), ABIM can enable a new world of collaborative tools and be the vehicle of Asset Management Systems, Integrated Operations Management Systems, etc. that could benefit from the merger of these databases.

The last generation of Airfield Ground Lighting (AGL) systems are monitored and driven from control centers that can verify the status of each light individually. The status of aviation pavements (runways and taxiways) during winter conditions can be monitored too with sensors, facilitating the management of snow removal and pavement deicing. By combining pavement monitoring and weather forecast, it is possible to proactively develop strategies anticipating adverse weather conditions hours before they happen – another domain where machine learning (ML) and artificial intelligence (AI) could open new doors. Radars and cameras are already capable of detecting Foreign Object Debris (FOD) on the runways. Using data from the air traffic control radars – and perhaps tomorrow's data sharing with the aircraft, it is possible to deduct the deceleration profile of aircraft on the runway, detect abnormal patterns, and identify loss of adherence on the runway or unsafe flight operations procedures or practices.

In Sweden, air navigation services at Örnsköldsvik Airport (OER) have been provided since 2015 from Sundsvall–Timrå Airport (SDL) – 125 km away – using a Remote Tower (rTWR) system. rTWR works with locally-based sensors, a secure datalink, and a virtual air traffic control environment (virtual reality). Remote Tower Centers (RTC) will increase safety at airports with low-intensity traffic that are or might become non-towered, or with AFIS only (2020-2040). Moreover, the technologies developed for the RTC might bring augmented reality, enhancing air traffic control, increasing safety and resilience at "conventional" towers (during construction works and low-visibility procedures for instance). The next step might be more automated air traffic control. The emergence of Urban Air Traffic Management (UATM) that will advance automation in air traffic management could be a decisive factor in the development of the needed innovations (2040-2070).

Airports manage flows of passengers, aircraft, bags, and vehicles. Their waiting time and outflow are the parameters of its efficiency. From the moment the aircraft is at the gate (In-Block Time) to its

pushback (Off-Block Time), the turnaround time (TRT) shall be monitored to ensure the aircraft leaves on time. Ground handling operations involve several functions and different stakeholders that need to be coordinated and supervised. Information technologies radically changed this work. At large airports, coordinators overseeing multiple flights from a control center in communication with field supervisors – increasingly equipped with smartphones or tablets for communicating with operations management solutions. Decision making on a flight does not rely anymore on individual visual information only but is assisted by real-time indicators shared with the stakeholders and providing a broader view on the impact of delayed individual tasks on the performance of the entire flight and of hub operations more generally.

This facilitates the overall management of performance and communication to the Operations Control Center (OCC) of the clients (air carriers). These ground operations control centers tend to be similar in their organizations and equipment – e.g., the Hub Control Centers (HCC) of Air France at Paris-Charles de Gaulle (CDG) and AeroDarat at Kuala Lumpur International Airport (KUL) are comparable. Such organizations require information systems and connection to other stakeholders' systems – especially under Collaborative Decision Making (CDM) agreements or similar integration. The next step in ground handling operations at large hub airports might be the introduction of machine learning and artificial intelligence to perform real-time and post-operations analysis, detect patterns creating delays and providing assistance to decision-making to the coordinators.

Smart Airports Are Connected to the Field and to the World

The need to increase punctuality and minimize the impact of adverse conditions on flight operations led to Airport Collaborative Decision Making (A-CDM). This concept relies on information sharing between the stakeholders of the real-time status of each flight – defined with "milestones" (defined moments on the timeline of a flight). Each stakeholder is responsible for updating specific milestones – for instance, the ground handler with the Target Off-Block Time (TOBT), which is the expected moment the flight will be leaving the gate. A software solution typically consolidates these inputs and delivers takeoff times. With A-CDM, the airport community including the Air Traffic Control, can work with target times that take into consideration the reality of the field instead of theoretical estimates. Reducing uncertainty and increasing transparency make operations more efficient and resilient.

The extension of the Collaborative Decision Making (CDM) concepts to the whole airport is called Total Airport Management (TAM). TAM provides a holistic approach to real-time airport operations, from the curbside to the air. Such a concept is supported by Airport Operations Centers (APOC), integrating the various functions of airport operations (including external stakeholders). It is connected to the entire airport ecosystem – from the crews in the field to the regional ACC as needed. APOC can be seen as a center of anticipation, supervision and decision bringing together all the stakeholders of airport operations – including air carriers, airport operators, air navigation service providers, apron management service providers, ground handlers, transit agencies, law enforcement, and immigration forces, etc.

Together, they monitor flows and capacities in real-time, plan and anticipate for the next days, and react to prevent adverse conditions to turn into a crisis. In their task, they are assisted by imagery provided by CCTV, and data gathered by sensors in the field. More important, they shall rely on agents in the field – sensors cannot address operational issues alone. The acting staff should be connected to their supervisors under the authority of the Airport Operations Manager. A-CDM and APOC empower the Airport Operations Manager and his team as they lower the monitoring workload, assist decision making with key performance indicators, and provide them with powerful C4I (Command, Control, Communications, Computers, and Intelligence) tools to manage the airport proactively with a comprehensive view of its operations, instead of reactively with a focus on one specific issue. A-CDM and APOC implementation are objectives of the ICAO 2016-2030 Global Air Navigation Plan (GANP).

At a broader scale, the System Wide Information Management (SWIM) that is being implemented in North America and Europe will provide unified platforms and standards for information-sharing in order to provide a single point of access to ATFM data. SWIM will provide an information-centric system to support ATM modernization programs such as NextGen and SESAR. As part of ICAO's GANP, it will enable and facilitate a worldwide exchange of real-time information, and connection to a new wide range of applications and users. Today, the Air Navigation Service Providers (ANSP) in Europe (Eurocontrol), the United States (FAA), Brazil (DECEA), and the United Arab Emirates (GCAA) already exchange flight data in real-time – prefiguring worldwide exchanges at the 2040 horizon.

Deep Automation and Blockchain Could Drive a Second IT Revolution

The collection and treatment of such volumes of data require adequate standards and infrastructure for supporting their transfer and storage. Most commercial airports now have data centers. They will be fed by the Internet of Things (and ultimately the Internet of Everything) supported by 5G infrastructure – and its next iterations. The data themselves have limited value for the airports and their stakeholders. Investing in big data should serve a purpose – and will depend upon the value added that could be extracted from these data. Emerging means and processes to analyze data are dramatically expanding the horizon of possibilities. Machine learning and artificial intelligence can extract patterns and trends from Airport Operations Data Bases (AODB) and other stakeholders- or function-specific database for planning, situational awareness, or decision-making purpose. Deep learning using artificial neural networks (ANN) and deep automation will be the next step and could assist, supplement, and even replace human analysis and decision-making in domains such as operational resource management and asset management. These intelligence technologies could provide analytics and direct assistance to decision-making with "what if" scenarios – a move from current practices similar to recent changes from reactive management mainly based on a visual assessment to a proactive organization basing decisions on indicators providing a broader vision of the field. Blockchain is another emerging technology based on cryptography that can help with securing the exchanges of information and facilitating approval/validation processes ("contracts") in a wide range of activities such as construction (document reviews, field inspections), operations (ground handling contracts, TOBT updates, aircraft recovery agreements) and regulation (airport certification, security clearances).

The airport industry is aware of the potential of information and intelligence technologies. The larger airports can and want to be at the front edge of this new revolution. San Diego, MWAA, and Groupe ADP have different strategies ranging from innovation challenges to intrapreneurial labs and even direct investments into startups.[1] In the long run, these technologies will be accessible to regional airports, and even general aviation airports with scalable solutions tailored for simpler facilities and lower traffic. Meanwhile, there is a risk for local governments, smaller airports, and the least developed regions of the world to stay behind. The industry shall work on closing the gap on information technologies as their dissemination will make the whole air transportation system more resilient. In the short-term, it is possible to be a connected airport for a fistful of hundred U.S. dollars. In 2015, the Executive Director of Tupelo Regional Airport (TUP) presented at the TRB Annual Meeting low-cost connected airport systems developed in-house and using the GSM network to send NOTAMs and pilot information by text messages to the pilot community, and messages on the status of emergency generators and fire suppression systems to the airport management.

As airports rely increasingly on information systems and data exchange, they become more vulnerable to any disruptions. Upon transitioning to new systems for supporting their operations, airports shall develop IT resilience and contingency plans for business continuity when they are down. They are also exposed to cyber-criminality and cyberterrorism. They shall consider their cybersecurity aspects. Data gathering and exchange through open or poorly protected networks create new opportunities for criminal

organizations, individual hackers, and State-sponsored groups with hostile intentions to penetrate databases and endanger the integrity of networks and systems. Cybersecurity is now a hot topic worldwide in aviation. During the last Air Navigation Conference (ANC) of ICAO, nearly all the papers discussed included elements of cybersecurity.

Abbreviations

A-CDM	Airport Collaborative Decision Making
AFIS	Aerodrome Flight Information Service
AI	Artificial Intelligence
ANN	Artificial Neural Network
APOC	Airport Operations Center
ATL	Hartsfield-Jackson Atlanta International Airport
ATM	Air Traffic Management
CDG	Paris-Charles de Gaulle Airport
CDM	Collaborative Decision Making
CNS	Communication, Navigation and Surveillance
DAC	Dubai Airports Company
DAESP	Departamento Aeroviário do Estado de São Paulo
DFW	Dallas-Fort Worth International Airport
DOK	Donetsk Airport
ECAA	European Common Aviation Area
EGSA	Etablissement de Gestion de Services Aéroportuaires
EHCAAN	Egyptian Holding Company for Airports and Air Navigation
EMI	Electromagnetic Impulse
ENAC	Ecole Nationale de l'Aviation Civile
ERAU	Embry-Riddle Aeronautical University
FIT	Florida Institute of Technology
GASeP	Global Aviation Security Plan
GMF	Global Market Forecast
GTAA	Greater Toronto Airport Authority
HCC	Hub Control Center
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
Infraero	Empresa Brasileira de Infraestrutura Aeroportuária
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IST	Istanbul Airport
KUL	Kuala Lumpur International Airport
LAWA	Los Angeles Airport World
LGP	LaGuardia Gateway Partners
LHR	London-Heathrow
MANPAD	Man-Portable Air-Defense System
MDAD	Miami-Dade Aviation Department
MIA	Miami International Airport
ML	Machine Learning
MRS	Marseille-Provence International Airport
MWAA	Metropolitan Washington Airports Authority
NEXTT	New Experience Travel Technologies
NFC	Near-Field Communication
O&C	Ownership & Control
OCC	Operations Control Center
OER	Örnsköldsvik Airport

ONDA	Office National Des Aéroports
ORD	Chicago-O'Hare International Airport
ORY	Paris-Orly International Airport
PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PKX	Beijing Daxing International Airport
RPA	Regional Plan Association
RTC	Remote Tower Center
rTWR	Remote Tower
RVA	Régie des Voies Aériennes de la République Démocratique du Congo
SAAS	San Antonio Airport System
SAATM	Single African Air Transport Market
SAT	San Antonio International
SDL	Sundsvall–Timrå Airport
SFB	Orlando Sanford International Airport
SIIED	Surgically Implanted Improvised Explosive Device
SIN	Singapore-Changi International Airport
SJU	San Juan Luis Muñoz Marín International Airport
SWIM	System Wide Information Management
TAM	Total Airport Management
TIP	Tripoli International Airport
TNC	Transportation Network Companies
TRT	Turnaround Time
TUP	Tupelo Regional Airport
UAM	Urban Air Mobility
UATM	Urban Air Traffic Management

References

[1] San Diego International Airport Innovation Lab. San Diego International Airport/Detecon Innovation Institute, San Diego, CA, USA, July 30, 2018