The Future of Airports

A Vision of 2040 and 2070

Topic No. 5: Enhancing Aviation Safety Under a Growing and More Diverse Traffic

White Paper

ENAC Alumni – Airport Think Tank

April 2020

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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. 5: Enhancing Aviation Safety Under a Growing & More Diverse Traffic

Cooperation Can Build a Collective Expertise in Safety and Fast-Track Enhancements

Generally speaking, the number of fatalities per revenue passenger kilometers (RPK) has decreased quasi-continuously since the years 1970.[1] However, this function has a logarithm-like shape – which means that it is becoming increasingly difficult with our current conception of safety to reduce fatalities as we are improving safety overall. This calls for a revolution in aviation safety as we are at the threshold of several groundbreaking changes. Also, RPK does not consider general aviation. While the number of accidents has decreased as well for these activities, they have its specificities – such as a peak of fatalities around 200 hours of experience[2]. Finally, we should not consider fatalities only in a comprehensive risk-based approach. Incidents of lower criticality can be the precursors of fatal occurrences, and aviation safety shall prevent injuries and damages to aviation assets as well.

Over the second half of the 20th century, standards in airfield design were mainly conservative and prescriptive. The progress of the overall knowledge in flight control and airport engineering bolstered by the need for accommodating larger aircraft at existing infrastructure showed these standards were often overestimating risks and sometimes underestimating them. These efforts fostered a mutual understanding of the stakeholders of airfield design and certification – airport operators, aircraft manufacturers, and civil aviation authorities. More importantly, this created a momentum in safety and regulations that enabled the emergence and rise of the risk-based approach. This new vision of risks led to the redefinition of several airfield design criteria and standards in the 7th and 8th editions of Annex 14.

We have already developed most of the infrastructure enhancements possible for ensuring aviation safety at airports. “Hardware” design standards have reached an exceptional maturity. Mitigations were developed for addressing the most impactful deviations to these standards. Arresting systems[3,4] provide since the late years 1990, a solution to airports lacking space for a standard Runway End Safety Areas (RESA). More competition on this market is coming, meaning that innovation and lower prices are coming. A cost-efficient solution could make the case for equipping general aviation airports. Another improvement of international standards could be a better protection of people and assets on the ground against the fall of an aircraft in the vicinity of runways.[5] To date, only the United States requires airport operators to freeze the land beyond the RESA – up to 810 m beyond the runway extremities for this purpose. These areas are called Runway Protection Zones (RPZ)[6,7].

Safety Management System (SMS) is a systemic and systematic vision of safety that was adopted by the ICAO in 2004.[8] While some countries are still in the process of implementing it at airports, it is now a well-accepted international standard that has significantly contributed to the advancement of operational safety – including on the traffic and non-movement areas with the inclusion of ramp safety and ground handling. SMS has helped to bring together the stakeholders of airport operations at individual airports to build a joint ambition in aviation safety. Industry working groups[a] and forums[b] with an emphasis on safety have tremendously helped airports sharing best practices and advancing safety. The Transportation Research Board (TRB) and its Airport Cooperative Research Program (ACRP)[9] in the United States have produced a considerable amount of research studies, synthesis on practices, and guidance materials that have helped practitioners around the world. Groups of airport operators have led

[a] Such as the Technical, Operations & Safety Committee (TOSC) of ACI Europe, the Infrastructure Workgroup of The French-Speaking Airports (UAF&FA), and the Airport Construction Advisory Council (ACAC) of the Federal Aviation Administration (FAA).
[b] Recent national and regional events include the AAAE/FAA Airfield Safety, Sign Systems and Maintenance Management Workshop (United States), Eurocontrol Airport Surface Risk Safety Forum 2020 (Belgium), 2017 DSAC Symposium on Runway Construction Safety (France), and 2019 ANAC Fórum Técnico de Obras (Brazil).

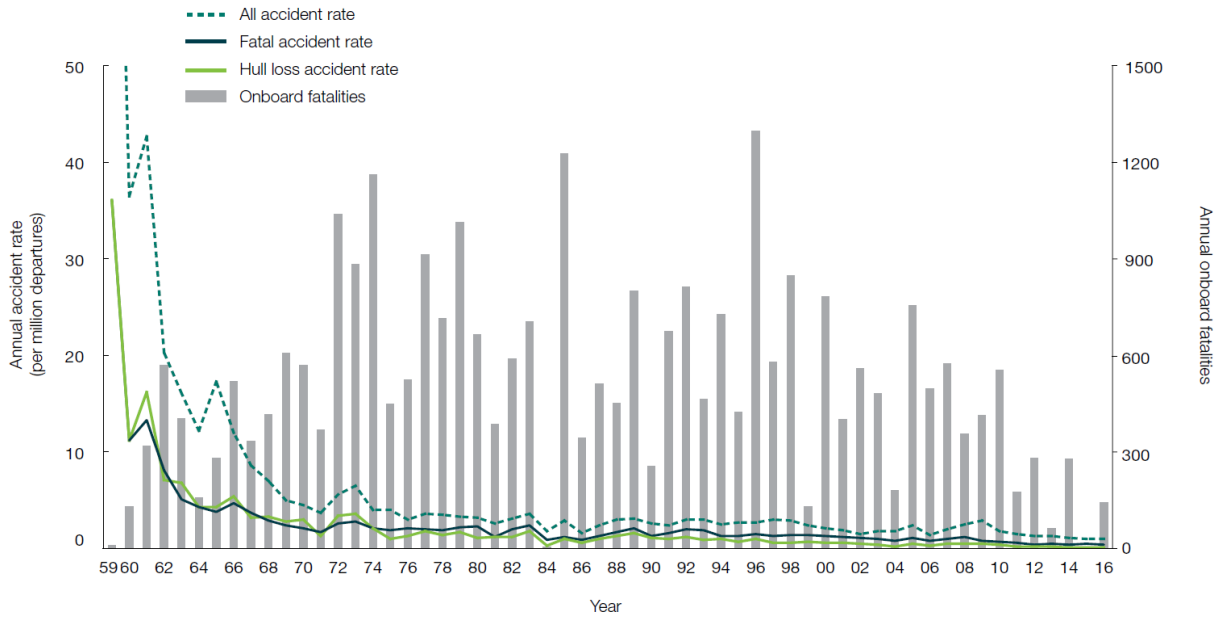

Figure 5-1 - Accident Rates and Onboard Fatalities by Year for Commercial jet Aviation
Source: Boeing, 2017

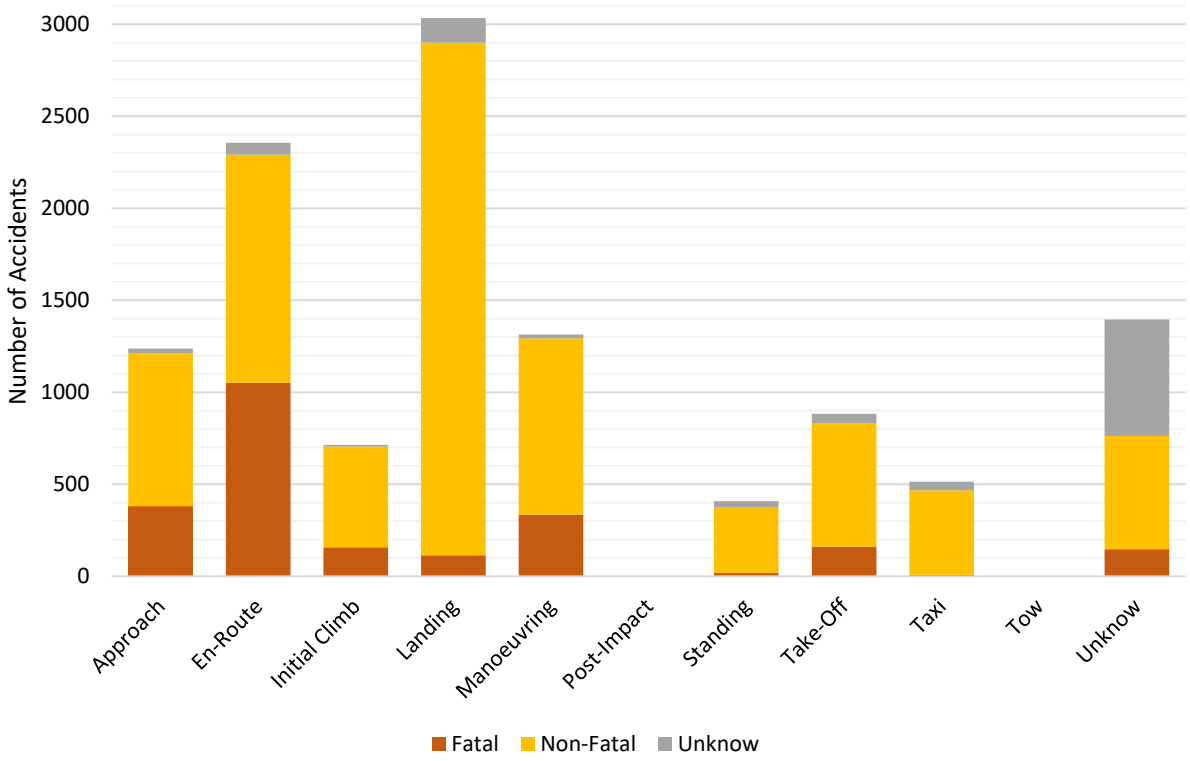

Figure 5-2 - Accidents per Phase of Flight from 2008 to 2020
Source: ICAO iSTARS API Data Service, April 2020

the way and addressed together significant operational safety challenges – some of their answers have become standards.

Paving the Way to the Future of Airport and Aviation Safety

The next frontier to improve safety standards is made of real-time systems and data. Data sharing and real-time analysis of these data will increase both operational performance and safety. For example, the lack of safety data available have prevented airport safety risk analyses from being as quantitative and comprehensive as they should be, and National Aviation Authorities to get a detailed vision of safety issues – a condition for designing an efficient State Safety Programme (SSP). A more systematic reporting of accidents and incidents, and the centralization of these data, start helping airports and agencies to get this vision and utilize data to improve safety in complement of lessons learned directly from the field.

Sensors available can now provide an estimate of the surface condition of runways. Radars and visual systems detecting Foreign Object Debris (FOD) are coming on the market and could tackle an issue that is still not fully addressed[c]. Autonomous Runway Incursion Warning System (ARIWS)[10] such as the Runway Status Light (RWSL)[11] provides visual information on runway occupancy to the crew, preventing runway collisions. Simpler technologies of runway incursion prevention on the ground are being developed in the United States through the Runway Incursion Reduction Program (RIRP).

The next step may not be based of ground equipment. The future of airside safety also resides in cockpit equipment such as Runway Incursion Prevention Systems (RIPS), aircraft-ground data exchange, and the use of big data. Several cockpits already navigate airfields with the assistance of dynamic digital aerodrome charts. With inflight updates, these charts could include the latest aeronautical information published by airports, provide enhanced guidance information during taxiing, and raise awareness and generate alerts on airfield safety issues such as runway incursions and wingspan restrictions.

Runway adherence is an essential information for preventing runway excursions, and triggering runway deicing and snow removal.[12] Airbus[13] and Boeing[14] both developed onboard Runway Overrun Awareness and Alerting System (ROAAS) (resp. ROPS and SAAFER). Next, these systems could exchange their assessment of the friction coefficient with other aircraft and the ground, providing a real-time, reliable, and aircraft-centered measurement of this value in a complement of the estimate derived from heterogeneous methods currently in use around the world.[15,16] Combined with Artificial Intelligence, this information could assist airports in their decision-making for continuing operations under rainstorm or winter conditions, triggering rubber removal and winter operations, and for enhancing airline procedures and individual pilot safety performance.

The revival of Urban and Rural Air Mobilities (UAM/RAM) with a new generation of vehicles (eVTOL) raises questions in airside/airspace safety. The experience in UAM over cities such as São Paulo, Brazil demonstrates that it can be safe with today's helicopters and specific procedures and practices. However, the extension of the domain of operations to IMC, the introduction of new players and vehicles, and the coexistence of piloted, remotely piloted and fully automated vehicles in the lower airspace call for new concepts of operations and standards. The ongoing research efforts in Urban Air Traffic Management (UATM) aim at addressing these issues and allow a safe and efficient deployment of UAM.

Concepts and technologies developed for UATM and Remote Tower Centers (RTCs) could contribute to the improvement of safety at "conventional" ATC facilities. At the 2040 and 2070 horizons, the stakeholders of real-time airfield and airspace operations will have more tools assisting them in the

[c] After the crash of Concorde at Paris-CDG in July 2000, standards and practices on runway inspections were tightened. However, the possibility of a FOD on the runway between two inspections mostly relies on pilot vigilance and reporting.

decision-making tasks and providing predictive scenarios during adverse conditions. At some point, the complexity of some concepts of operations might take part of the human decision out of the loop. This transition towards more automation in critical tasks and safety nets will require a careful assessment of the potential adverse impacts, and contingency plans in case these systems fail.

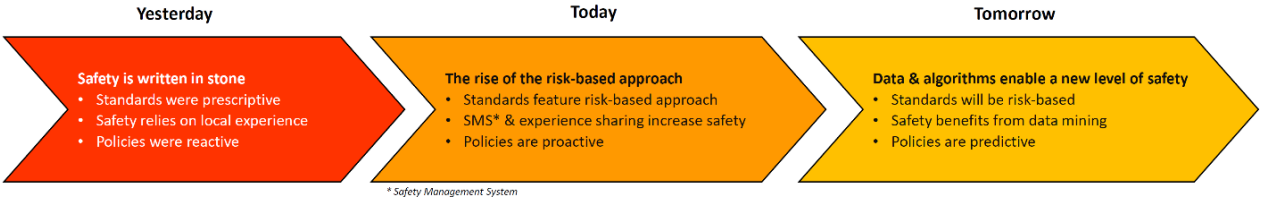

Figure 5-3 - Long-Term Trends in Aviation Safety

The Aviation Community in the Emerging World Must Improve its Safety Culture

According to IATA[17], the P.R. of China will overpass the United States and become the world's largest aviation market around 2025. Thailand should make the top 10 by 2030. By 2040, India and Indonesia should be among the 5 largest markets. In the meantime, Africa will be the fastest-growing region with a CAGR of 4.6%. Latin American and Caribbean (LAC) will follow closely with a CAGR of 3.6%. As air traffic should dramatically increase in the newly industrialized and developing world over the coming decades, it is crucial that the less safe countries keep up with the rest of the world. Their unpreceded growth is synonymous with an urgent and large need for aviation professionals. In an industry where experience and mentoring can make a difference in the field, an afflux of young professionals on critical positions of all the components of the local air transportation system can threaten safety.

It is vital to acknowledge that the level of safety is not the same throughout the world. Airports and oversight authorities shall work at closing the gap on ICAO standards. They should be inspired by the recommended practices as well to champion safety. Moreover, they shall become aware of their local specificities and gaps, and work on addressing them timely. The ICAO Global Aviation Safety Plan (GASP) is calling for such effort worldwide. The previous plan fell short in bringing all states up to the target on effective oversight implementation by 2017.[18,19] The ongoing plan aims at getting each country to define and implement a State Safety Program (SSP).[20] It is expected that the next period to the 2028 horizon focuses on implementing advanced safety oversight systems, including predictive risk management – a step that the most advanced countries have already achieved.

As of today, the Universal Safety Oversight Audit Programme (USOAP)[d] reveals that the average global effective implementation of ICAO's standards and recommended practices (SARP) with regard to aerodromes is of 62.29%. Considering the items at stake, this is a poor performance – and it is one of the lowest implementation rates of all the USOAP domains. Airports and the other stakeholders of flight operations need strong National Aviation Authorities to support national industries and ensure the safety of the overall air transportation ecosystem. In the less performant regions, a safety revolution is urgently needed to safeguard passengers and aviation assets. Beyond compliance with ICAO standards on oversight, each segment of the air transportation system shall comply with international standards and best practices, and a safety culture shall develop inside the aviation community, from the field to the executive management and governments. As these countries are at the threshold of unpreceded growths of air transportation, it is now that their governments must realize the imperative need for safety and pave the way to a bright and safe future for their aviation and airport industry.

[d] USOAP audits focus on validating a State's capability of performing safety oversight of its industry.

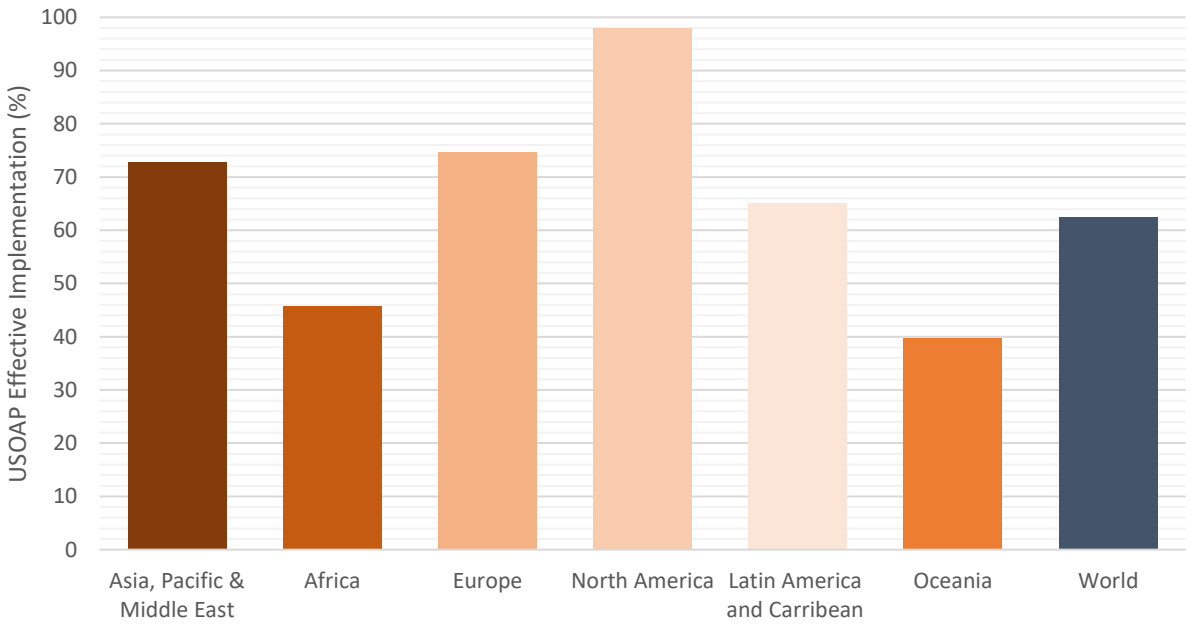

Figure 5-4 - USAOP Effective Implementation on Aerodrome and Ground Aids
Source: ICAO iSTARS API Data Service, April 2020

Achieving this requires specific progress in the funding, governance, and continuous improvement of aviation safety.[21] First, governments shall provide the National Aviation Authorities (NAA) with adequate financial means and workforce, organic and effective independence, and a strong commitment to "safety first". The partial delegation of monitoring and certification to the operators cannot be a solution to organic deficiencies of the NAA. Then, major deviations to airport standards shall be removed. Airport operators cannot be expected to undertake alone all corrective actions. Grading runway strips, creating Runway End Safety Areas (RESA), removing obstacles and moving habitations, installing airside fencing, procuring rescue and firefighting (RFF) apparatus, and wildlife mitigation equipment might call in some cases for governmental coordination and public funding.[e] Adequate land use planning and strict enforcement of good sense rules shall prevent the errors of the past to be repeated. In some cases, international institutions such as the World Bank, ICAO, and other assistance mechanisms can provide funding to infrastructure projects and studies. The support of the ICAO is also offered as part of the No Country Left behind (NCLB) initiative.

Beyond the needs in infrastructure and equipment ("hardware"), a strong airport safety culture shall emerge within the airport staff and among the stakeholders ("software"). It should take into consideration the human and organizational aspects of safety. It shall be supported by the top management, embraced by the field, enable bottom-up reporting, be transverse throughout the airport organization, include the stakeholders as well. It means providing adequate means and training to the acting staff, and ultimately implementing Safety Management Systems (SMS). It also means fostering a safety culture based on transparency, non-punitive reporting, lessons learned and risk management.

A great deal can be achieved with cooperation within the airport community in each country, with the National Aviation Authority, and through international cooperation as well. Making the information accessible to the industry is a must-do, and while internet accessibility is now widespread in the whole world, too many countries – including among the developed nations – do not provide a great extent to

[e] This is applicable to developed countries as well. In the United States, RESA and arresting beds were implemented with the help of the Airport Improvement Program (AIP) and coordinated by the FAA through the Runway Safety Program.

safety regulation and practices on their website. We call for sharing accident and incident databases with the industry to make this knowledge available to the practitioners and facilitate the lessons learned process. National or local symposiums and safety task forces or action teams can help tackle the top priorities. Learning from others, gathering external lessons learned, and implementing best practices is a way to fast-track safety enhancement. High-level regional meetings at the governmental or industry levels are not enough and do not address alone the safety challenges ahead. Direct cooperation between airports, workshop between field operations teams, transnational collaborative work on specific issues, and dissemination of industry best practices may provide the complement to fill the gap.

Appendix 5-1 - Enhancing Aviation Safety During Airport Construction

This case study provides an example of how stakeholders can tackle together significant operational safety challenges in a reduced timeframe and cost-efficiently with a risk-based approach.

Prior to the mid-2010s, standards and practices in operational safety during airfield construction were deficient. The ICAO Standards and Recommended Practices (SARPs) still feature very few provisions on this matter.[22] One of them (Pattern A for displaced threshold) can actually be confusing. Few countries (Australia, United States) have local standards. Some of them are still a potential source of accidents.[23,24]

In 2009, Chicago O'Hare Intl. Airport (ORD) and John F. Kennedy Intl. Airport (JFK) prepared for runway construction projects involving a temporarily shortened runway with a displaced threshold. Despite a long preparation with the stakeholders and a detailed safety risk assessment with a mitigation plan going beyond the standards, serious incidents happened.[25] In 2011, Paris-Charles de Gaulle (CDG) performed a comprehensive safety risk assessment for a similar configuration to be implemented the next year. The initial search for previous incidents revealed a tremendous number of precursors all around the world and highlighted the lack of a standardized approach for mitigating the related risks.[26]

Research efforts were quickly initiated to correct these deficiencies. The two groups met in Paris in 2011. They shared their views and mutually benefited from their lessons learned. They have maintained contact since then. In the United States, the FAA developed an orange construction signage[27] and new standard layouts for markings that are now featured in AC 150/5370-2G. In Europe, Paris-CDG evaluated different messages for these signs[28], and developed various safety devices within the Infrastructure WG of The French-Speaking Airports (UAF&FA). Both sides worked on enhanced phraseology and dissemination of the aeronautical information to the cockpit.

In September 2016, the Infrastructure Workgroup of The French-Speaking Airports released the initial version of its guidebook on Markings and Signage During Airfield Construction[29]. This publication provides comprehensive guidance on markings and signage, lessons learned on the information of the airfield users, and best practices in safety risk management and stakeholder involvement. Plates propose comprehensive safety mitigation systems combining obliteration of existing items non-applicable during construction and the creation of temporary visual aids. They cover 20 situations including runway, taxiway, helipad, and service roads. They most importantly propose a mature configuration for temporarily shortened runways and runway closures. They introduce innovations such as color runway closure markers, mobile runway closure markers, and the orange construction sign.

In 2017, the European Action Plan for the Prevention of Runway Incursions (EAPPRI) V3.0 featured a new Appendix L on Maintenance, Inspections, Works in progress and Temporary Modifications of the Aerodrome that referenced the guide of The French-Speaking Airports and presented some of its signature mitigation – including the orange construction sign.[30] The same year, the French CAA (DGAC) discussed it during the National Symposium on Runway Construction Safety.[31] In 2018, Airports Council International (ACI) published the most important items of the guide in its guidebook on Managing Operations During Construction[32]. Most of the safety items were adopted by ANAC (Brazil) in its new Manual of Maintenance and Airfield Construction.[33]

In 2020, the Infrastructure Workgroup of The French-Speaking Airports will revise the guidebook to take into consideration the Amendment 14 to the Annex 14 and subsequent update of national and regional standards (e.g. CS-ADR-DSN Issue 4 or the coming FAA Draft AC 150/5300-13B). They will also introduce novelties such as the built-in lighted "X" runway closure lighting system. It will also prepare an action plan to disseminate best practices in the less developed regions of the world.

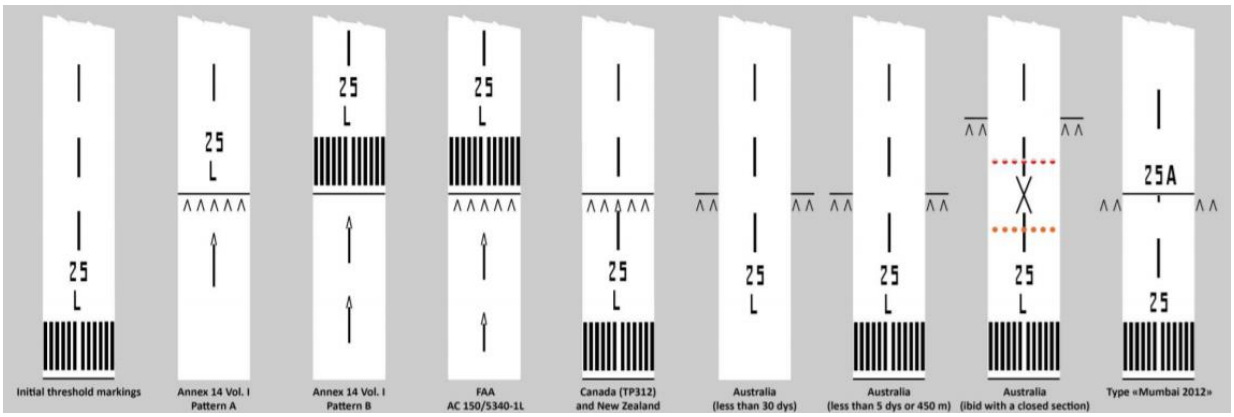

Figure A5-1 - Standards and Practices on Temporarily Displaced Threshold Markings

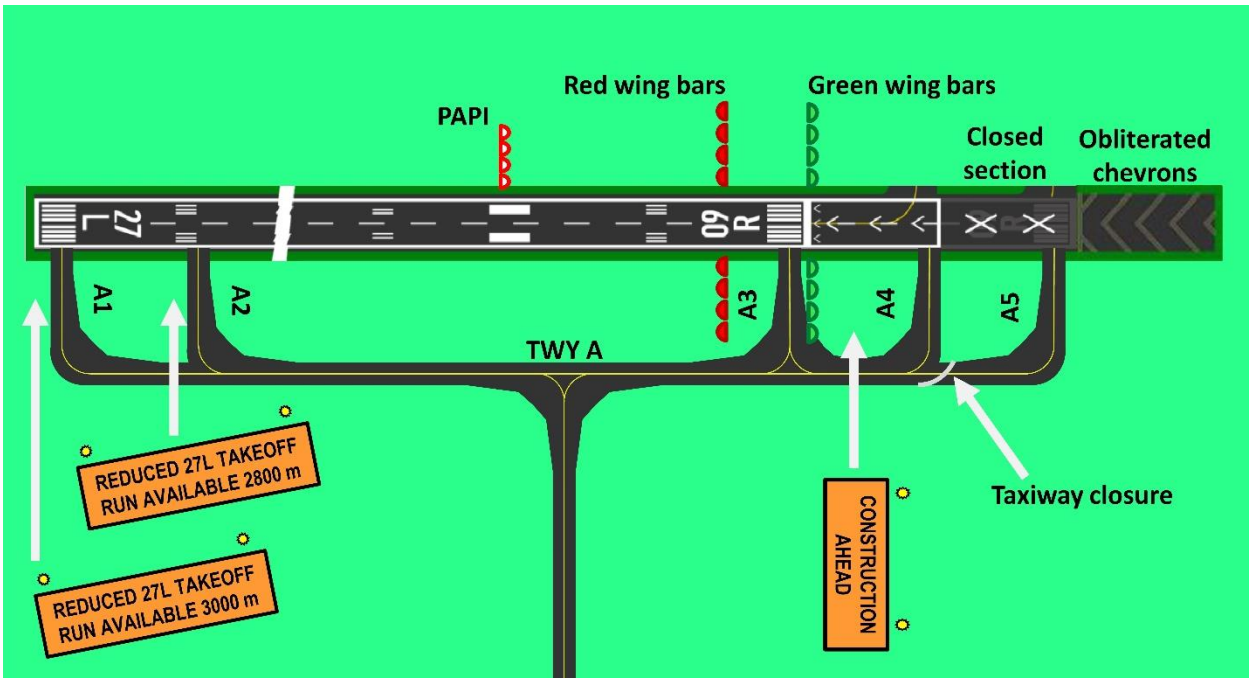

Figure A5-2 - Safety Devices Recommended for Temporarily Displaced Thresholds, Infrastructure WG of The French-Speaking Airports (UAF&FA)

Figure A5-3 - Improving Operational Safety During Airfield Construction

Abbreviations

ACAC	Airport Construction Advisory Council
A-CDM	Airport Collaborative Decision Making
ACRP	Airport Cooperative Research Program
AFIS	Aerodrome Flight Information Service
AI	Artificial Intelligence
ANN	Artificial Neural Network
APOC	Airport Operations Center
ARIWS	Autonomous Runway Incursion Warning System
ATL	Hartsfield-Jackson Atlanta International Airport
ATM	Air Traffic Management
CAG	Changi Airport Group
CDG	Paris-Charles de Gaulle Airport
CDM	Collaborative Decision Making
CNS	Communication, Navigation and Surveillance
DFW	Dallas-Fort Worth International Airport
DOK	Donetsk Airport
ENAC	Ecole Nationale de l'Aviation Civile
ERAU	Embry-Riddle Aeronautical University
FIT	Florida Institute of Technology
GANP	Global Air Navigation Plan
GASP	Global Aviation Safety Plan
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
LAC	Latin American and Caribbean
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
NCLB	No Country Left behind
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
RAM	Rural Air Mobility
RESA	Runway End Safety Area
RIPS	Runway Incursion Prevention System
RIPSA	Runway Incursion Prevention through Situational Awareness
RIRP	Runway Incursion Reduction Program
ROAAS	Runway Overrun Awareness and Alerting System
ROPS	Runway Overrun Prevention System
RPA	Regional Plan Association
RPK	Revenue Passenger Kilometer
RPZ	Runway Protection Zone
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
SARP	Standards and Recommended Practices
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
SMS	Safety Management System
SWIM	System Wide Information Management
TAM	Total Airport Management
TIP	Tripoli International Airport
TNC	Transportation Network Companies
TOSC	Technical, Operations & Safety Committee
TRB	Transportation Research Board
TRT	Turnaround Time
UAM	Urban Air Mobility
UATM	Urban Air Traffic Management
USOAP	Universal Safety Oversight Audit Programme

References

[1] Statistical Summary of Commercial jet Airplane Accidents, Worldwide Operations | 1959-2016, Boeing, 2017
[2] Craig, P. A. The Killing Zone – How and Why Pilots Die, 2nd Edition, McGraw-Hill, 2013, pp. 1-16.
[3] Annex 14 to the Convention on International Civil Aviation, Volume I – Aerodrome Design and Operations, 8th Edition, ICAO, July 2018, Montréal, Canada
[4] Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns, Advisory Circular 150/5220-22B, FAA/AAS-100, September 2012, Washington, D.C.
[5] The Airport and its Neighbors, The Reprt of the Preisdent's Airport Commission, Washington, D.C., May 16, 1952
[6] Section 310 – Runway Protection Zones, "Airport Design", Advisory Circular 150/5300-13A Chg. 1, FAA, February 2012, Washington, D.C.
[7] Interim Guidance on Land Uses Within a Runway Protection Zone, Memorandum, FAA, September 2012, Washington, D.C.
[8] Safety Management Manual (SMM), Doc 9859, 2nd Edition, ICAO, 2009
[9] Airport Cooperative Research Program, Transportation Research Board. http://www.trb.org/ACRP/ACRP.aspx. Accessed January 25, 2020.
[10] Autonomous runway incursion warning system, "Annex 14 to the Convention on International Civil Aviation", Volume I – Aerodrome Design and Operations, 8th Edition, ICAO, July 2018, Montréal, Canada, pp. 9-16 to 9-17 & ATT A-31 to A-33.
[11] Runway Status Light (RWSL), FAA. https://www.faa.gov/air_traffic/technology/rwsl/. Accessed January 25, 2020.
[12] Runway friction characteristics measurement and aircraft braking (RuFAB), EASA.2008/4, March 2010. https://www.easa.europa.eu/document-library/research-reports/easa20084. Accessed January 25, 2020.
[13] Jacob A. et. al. The Runway Overrun Prevention System, Safety First #08, Airbus, July 2009
[14] Jenkins, M. & Aaron R. F. Jr. Reducing Runway Landing Overruns, Aero QTR 03.12, Boeing, 2012
[15] The New Global Reporting Format for Runway Surface Conditions, ICAO. https://www.icao.int/safety/Pages/GRF.aspx. Accessed January 25, 2020.
[16] Chapter 4. Coefficient of Friction and Friction Measuring Devices, "Industry best Practices Manual for Timely and Accurate Reporting of Runway Surface Conditions by ATS/AIS to Flight Crew, Draft Version 4.0, ICAO/RASG/APRAST, June 2013
[17] IATA Forecast Predicts 8.2 billion Air Travelers in 2037, October 2018. https://www.iata.org/pressroom/pr/Pages/2018-10-24-02.aspx. Accessed April 19, 2020.
[18] 2017-2019 Global Aviation Safety Plan, Doc 10004, Second Edition, ICAO, 2016
[19] Safety Report, 2018 Edition, ICAO, 2018
[20] State safety programme (SSP), Chapter 6. ICAO Safety Management SARPs, Safety Management Manual (SMM), Doc 9859, 2nd Edition, ICAO, 2009, Montréal, QC, Canada, p 6-2.
[21] Nzuzi, A. A Balanced Approach to Safety Oversight and Management in States with a Low Level of Compliance to ICAO SARPs, ENAC Alumni Magazine No. 20, September 2017, pp. 44-46.
[22] Displaced thresholds (5.2) and Runway closure markers (7.1). In *Annex 14 to the Convention on International Civil Aviation*, Volume I – Aerodrome Design and Operations, 8th Edition, ICAO, July 2018, Montréal, Canada
[23] Aviation safety investigations & reports Airbus A340 ZS-SLA. Investigation No 200501819, ATSB
[24] Operational non-compliance at Perth Airport, WA on 9 May 2008. Transport Safety Report (Final), AO-2008-033, ATSB, June 2009
[25] Rosenkrans, W. What's on Your Runway? Lessons Learned During RWY28 Threshold Relocation at ORD, AeroSafety World, Flight Safety Foundation, 2009
[26] Le Bris, G. Working Safely on an Operative Runway, AeroSafety World, Flight Safety Foundation, 2013
[27] Bassey, R. Development and Evaluation of Safety Orange Airport Construction Signage, FAA, 2015
[28] Berlucchi, R., Le Bris, G. and Siewert, D. Enhanced airfield signage to improve situational awareness in the vicinity of construction works, HindSight no 23, Eurocontrol, Brussels, 2016
[29] Markings and Signage during Airfield Construction [Marquages et signalization temporaires (chantier)], Infrastructure WG of The French-Speaking Airports (UAF&FA), November 2017
[30] Eurocontrol et al., European Action Plan for the Prevention of Runway Incursion, Brussels, 2017

[31] Travaux sur Pistes – Construire Ensemble la Sécurité, DGAC/DSAC, 2017

[32] Airports Council International, Managing Operations during Construction Handbook, 2018, http://www.aci.aero/Publications/Safety-Security-Operations/Managing-Operations-During-Construction-Handbook

[33] Manual de Obras e Serviços de Manutenção, ANAC, 2018.