ICAO

SAFETY

State of Global Aviation Safety

Coordinated, Risk-based Approach to Improving Global Aviation Safety

The air transport industry plays a major role in global economic activity and development. One of the key elements to maintaining the vitality of civil aviation is to ensure safe, secure, efficient and environmentally sustainable operations at the global, regional and national levels.

A specialized agency of the United Nations, the International Civil Aviation Organization (ICAO) was established in 1944 to promote the safe and orderly development of international civil aviation throughout the world.

ICAO promulgates Standards and Recommended Practices (SARPs) to facilitate harmonised regulations in aviation safety, security, efficiency and environmental protection on a global basis. Today, ICAO manages over 12 000 SARPs across the 19 Annexes and five Procedures for Air Navigation Services (PANS) to the Convention on International Civil Aviation (Chicago Convention), many of which are constantly evolving in tandem with latest developments and innovations. ICAO serves as the primary forum for co-operation in all fields of civil aviation among its 193 Member States.

Improving the safety of the global air transport system is ICAO's guiding and most fundamental strategic objective. The Organization works constantly to address and enhance global aviation safety through the following coordinated activities:

- Policy and Standardization;
- Monitoring of key safety trends and indicators;
- Safety Analysis; and
- Implementing programmes to address safety issues.

The ICAO Global Aviation Safety Plan (GASP) presents the strategy in support of the prioritization and continuous improvement of aviation safety. The GASP sets the goals and targets and outlines key safety enhancement initiatives (SEIs). These global and regional initiatives are established and monitored on the basis of safety management principles.

This year, ICAO publishes a special edition of the annual safety report on the occasion of the 75th Anniversary of the Organization and the convening of the 40th Session of the ICAO Assembly. This special edition, which presents the state of global aviation safety, is structured in alignment with the GASP and the Global Air Navigation Plan (GANP) which provides global strategic guidelines to drive the evolution of the air navigation system. This report provides a comprehensive account of ICAO's safety achievements over the past 75 years and updates on safety performance indicators (SPIs), including accidents that occurred in 2018, and related risk factors. Results of analysis from the 2014–2018 reports are used as benchmarks for comparison, although it must be noted that numbers presented in this report may not exactly match earlier editions due to data updates during the intervening period.

Disclaimer

Note:

The ICAO Regional Aviation Safety Group (RASG) regions are used in the report and are listed in Appendix 1. This document focuses primarily on scheduled commercial flights. The scheduled commercial flights data was based on the Official Airline Guide (OAG) combined with internal ICAO preliminary estimates.

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Executive Summary

Yearly accident statistics indicate an increase in both the total number of accidents as well as the global accident rate in 2018. From 2017 to 2018, there was an 11 per cent increase in the total number of accidents, as reported by States. The global accident rate of 2.6 accidents per million departures also increased by 8 per cent from the 2017 rate of 2.4 accidents per million departures. The accidents used for these statistics were reviewed and validated by the ICAO Safety Indicators Study Group (SISG), and involved scheduled commercial operations of aircraft with a certified maximum take-off weight (MTOW) of over 5 700 kg as defined in ICAO Annex 13 — *Aircraft Accident and Incident Investigation.*

Chart 1: Accident Records: 2014–2018 Scheduled Commercial Operations

	2014	2015	2016	2017	2018
Number of Accidents	97	92	75	88	98
Accident rate	3.0	2.8	2.1	2.4	2.6
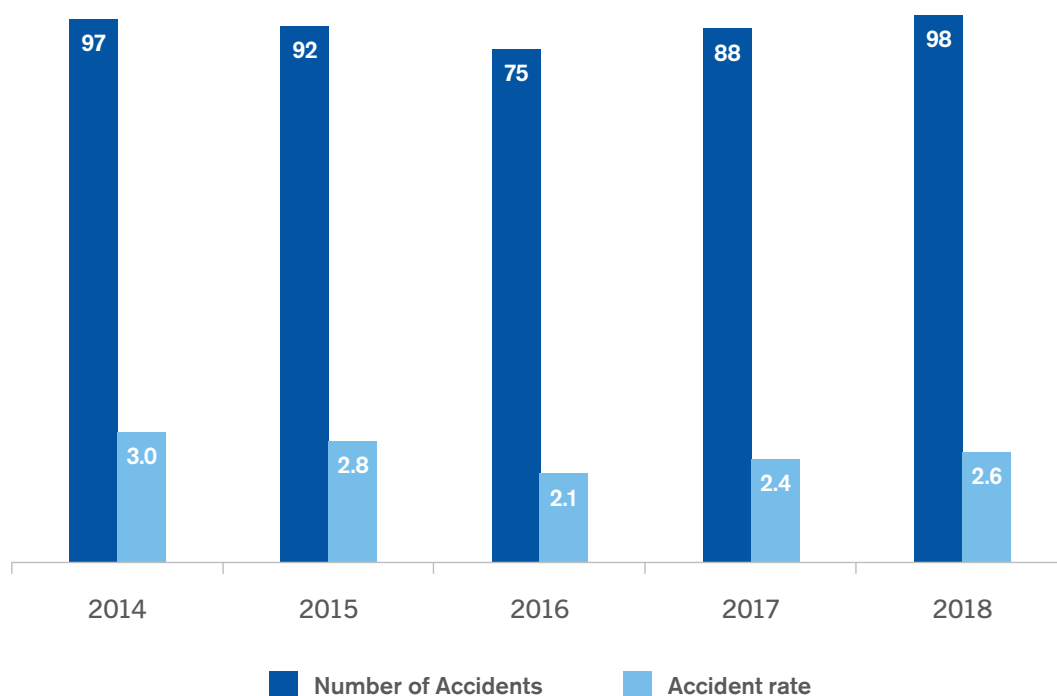
In 2018 scheduled commercial air transport accidents resulted in 514 fatalities representing a significant increase from 50 in 2017, the safest year ever on the record of aviation. The number of fatal accidents also increased from five in 2017 to 11 in 2018, and was distributed across ICAO RASG regions as shown in Map 1.

ICAO continues to focus on its safety priorities which include Runway Safety (RS), Controlled Flight into Terrain (CFIT) and Loss of Control In-Flight (LOC-I) as identified in the 2017–2019 edition of the GASP. One important new safety initiative under Runway Safety is the development and implementation of the Global Reporting Format (GRF) for runway surface conditions to help mitigate the risk of runway excursion.

In 2018, the Thirteenth Air Navigation Conference (AN-Conf/13) was held in Montréal, and was attended by 1 022 Delegates nominated by 116 ICAO Member States and 37 international organizations, as well as by advisers and others. The AN-Conf/13 made 34 recommendations under Committee A (Air Navigation Capacity and Efficiency) and 18 recommendations under Committee B (Safety) on matters related to its agenda. The follow-up on AN-Conf/13

Chart 2: Fatal Accident Records: 2014–2018 Scheduled Commercial Operations

Legend:
■ Number of Fatalities ■ Number of Fatal accidents
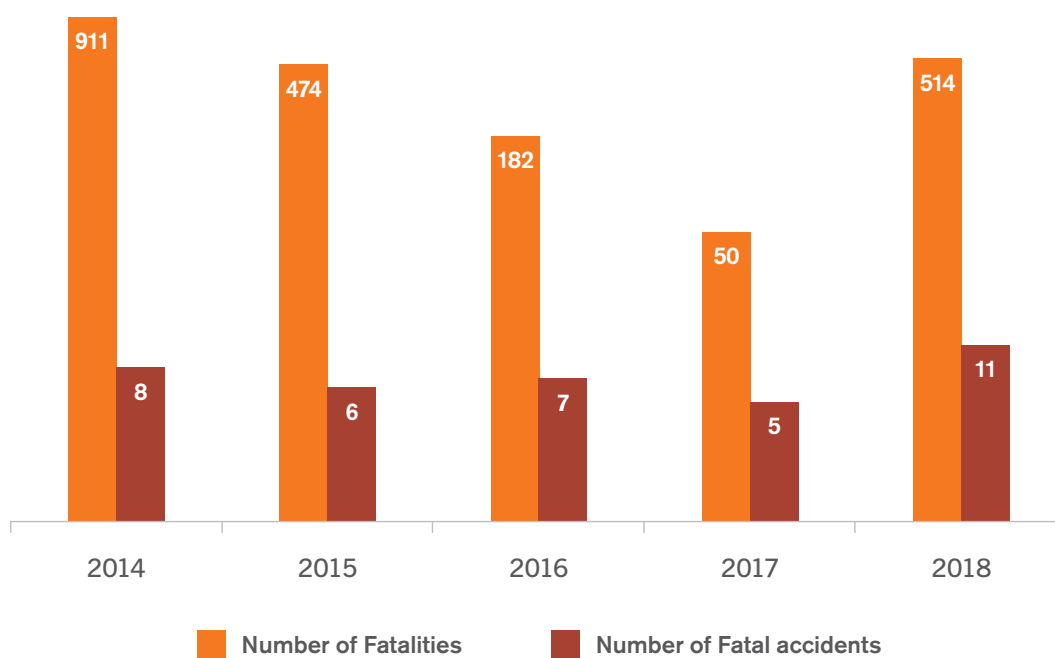
Chart 3: Historical Trends for Scheduled Commercial Operations

Legend:
— Fatalities
— Accidents
— Fatal Accidents
— Accident Rate
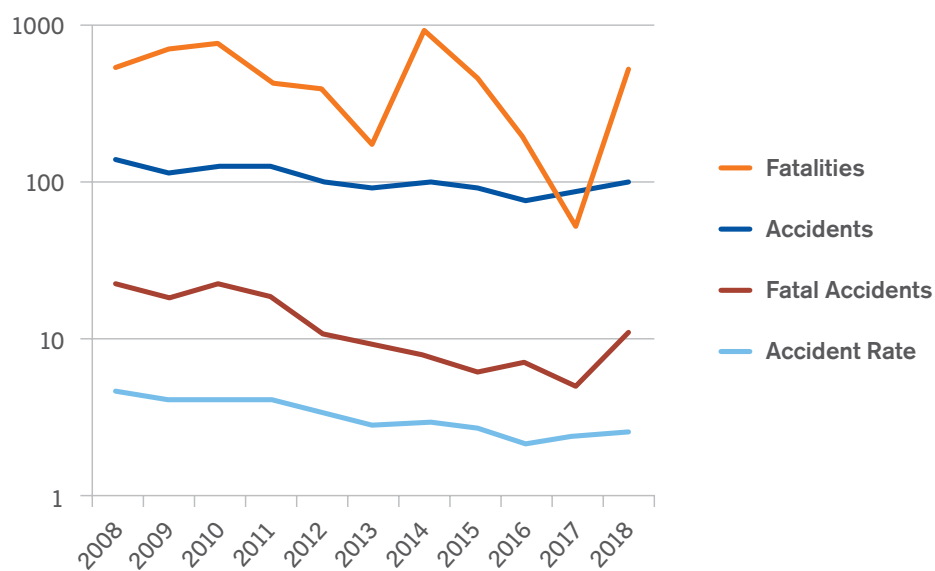
Map 1: Number of Fatal Accidents in each RASG Region
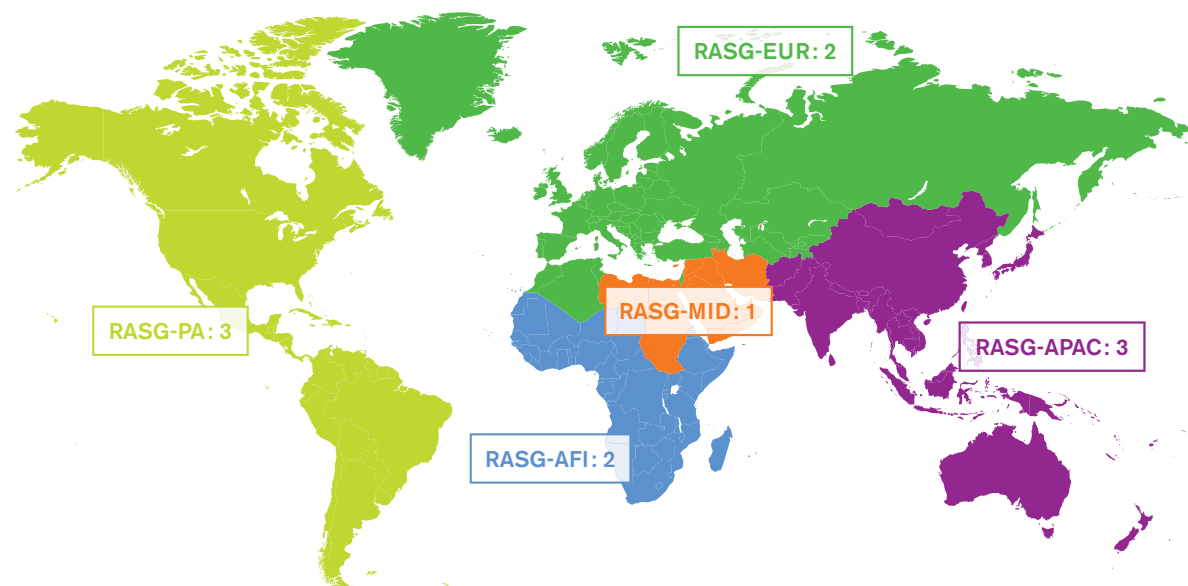
recommendations will involve considerable work by ICAO to further enhance aviation safety.

The 2020–2022 draft edition of the GASP was also discussed and reviewed during the AN-Conf/13 and will be endorsed by the 40th Session of ICAO Assembly in September 2019. This edition of the plan identifies five high risk categories (HRCs) of occurrences including LOC-I, CFIT, runway excursion (RE), runway incursion (RI) and mid-air collision (MAC).

ICAO is committed to improving aviation safety and enabling seamless cooperation and communication among stakeholders. As such, continuous collaboration takes place with established regional bodies/organizations, such as Regional Aviation Safety Groups (RASGs), Regional Safety Oversight Organizations (RSOOs) and Regional Accident and Incident Investigation Organizations (RAIOs), to promote and develop capacity building and the implementation support necessary to address emerging safety issues.

The ICAO Universal Safety Oversight Audit Programme (USOAP) Continuous Monitoring Approach (CMA) determines States' capabilities for safety oversight using

a risk-based approach in assessing and monitoring the effective implementation (EI) of the Critical Elements (CEs) of a safety oversight system. The global average EI increased from 65.5 per cent in 2017 to 67.43 per cent in 2018, with 72.43 per cent of States having achieved the target of 60 per cent EI, as suggested by the 2017–2019 edition of the GASP. In 2018, four ICAO Member States had a total of four Significant Safety Concerns (SSCs) in the areas of Air Navigation Services and Aircraft Operations.

In response to existing and emerging trends, ICAO is working in partnership with the international aviation community to achieve future safety improvements, with an emphasis on improving safety performance through standardization, monitoring and implementation. The 2019 edition of the Safety Report, as usual, provides a high-level summary of ICAO's achievements to enhance aviation safety in 2018 and updates key safety performance indicators with reference to the 2014–2018 time period. Also included is an overview of some technological and/or regulatory breakthroughs of the aviation industry over the past 75 years. Appendix 3 of this report presents articles that shed light on challenges States and the aviation industry are currently facing, in addition to facts about aviation safety in various technical domains.

Aviation Safety Milestones over the Past 75 Years

In 1944, Delegates from 54 States attended the International Civil Aviation Conference in Chicago by invitation from the United States Government, and by its conclusion on 7 December 1944, 52 of them had signed the Convention on International Civil Aviation, today commonly known as the "Chicago Convention". This landmark agreement laid the foundation for the establishment of the International Civil Aviation Organization (ICAO) and the development of

Standards and Recommended Practices (SARPs) and procedures for global air navigation to support the development of aviation in a safe and orderly manner.

This section lists some milestones that mark the progress made in improving safety over the past 75 years, including the technological and regulatory breakthroughs in the aviation industry as a whole.

1944 Convention on International Civil Aviation signed in Chicago on 7 December 1944.

1945 Commercial aviation commenced using ex-military aircraft from World War II with unreliable piston engines and unpressurized cabins. There was no radio for communication and navigation was astral. At this time, it took 19 hours for a transatlantic flight.

1948 The first set of SARPs relating to Personnel Licensing (Annex 1 to the Convention), Rules of the Air (Annex 2), Meteorological Codes (Annex 3), Aeronautical Charts (Annex 4), Dimensional Units for Air-Ground Communications (Annex 5) and Operation of Aircraft (Annex 6) were adopted by the ICAO Council.

1949 SARPs relating to Aircraft Nationality and Registration Marks (Annex 7), the Airworthiness of Aircraft (Annex 8), the Facilitation of International Air Transport (Annex 9) and Aeronautical Telecommunications (Annex 10) were adopted by the ICAO Council.

1949 The instrument landing system (ILS) was included in the first edition of Annex 10. It was first used commercially in 1939, and in civil use for the equivalent of Category I landings since 1947.

1950 SARPs relating to Air Traffic Services (Annex 11) and Search and Rescue (Annex 12) were adopted by the ICAO Council.

1951 SARPs relating to Aircraft Accident Inquiry (Annex 13) and Aerodromes (Annex 14) were adopted by the ICAO Council.

1952 SARPs relating to Aeronautical Information Services to the Convention for the promulgation of information essential to the safety, regularity and efficiency of air navigation (Annex 15) were adopted by the ICAO Council.

1955 First jet engine was built allowing aircraft to fly higher in bad weather. Voice transmission, air traffic control centres and the use of more advanced navigation aids began.

1956 The final version of ICAO alphabet (printed in Annex 10, Volume II, Chapter 5) is implemented by ICAO. It is adopted by many other international and national organizations, including the North Atlantic Treaty Organization (NATO), International Telecommunications Union (ITU), and the International Maritime Organization (IMO).

1958 The first commercial flight by a Boeing 707 jet airliner took place on Pan American World Airways flying from New York City to Paris. Transatlantic flight time was reduced to nine hours.

1964 The first fully automatic landing using ILS occurred in March 1964 at Bedford Airport in the UK.

1969 The provisions on bird strike hazard reduction were first introduced in Annex 14, Volume I. In 2009, this was expanded upon to include a broader focus on wildlife strike hazard reduction in the fifth edition of Annex 14, Volume I to minimize the likelihood of collisions between wildlife and aircraft. The ICAO Bird Strike Information System (IBIS) was established in 1979 to provide analyses of bird/wildlife strike reports received from States.

1969 The Boeing 747 jumbo jet, equipped with turbofan engines, was introduced.

1971 SARPs for Aircraft Noise were first adopted by the Council pursuant to the Provisions of Article 37 of the Convention on International Civil Aviation (Chicago, 1944) and designated as Annex 16 to the Convention.

1973 Introduction of provisions in Annex 6, Part I for civil aeroplanes to be equipped with flight recorders.

1974 The precision approach path indicator (PAPI) system was first devised. It is a visual aid which provides guidance information to help a pilot acquire and maintain the appropriate approach to a runway. The SARPs for PAPI were adopted in Annex 14, Volume I in 1983 for world application. The PAPI system is now installed in many airports around the world, contributing to the safe operations of aircraft.

1975 SARPs relating to Security (Annex 17 to the Convention) became applicable.

1976 Feasibility study proves that it was possible and safe to reduce vertical separation between FL 290 and 410 from 2 000 ft to 1 000 ft.

1976 First generation of the ICAO Accident/Incident Data Reporting (ADREP) system was introduced. Data was back-loaded for the years 1970 to 1976 from various sources.

1976 Title of Annex 13 is changed to replace the word "Inquiry" with "Investigation", along with a new provision which read: "The fundamental objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."

1976 Introduction of the runway end safety area (RESA) provisions in Annex 14 which were further refined in 1999 and 2013, intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway. This involved the installation of an arresting system in lieu of part or all of a RESA subject to acceptance by the State. Some guidance material is developed on the parameters that should be considered in the design of an arresting system to further mitigate injury to persons and damage to aircraft in the event of overruns.

1978 ICAO required the fitting of ground proximity warning systems (GPWS) to certain aeroplanes (provisions continued to be enhanced in subsequent amendments to Annex 6). GPWS is a major mitigation for controlled flight into terrain (CFIT) occurrences.

1981 SARPs for the safe transport of dangerous goods by air (Annex 18 to the Convention) were adopted by the ICAO Council.

1982 The introduction of aircraft equipped with "glass cockpit", combined with electronic cockpit displays and improved navigation systems as well as the introduction of terrain awareness and warning systems (TAWS), significantly reduced the rate of CFIT accidents.

1984 Introduction of provisions in Annex 3 related to the establishment of the world area forecast system (WAFS), a worldwide ICAO system for the provision of aeronautical meteorological en-route forecasts in uniform standardized formats.

1986 Introduction of provisions in Annex 6, Part III for helicopters to be equipped with flight recorders.

1987 Introduction of provisions in Annex 3 for the preparation and dissemination of volcanic ash warnings, the foundation of the international airways volcano watch (IAVW).

1987 Aircraft using Fly-by-Wire (FBW) technology with Flight Envelope Protection functions were introduced. This helps to protect against Loss of Control In-Flight (LOC-I) accidents.

1993 The Global Positioning System (GPS) was declared fully operational.

1994 The United States offered GPS to support the needs of international civil aviation; the ICAO Council accepted the offer. GPS was used as the cornerstone of the ICAO Global Navigation Satellite System (GNSS), leading to a number of safety and efficiency related enhancements to air navigation.

1994 Introduction of carriage requirements for emergency locator transmitters (ELTs) to replace provisions regarding survival radio equipment and emergency location beacons in Annex 6.

1994 Applicability of Annex 13 provisions are expanded to be binding on aircraft accidents and incidents wherever they occurred, including domestic accidents and incidents.

1995 First operational use of controller-pilot data link communications (CPDLC) automatic dependent surveillance — contract (ADS-C) in the South Pacific.

1996 The Russian Federation offered Global Navigation Satellite System (GLONASS) to support the needs of international civil aviation; the ICAO Council accepted the offer.

1996 Requirements concerning pressure-altitude reporting transponders and the carriage of airborne collision avoidance systems (ACAS) were introduced in Annex 6. Subsequent widespread use of cooperative surveillance resulted in the increased range for surveilled airspace, robust correlations of target and label, surveillance data processing systems (SDPS) and flight data processing systems (FDPS). These systems were able to "talk to each other", consequently enabling safety nets such as short-term conflict alert (STCA), approach path monitor (APM) and minimum safe altitude warning (MSAW).

1997 ICAO introduced the first version of the Global Aviation Safety Plan (GASP) which sets out the strategic planning and implementation policy to support prioritization and the continuous improvement of aviation safety.

1997 First operational use of reduced vertical separation minimum between FL 290 and 410 in the NAT Region.

1999 ICAO officially established the Universal Safety Oversight Audit Programme (USOAP). USOAP audit activities determine States' safety oversight capabilities and continue to serve as an essential component in the global aviation safety framework.

2001 SARPs on the certification of aerodromes were introduced into ICAO Annex 14, Volume I. Over the years, aerodrome certification has proven to be an effective mechanism to ensure that aerodrome facilities and operations are in compliance with the relevant SARPs to support the safety, regularity and efficiency of aircraft operations.

2001 The initial SARPs related to safety management were introduced in Annexes 6, 11 and 14.

2001 ICAO adopted SARPs supporting Global Navigation Satellite System (GNSS) operations based on augmenting core satellite constellation signals to meet safety and reliability requirements. The GNSS SARPs and avionics standards were developed to meet recognized safety targets. In particular, availability of GNSS-based vertical guidance, in addition to enabling efficiency gains via approaches with the lowest possible minima, contributes significantly to the reduction of controlled flight into terrain (CFIT). GNSS supports positioning, navigation and timing (PNT) applications and is the foundation of performance-based navigation (PBN), automatic dependent surveillance — broadcast (ADS-B) and automatic dependent surveillance — contract (ADS-C).

Today, the United States and the Russian Federation are upgrading their GNSS, and have committed to take all necessary measures to

maintain service reliability. Europe and China are developing systems (Galileo and the BeiDou Navigation Satellite System, respectively) which will be interoperable with upgraded GPS and GLONASS. ICAO SARPs are being updated accordingly.

2001 ICAO introduced SARPs and procedures for a wide range of subjects in relation to the implementation of ATS data link services (CPDLC, ADS-C, etc.).

2006 First Edition of Doc 9859 — *Safety Management Manual* published including guidance on Safety Management Systems (SMS) and specific reference to Safety Culture.

2010 First SARPs addressing Unmanned Aircraft Systems (UAS) were introduced in Annex 13.

2011 The ICAO Global Runway Safety Programme was launched, recognising that this category represents the highest number of occurrences.

2013 ICAO Member States adopt the first new Annex to the Chicago Convention in more than 30 years. The new Annex 19 — *Safety Management* consolidated provisions from existing Annexes regarding State Safety Programmes (SSPs) and SMS, as well as related elements, including the collection and use of safety data and State safety oversight activities. The main intent was to focus States' attention on the importance of integrating their safety management activities and facilitating the evolution of safety management provisions.

2014 The use of digital formats for volcanic ash and tropical cyclone advisories, AIRMET information and the provision of METAR, SECI, TAF and SIGMET information were introduced in Annex 3 as a recommended practice. This paved the way for the future digital exchange of MET information.

2014 ICAO began to develop a comprehensive flight tracking system, Global Aeronautical Distress and Safety System (GADSS). The first stage was the adoption of Standards in Annex 6, Part I which established the responsibility of the Air Operator to track their flights throughout their area of operations, and the requirement for a 15-minute reporting minima to be established over oceanic areas. This became applicable on 8 November 2018.

2015 Introduction of the first edition of the *Procedures for Air Navigation Services — Aerodromes* (PANS-Aerodromes) (Doc 9981), which specifies procedures to ensure aerodrome operational safety, as well as for initial aerodrome certification, continuing aerodrome safety oversight, and aerodrome compatibility studies.

2016 To help mitigate the risk of runway excursion, ICAO developed a harmonized methodology for assessing and reporting runway surface conditions. This methodology, known as the Global Reporting Format (GRF), will be globally applicable from November 2020.

2016 In Annex 13, the introduction of standards on the establishment of an accident investigation authority (AIA) that is independent from State aviation authorities and others which could potentially interfere with the conduct or objectivity of an investigation.

2016 The autonomous runway incursion warning system (ARIWS) was introduced with the objective of providing autonomous detection of potential incursions or occupancy of an active runway by means of a direct warning to a flight crew or vehicle operator. Its main function is to reduce the prevalence and consequences of runway incursions.

Implementation of Global Aviation Safety Plan

The global aviation safety roadmap presented in the ICAO 2017–2019 edition of Global Aviation Safety Plan (GASP) contains three distinct phases in achieving the GASP goals and objectives. They are detailed in Figure 1 and are as follows:

a) Phase I: effective safety oversight;
b) Phase II: State Safety Programme (SSP) implementation; and
c) Phase III: predictive risk management.

Figure 1: GASP Objectives and Associated Timelines

Effective safety oversight	SSP implementation	Predictive risk management
RASGs and other fora: mechanisms for sharing of safety information	RASGs: mature regional monitoring and safety management programmes	All States: implement advanced safety oversight systems, including predictive risk management
States with EI > 60%: SSP implementation	All States: SSP implementation	
All States: achieve 60% EI of CEs		
2017 (near term)	2022 (mid term)	2028 (long term)

Effective Implementation of State Safety Oversight (SSO) System

Each ICAO Member State should establish and implement an effective safety oversight system, in order to address all areas of aviation activities. The Universal Safety Oversight Audit Programme (USOAP) Continuous Monitoring Approach (CMA) measures the effective implementation of a State's safety oversight system.

To standardize the conduct of audits under USOAP CMA, ICAO established protocol questions (PQs) that are based on the safety-related ICAO Standards and Recommended Practices (SARPs) established in the Annexes to the Chicago Convention, Procedures for Air Navigation Services (PANS) and ICAO guidance material. Each PQ contributes

to assessing the effective implementation (EI) of one of the eight critical elements (CEs) in one of the eight audit areas. These eight CEs are:

- primary aviation legislation (CE-1);
- specific operation regulations (CE-2);
- State system and functions (CE-3);
- qualified technical personnel (CE-4);
- technical guidance, tools, provisions of safety-critical information (CE-5);
- licensing, certification, authorization and/or approval obligations (CE-6);
- surveillance obligations (CE-7); and
- resolution of safety issues (CE-8).

The eight audit areas identified in the USOAP are:
1) primary aviation legislation and civil aviation regulations (LEG);
2) civil aviation organization (ORG);
3) personnel licensing and training (PEL);
4) aircraft operations (OPS);
5) airworthiness of aircraft (AIR);
6) aircraft accident and incident investigation (AIG);
7) air navigation services (ANS); and
8) aerodromes and ground aids (AGA).

The use of standardized PQs ensures transparency, quality, consistency, reliability and fairness in the conduct and implementation of USOAP CMA activities.

As of 30 April 2019, the average effective implementation (EI) for audited States was 67.43 per cent. It was 65.51 per cent for the same period of 2018. 72.43 per cent of the States have achieved the target of 60 per cent EI, a benchmark suggested by the 2017–2019 edition of the GASP as shown in Figure 2. Figure 3 shows a map of all the ICAO Member States having achieved an overall EI. Six of ICAO's 193 Member States had not yet received a USOAP audit.

Figure 2: Global USOAP results

Overall EI

Global Average

67.43%

Effective Implementation (%)

States above 60% EI

72.43%

Percentage of States in group (%)

USOAP Audit Results

Effective Implementation (%)

GASP Target
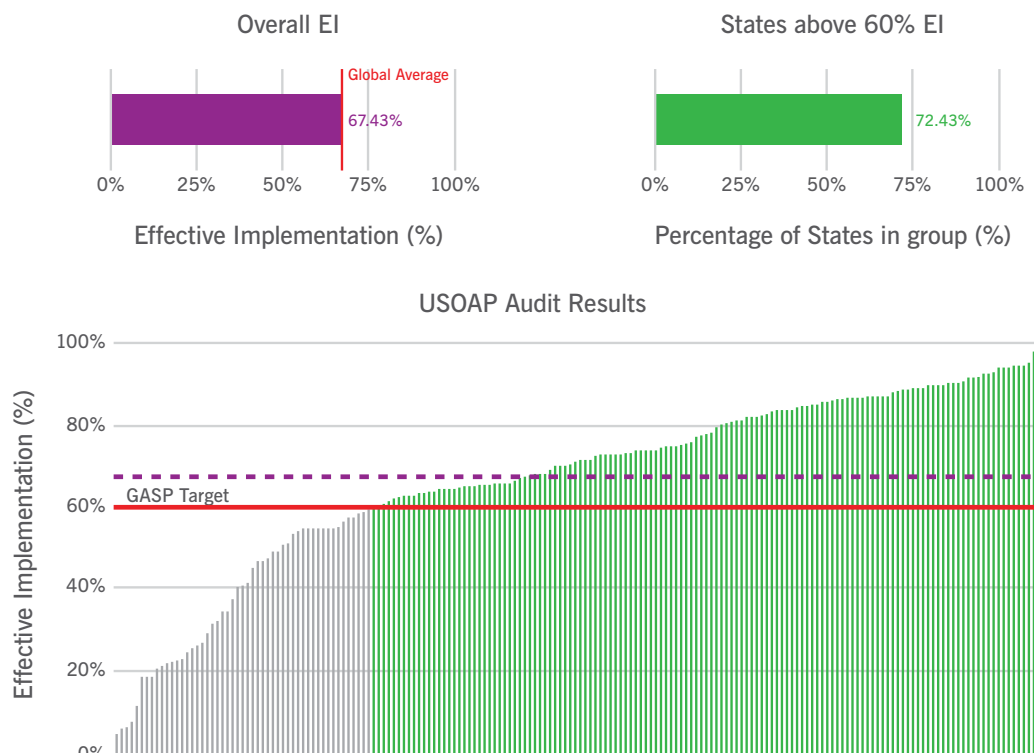
Figure 3: Overall Effective Implementation (EI)

Overall effective implementation score (%)
0%   50%   100%
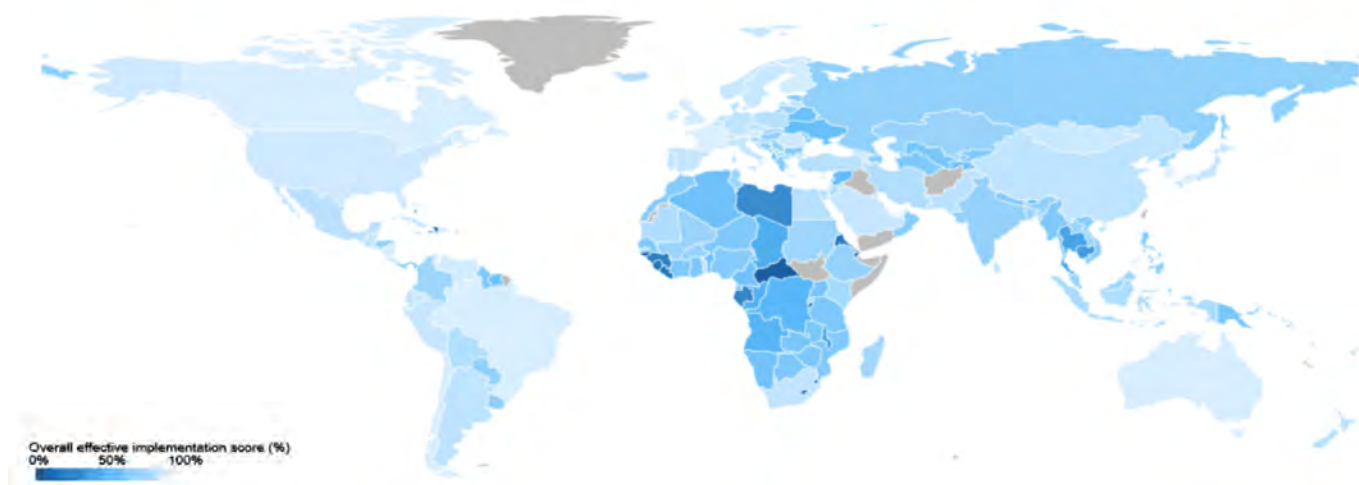
States, listed in alphabetical order, with an **EI above 60 per cent** (as of 30 April 2019):

Argentina	Chile	Guatemala	Luxembourg	Norway	Sri Lanka
Armenia	China	Honduras	Madagascar	Oman	Sudan
Australia	Colombia	Hungary	Malaysia	Pakistan	Suriname
Austria	Costa Rica	Iceland	Maldives	Paraguay	Sweden
Azerbaijan	Croatia	India	Mali	Peru	Switzerland
Bahrain	Cuba	Indonesia	Malta	Philippines	Togo
Bangladesh	Cyprus	Iran (Islamic Republic of)	Mauritania	Poland	Trinidad and Tobago
Belgium	Czechia		Mauritius	Portugal	Tunisia
Belize	Democratic People's Republic of Korea	Ireland	Mexico	Republic of Korea	Turkey
Bolivia (Plurinational State of)	Denmark	Israel	Mongolia	Republic of Moldova	United Arab Emirates
		Italy	Morocco	Romania	United Kingdom
Bosnia and Herzegovina	Dominican Republic	Jamaica	Mozambique	Russian Federation	United States
Botswana	Ecuador	Japan	Myanmar	Rwanda	Uruguay
Brazil	Egypt	Jordan	Nepal	San Marino	Uzbekistan
Brunei Darussalam	El Salvador	Kazakhstan	Netherlands	Saudi Arabia	Venezuela (Bolivarian Republic of)
Bulgaria	Ethiopia	Kenya	New Zealand	Serbia	
Burkina Faso	Finland	Kuwait	Nicaragua	Singapore	Viet Nam
Cabo Verde	France	Lao People's Democratic Republic	Niger	Slovakia	Zambia
Cameroon	Gambia	Latvia	Nigeria	South Africa	Zimbabwe
Canada	Germany	Lithuania	North Macedonia	Spain	
	Greece				

Examining the results by CE, Chart 4 shows that CE-4, CE-7 and CE-8 have not yet achieved the target of 60 per cent.

All audit areas, however, with the exception of AIG, have achieved the target of 60 per cent EI as indicated in Chart 5.

Chart 4: Global Audit Results (Average EI Percentage by CEs)

CE-1	CE-2	CE-3	CE-4	CE-5	CE-6	CE-7	CE-8
77.08	73.77	69.17	57.8	68.91	70.3	58.91	53.39
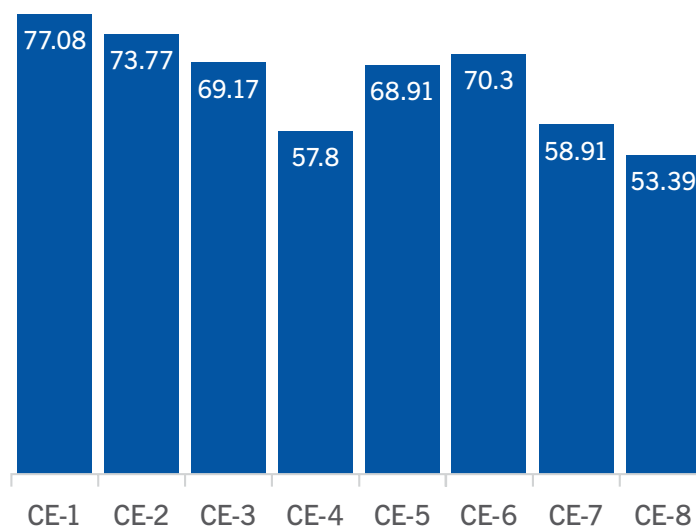
Chart 5: Global Audit Results (Average EI Percentage by Audit Area)

AGA	ANS	AIG	AIR	OPS	PEL	ORG	LEG
61.1	65.6	57.0	78.9	69.8	73.5	70.3	73.6
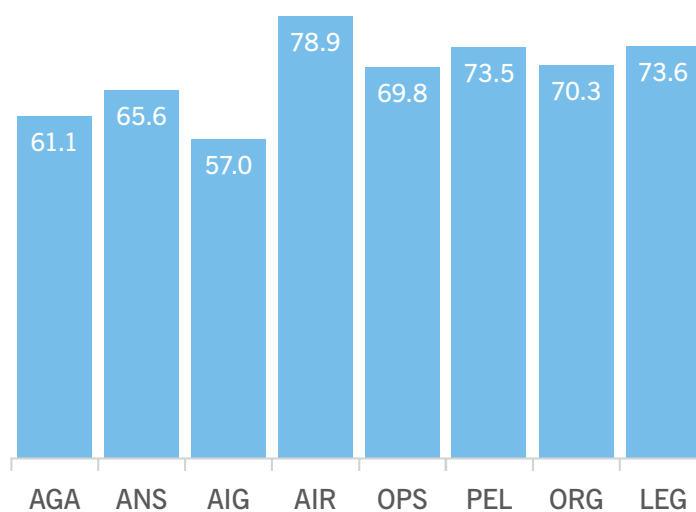
Implementation Support for Safety Management

Safety Management Manual, Fourth Edition with Complementary SMI Website

The fourth edition of the *Safety Management Manual* (SMM) (Doc 9859) was published in October 2018 and made available at the Thirteenth Air Navigation Conference (AN-Conf/13). The manual contains additional guidance to support the first amendment to Annex 19 — *Safety Management*, and is complemented by a Safety Management Implementation (SMI) website (www.icao.int/SMI).

The SMI website serves as a repository for the sharing of practical examples and tools among the aviation community in support of effective safety management implementation, including those related to safety oversight systems in support of the No Country Left Behind (NCLB) initiative. Updated examples from the third edition of the SMM have already been posted and States, international organizations as well as ICAO expert groups have been invited to submit additional material to be validated and posted.
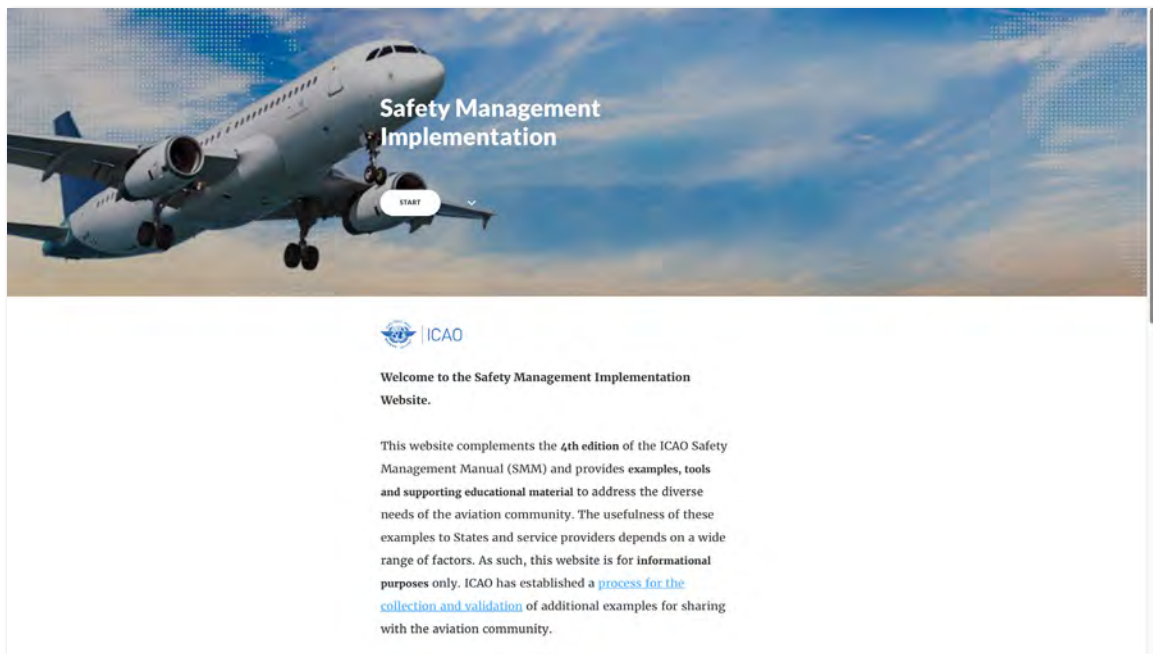
Safety Management Tools

The second High-level Safety Conference held in Montréal, from 2 to 5 February 2015 (HLSC/2015) recommended that States use the self-reporting SSP gap analysis tool, found on the ICAO integrated Safety Trends Analysis and Reporting System (iSTARS). This app comprises 62 questions, which cover all the requirements of an SSP and were updated in 2019 to reflect Amendment 1 to Annex 19 and the fourth edition of the SMM.

In 2017, the SSP Foundation application was made available on iSTARS. This app is based on a subset of 299 USOAP Protocol Questions (PQs) considered as the foundation for a State Safety Programme (SSP), with the aim of facilitating and monitoring its sustainable and effective implementation.

The USOAP has also developed a set of SSP-related PQs which are available on the CMA Online Framework (OLF). They are currently being used to conduct voluntary assessments as part of the roll-out plan under the USOAP CMA.

As of April 2018, 133 States had created an SSP gap analysis project on iSTARS, with three States indicating completion at level 4. Detailed information can be found in Chart 6. In addition, approximately 30 States have performed a self-assessment using at least half of the USOAP SSP-related protocol questions (PQs) on the OLF.

Chart 6: SSP Implementation Progress - Gap Analysis

	Level 1	Level 2	Level 3	Level 4
Completed	117	91	56	3
In Progress	0	26	35	53

Completed   In Progress
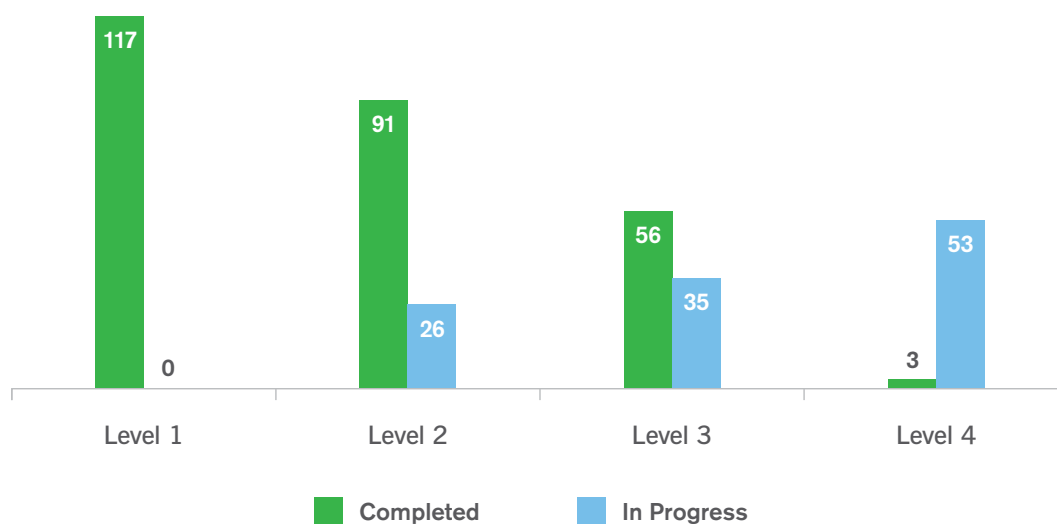
State Safety Programme (SSP) Implementation

ICAO measures SSP implementation in levels as follows:

- Level 1: States having started a gap analysis
- Level 2: States having reviewed all the gap analysis questions
- Level 3: States having defined an action plan for all non-implemented questions
- Level 4: States having closed all actions and fully implemented their SSPs

Safety Management Symposia and Workshops

Further to the first Regional Safety Management Symposium and Workshop delivered in 2017 for the EUR/NAT Region, three more were delivered in 2018 as shown in Table 1 below.

The symposia provided insights on the effective implementation of State Safety Programmes in support of the Global Aviation Safety Plan (GASP) objectives. The workshops following the symposia focused on some of the more practical aspects of safety management implementation.

Since December 2018, ICAO has been delivering Safety Management Capacity Building Workshops (SMCBW)

based on the content of the SMM, fourth edition and the refined message regarding implementation that is more practical and performance-based. As of April 2019, three workshops have already been held in Bangkok, Cairo and Paris on a partial cost-recovery basis. The workshops helped States and industry build an understanding and capacity for the effective implementation of SSP in support of GASP objectives. Under the ICAO No Country Left Behind (NCLB) initiative, using a measure combining EI and level of activity and then filtering out the States with a GDP per capita greater than USD 17 500 in 2018, some States were sponsored to participate in the workshops with two free registrations for each sponsored State.

Table 1: Safety Management Symposia and Workshops Delivered by ICAO

Region	Location	Dates	Symposia attendance	Workshop attendance
European and North Atlantic	Tallinn, ESTONIA	16–18 October 2017	250	73
South America	Lima, PERU	13–14 March 2018	159	148
North America, Central America and Caribbean				
Asia and Pacific	Singapore	23–26 April 2018	138	142
Middle East				
Eastern and Southern Africa	Kigali, RWANDA	22–25 May 2018	248	98
Western and Central Africa				

ICAO Technical Assistance Activities

ICAO has been striving to help States implement SARPs in a timely manner through a variety of assistance programmes at Headquarters in Montréal as well as Regional Offices. Although many States have successfully enhanced their safety oversight capacity by means of in-house initiatives or external assistance, there are still a number of States that have not addressed their safety deficiencies. Due to lack of resources available, these States have sought outside assistance from ICAO in partnership with all stakeholders, including States, international and regional organizations, and industry.

As part of on-going efforts to support these States, ICAO is providing assistance utilizing not only voluntary contributions received from donors, international organizations and industry, namely the Safety Fund (SAFE), but also limited resources available from the regular programme budget.

In 2018, ICAO approved and launched three technical assistance projects funded by the SAFE, with the aim

of building capacity in Sierra Leone and Cambodia. Five projects were also successfully completed which assisted Member States of the East African Community Civil Aviation Safety and Security Oversight Agency (CASSOA), built capacity in Kyrgyzstan and Jordan, and availed training for Aerodrome Certification in the Caribbean and some APAC States. The performance of these projects is measured by USOAP CMA activities and the resulting impact on effective implementation (EI). Some of these performance measurements are available at the ICAO website (www.icao.int/SAFE).

In order for ICAO to seamlessly advance assistance programmes for States, particularly in connection with the NCLB initiative, continuing support and contributions from all stakeholders are vital. Strengthening States' safety oversight systems will, in turn, support the implementation of State Safety Programmes and lead to a safer global air transport system.

Safety Recommendations Addressed to ICAO

Annex 13 — *Aircraft Accident and Incident Investigation* requires States to investigate accidents and incidents for the prevention of such occurrences.

One of the outputs of the safety investigation process is a set of Safety Recommendations (SRs) which may be addressed to States, for example the State of Design of an aircraft, or to ICAO if the investigators have suggestions for changes to ICAO documents. In the case of the latter, ICAO will inform the originating body within 90 days of receipt of the SR, actions taken, actions intended to be taken,

or reasons why no action will be taken by ICAO. Some of the SRs addressed to ICAO are also forwarded to relevant expert groups, which may lead to amendments and/or the development of ICAO documents.

In 2018, ICAO received six SRs from six States. These recommendations may be accessed at https://www.icao.int/safety/airnavigation/AIG/Pages/Safety-Recommendations-addressed-to-ICAO.aspx. Chart 7 below depicts the number of SRs addressed to ICAO in the past five years.

Chart 7: Safety Recommendations Received by ICAO (2014–2018)

Year	Number of SRs
2014	5
2015	15
2016	17
2017	10
2018	6
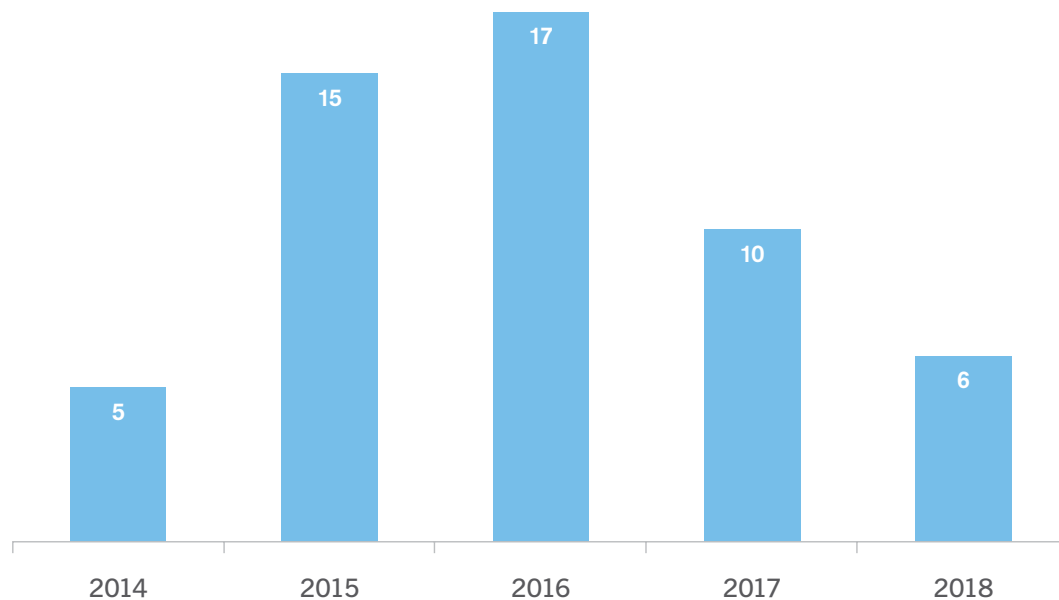
Accident Statistics and Analysis – Scheduled Commercial Air Transport

Overall Safety Performance Indicator – Global Accident Rate

ICAO's global accident rate provides an overall indicator of safety performance. The accident rate is based on scheduled commercial operations involving fixed-wing aircraft with a maximum take-off weight (MTOW) above 5 700 kg. Aircraft accidents are reviewed and categorized by the ICAO Safety Indicators Study Group (SISG) using definitions provided in Annex 13 — *Aircraft Accident and Incident Investigation.*

Data on departures is collated by ICAO's Air Transport Bureau, and comprises scheduled commercial operations that involve the transportation of passengers, cargo and mail for remuneration. Estimates are made where data

has not been provided by States, and as new data is provided to ICAO, it will be incorporated into the database. It is worth noting that this may cause small changes to the calculated rates from year to year.

Chart 8 below shows the global accident rate trend (per million departures) over the previous five years, with 2018 having an accident rate of 2.6 accidents per million departures, slightly increased from the previous year.

Scheduled commercial accidents occurred in 2018 are listed in Appendix 2.

Chart 8: Global Accident Rates (Accidents per Million Departures)

2014	2015	2016	2017	2018
3.0	2.8	2.1	2.4	2.6
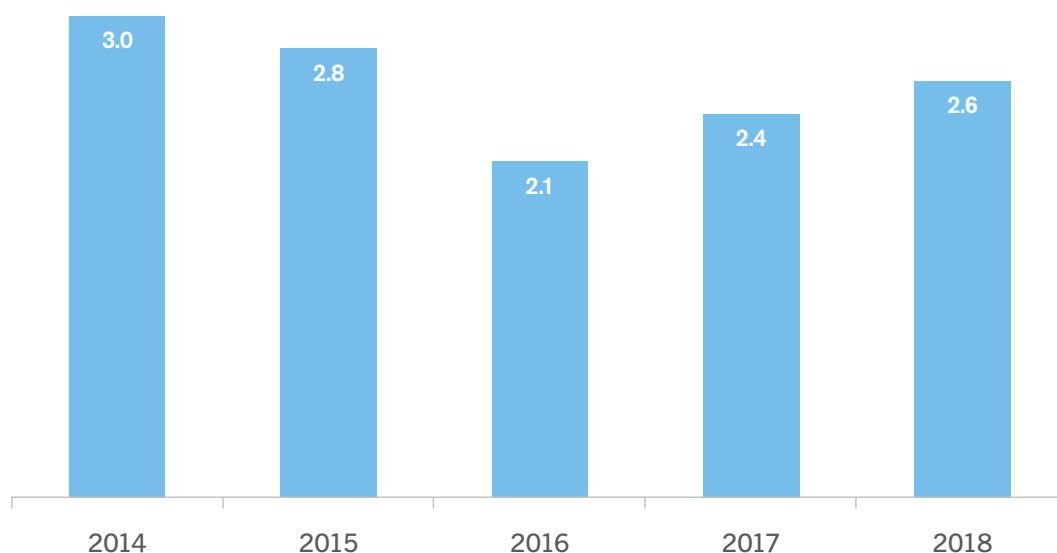
High-Risk Accident Occurrence Categories

Based on an analysis of accident data for scheduled commercial air transport operations, ICAO has identified three high-risk accident categories as its safety priorities in the 2017–2019 edition of the Global Aviation Safety Plan (GASP):

- Runway safety (RS) related events*;
- Loss of Control In-Flight (LOC-I); and
- Controlled flight into terrain (CFIT).

ICAO uses these high-risk accident categories (HRCs) as a baseline in its safety analysis.

Chart 9 shows that in 2018, the three categories represented 96 per cent of all fatalities, 73 per cent of fatal accidents, 54 per cent of the total number of accidents and 80 per cent of the accidents that destroyed or caused substantial damage to aircraft.

Chart 9: High-Risk Category Accident Distribution

Category	HRC	Others
Fatalities	96%	4%
Fatal Accidents	73%	27%
Accidents	54%	45%
Accidents with Aircraft Substantially Damaged	80%	20%
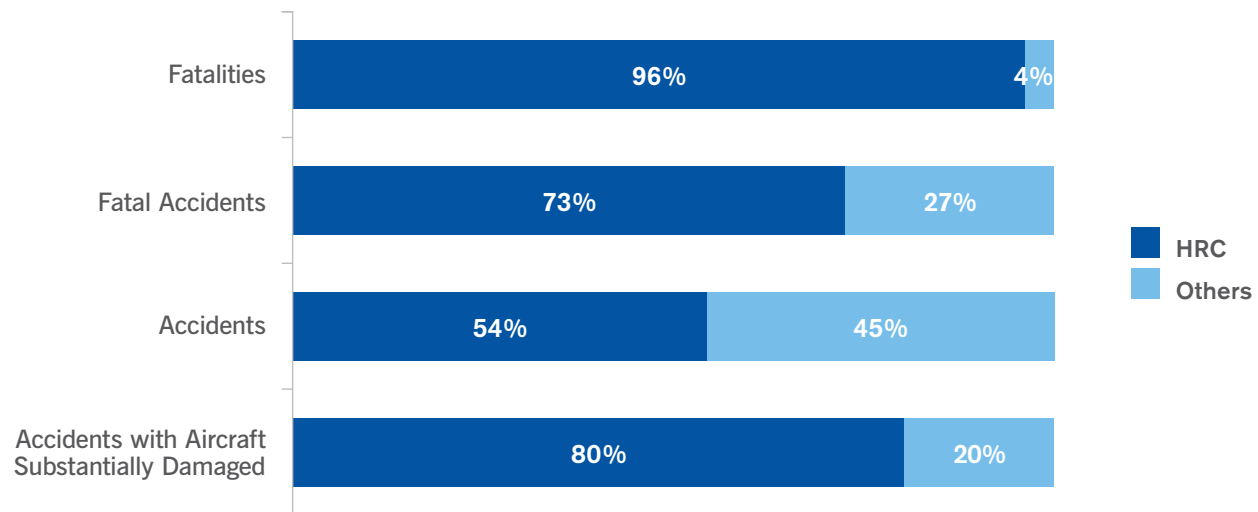
* Events related to runway safety include the following ICAO accident occurrence categories: abnormal runway contact, runway excursion, runway incursion, loss of control on ground, ground collision, collision with obstacles, undershoot/overshoot.

Chart 10 below shows a breakdown of the three high-risk occurrence categories in 2018 and the respective distribution of accidents, fatal accidents, fatalities and accidents in which aircraft were destroyed or substantially damaged.

Accidents related to runway safety (RS) accounted for nearly half of all accidents in 2018 (48 per cent, compared with 53 per cent in 2017), and included 4 fatal accidents with 54 fatalities. Loss of Control In-Flight (LOC-I) represented 36 per cent of fatal accidents (up from 20 per cent in 2017) with total 438 fatalities. There were no fatal accidents related to controlled flight into terrain (CFIT) in 2018.

Notable observations and trends from the accident data for 2018 include:

- Accidents related to RS remain as the highest percentage of all accidents, and continue to represent the highest percentage of the accidents that destroyed or caused substantial damage to aircraft. RS also represented 36 per cent of fatal accidents resulting in 54 fatalities;
- Although LOC-I accident category represented only 5 per cent of all 2018 accidents, it remains a significant concern as it accounted for 85 per cent of all fatalities and 36 per cent of total fatal accidents; and
- There were no fatal accidents related to CFIT.

Chart 10: High-Risk Category Accident Overview
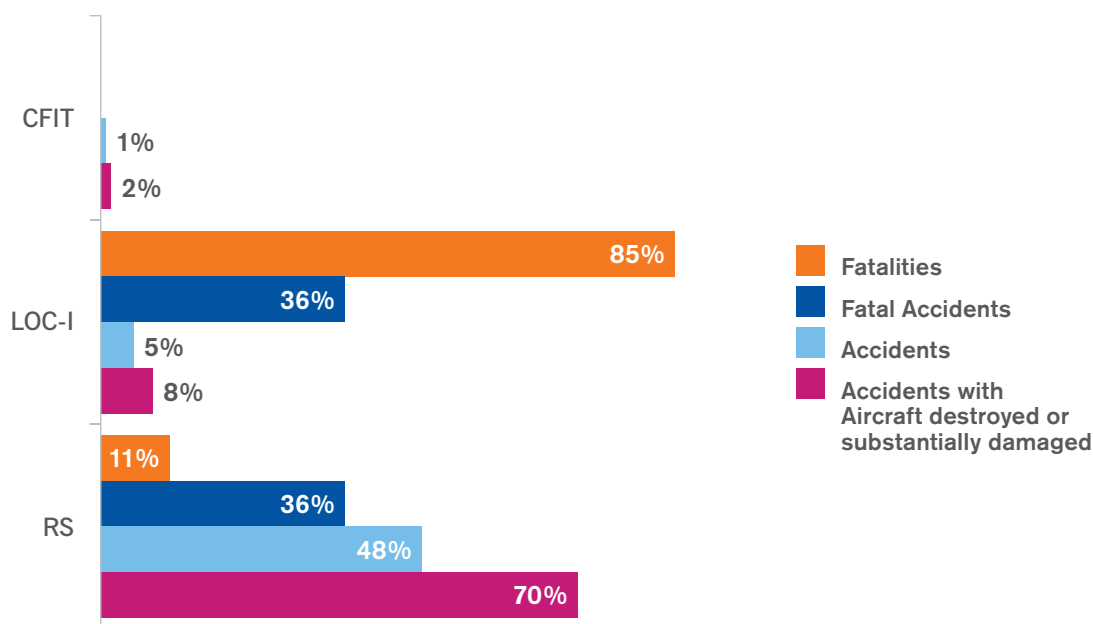
Regional Accident Statistics

To further analyse the state of aviation safety, the accident data for scheduled commercial air transport operations is categorized according to RASG regions, by State of Occurrence. The Tables 2 and 3 below provide details on the state of aviation safety in different RASG regions for 2018 in the context of global outcomes. The States included in each RASG region used in this report can be found in Appendix 1.

It is worth noting that these statistics are based on the ICAO Accident/Incident Data Reporting (ADREP) data reported by States of Occurrence in 2018. Partly due to the small number of departures, some regions experience a large fluctuation in the accident rate from year to year. For this reason, these numbers should be considered in relation to the total number of accidents to gain an overall perspective.

Table 2: Departures, Accidents and Fatalities by RASG Region Based on State of Occurrence

RASG Region	Estimated Departures	Number of Accidents	Accident Rate (per million departures)	Fatal Accidents	Fatalities
AFI	1 440 702	4	2.8	2	21
APAC	12 445 017	20	1.6	3	241
EUR	9 298 706	26	2.8	2	72
MID	1 326 656	3	2.3	1	66
PA	13 575 682	45	3.3	3	114
WORLD	38 086 763	98	2.6	11	514

Table 3: Share of Traffic and Accidents by RASG Region Based on State of Occurrence

RASG Region	Share of Traffic (%)	Share of Accidents (%)
AFI	3.8	4.1
APAC	32.7	20.4
EUR	24.4	26.5
MID	3.5	3.1
PA	35.6	45.9

Accidents by RASG Region

Chart 11 below indicates the percentage of accidents and related fatalities for each ICAO RASG region based on State of occurrence for scheduled commercial operations in 2018. States included in each RASG region are listed in Appendix 1.

In 2018, each ICAO RASG region experienced fatal accidents. It is noteworthy that the RASG-EUR region accounted for 94 per cent of fatalities in 2017 and this figure has dropped to 14 per cent in 2018.

Chart 11: Accident Overview by RASG Region

Legend:
- Fatalities
- Fatal Accidents
- Accidents
- Accidents with Aircraft destroyed or substantially damaged
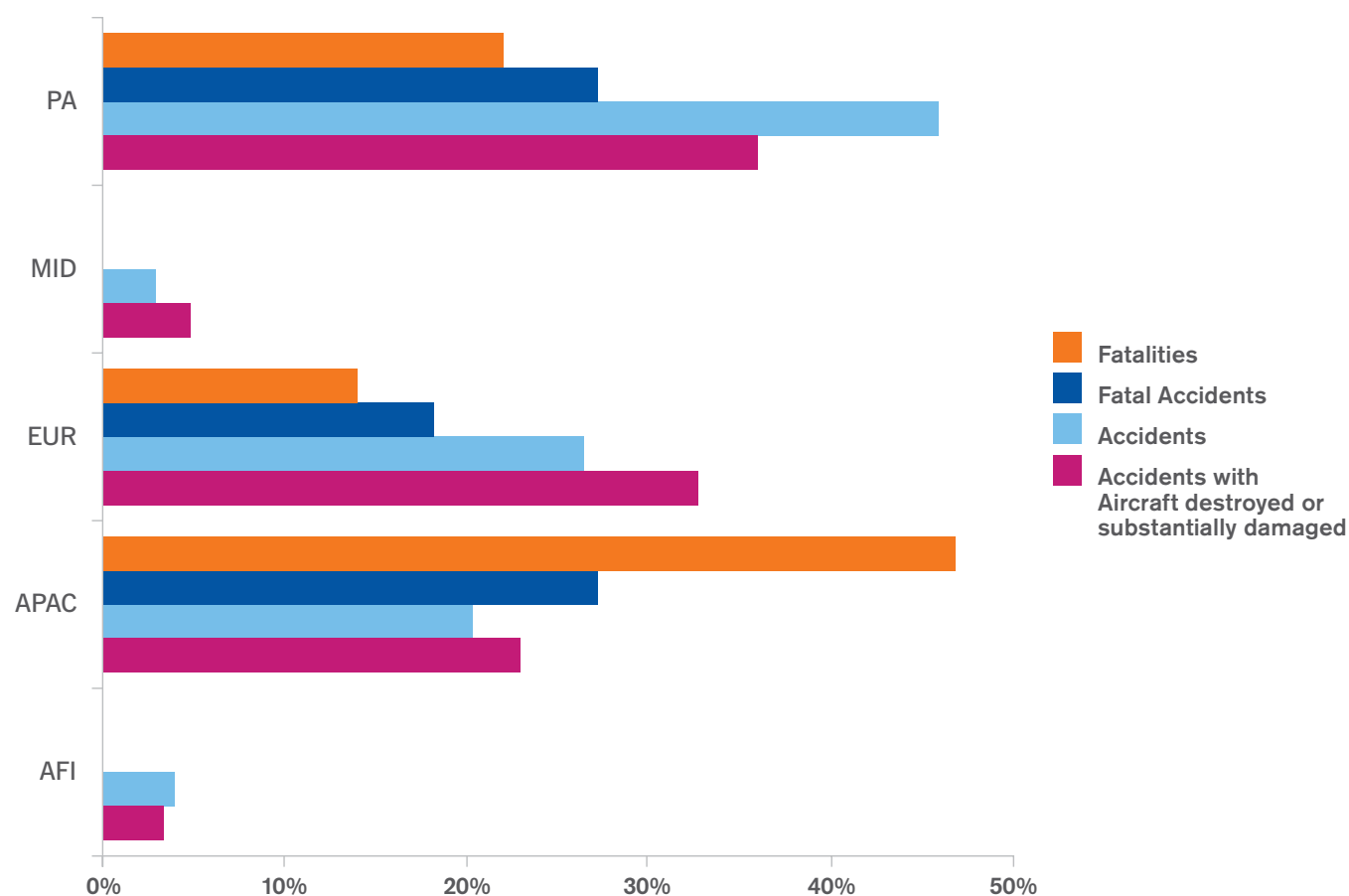
Accident Trends

The number of worldwide accidents and fatal accidents on scheduled commercial flights during the 2014–2018 period are shown in Chart 12.

Between the years 2014 to 2018, the annual number of accidents has generally remained constant. The lowest count recorded was 75 accidents in 2016, and the highest was 98 in 2018. However, the number of fatal accidents per year more than doubled from 5 to 11 within the one-year period between 2017 and 2018. Chart 13 shows the number of fatalities associated with the above-mentioned fatal accidents and a 10-fold increase of fatalities for the aforementioned one-year period between 2017 and 2018.

Chart 12: Accident and Fatal Accident Trend (2014–2018)

● Accidents
● Fatal Accidents

	2014	2015	2016	2017	2018
Accidents	97	92	75	88	98
Fatal Accidents	8	6	7	5	11
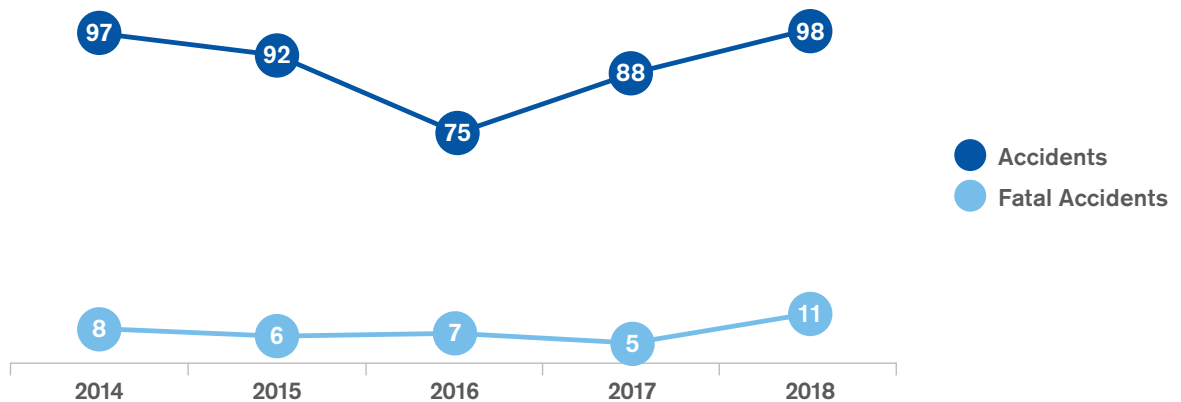
Chart 13: Fatalities Trend (2014–2018)
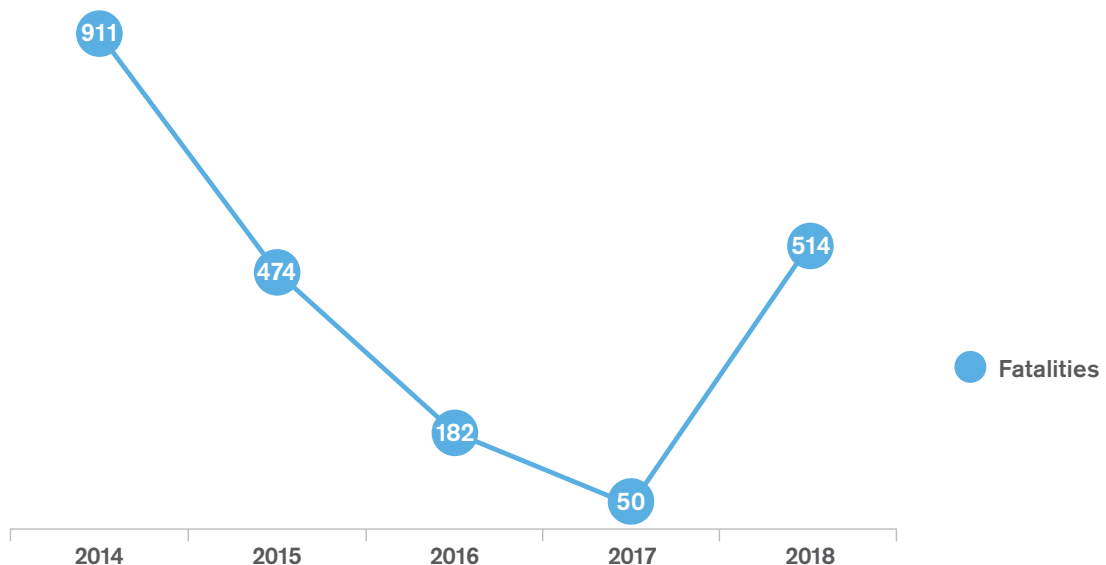
● Fatalities

	2014	2015	2016	2017	2018
Fatalities	911	474	182	50	514

GSIE Harmonized Accident Rate

on 28 September 2010 during the 37th Session of the ICAO Assembly. The objective of the GSIE is to identify information that can be exchanged between the parties to enhance risk reduction activities in the area of aviation safety.

The GSIE developed a harmonized accident rate beginning of 2011. This was accomplished through close co-operation between ICAO and IATA to align accident definitions, criteria and analysis methods used to calculate the harmonized accident rate, which is considered a key safety indicator for commercial aviation operations worldwide. The joint analysis includes accidents following the ICAO Annex 13 criteria for all typical commercial airline operations for scheduled and

non-scheduled flights. These accidents were reviewed and validated by the ICAO Safety Indicators Study Group (SISG).

Starting in 2013, ICAO and IATA have increasingly harmonized the accident analysis process and have developed a common list of accident categories to facilitate the sharing and integration of safety data between the two organizations.

Harmonized Analysis of Accident

A total of 119* accidents were considered as part of the harmonized accident criteria in 2018. These comprise scheduled and non-scheduled commercial operations, including ferry flights for aircraft with an MTOW above 5700kg. The GSIE harmonized accident rate for the period from 2014 to 2018 is shown below. Since 2013, the accident rate has been broken down by operational safety component: accidents involving damage to aircraft with little or no injury to persons and accidents with serious or fatal injuries to persons.

Chart 14: GSIE Harmonized accident rate (accidents per million sectors)
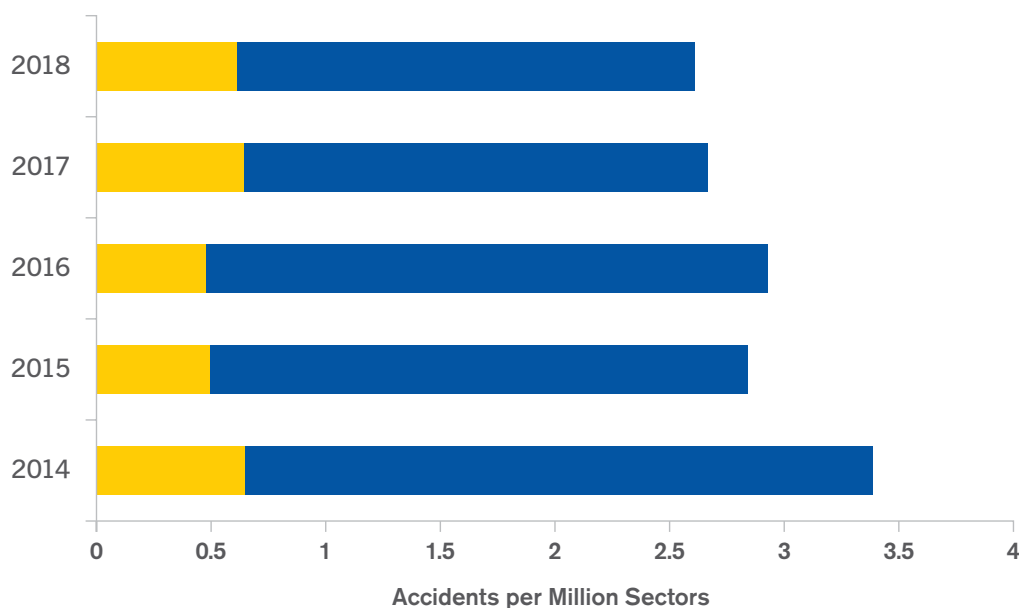
Number of sectors flown source: Ascend ▮ **Injuries to Persons** ▮ **Damage to aircrafts**

* Two accidents were added in May 2019 following a RASG-EUR Accident Investigation workshop which took place on April 2019.

Definitions and Methods

In order to build upon the harmonized accident rate presented in the last five safety reports, ICAO and IATA worked closely to develop a common taxonomy that would allow for a seamless integration of accident data between the two organizations. A detailed explanation of the harmonized accident categories and how they relate to the Commercial Aviation Safety Team/ICAO Common Taxonomy Team (CICTT) occurrence categories can be found in table 4.

Accidents by Category

Differences between the approaches of the ICAO (CICTT Occurrence Categories) and IATA (Flight-crew centric Threat and Error Management Model) classification systems required the harmonization of the accident criteria to be used. The breakdown of accidents by harmonized category is shown below.

Full details of categories can be found in table 4.

Chart 15: Number of Accidents by Category
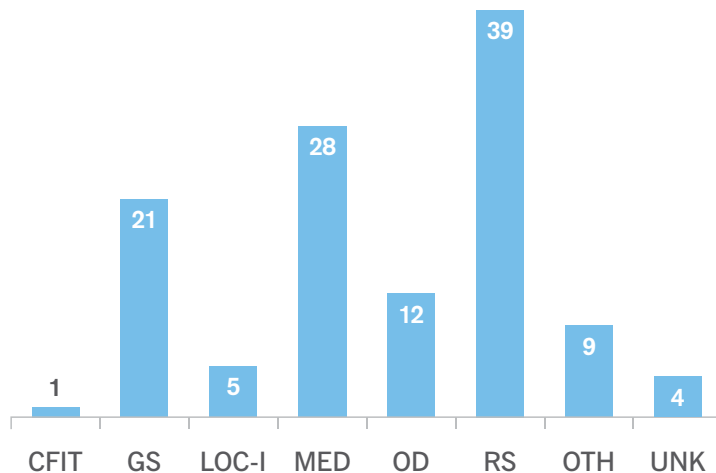
Accident Categories	
CFIT	Controlled Flight into Terrain
GS	Ground Safety
LOC-I	Loss of Control in-Flight
MED	Injuries to and/or Incapacitation of Persons
OD	Operational Damage
RS	Runway Safety
OTH	Other
UNK	Unknown

Note: One accident included in LOC-I was classified as CFIT by IATA Accident Classification Technical Group (ACTG) in January 2019. In February 2019, the interim ADREP report was generated and, based on this information, SISG classified the accident as LOC-I.

Accidents by Region of Occurrence

A harmonized regional analysis is provided by the ICAO RASG regions based on State of Occurrence. The number of accidents and harmonized accident rate (accidents per million sectors) by region are shown in the charts below.

Future Development

Both ICAO and IATA continue to work closely together and, through their respective expert groups, provide greater alignment in their analysis methods and metrics for the future. This ongoing work will be shared with GSIE participants, States, international organizations and safety stakeholders in the interest of promoting common, harmonized safety reporting at the global level.

Chart 16: Number of Accidents per Region of Operator

AFI	APAC	EUR	MID	PA	INTERNATIONAL WATERS
9	22	28	3	56	1

Number of sectors flown source: Ascend

Chart 17: Accident Rate per Region of Operator

AFI	APAC	EUR	MID	PA
4.9	1.6	2.3	1.4	3.6
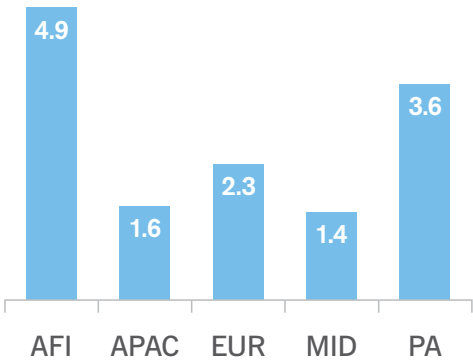
Table 4: GSIE Harmonized Accident Categories

Category	Description
Controlled Flight into Terrain (CFIT)	Includes all instances where the aircraft was flown into terrain in a controlled manner, regardless of the crew's situational awareness. Does not include undershoots, overshoots or obstacles on takeoff and landing which are included in Runway Safety.
Loss of Control in-Flight (LOC-I)	Loss of control in-flight that is not recovered.
Runway Safety (RS)	Includes runway excursions and incursions, undershoot/overshoot, tail strike and hard landing events.
Ground Safety (GS)	Includes ramp safety, ground collisions, all ground servicing, pre-flight, engine start/departure and arrival events. Taxi and towing events are also included.
Operational Damage (OD)	Damage sustained by the aircraft while operating under its own power. This includes in-flight damage, foreign object debris (FOD) and all system or component failures.
Injuries to and/or Incapacitation of Persons (MED)	All injuries or incapacitations sustained by anyone coming into direct contact with any part of the aircraft structure. Includes turbulence-related injuries, injuries to ground staff coming into contact with the structure, engines or control surfaces aircraft and on-board injuries or incapacitations and fatalities not related to unlawful external interference.
Other (OTH)	Any event that does not fit into the categories listed above.
Unknown (UNK)	Any event whereby the exact cause cannot be reasonably determined through information or inference, or when there are insufficient facts to make a conclusive decision regarding classification.

Category	CICTT Occurrence Categories	IATA Classification End States
Controlled Flight into Terrain (CFIT)	CFIT, CTOL	CFIT
Loss of Control in-Flight (LOC-I)	LOC-I	LOC-I
Runway Safety (RS)	RE, RI, ARC, USOS	Runway Excursion, Runway Collision, Tailstrike, Hard Landing, Undershoot, Gear-up Landing / Gear Collapse
Ground Safety (GS)	G-COL, RAMP, LOC-G	Ground Damage
Operational Damage (OD)	SCF-NP, SCF-PP	In-flight Damage
Injuries to and/or Incapacitation of Persons (MED)	CABIN, MED, TURB	None (excluded in IATA Safety Report)
Other (OTH)	All other CICTT Occurrence Categories	All other IATA End States
Unknown (UNK)	UNK	Insufficient Data

Appendix 1

Regional Aviation Safety Group (RASG) Regions

The assignment of States or areas to specific groupings is for statistical convenience and does not imply any assumption regarding political or other affiliation of States or territories by ICAO.
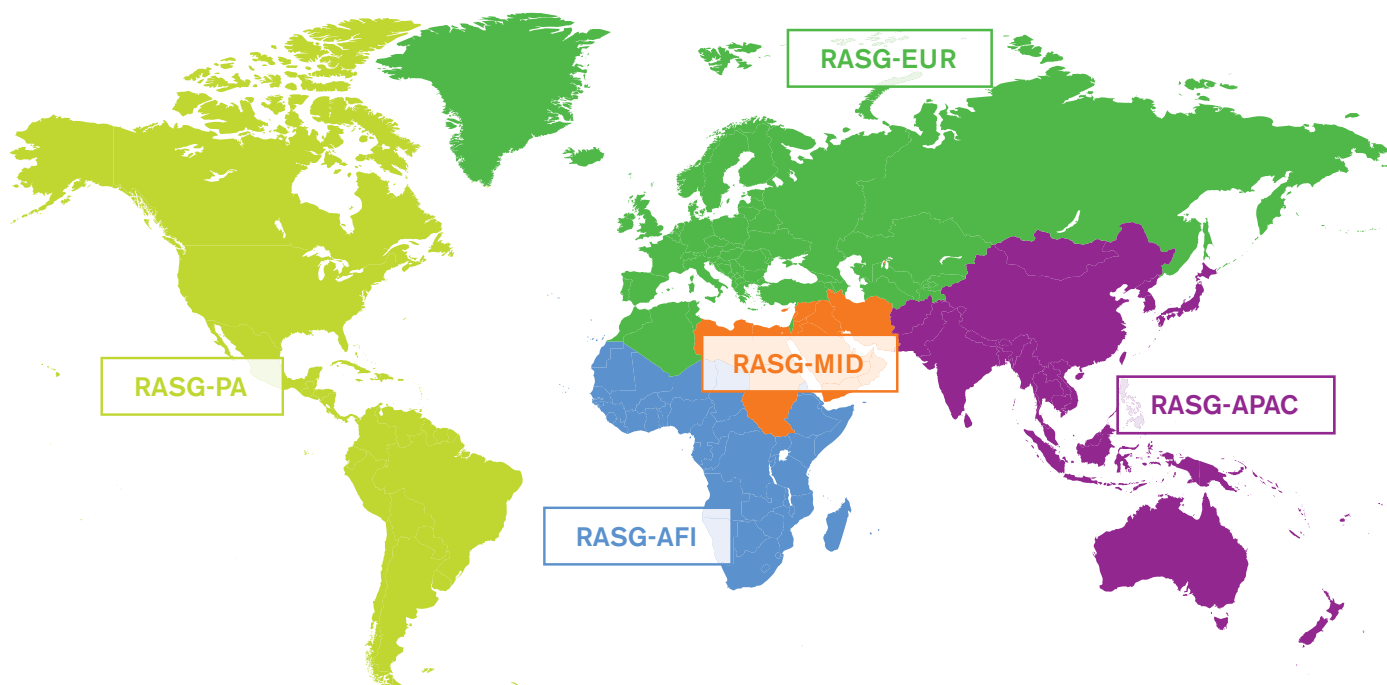
RASG-AFI (48)				
Angola	Congo	Ghana	Mauritius	Somalia
Benin	Côte d'Ivoire	Guinea	Mozambique	South Africa
Botswana	Democratic Republic of the Congo	Guinea-Bissau	Namibia	South Sudan
Burkina Faso	Djibouti	Kenya	Niger	Togo
Burundi	Equatorial Guinea	Lesotho	Nigeria	Uganda
Cameroon	Eritrea	Liberia	Rwanda	United Republic of Tanzania
Cabo Verde	Eswatini	Madagascar	Sao Tome and Principe	Zambia
Central African Republic	Ethiopia	Malawi	Senegal	Zimbabwe
Chad	Gabon	Mali	Seychelles	
Comoros	Gambia	Mauritania	Sierra Leone	

RASG-APAC (39)

Afghanistan	Democratic People's Republic of Korea	Malaysia	New Zealand	Solomon Islands
Australia		Maldives	Pakistan	Sri Lanka
Bangladesh	Fiji	Marshall Islands	Palau	Thailand
Bhutan	India	Micronesia (Federated States of)	Papua New Guinea	Timor-Leste
Brunei Darussalam	Indonesia		Philippines	Tonga
Cambodia	Japan	Mongolia	Republic of Korea	Tuvalu
China	Kiribati	Myanmar	Samoa	Vanuatu
Cook Islands	Lao People's Democratic Republic	Nauru	Singapore	Viet Nam
		Nepal		

RASG-EUR (56)

Albania	Cyprus	Israel	North Macedonia	Sweden
Algeria	Czechia	Italy	Norway	Switzerland
Andorra	Denmark	Kazakhstan	Poland	Tajikistan
Armenia	Estonia	Kyrgyzstan	Portugal	Tunisia
Austria	Finland	Latvia	Republic of Moldova	Turkey
Azerbaijan	France	Lithuania	Romania	Turkmenistan
Belarus	Georgia	Luxembourg	Russian Federation	Ukraine
Belgium	Germany	Malta	San Marino	United Kingdom
Bosnia and Herzegovina	Greece	Monaco	Serbia	Uzbekistan
Bulgaria	Hungary	Montenegro	Slovakia	
Croatia	Iceland	Morocco	Slovenia	
	Ireland	Netherlands	Spain	

RASG-MID (15)

Bahrain	Iran (Islamic Republic of)	Lebanon	Qatar	Syrian Arab Republic
Egypt	Jordan	Libya	Saudi Arabia	United Arab Emirates
Iraq	Kuwait	Oman	Sudan	Yemen

RASG-PA (35)

Antigua and Barbuda	Canada	El Salvador	Nicaragua	Suriname
Argentina	Chile	Grenada	Panama	Trinidad and Tobago
Bahamas	Colombia	Guatemala	Paraguay	United States
Barbados	Costa Rica	Guyana	Peru	Uruguay
Belize	Cuba	Haiti	Saint Kitts and Nevis	Venezuela (Bolivarian Republic of)
Bolivia (Plurinational State of)	Dominica	Honduras	Saint Lucia	
Brazil	Dominican Republic	Jamaica	Saint Vincent and the Grenadines	
	Ecuador	Mexico		

Appendix 2

List of Scheduled Commercial Accidents in 2018

Date	Model	State of Occurrence	RASG Region	Fatalities	Accident Category
2018-01-01	Airbus A319-111	Spain	EUR	0	TURB
2018-01-03	Airbus A319-131	Italy	EUR	0	TURB
2018-01-05	Boeing 737-800/ Boeing 737-800	Canada	PA	0	GCOL, F-POST, EVAC
2018-01-06	Boeing 777-300ER	United States	PA	0	RAMP
2018-01-10	de Havilland Dash 8	Poland	EUR	0	ARC, SCF-NP
2018-01-13	Boeing 737-800	Turkey	EUR	0	RE, LOC-G
2018-01-25	Airbus A320-214	Germany	EUR	0	RAMP
2018-02-10	Boeing 737-800	Spain	EUR	0	AMAN
2018-02-11	Antonov An-148	Russia	EUR	71	LOC-I
2018-02-13	Airbus A330-200	Nigeria	AFI	0	SCF-PP, F-NI, EVAC
2018-02-16	Fokker F28 MK 0100	Iran (Islamic Republic of)	MID	0	ARC, SCF-NP
2018-02-18	ATR 72-212	Iran (Islamic Republic of)	MID	66	LOC-I, TURB, NAV
2018-02-20	Boeing MD83	Nigeria	AFI	0	RE, ARC
2018-02-24	Airbus A330-323	United States	PA	0	TURB
2018-03-12	de Havilland Dash 8-400	Nepal	APAC	51	RE, F-POST, ARC
2018-03-14	Boeing 777-300ER	Uganda	AFI	1	RAMP
2018-03-17	Bombardier CRJ200	Canada	PA	0	GCOL, RAMP
2018-03-22	Airbus A320-232	Australia	APAC	0	TURB
2018-03-23	Boeing 737-800	Hungary	EUR	0	EVAC
2018-03-27	Airbus A319-111	Spain	EUR	0	BIRD
2018-03-28	Boeing 737-800/ Boeing 767-300	Israel	EUR	0	GCOL
2018-03-29	Fairchild SA227-DC	Bolivia (Plurinational State of)	PA	0	RE, BIRD
2018-04-01	Airbus A321-200	Vietnam	APAC	0	ARC
2018-04-09	Boeing 737-900	Japan	APAC	0	ARC
2018-04-17	Boeing 737-700	United States	PA	1	SCF-PP
2018-04-17	de Havilland Dash 8-402	UK	EUR	0	ARC
2018-04-18	Airbus A330-323	United States	PA	0	SCF-PP, F-NI
2018-04-29	Boeing 737-800	Indonesia	APAC	0	RE
2018-04-29	Airbus A321-231	Vietnam	APAC	0	NAV, ADRM

List of Scheduled Commercial Accidents in 2018 (continued)

Date	Model	State of Occurrence	RASG Region	Fatalities	Accident Category
2018-05-02	Boeing 767-300/ Bombardier CL 600	United States	PA	0	GCOL
2018-05-02	Boeing 737-800	Morocco	EUR	0	ARC
2018-05-03	Boeing 737-300	Bolivia (Plurinational State of)	PA	0	WSTRW
2018-05-07	Boeing 737-800	United States	PA	0	GCOL
2018-05-12	Lockheed Hercules/ Boeing 737-800	Papua New Guinea	APAC	0	GCOL
2018-05-13	Airbus A330-323/ Airbus A321-231	Turkey	EUR	0	GCOL
2018-05-18	Boeing 737-200	Cuba	PA	112	LOC-I
2018-05-21	Airbus A330-200	Saudi Arabia	MID	0	ARC, SCF-NP
2018-05-26	Boeing 777-200	Myanmar	APAC	0	WSTRW, TURB
2018-06-10	Boeing 737-800	Greece	EUR	0	ARC
2018-06-10	Boeing 777-223	United States	PA	0	TURB
2018-06-10	Boeing 787-9	United States	PA	0	CABIN
2018-06-10	de Havilland Dash 8-400	Canada	PA	0	TURB
2018-06-12	Boeing 737-800	United States	PA	0	CABIN
2018-06-14	Boeing MD83	United Kingdom	EUR	0	RE
2018-06-16	Embraer ERJ175	United States	PA	0	TURB
2018-06-22	Boeing 737-800	Norway	EUR	0	RAMP
2018-06-29	Airbus A330-300	Canada	PA	0	TURB
2018-07-06	ATR 72-212A	Morocco	EUR	0	ARC
2018-07-16	Boeing 737-800	Brazil	PA	0	SCF-NP, ARC
2018-07-16	Boeing 737-800	Argentina	PA	0	ARC
2018-07-20	Boeing 767-300	Canada	PA	0	CABIN
2018-07-23	Boeing MD88	United States	PA	0	WSTRW, TURB
2018-07-26	Boeing 757-200	Kazakhstan	EUR	0	ARC
2018-07-28	ATR 72-212A	Vanuatu	APAC	0	RE, F-NI, LOC-G, SCF-PP
2018-07-31	Boeing 757-200	United States	PA	0	ARC
2018-07-31	Embraer ERJ190-100	Mexico	PA	0	LOC-I, WSTRW
2018-08-06	Airbus A321-200	Brazil	PA	0	OTHR
2018-08-09	Boeing 787-8/ Boeing 777-300	Turkey	EUR	0	GCOL

List of Scheduled Commercial Accidents in 2018 (continued)

Date	Model	State of Occurrence	RASG Region	Fatalities	Accident Category
2018-08-13	Airbus A321-271	United States	PA	0	ARC, SCF-NP
2018-08-16	Boeing 737-800	Philippines	APAC	0	RE
2018-08-19	de Havilland Dash 8-400	Peru	PA	0	ARC
2018-08-22	ATR72-212A	China	APAC	0	RE
2018-08-24	Boeing 757-200	United States	PA	0	RAMP
2018-08-26	Boeing 767-300	Canada	PA	0	SCF-PP
2018-08-27	Airbus A320-214	Japan	APAC	0	TURB
2018-08-28	Airbus A320-214	China	APAC	0	ARC
2018-09-01	Boeing-737-800	Russian Federation	EUR	0	RE
2018-09-06	Boeing 757-200	United States	PA	0	AMAN
2018-09-09	Let L-410	South Sudan	AFI	20	UNK
2018-09-10	Boeing 737-800	United States	PA	0	TURB
2018-09-15	Boeing 777-300	Canada	PA	0	CABIN
2018-09-16	Boeing 747-400F	Germany	EUR	0	SCF-NP
2018-09-23	Boeing 757-200	United States	PA	0	CABIN
2018-09-24	Airbus A340-300	Canada	PA	0	SCF-NP
2018-09-26	Airbus A321-231	United States	PA	0	CABIN
2018-09-26	Boeing 737-800	Bangladesh	APAC	0	ARC, SCF-NP
2018-09-28	Boeing 737-800	Micronesia (Federated States of)	APAC	1	USOS
2018-10-03	Beech 1900	United States	PA	0	ARC
2018-10-08	Boeing 747-400	Thailand	APAC	0	RE
2018-10-09	Boeing 737-700	United States	PA	0	CABIN
2018-10-10	Boeing 737-700	Russian Federation	EUR	0	RE
2018-10-11	Boeing 737-700	United States	PA	0	CABIN
2018-10-12	Airbus A319-112	United States	PA	0	TURB
2018-10-12	Boeing 737-800	India	APAC	0	CTOL
2018-10-15	Boeing 737-700	United States	PA	0	TURB
2018-10-29	Boeing 737 MAX 8	Indonesia	APAC	189	LOC-I, SCF-NP
2018-10-31	Airbus A330-300/ Airbus A330-200	France	EUR	0	GCOL

List of Scheduled Commercial Accidents in 2018 (continued)

Date	Model	State of Occurrence	RASG Region	Fatalities	Accident Category
2018-11-09	Boeing 757-200	Guyana	PA	1	EVAC, RE, SCF-NP
2018-11-20	Boeing 737-800	Russian Federation	EUR	1	SEC
2018-11-28	Boeing 737-500	Bolivia (Plurinational State of)	PA	0	SCF-NP
2018-12-01	Bombardier CL 600	United States	PA	0	RAMP
2018-12-02	Airbus A320-232	United States	PA	0	TURB
2018-12-03	Boeing 737-800	United States	PA	0	CABIN
2018-12-04	Boeing 767-300ER	United States	PA	0	WSTRW, TURB
2018-12-04	Airbus A320-214	Greece	EUR	0	RAMP
2018-12-08	Airbus A320-232	Thailand	APAC	0	TURB
2018-12-11	Boeing 777-300ER	China	APAC	0	ARC
2018-12-18	Boeing 787-9	Norway	EUR	0	GCOL

Accident Categories

Code	Description	Code	Description
ADRM	Aerodrome	LOC-I	Loss of control in-flight
AMAN	Abrupt Maneuver	LOC-G	Loss of control-ground
ARC	Abnormal runway contact	OTHR	Other
BIRD	Bird	RAMP	Ground handling
CABIN	Cabin safety events	RE	Runway excursion
CFIT	Controlled flight into/towards terrain	SCF-NP	System/component failure (non-powerplant)
CTOL	Collision with obstacles during takeoff and landing	SCF-PP	System/component failure (powerplant)
EVAC	Evacuation	TURB	Turbulence encounter
F-NI	Fire/smoke (non-impact)	UNK	Unknown or undetermined
F-POST	Fire/smoke (post-impact)	USOS	Undershoot/overshoot
GCOL	Ground collision	WSTRW	Wind shear or thunderstorm

Appendix 3

Important Facts about Aviation Safety

ICAO's 75th Anniversary: Celebrating the pivotal importance of safety

by Catalin Radu

The continuous enhancement of safety has always been the cornerstone of the sustainable development of civil aviation. This fact itself is no accident: the visionaries who conceived the 1944 Convention on International Civil Aviation, which is the foundation of international air connectivity and ICAO itself, fully understood the imperative of placing safety as the first priority of flight. That is why they gave ICAO's member States the means to cooperate to ensure safety as a way to foster the development of the then-nascent industry.

Seventy-five years later, the international civil aviation network carries over four billion passengers annually. Thanks to the tremendous safety achievements that our industry has accomplished, they take to the skies confidently, seeking family and friends, commercial opportunities and cultural discoveries, and they deliver these benefits to the communities at their destinations, too.

As part of ICAO's 75th Anniversary Celebrations, ICAO would like to highlight some of the crucial safety achievements that have enabled this.

The following section presents these highlights about different topics from various technical domains that had an impact on the enhancement of aviation safety in the last 75 years. These articles were also published on the website of Uniting Aviation every Friday of the first six months of 2019.

ICAO 2019

75 YEARS OF CONNECTING THE WORLD

About the Author

Catalin Radu has been the Deputy Director of the Air Navigation Bureau at ICAO in charge of Aviation Safety since September 2014. He held a number of executive and managerial positions at the Romanian Ministry of Transport and at the European level with over 20 years' experience in aviation safety and international aviation organizations. He also served as President of ECAC, Vice President of EUROCONTROL and ECAC's Focal Point for Safety Matters.

Underwater Locator Devices

by Dr. André de Kock

Aircraft are required to be equipped with emergency locator transmitters (ELT). When an aircraft is involved in an accident, the ELT transmits a signal for search and rescue teams to be able to locate it, expediting the rescue of persons involved in the occurrence. Once the location of the accident site is known, accident investigators would be able to timely recover the flight recorders for downloading and analysis. When an aircraft crashes into water and submerges, the ELT radio frequency signal would no longer be transmitted. In such cases, accident investigators depend on underwater locator devices (ULDs), commonly known as "pingers" and fitted to the flight recorders, to locate the wreckage and recover the flight recorders. Each flight recorder has a ULD attached to it. The moment the ULD becomes wet, it starts to "ping".

In the past, the requirement for the duration of operation of ULDs was 30 days. However, during recent extended searches for aircraft wreckage in water, it was realized that if the ULD had been capable of transmitting the pings for 90 days (instead of 30 days), search crews would have had a higher probability of finding the wreckage. As a result, ICAO provisions were amended in 2010 for ULDs to have a 90-day operational duration from 1 January 2018. Another requirement called for aircraft to be equipped with a ULD operating on a lower frequency, enabling its detection over a longer distance below the surface of the water.

These new provisions on ULDs ensure that wreckage under water will be found without delay, allowing the timely recover of flight recorders, enhancing efficiency and effectiveness of investigations for the improvement of safety.

About the Author

Dr. André de Kock joined ICAO in 2007 with the Accident Investigation Section. He holds an Engineering Diploma for Technicians and a Doctorate in Curriculum Studies. Having a private pilot license, André has investigated over 200 aircraft accidents. He is currently the Secretary of the ICAO Accident Investigation Panel and the Flight Recorder Specific Working Group.

Cabin Safety Improvement

by Martin Maurino

Cabin safety contributes to the prevention of accidents and incidents, the protection of the aircraft's occupants, through proactive safety management, including hazard identification and safety risk management, and the increase of survivability in the event of an emergency situation.

With a total of 50 fatalities for scheduled commercial operations transporting 4.1 billion passengers, the year of 2017 had a global fatality rate of 12.2 fatalities per billion passengers. A review of ICAO accident data from 2013-2017 involving commercial scheduled air transport indicated that there were average 2.6 accidents per million flight departures yearly. The fact that most occupants survive accidents can be linked to improvements made in occupant protection. These improvements result from survival factor investigations, which address cabin safety aspects during accident investigations.

Over the past thirty years, cabin safety improvements have included the following:

16G seats

16G dynamic standards for all passenger and cabin crew seats improved protection against serious head injury (where head contact with seats or other structures occurred). The 16G seats also protect crew members from serious chest injury when upper-torso restraints are used, and prevent occupants from being trapped in their seats due to excessive seat deformation.

Fire retardant materials

Cushion material provides 40 to 60 seconds of additional time for aircraft evacuation compared to the previously used cushions. Improved test standards for large surface area panels (e.g. ceilings, walls, galleys, overhead bins, and partitions) have been implemented since 1985 to delay the onset of a cabin flashover (flash fire) event. The improved standards give passengers and crew members more time to evacuate the aircraft after an accident. This improvement

in cabin material flammability was demonstrated to delay flashover in the cabin.

Floor proximity emergency escape path marking

Floor proximity emergency escape path marking aids passengers by marking evacuation paths and identifying exits utilizing illumination sources close to the floor. This system is aimed at improving the evacuation rate under significant smoke conditions in the cabin.

Lavatory smoke detectors and fire extinguishers

Since 1986, all aircraft lavatories are required to be equipped with smoke detectors and, since 1987, automatic fire extinguishers in the waste paper bin in all aircraft lavatories. Through a 1992 ICAO Assembly Resolution, ICAO member States consensually agreed "to take necessary measures as soon as possible to restrict smoking progressively on all international passenger flights."

Low heat/smoke release tests

The requirement for aircraft cabin materials (e.g. ceiling, sidewall, stowage bins, partitions) to meet low heat/smoke release tests help reduce heat and smoke in the aircraft.
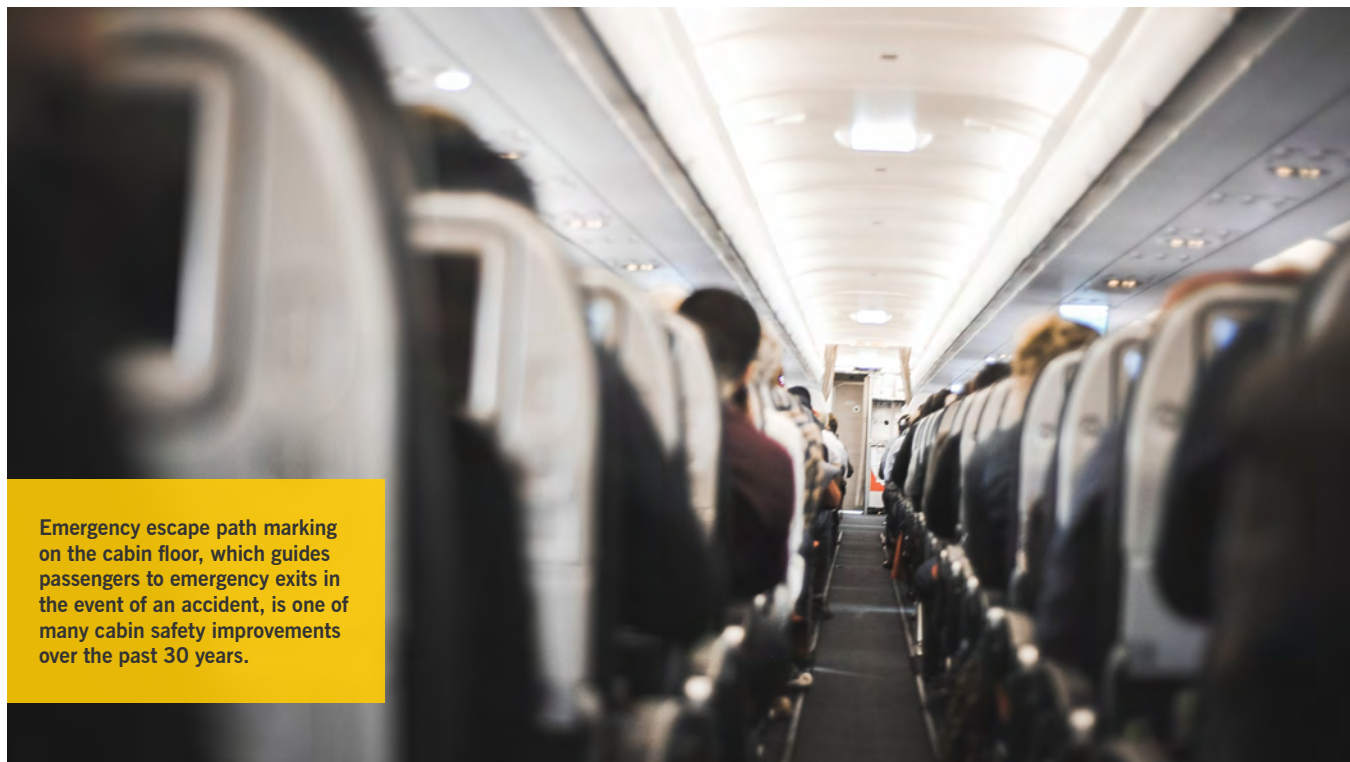
Radiant heat resistant evacuation slide

In 1983, changes made to Technical Standard Order (TSO) for emergency evacuation slides to incorporate a radiant heat test for slide material improved the ability of a slide to resist heat from a large fuel fire nearby.

Exit design

The minimum width specified for the passageway from the aisle to the exit for aircraft with 60 or more passengers was modified to improve access to Type III exits. Egress rates through the exits were found to be faster than previous narrower passageways. Use of an Automatically Disposable

Emergency escape path marking on the cabin floor, which guides passengers to emergency exits in the event of an accident, is one of many cabin safety improvements over the past 30 years.

Hatch (ADH), instead of the conventional Type III exit for new aircraft types, removes manual intervention to ensure that the hatch's final location after opening does not impede the evacuation path inside or outside the aircraft.

Distances between emergency exits

Since 1989, for aircraft with more than one passenger emergency exit on each side of the fuselage, no passenger emergency exit must be more than 60 feet from any adjacent passenger emergency exit on the same side of the same deck of the fuselage. This is meant to ensure adequate exits for passengers' use in an emergency. Exits are required to be distributed as uniformly as practicable, since this is considered to provide a reasonable seat-to-exit and exit-to-exit distance.

Many of these significant improvements date back to the 1980s, when accidents were more frequent. As aviation's safety record has considerably improved since, the field of cabin safety now focuses on proactive initiatives to prevent accidents and possible fatalities. In 2014, ICAO launched a competency-based approach to cabin crew safety training, to ensure that cabin crew members can best respond to emergencies on board. In 2015, work was undertaken to promote the use of child restraint systems for the safe travel of infants and children and prevent injuries during flight. The challenges related to cabin safety are continuously evolving and require ongoing improvements. The proliferation of Lithium batteries in many devices carried by passengers and crew has led to a recent revision of cabin crew firefighting procedures to mitigate the risk of inflight fires. The digitalisation of safety information is creating a move towards cabin-electronic flight bags (C-EFBs). New security threats call for procedures and training to respond to chemical, biological and radiological incidents, as well as suspected cases of trafficking in persons, for cabin crew members to identify and respond to these situations adequately.

About the Author

Martin Maurino, M.Eng. is Safety, Efficiency and Operations Officer at ICAO. He heads the ICAO Cabin Safety Programme. Before joining ICAO, he held safety analysis and safety management roles at Transport Canada and the International Air Transport Association (IATA). Martin began his career in aviation as a cabin crew member at Air Canada.

Aircraft Fire Extinguishing Systems: Replacing the Halon

by Maimuna Taal

Halogenated hydrocarbons (halons) have traditionally been the only fire-extinguishing agents used in civil transport aircraft as a fire extinguisher because they are effective on different kinds of fires and they are very lightweight. However, due to their high ozone depletion, the Montreal Protocol on Substances that Deplete the Ozone Layer called for an end to their production by 1994 in developed countries and by 2010 in developing countries. As a result, of this international agreement, production of halon is prohibited, and halon supplies are diminishing. The updated breakout of Global Inventories of Halon 1301 from the United Nations Environment Programme (UNEP) Halons Technical Options Committee (HTOC) 2018 Assessment Report is shown in the chart below.

Chart 18: Breakout of Global Inventories (Bank) of Halon 1301 by HTOC Model Regions
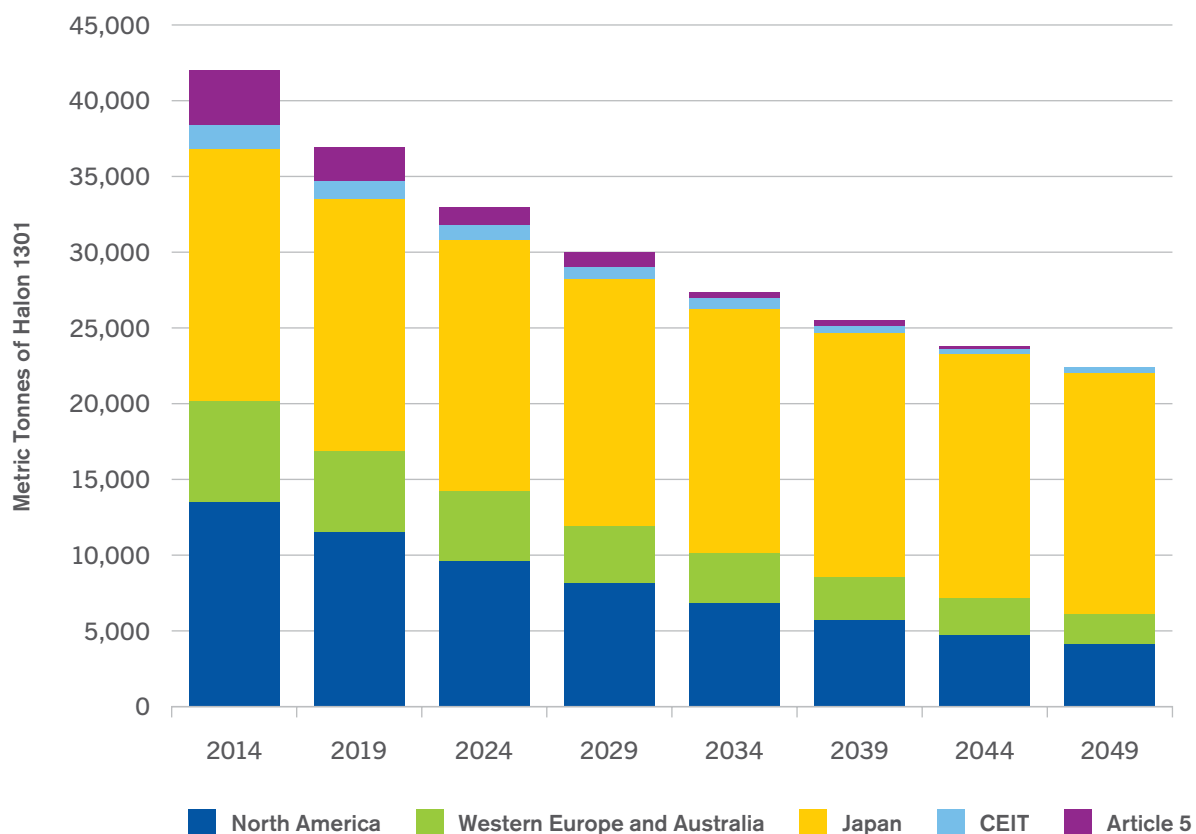
This chart reproduced from HTOC UNEP report (December 2018)

Portable fire extinguisher

ICAO has mandated the use of Halon replacements in fire extinguishers used on civil transport aircraft. Several ICAO Provisions already exist in Annex 6 — *Operation of Aircraft* and Annex 8 — *Airworthiness of Aircraft* that stipulate requirements for the use of a non–halon alternate agent for fire suppression as presented in the table below.

Table 5: The Halon replacement cut off dates in ICAO SARPs contained in Annex 6 and 8:

Extinguishing systems in civil aircraft	ICAO SARP Cut-off date
Lavatory fire extinguishing systems	31 Dec 2011
Portable fire extinguishers	31 Dec 2018
Engine and APU fire extinguishing systems	31 Dec 2014
Cargo compartment fire extinguishing systems	28 Nov 2024

At present, halons are used for fire suppression on civil aircraft in four extinguishing applications as shown above. Worldwide, there are many States and organizations testing alternatives to halon. Unfortunately, there is no single substance which can be used for all of the extinguishing applications. Therefore, aviation will have to use different types of extinguishers for each application.

Halon replacement agent for portable and lavatory fire extinguishers which are reported to be neither a greenhouse gas nor an ozone-depleting substance are already available. Research and development are progressing towards halon replacement for engine and auxiliary power unit (APU) fire extinguishing systems. However, the industry is still far from developing a viable replacement agent for this application that can be fully tested, certified and implemented on commercial transport aircraft. The cargo compartment extinguishers are the most difficult to replace, research and testing still have a long way to go. Halon replacement will require the full cooperation of all stakeholders to
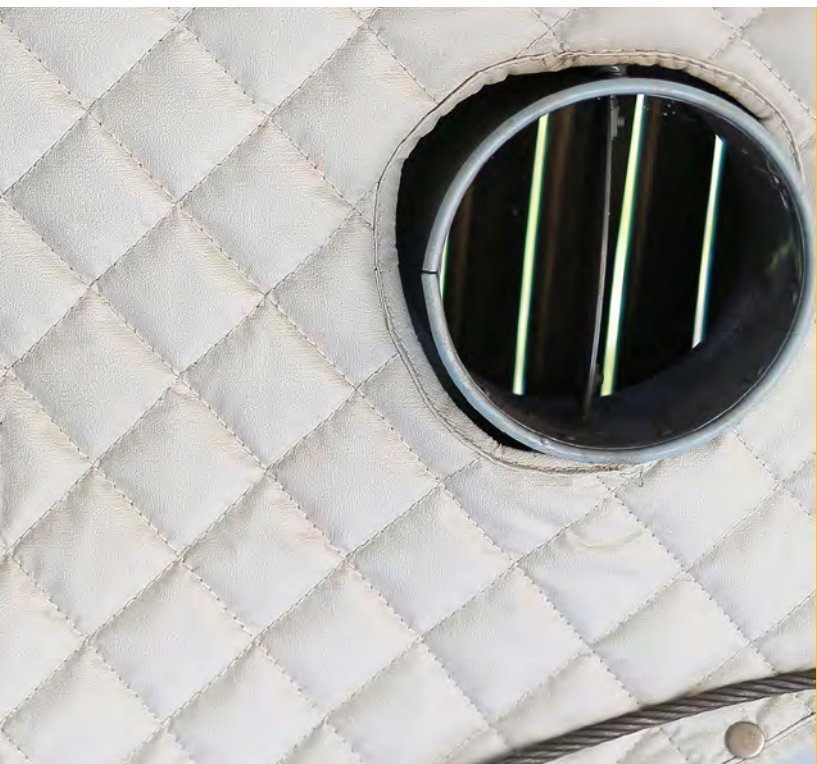
Worldwide, there are many States and organizations testing alternatives to halon. Unfortunately, there is no single substance which can be used for all of the extinguishing applications.

collaborate under the auspices of ICAO to achieve a viable solution which provides adequate technical performance, certification, and long-term environmental benefit.

The 2018 HTOC model estimates the remaining worldwide bank of halon 1301 to be approximately 37,750 metric tonnes at the end of 2018 in accordance with Chapter 5 of the 2018 HTOC Assessment Report. This remaining bank of halon 1301 is assumed to be currently installed in fire suppression equipment (e.g., in aviation, computer facilities, oil and gas, military, maritime, etc.), as well as in available stockpiles. It is estimated that 12,500 metric tonnes of halon 1301 could become available to support civil aviation if all of it went only to civil aviation. However, many other on-going uses of halon 1301 will also need to share in

this available supply to meet their ongoing needs to refill discharged systems and/or leaks.

The aviation industry continues to use halon today under an exemption to the international agreement because of its unique situation. This cannot and should not continue indefinitely.

Halon is currently available for aircraft use by recycling existing supplies; Although ICAO member States have taken measures to mitigate contamination, the potential risk of contamination of the reserves remains. In recognition of these issues and their potential impact on safety, transitioning promptly from halon to safe and effective halon alternatives now become urgent.

About the Author

Maimuna Taal is the Technical Officer Airworthiness in the Air Navigation Bureau (ANB) of the International Civil Aviation Organization (ICAO). She is an Aerospace Engineer and a holder of an Airframe and Powerplant Engineer License from the US Federal Aviation Administration (FAA). She has over 20 years of experience in the field of Civil Aviation Safety oversight related to continuing airworthiness. Before joining the ICAO, she held the position of Director General of the Gambia Civil Aviation Authority GCAA) where she was responsible for the full range of aviation regulatory activities. Maimuna is a recipient of the 2007 Flight Safety Foundation President's Citation for her work in improving aviation safety in Africa.

The ICAO Runway Safety Programme

by Brian DeCouto

Runway safety is a long-standing safety issue and has been aviation's number one safety challenge for the past 20 years. About half of all aviation accidents reported to ICAO have been linked to runway safety. In September 2010, the 37th ICAO Assembly agreed on resolution A37-6, urging States to take measures to enhance runway safety and calling on ICAO to lead the collaborative efforts required to reduce runway safety related accidents and incidents worldwide. Since then, ICAO and its Runway Safety Programme

Partners have been working together to minimize and mitigate the risks of events linked to runway safety.

Impact on global aviation: As seen in the charts below, the good news in recent years is that accidents related to runway safety have steadily declined and resulted in relatively low numbers of fatalities. Since 2011 the number of runway safety related accidents has declined by 43%.

Accidents by Risk Category
Scheduled Commerical flights on airplanes above 5.7t only

Fatalities by Risk Category
Scheduled Commerical flights on airplanes above 5.7t only
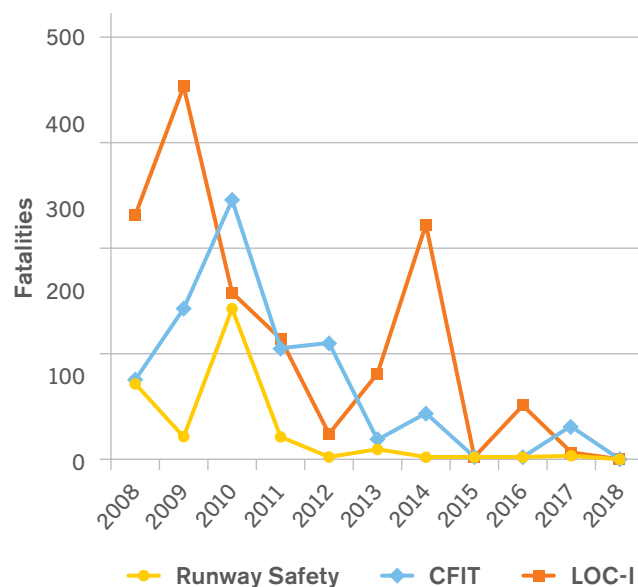
The charts above show how runway safety related accident and fatality rates compare with the other high-risk accident categories, controlled flight into terrain (CFIT) and loss of control in-flight (LOC-I).

Source: iSTARS 3.0 – ADREP et al. (https://portal.icao.int/space)

Much of the success can be accredited to the work of ICAO's collaborative Runway Safety Programme, enhancement of ICAO runway safety related provisions and stakeholders' efforts, such as the establishment of Runway Safety Teams at airports. Still, with global air traffic predicted to double in the next fifteen years and the aviation industry becoming more and more complex, it's important to continue efforts to reduce runway related risks to as low as possible.

Runway Safety Programme Initiatives: The ICAO Runway Safety Programme has led many initiatives aimed at improving global runway safety. Some key initiatives include:

- **Regional Runway Safety Seminars:** 15 regional runway safety seminars have been held in countries around the world, to promote stakeholder collaboration and the establishment of multidisciplinary airport Runway Safety Teams (RSTs).
- **Runway safety implementation kit (I-Kit):** The Runway Safety I-Kit provides a single reference platform for runway safety related information, guidance and tools for stakeholders.
- **ICAO Runway Safety Team Handbook:** The RST handbook provides guidance on how to establish an airport RST and promotes the sharing and exchange of safety information between stakeholders.
- **ICAO Runway Safety Go-Team Missions:** To support the establishment of effective RSTs, ICAO and its Runway Safety Programme Partners conduct Runway Safety Go-Team missions at requesting airports. The Go-Team missions aim to provide airports with international technical assistance for the implementation of RSTs, including training, assessments, gap analyses, expert advice and guidance, based on best practices.
- **Global Runway Safety Action Plan (GRSAP):** The GRSAP was developed in collaboration with the ICAO Runway Safety Programme Partners and provides recommended actions for all runway safety stakeholders as indicated in Table 6, with the aim of reducing the global rate of runway excursions and runway incursions. Runway excursions occur when aircraft veer off or overrun the runway surface, while runway incursions involve the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft. The GRSAP was unveiled at the Second Global Runway Safety Symposium held in Lima, Peru, in November 2017.

For more information on ICAO's Runway Safety Programme initiatives and access to runway safety guidance, please visit www.icao.int/safety/runwaysafety.

Table 6: Global Runway Safety Action Plan Key Recommended Actions

Stakeholder	Actions
State CAAs and Industry	• Collect and analyze data and develop/implement action plans • Participate in Aerodrome Runway Safety Team activities • Implement the elements of Safety Management • Ensure runway safety training is part of initial and recurrent training for relevant operational staff
Regional Organisations	• Collect and analyze regional safety data • Develop and implement regional action plans • Monitor and manage regional action plans • Offer support to States that need it
Runway Safety Programme Partners	• Continue to collaborate on the monitoring of runway safety related data, conduct analysis and identify appropriate mitigations • Continue to support the establishment of effective Airport RSTs with RST Go-team missions • Organize a global runway safety event at least every six years
ICAO	• Enhance Assembly Resolution, SARPs and existing guidance material for Runway Safety • Develop recommended practices for prevention of runway excursions • Develop guidance to States on State Runway Safety Programmes • Enhance ICAO runway safety related training • Deploy the Global Reporting Format for assessing and reporting runway surface conditions

Regardless of the success achieved thus far, runway safety, particularly runway excursions and incursions, continues to be one of aviation's top safety risk categories. The GRSAP will drive improved runway safety risk mitigation over the next several years, while the ICAO Runway Safety Programme Partners continue to lead collaborative efforts and global initiatives. Runway safety stakeholders worldwide must also do their part by implementing the actions in the GRSAP and by working together to resolve this complex problem.

The ICAO Runway Safety Programme Partners

About the Author

Brian DeCouto is the Safety Implementation Support Officer - Safety at ICAO responsible for runway safety. He is a secondee from the Bermuda Civil Aviation Authority where he has been an Airworthiness Inspector since 2008. He possesses a Bachelor's of Science degree in Aerospace Engineering from Florida Institute of Technology and a Master's degree in Aviation Safety and Airworthiness from ENAC in Toulouse, France.

The Global Reporting Format (GRF) for runway surface conditions

by Paul Adamson

Runway safety related accidents and incidents are aviation's number one safety related risk category, with 59 reported accidents in 2016, of which more than half were due to runway excursions (source: ICAO iSTARS).

A runway excursion is defined as a "veer off or overrun of the runway surface", which can happen during landing or take off. One of the main contributing factors is adverse weather that results in the runway surface being contaminated by snow, ice, slush or water, with a potentially negative impact on an aircraft's braking, acceleration or controllability.

To help mitigate the risk of excursion ICAO has developed a harmonized methodology for the assessing and reporting of runway surface conditions. This methodology, known as the Global Reporting Format (GRF), will be globally applicable from November 2020, with deployment activities now underway.

The GRF is intended to cover conditions found in all climates. It provides a means for aerodrome operators to rapidly and correctly assess runway surface conditions, whether they are exposed to wet runway conditions, snow, slush, ice or frost, including rapidly changing conditions such as those experienced during winter or in tropical climates. The GRF comprises an evaluation of a runway by human observation (normally done by airport operations staff)

and, using a runway condition matrix as shown in Table 7, the consequent assignment of a Runway Condition Code (RWYCC). This code is complemented by a description of the surface contaminant based upon its type, depth and coverage for each third of the runway. This evaluation should of course be performed by a trained runway assessor.

The outcome of the evaluation and associated RWYCC are then used to complete a standard report called the Runway Condition Report (RCR) which is forwarded to air traffic services and the aeronautical information services for dissemination to pilots.

Pilots use the RWYCC to determine their aircraft's performance by correlating the code with performance data provided by their aircraft's manufacturer. This helps pilots to correctly carry out their landing and take-off performance calculations for wet or contaminated runways.

Another important element of the GRF is a process that enables pilots to report their own observations of runway conditions, thereby confirming the RWYCC or providing an alert to changing conditions.

Other key qualities of the GRF are its relative simplicity and its global applicability. A methodology that is easily

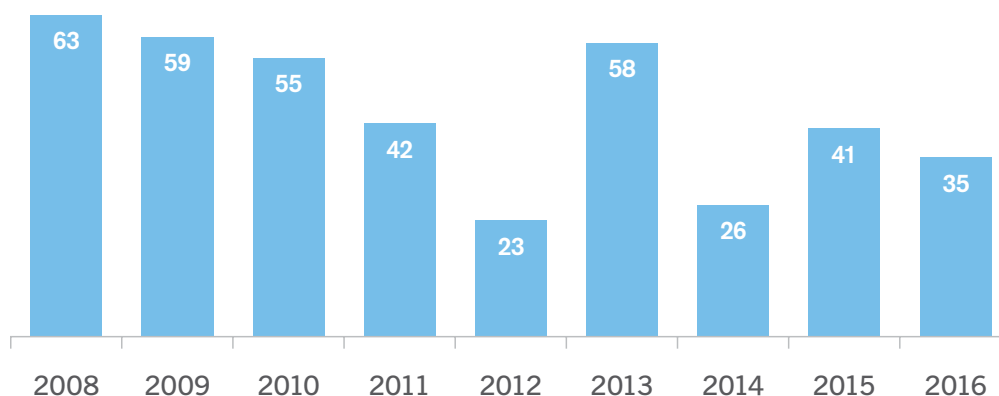## Runway Excursion Accidents 2008–2016
Source: ICAO iSTARS

Year	Accidents
2008	63
2009	59
2010	55
2011	42
2012	23
2013	58
2014	26
2015	41
2016	35

Table 7: The Runway condition Matrix (used to assign the RWYCC)

Assessment criteria		Downgrade assessment criteria	
Runway condition code	Runway surface description	Aeroplane deceleration or directional control observation	Pilot report of runway braking action
6	• DRY	---	---
5	• FROST • WET (The runway surface is covered by any visible dampness or water up to and including 3 mm depth) **Up to and including 3 mm depth:** • SLUSH • DRY SNOW • WET SNOW	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	GOOD
4	**-15°C and Lower outside air temperature** • COMPACTED SNOW	Braking deceleration OR directional control is between Good and Medium.	GOOD to MEDIUM
3	• WET ("slippery wet" runway) • DRY SNOW or WET SNOW (any depth) ON TOP OF COMPACTED SNOW **More than 3 mm depth:** • DRY SNOW • WET SNOW **Higher than -15°C outside air temperature[1]:** • COMPACTED SNOW	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	MEDIUM
2	**More than 3 mm depth of water or slush:** • STANDING WATER • SLUSH	Braking deceleration OR directional control is between Medium and Poor.	MEDIUM to POOR
1	• ICE[2]	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	POOR
0	• WET ICE[2] • WATER ON TOP OF COMPACTED SNOW[2] • DRY SNOW or WET SNOW ON TOP OF ICE[2]	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	LESS THAN POOR

understood and implemented globally is an important means by which the runway excursion risk can be mitigated and the safety of runway operations improved.

Finally, as we prepare for the applicability date in 2020, the importance of awareness, education and training is not being overlooked by ICAO. This need was being addressed through an ICAO/ACI symposium hosted in Montreal 26 to 28 March 2019, with follow-up through more focused regional seminars. In addition, training resources are being developed, initially for airport operations staff, but eventually also for pilots and air traffic control staff.

About the Author

Paul Adamson has joined ICAO as a technical officer on a four year secondment from EUROCONTROL, where his last position was Head of Airports for the Network Manager. Previous to that he was responsible for runway safety and A-SMGCS projects in EUROCONTROL.

He also spent 4 years on secondment to the SESAR Joint Undertaking, where he was the programme manager for the SESAR airports-related activities. His background is as an air traffic controller and he has an M.Sc. in airport planning.

Introduction of "Online Airworthiness Information Network"

by Jonathan Lee

Aviation has always been an international business, but is also an increasingly *transnational* business. Its continued and sustainable development and success are dependent on cooperation and communication between Competent Authorities, international organizations and industry stakeholders involved in its operation.

There has been significant growth in the aircraft leasing industry driven by the steady expansion of international air transport in a more competitive and favourably regulated environment. The use of operating leases has grown significantly from 2% in the 1980s to more than 50% in 2016 and is expected to grow further. Air operators may lease or return aircraft at relatively short notice, which presents challenges given the complex differences in regulatory requirements, particularly in the cross border transferability of aircraft.

In light of this, the "Online Airworthiness Information Network", formerly known as "The Continuing Airworthiness of Aircraft in Service (Circular 95)", was created by ICAO to facilitate the provision of information between Competent Authorities to maintain continuing airworthiness of aircraft in service.

Launched on 29 Oct 2014, the "Online Airworthiness Information Network" is an interactive web-based application to replace the paper-based version of Circular 95. It is a repository for States to directly update their information online to provide users with faster access to up-to-date information. This helps States establish contact with other States responsible for the continuing airworthiness of aircraft and equipment and facilitate the cross border transferability of aircraft.

The network is a web-based application within ICAO's "integrated Safety Trend Analysis and Reporting System". Key sections include contact information of the authority responsible for continuing airworthiness and design organizations responsible for type design, as well as information on continuing airworthiness agreements and arrangements. Other sections include regulations, policies and procedures of type certification, aircraft registration and certificates of airworthiness. Also included are sections related to regulations, policies and procedures for the approval of aircraft maintenance programme, modifications and repairs and acceptance of authorized release certificates. The remaining sections include regulations, policies and procedures on handling mandatory continuing airworthiness information and systems for reporting of information on faults, defects and malfunctions.

As of January 2019, 186 of 193 ICAO Member States are registered users with the "Online Airworthiness Information Network". For this tool to be used effectively, ICAO encourages all Member States Focal Points to register and update their information accordingly.

Screenshot of the Online Airworthiness Information Network

Screenshot of Section A

The Continuing Airworthiness of Aircraft in Service
(ICAO Circular 95) - *Launch V1.0*

DRAFT FORM - FOR INPUT

SECTION A : NAME AND ADDRESS OF AUTHORITY RESPONSIBLE FOR CONTINUING AIRWORTHINESS

This section should contain the full mailing address, telephone and fax numbers, website and e-mail address of the national authority directly responsible for continuing airworthiness (e.g. State's Civil Aviation Authority – Airworthiness Division) and/or the delegated and authorized agency by a State to fulfil its responsibility for continuing airworthiness (e.g.: European Aviation Safety Agency (EASA), Technical Oversight Agency).

In circumstances where responsibility has been divided between two or more organizations, information should be included to indicate the demarcation.

It will also contain details of where regulations, procedures, instructions and forms referred to in this circular are published and how they can be obtained.

State*

Name of authority responsible for continuing airworthiness

Address

Mailing address of authority

Contacts person(s) for continuing airworthiness*

Primary e-mail address of contact person(s)*
[Please enter only 1 address. To receive a confirmation email after submission to ICAO, you must have a valid email address listed]

Additional E-mail addresses of contact person(s) *(if applicable)*

Phone/Fax number*

CAA website URL

Contact information for ordering publication, including legislation, regulations, airworthiness directives, procedures and forms

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About the Author

Jonathan Lee is an Airworthiness Technical Support Officer in the Operational Safety Section of the Air Navigation Bureau. He was seconded from the Civil Aviation Authority of Singapore, and his field of expertise is in the area of continuing airworthiness. He is an Aeronautical Engineer who began his aviation career with Pratt & Whitney.

Introduction of the clean Aircraft Concept for Winter Operations

by David Scorer

A primary concern for air operators, airport authorities, and air traffic control is maintaining safe aeroplane operations during all types of weather conditions. This is important for the passengers we collectively serve, since there is an ever-increasing expectation that weather should not disrupt our travelling plans. Whilst this is progressively more achievable with modern technology and procedures, we must also learn from lessons of the past. The Clean Aircraft Concept came to be from many lessons over the years that help us continue to operate safely when faced with a little inclement weather!

The Effects of Ice

The effects of ice on an aeroplane are wide-ranging, unpredictable, and potentially extremely hazardous. All aeroplanes are designed to fly 'clean'. Crucially, take-off performance is based upon clean aeroplane surfaces and the predictable effects of airflow over clean wings. When an aircraft is parked at a gate for even a short period of time, common winter-related environmental conditions can lead to the build-up of ice and snow on wings, the fuselage, engine nacelles, control surfaces and so on, with potentially hazardous consequences. Wind tunnel and flight tests demonstrate that ice, frost or snow formations on the leading edge and upper surface of a wing can reduce wing lift by as much as 30 per cent and increase drag by up to 40 per cent (dependent on aerofoil shape, contaminant thickness, surface roughness, etc.).

These kinds of contamination will significantly alter aeroplane flight dynamics, with increased weight, increased stall speed, and reduced stability and control, with potentially severe roll problems caused by uneven lift across the wings, or abnormal pitch characteristics during take-off rotation and initial climb. Ice that forms on pitot tubes and static ports or on the angle of attack vanes may give false airspeed, angle of attack and engine power information for air data systems. Ice may also break free during take-off and be ingested by engines, causing damage to fan and compressor blades.

Lessons of the Past

A review of historical aeroplane accidents in the air transportation industry reveals that a substantial number of accidents are related to winter operations, with frost, snow or ice adhering to critical surfaces of the aeroplane before take-off. The cause of the Air Florida Flight 90 accident in January 1982, where a Boeing 737 crashed into the Potomac River after departing from Washington National Airport, was directly attributed to improper de-icing procedures on the ground that led to insufficient lift and significant handling difficulties during take-off. This was also the case for the USAir Flight 405 accident from LaGuardia Airport in March 1992 and the Air Ontario Flight 1363 accident from Dryden Regional Airport in March 1989, both of which involved Fokker F28 aircraft.

Over the years, it became increasingly evident that take-off was not be attempted unless there was assurance that all critical surfaces of the aeroplane and all instrument probes are free of adhering snow, frost or other ice formations. This vital requirement is known as the "clean aircraft concept (CAC)". An aeroplane is considered to be clean when all surfaces are completely clean - that is, free of frozen contaminants, or when surfaces are protected by de-icing/anti-icing fluid and the surface aerodynamic characteristics are unaffected. As early as 1950, some States had

Image on the right was reproduced by kind permission of the National Aeronautics and Space Administration (NASA) and are found in the online training course entitled, "A Pilot's Guide to Ground Icing" (https://aircrafticing.grc.nasa.gov/).

established regulations prohibiting take-off for aeroplanes with frost, snow or ice adhering to the wings, propellers or control surfaces of the aeroplane.

As recognition grew that safe winter operations required special coordinated procedures by airline maintenance, engineering, flight, and de-icing personnel, a need for formally developed regulations and procedures directed towards all segments of aviation was identified. New ICAO provisions related to the de-icing/anti-icing of aircraft on the ground were introduced to Annex 6: Operation of Aircraft in 1998, with supporting guidance material published in the first edition of the Manual of Aircraft Ground De-Icing/Anti-Icing Operations (Doc 9640).

ICAO published the Manual of Aircraft Ground De-Icing/Anti-Icing Operations (Doc 9640) to provide general guidance material and to increase the basic understanding of aeroplane ground de-icing/anti-icing operations to facilitate the development of standardized procedures for the various segments of the aviation industry.

The Desirable Delay to your Journey

So how does this impact day to day operations? If you have ever taken a flight in the middle of winter, you may well have experienced a de-icing/anti-icing procedure for yourselves, with your aircraft taxiing to a special location on the airfield, followed by a flurry of ground support vehicle activity outside your window. The process of de-icing removes accumulated frost, ice, or snow, typically through the spray-application of a special de-icing fluid. And following this, the application of an anti-icing fluid prevents the adherence of frost, ice, or snow on the surfaces for a certain period of time.

In practical terms, this equates to the time it takes for the aeroplane to complete the take-off safely, preventing further accumulation on the surfaces as the aircraft taxis to the runway threshold, awaits its turn in the queue, and rolls down the runway and into the sky. So the next time you're in a rush to get underway, consider the importance of this little detour. It might take you a little longer to get where you're going, but this is one delay that you should be very grateful to endure!

About the Author

David Scorer is an Associate Technical Officer in Operational Safety in the Air Navigation Bureau of ICAO. An Aeronautical Engineer originally from the UK, he is a formally trained Flight Test Engineer (FTE) graduate of the Empire Test Pilots School (ETPS). Prior to joining ICAO, David worked as an FTE on multiple military and civil aircraft development programs, with a focus on aircraft dynamics and handling qualities. This included key roles on the Pilatus PC-21 military jet trainer program in Switzerland, and more recently, lead FTE for the first Bombardier C-Series test aircraft in Montreal.

Introducing ICAO's
Aircraft Type Designator on-line website

by Steven Laskie

One important aviation innovation developed by ICAO that has had an impact on the enhancement of aviation safety, is the development of the searchable on-line ICAO web-site for aircraft type designators. This website is constantly updated and lists aircraft types commonly provided with air traffic services (ATS). The database is searchable using the common names of aircraft manufacturers, their models and type designators. You can also find in the database additional information concerning the description of a particular model, the engine type and count as well as the wake turbulence category (WTC). Access to this web-site is free of charge and offers the user the ability to search and print out the information they require in a tab-separated text format. Please see the attachment below for an example of what this web-site looks like or you can access the web-page at the following link:

https://www.icao.int/publications/DOC8643/Pages/
Search.aspx

The Aircraft type designator database was originally prepared as a result of recommendations of the Rules of the Air and Air Traffic Services/Operations Divisional Meeting (May 1963) and the Third Meeting of the Air Traffic Control Automation Panel (October 1963) and was published in accordance with directives of the Council. As a result of the substantial comments received from the air traffic service units, the most common operational users of designators, the Secretariat with the assistance from Air Traffic Control the Netherlands and the European Organization for the Safety of Air Navigation (EUROCONTROL), undertook in 1996 a major revision of the document. The revision was done with the aim of ensuring that the document satisfies its original purpose and amended to accommodate the increased use of automation in ATS and in data exchange.

The ICAO aircraft type designator is a two-, three- or four-character alphanumeric code designating every aircraft type (and some sub-types) that may appear in flight planning. These codes are defined by the International Civil Aviation Organization (ICAO), and published in ICAO Document 8643 *Aircraft Type Designators*. ICAO codes are used by air traffic control and airline operations such as flight planning. The need for the development of an on-line searchable web-site that could instantly provide accurate aircraft type designator information arose from a demand in the aviation industry for timely up to date information. With over ten thousand different aircraft types designators and over fifteen hundred different aircraft manufacturers in the current Doc 8643 database, the need for a reliable web-site to provide designators to air traffic controllers, commercial and private pilots who require the correct ICAO aircraft type designator to use when filing a flight plan is an absolute necessity for aviation safety.

It is important to note that according to the ICAO publication for the Procedures of Air Navigation Services: Air Traffic Management (PANS-ATM) (Doc 4444), specifically Appendix 2 concerning Flight plans, item 9 outlines the number and type of aircraft and wake turbulence category that must be used when filing a flight plan. The information concerning the type of aircraft and the appropriate designator to use can be found in the ICAO publication Doc 8643.

About the Author

Steven Laskie is the Air Navigation Planning and Support Officer in the Operational Safety Section of the Air Navigation Bureau of ICAO with over 26 years of experience in the field of Civil Aviation.

Ground Proximity Warning Systems (GPWS)

by Ian Knowles

In the 2017–2019 edition of the Global Aviation Safety Plan (GASP), ICAO identifies a number of high-risk accident categories which are listed as global safety priorities. There are three accident categories that account for more than 60 per cent of worldwide fatalities. Of these three categories, controlled flight into terrain (CFIT) is identified as being responsible for nearly a quarter of all worldwide fatalities, despite representing only 3 per cent of the number of accidents.

CFIT occurs when an otherwise completely serviceable (airworthy) aircraft, while under control of the pilot, is flown into the ground, into water, or into an obstacle. The majority of such accidents occur in the landing phase of flight. Many of these are due to the incorrect reading of instruments or a loss of situational awareness – the understanding a pilot has about where the aircraft is, what it is doing and what the surroundings are.

A typical example of CFIT in the landing stage is represented in the following figure, which indicates where the correct descent path (glideslope) is, and where the aircraft was mistakenly flown, resulting in a crash short of the intended landing runway.

A typical example of CFIT in the landing stage

Aircraft decsent path

Glideslope
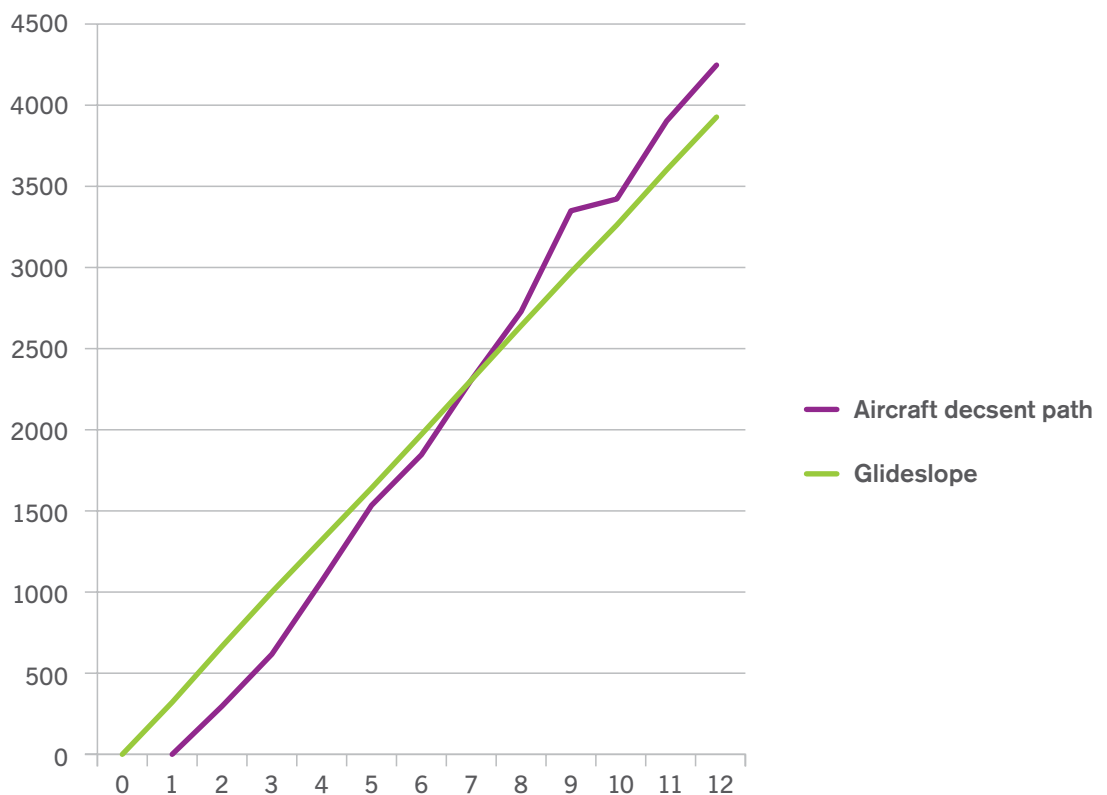
Though CFIT has always been a major cause of accidents, in the late 1960's a high number of such accidents resulted in hundreds of fatalities, leading to a study to determine the causes and possible ways of preventing these type of events. This study determined that a warning of the approaching terrain would have provided sufficient indication to the pilot to allow them to take avoiding action, and that a majority of such accidents could therefore be avoided. Canadian engineer Donald Bateman is credited with the development of the first 'Ground Proximity Warning System' (GPWS).

Initial systems relied on the use of radio altimeters to monitor the aircraft height above terrain and provide a warning if certain parameters were exceeded. Several modes are included in a basic GPWS system:

- Mode 1 – High rate of descent
- Mode 2 – High rate of closure with the ground
- Mode 3 – Loss of altitude after take-off
- Mode 4 – Proximity to the ground when not in the landing configuration
- Mode 5 – Descent below the Instrument Landing System (ILS) glideslope

Warnings are provided by means of a light on the instrument panel in the primary field of view of the pilot, and a characteristic warning sound (whoop whoop), along with a spoken annunciation of the trigger. As an example, a high rate of closure with the ground (mode 2) would generate a warning light and the aural warning 'whoop whoop, PULL UP, PULL UP'. Regular training for pilots in simulator sessions reinforces the correct response to a GPWS warning, allowing for it to become instinctive.

ICAO mandated the use of GPWS systems (also referred to as Terrain Awareness and Warning System or TAWS) on commercial aircraft produced after 1 July 1979, with a take-off mass in excess of 15 000 Kg or authorized to carry more than 30 passengers. Over time the requirements for the carriage of GPWS have steadily improved, and this equipment is now required for all commercial aircraft over 5700 Kg, or authorized to carry more than nine passengers.

From the 1980's, the introduction of third generation aircraft – which incorporated electronic cockpit displays, improved navigation systems and warning systems such as GPWS – is credited with a significant reduction in the CFIT accident rate. With almost 99% of all flights now operated with aircraft equipped with some form of terrain warning system, the CFIT accident rate has reduced by a factor of seven from 1998[i].

[i] A Statistical Analysis of Commercial Aviation Accidents 1958-2017, May 2018
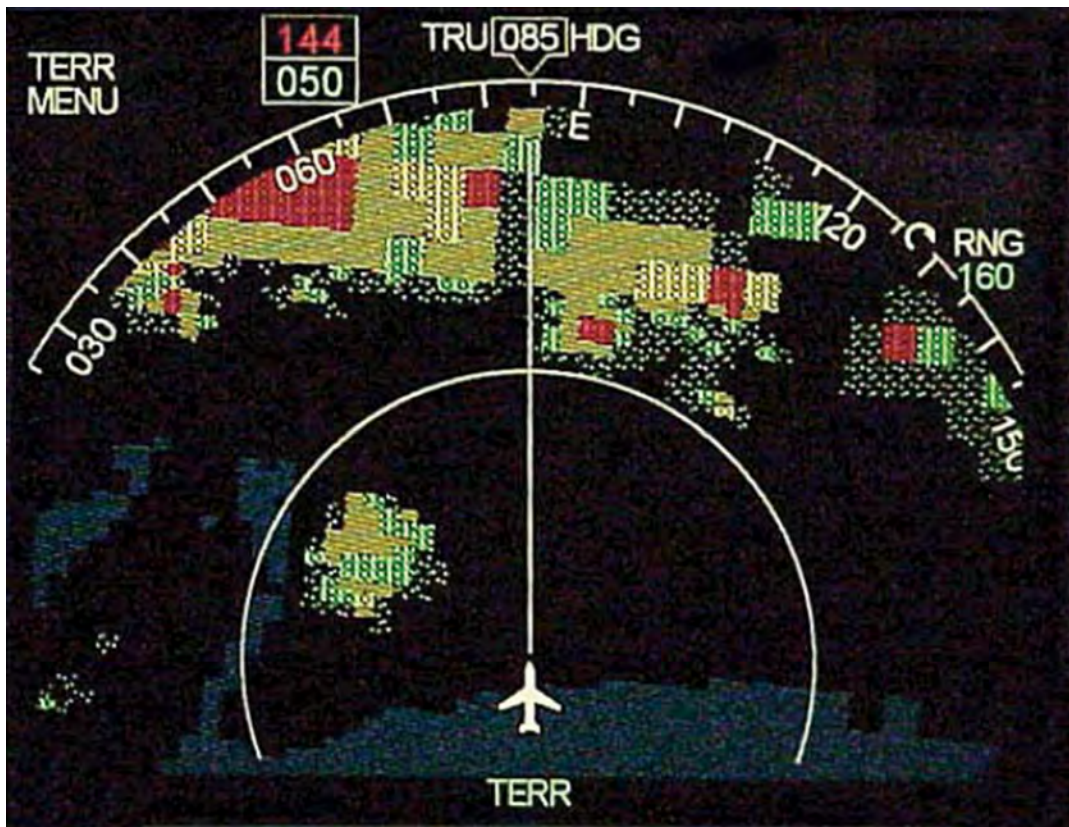
Image credited to Honeywell, Mark V and Mark VII EGPWS Pilot's Guide

Despite the success of GPWS in reducing CFIT accidents, the original system had some weaknesses. One particular issue was the identification of risk for rapidly rising terrain. Since the GPWS system used radio altimeters to determine the rate of closure with the ground, approaching a sharply rising area of terrain would not generate sufficient warning for reaction by the pilot. The system was not capable of 'looking ahead' to identify potential risks on the aircraft flight path.

The solution was to introduce, in the 1990's, an Enhanced Ground Proximity Warning System (EGPWS) which included a terrain and obstacle database. Using information about the aircraft position, altitude and speed, it is possible to determine the projected flight path of the aircraft and analyse whether this will result in infringement of any of the EGPWS warning parameters. This allows for warnings to be given to the pilot at around 60 seconds before any potential terrain event, providing sufficient time for recovery action. Additionally, the terrain data can be displayed on the pilots navigation display to assist with their situational awareness of terrain in the immediate surroundings.

ICAO, through the GPWS Standards in Annex 6, mandates that all aircraft over 5700 Kgs carry GPWS systems that include a forward-looking terrain avoidance function such as EGPWS. These Standards continue to be reviewed and updated in the ongoing effort to eliminate CFIT as a source of accidents.

About the Author

Ian Knowles is a Technical Officer in the Operational Safety Section of the Air Navigation Bureau, where he acts as Secretary for the Flight Operations Panel and the Performance-based Navigation Study Group. Prior to joining ICAO, he worked for as a commercial pilot for a major airline, operating Boeing 757, 767 and the Airbus A320 family of aircraft. He also holds a Master's degree in Operational Research and has experience in applying the principles of OR in an airline environment.

Operational Trial of Advanced Surveillance Enhanced Procedural Separation using Space-Based Automatic Dependent Surveillance-Broadcast

by Herman Pretorius

Background

ICAO's Planning and Implementation Regional Groups (PIRGs) were established by ICAO's Council to ensure the continuous and coherent development of the regional air navigation plans and to monitor and foster their implementation. A prime example of the work of a planning and implementation regional group involves the use of technology to further improve safety and efficiencies. ICAO's Air Navigation Bureau (ANB) is responsible for coordinating the PIRG and Regional Aviation Safety Group (RASG) activities in the ICAO Regions.

It is through the work of PIRGs, which serve as ICAO regional planning engines, that the Space-Based Automatic Dependent Surveillance-Broadcast (SB ADS-B) is being in-troduced. This trial service, which began on 28 March 2019, will enhance air traffic controllers' abilities to provide operators with more planning and tactical options in oceanic airspace. This will include greater flexibility for severe weather avoidance, requests and approval of new oceanic routes, optimized speed, and requests for, and approval of, flight level changes.

The Space-Based ADS-B ATS surveillance system will consist of a constellation of the Low Earth Orbiting Satellites (LEOS) hosting ADS-B receivers. A satellite will receive ADS-B data that includes position, velocity and altitude from an aircraft, which is then routed through other satellites and down-linked to a satellite operation ground station where it will be forwarded to Air Navigation Service Providers (ANSPs) and/or aircraft operators.

It is through the work of PIRGs, which serve as ICAO regional planning engines, that the Space-Based Automatic Dependent Surveillance-Broadcast (SB ADS-B) is being introduced.

ADS-B is automatic so no flight crew or air traffic control officer (ATCO) action is required for the information to be transmitted. It is considered dependent surveillance because the surveillance type information depends on the information from the aircraft's navigation system. The ADS-B OUT systems broadcast aircraft parameters such

as identification (24-bit address and flight identification as per the flight plan), position (latitude, longitude and pressure altitude), 3-D velocity and position integrity, via a broadcast-mode data link. The aircraft identification information is broadcast every five seconds while aircraft position and velocity data is typically broadcast twice per second.

Impact on aviation

The SB ADS-B surveillance will facilitate the application of Advanced Surveillance Enhanced Procedural Separations (ASEPs) between suitably equipped flights, resulting in a significant increase in airspace capacity, particularly in areas where there is a high volume of traffic, which will allow more flights to operate within their optimum flight profiles. New airspace capabilities will assist to reduce fuel burn with the associated environmental benefit of the decreased greenhouse gas (GHG) emissions.

Future

The expanded ATS surveillance coverage in the North Atlantic (NAT) airspace will enable more efficient use of airspace, increase fuel savings and enhances safety, as compared to the services and separation standards that can be provided in the current non-surveillance environment. The Air Traffic Control (ATC) in the NAT region will be enhanced by the real-time availability of aircraft positioning. If successful, this may be expanded to other oceanic areas through the PIRG mechanism of information sharing.

About the Author

Herman Pretorius is a Technical Officer, Safety Programmes Coordination and Implementation Section (PCI) at ICAO Headquarters in Montreal. Prior to joining ICAO in 1999, he was employed by the South African Civil Aviation Authority in Pretoria. He is a fully qualified Air traffic Controller and held fixed wing and helicopter pilot license.

Fatigue Management

by Dr. Michelle Millar

Fatigue is a natural consequence of human physiology.

In aviation operations, managing fatigue is important because it diminishes an individual's ability to perform almost all operational tasks. This clearly has implications for operational efficiency, but in situations where individuals are undertaking safety-critical activities, fatigue-effected performance can also have consequences for safety outcomes.

Because fatigue is affected by all waking activities (not only work demands), fatigue management has to be a shared responsibility between the State, service providers and individuals.

A brief history of flight and/or duty limitations

For most workers, hours of work are part of the working conditions and remuneration packages established through industrial agreements or social legislation. They are not necessarily established from a safety perspective.

However, the need to limit pilots' flight and duty hours *for the purpose of flight safety* was recognized in ICAO Standards and Recommended Practices (SARPs) in the first edition of Annex 6 published in 1949. At that time, ICAO SARPs required the operator to be responsible for establishing flight time limits that ensured that "fatigue, either occurring in a flight or successive flights or accumulating over a period of time, did not endanger the safety of a flight". These limits had to be approved by the State.

By 1995, ICAO SARPs required States to establish flight time, flight duty periods and rest periods for international flight and cabin crew. The onus was on the State to identify "informed boundaries" that aimed to address the general fatigue risk for flight operations nationally. At no time have ICAO SARPs identified actual flight and duty hours because it had proven impossible to identify global limits that adequately addressed operational contexts in different regions.

Fatigue is inevitable in a 24/7 industry such as aviation. If we are to remain an ultra-safe industry, fatigue-related risks have to be managed.

While ICAO SARPs apply only to international operations, many States also chose to establish similar flight and duty time limitations for domestic operations. States generally used the same flight and duty limits for helicopter crew as for airline crew.

The fallacy of flight and/or duty limitations is that staying within them means that operations are always safe. Buying into this fallacy suggests that scheduling to the limits is enough to manage fatigue-related risks. However, more recent SARP amendments related to prescriptive limits have highlighted the responsibilities of the operator to manage their particular fatigue-related risks within the limits using their SMS processes.

And then there was FRMS…

Fatigue Risk Management Systems (FRMS) represent an opportunity for operators to use their resources more efficiently and increase operational flexibility outside the prescriptive limits, whilst maintaining or even improving safety. In implementing an FRMS, the onus shifts to the operator to prove to the State that what they propose to do and how they continue to operate under an FRMS, is safe.

In 2011, SARPs enabling FRMS as an alternative means of compliance to prescriptive limitations were developed for aeroplane flight and cabin crew (Annex 6, Part I). At the time of development, it was necessary to address concerns that airline operators would take this as an opportunity to

schedule purely for economic benefits at the cost of safety. Therefore, while often referred to as "performance-based" approach, the FRMS SARPs are nevertheless very prescriptive about the necessary elements of an FRMS and require the explicit approval of an operator's FRMS by the State.

Since then, similar FRMS SARPs were made applicable for helicopter flight and cabin crew in 2018 (Annex 6, Part III, Section II).

But what about air traffic controllers?

Despite their obvious impact on flight safety outcomes, ICAO SARPs have never required the hours of work to be limited for air traffic controllers even though some States have had

hours of duty limitations for air traffic controllers for many years. This is about to change. Amendments to Annex 11, becoming applicable in 2020, will require that ICAO States establish duty limits and specify certain scheduling practices for air traffic controllers. As for international airline and helicopter operations, States will have the option of establishing FRMS regulations for air traffic service providers.

Fatigue Management SARPs today

Today, ICAO's fatigue management SARPs support both prescriptive and FRMS approaches for managing fatigue such that:
- Both approaches are based on scientific principles, knowledge and operational experience that take into account:
  - the need for adequate sleep (not just resting while awake) to restore and maintain all aspects of waking function (including alertness, physical and mental performance, and mood);
  - the circadian rhythms that drive changes in the ability to perform mental and physical work, and in sleep propensity (the ability to fall asleep and stay asleep), across the 24h day;
  - interactions between fatigue and workload in their effects on physical and mental performance; and
  - the operational context and the safety risk that a fatigue-impaired individual represents in that context.
- States continue to be obliged to have flight and duty time limitations but are under no obligation to establish FRMS regulations. Where FRMS regulations are established, the operator/service provider, can manage none, some or all of its operations under an FRMS, once approved to do so.

- Prescriptive fatigue management regulations now provide the baseline, in terms of safety equivalence, from which an FRMS is assessed.

In practice

In Airlines: The Fatigue Management amendments to the Annex 6, Part I, in 2011 led many States to reviewing their prescriptive limitation regulations for pilots based on scientific principles and knowledge (refer text box) and identifying further requirements for operators to manage their fatigue-related risks within the prescribed limits. Fewer States have reviewed their prescriptive limitation regulations for cabin crew.

In every case, despite a refocus on providing adequate opportunities for sleep and recovery, altering existing flight and duty limitations remains a very sensitive and difficult task because it impacts income and work conditions as well as the constraints of pre-existing employment agreements. It is made even more challenging for States whose flight and duty time limitations are legislated.

Where States have reviewed their prescribed flight and duty limits, the increased awareness of the relationship between sleep and performance has served to highlight the responsibilities of the individual crew member and the airline to manage fatigue, and in some cases have resulted in the prescribed limits sitting alongside a set of regulations that make these responsibilities more explicit, e.g. the FAA's Fatigue Risk Management Program, EASA's Fatigue Management requirements, CASA's Fatigue Management requirements and CAA South Africa's Fatigue Management Program.

THE SCIENTIFIC PRINCIPLES OF FATIGUE MANAGEMENT

1. Periods of wake need to be limited. Getting enough sleep (both quantity and quality) on a regular basis is essential for restoring the brain and body.

2. Reducing the amount or the quality of sleep, even for a single night, decreases the ability to function and increases sleepiness the next day.

3. The circadian body-clock affects the timing and quality of sleep and produces daily highs and lows in performance on various tasks.

4. Workload can contribute to an individual's level of fatigue. Low workload may unmask physiological sleepiness while high workload may exceed the capacity of a fatigued individual.

Many States have established, or plan to establish, FRMS regulations, often at the encouragement of their airlines. The FRMS challenge for States continues to be whether they have the resources to provide the necessary oversight from a scientific and performance-based perspective, particularly when the same regulations usually apply to a variety of domestic flight operations. While FRMS requirements are onerous and time consuming, the few airlines who have so far managed to get FRMS approval for particular routes have found the operational flexibility gained to be worth the effort.

In Helicopter Operations: For some States, the recent amendments to Annex 6, Part II (Section II) have highlighted the need to establish flight and duty time limits for helicopter crew members that better relate to the context of helicopter operations, rather than using the same limits as for airline pilots. Within those limits, the helicopter operator is expected to build crew schedules that use both fatigue science and operational knowledge and experience.

A new fatigue management guide for helicopter operators, currently under development in ICAO, identifies general scheduling principles based on fatigue science to guide helicopter operators in building "fatigue-aware" schedules that offer optimum opportunities for sleep and recovery (refer text box).

The particular challenge in helicopter operations, however, is that so many helicopter operations are unscheduled. While some helicopter operators will be able to operate within prescribed limits and effectively manage fatigue risks using an SMS, many types of helicopter operations, such as those that require unscheduled, immediate responses, possibly in high-risk settings, will benefit from the operational flexibility and safety gains of an FRMS.

GENERAL SCHEDULING PRINCIPLES

1. The perfect schedule for the human body is daytime duties with unrestricted sleep at night. Anything else is a compromise.

2. The circadian body clock does not adapt fully to altered schedules such as night work.

3. Whenever a duty period overlaps a crew member's usual sleep time, it can be expected to restrict sleep. Examples include early duty start times, late duty end times, and night work.

4. The more that a duty period overlaps a crew member's usual sleep time, the less sleep the crew member is likely to obtain. Working right through the usual night time sleep period is the worst case scenario.

5. Night duty also requires working through the time in the circadian body clock cycle when self-rated fatigue and mood are worst and additional effort is required to maintain alertness and performance.

6. The longer a crew member is awake, the worse their alertness and performance become.

7. Across consecutive duties with restricted sleep, crew members will accumulate a sleep debt and fatigue-related impairment will increase.

8. To recover from sleep debt, crew members need a minimum of two full nights of sleep in a row. The frequency of recovery breaks should be related to the rate of accumulation of sleep debt.

9. Keep short notice changes to a minimum, especially where they infringe or overlap the Window of Circadian Low (WOCL).

10. Duty periods associated with high workload (such as multiple, challenging landings and in marginal weather conditions) may need to be shortened and extensions avoided where at all possible.

In Air Traffic Control Services: Next year, States are expected to have established prescriptive work hour limits for air traffic controllers, while FRMS regulations remain optional and can be established at any time. However, the nature of the relationship between the Air Navigation Services Provider (ANSP) and the State will influence how the implementation of fatigue management regulations will unfold. In most cases, the State provides oversight of only one ANSP and although there is a current trend for privatisation, many of the ANSPs are fully or partially owned by the State.

In an industry sector that is often largely self-regulated, the distinction between a prescriptive fatigue management approach and FRMS may become blurred. However, a refocus on safety and not only organisational expediency or personal preference is likely to have substantial effects on the way controllers' work schedules are built in ANSPs across the world. This is a "watch this space".

Fatigue Management Guidance for ICAO States

The Manual for the Oversight of Fatigue Management Approaches (Doc 9966) received another update this year – Version 2 (Revised) - and an unedited version (in English only) will shortly replace the current manual available for download at https://www.icao.int/safety/fatiguemanagement/Pages/Resources.aspx.

Also available on that website are:
– Fatigue Management Guide for Airline Operators (2nd Edition, 2015)
– Fatigue Management Guide for General Aviation Operators of Large and Turboject Aeroplane (1st Edition, 2016)
– Fatigue Management Guide for Air Traffic Service Providers (1st Edition, 2016)

The Fatigue Management Guide for Helicopter Operators (1st Edition) is expected to be available later this year.

About the Author

Dr. Michelle Millar is the Technical Officer (Human Factors) and the NGAP Programme Manager at ICAO. She heads the ICAO FRMS Task Force and has *been involved in the development of ICAO fatigue management provisions since 2009. Her academic background is in sleep, fatigue and performance.*

# The evolution of visual aids in enhancing aerodrome safety

by Ryo Mizushima

The heart of the airport is the vast movement area extending before and including the runway, along the taxiways and onto the apron. New aircraft models, increased aircraft operations, operations in lower visibilities and technological advances in airport equipment combined make the ground environment at an airport one of the most challenging phase of a flight.

When darkness falls, a striking feature involves the hundreds, sometimes thousands of lights, which are used to guide and control aircraft movements. In contrast to flight, where guidance and control are done through radio aids, movements on the ground are primarily guided and controlled through visual aids. Annex 14, Volume I, defines in detail numerous systems for use under various types of meteorological conditions and other circumstances.

Since the publication of Annex 14 in 1951, the requirements for visual aids at airports have evolved through fifty-three amendments to the Annex. Since these visual aids must be obvious to pilots from around the world, standardization of their location and light characteristics is highly important.

Recent advances in lighting technology have led to great increases in the intensity of lights including the use of energy-saving light emitting diodes (LEDs). Modern high-intensity lights are effective for both day and night operations and, in some day conditions, simple markings may be highly effective. Airport signs are another type of visual aids. At large airports and airports with heavy traffic, it is important that guidance is provided to pilots to permit them to find their way about the movement area.
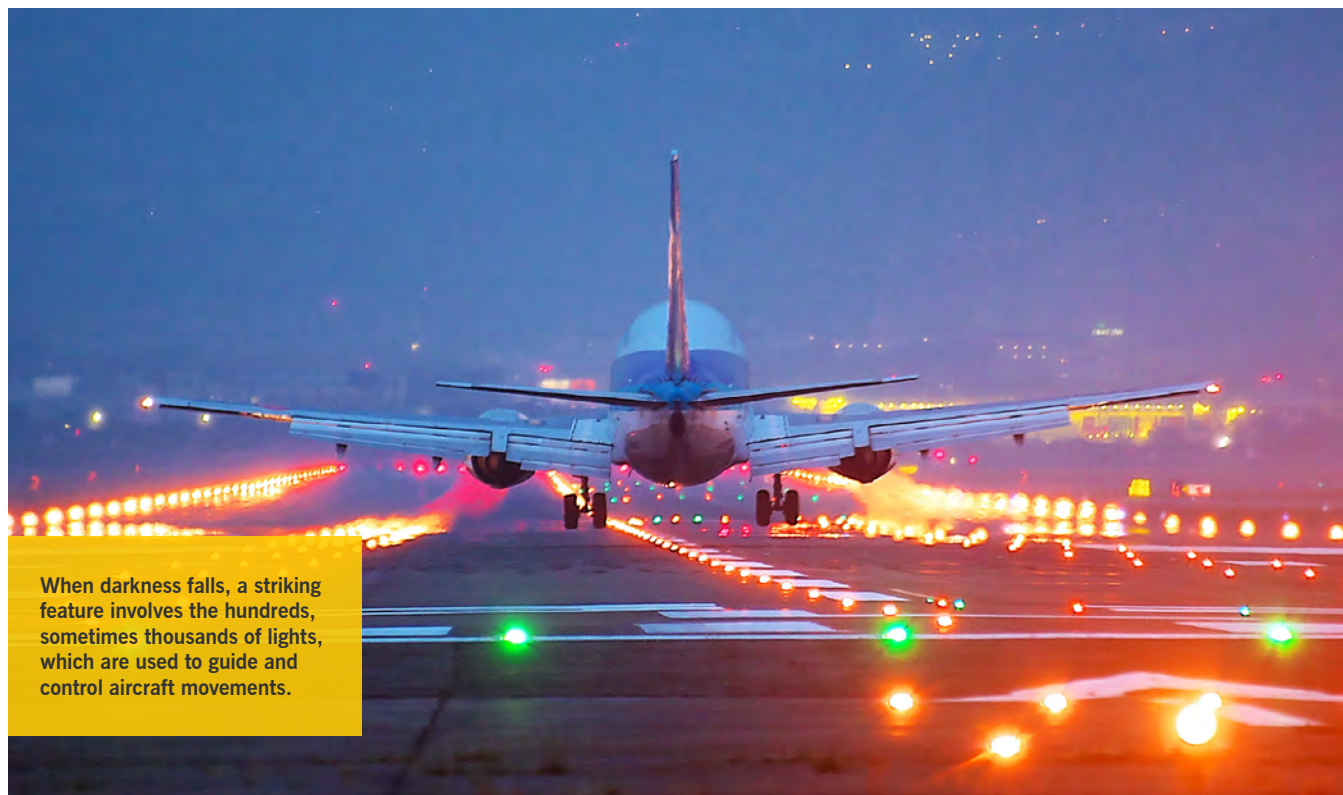
When darkness falls, a striking feature involves the hundreds, sometimes thousands of lights, which are used to guide and control aircraft movements.

Stop bars

Autonomous runway incursion warning system (ARIWS)

In addition to existing ICAO provisions that address the integrated use of visual aids to help prevent runway incursions, a recent amendment to Annex 14, Volume I introduced new provisions for, among others, the use of stop bars. Stop bars are a series of unidirectional red lights embedded in the pavement at right angles to the taxiway centre line, at the associated runway holding position. They are intended to provide additional protection of runway/taxiway intersections and reduce runway incursions.

In recent years, an autonomous runway incursion warning system (ARIWS) has been introduced at airports in some States for the purpose of further improving safety and preventing runway incursions. The operation of an ARIWS is based upon a surveillance system which monitors the actual situation on a runway and automatically returns this information to warning lights at the runway (take-off) thresholds and entrances.

When an aircraft is departing from a runway (rolling) or arriving at a runway (short final), red warning lights at the entrances will illuminate, indicating that it is unsafe to enter or cross the runway. When an aircraft is aligned on the runway for take-off and another aircraft or vehicle enters or crosses the runway, red warning lights will illuminate at the threshold area, indicating that it is unsafe to start the take-off roll. In comparison to stop bars which are operated by air traffic controllers, ARIWS is automatically controlled, allowing for the reduction of the workload of air traffic controller.

About the Author

Ryo Mizushima is a Technical Officer in the Airport Operations and Infrastructure Section at ICAO. He is a secondee from Narita International Airport Corporation where he has been involved in visual aids since 2002. He possesses a Master's degree in engineering from the Shibaura Institute of Technology in Tokyo, Japan.

ICAO Language Proficiency Requirements: Occurrence, Developments and Associated Documents

by Catalin Popa

Aviation history marked one of the most tragic mid-air collisions on 12 November 1996, over the village of Charkhi Dadri, around 100 km (62 mi) west of Delhi, India.

The event and its associated investigation's report determined India to submit, more than two decades ago, working paper A32-WP/148TE/12 to the 32nd Session of the ICAO Assembly, on September 1998.

The importance from safety angle of proficiency of flight crew in conducting radiotelephony communications in English language was highlighted and ICAO was urged to strengthen the provisions contained in Chapter 5 of Annex 10, Volume II, and Chapter 2 of Annex 1 for achieving the proficiency objective.

The Assembly adhered to that request and, consequently, Assembly resolution "A32-16: Proficiency in the English language for radiotelephony communications" captured, for the first time, the requirement to start developing English language proficiency "to ensure that air traffic control personnel and flight crews involved in flight operations in airspace where the use of the English language was required, were proficient in conducting and comprehending radiotelephony communications in the English language". Furthermore, following that decision to consider the matter with a high level of priority, the Air Navigation Commission initiated the development of language provisions in Annex 1 — *Personnel Licensing*, Annex 6 — *Operation of Aircraft*, Annex 10 — *Aeronautical Telecommunications*, and Annex 11 — *Air Traffic Services*.

To address the task, ICAO established the Proficiency Requirements in Common English Study Group (PRICESG) to assist the Secretariat in carrying out a comprehensive review of the existing provisions concerning all aspects of air-ground and ground-ground voice communications and to develop new provisions as necessary. The end result of PRICESG work was that, following its recommendation in 2001, on March 5th 2003, the Council adopted Amendment 164 to Annex 1 relating to language proficiency in international civil

aviation. Also, amendments to Annexes 6, 10, 11, and the PANS-ATM were adopted at the same time.

On September 2004, the ICAO Secretary General approved the first edition of the ICAO Doc 9835 — Manual on the Implementation of ICAO Language Proficiency Requirements, compiling comprehensive information on a range of aspects related to language proficiency training and testing, which was published in order to support States' efforts to comply with the strengthened provisions for language proficiency.
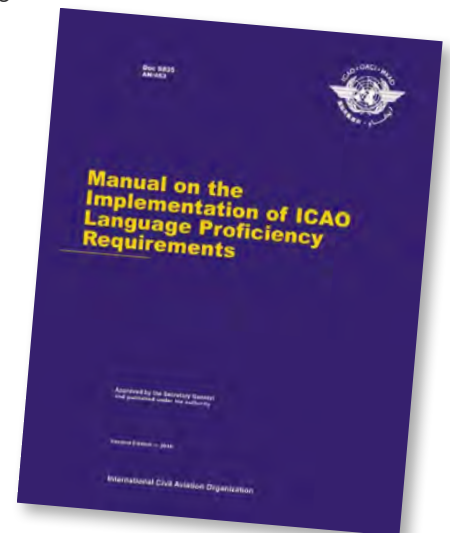
On 2007 the Council proposed and the Assembly adopted Resolution A36-11– *Proficiency in the English language used for radiotelephony communications,* which directed the Council to support Contracting States in their implementation of the language proficiency requirements by supporting globally harmonized language testing criteria; it was superseded by the Resolution A37-10 – *Proficiency in the English language used for radiotelephony communications*, adopted by the Assembly in 2010. Meanwhile, as of 5 March 2008, the ability to speak and understand the language used for radiotelephony that is currently required for pilots and air traffic controllers will have to be demonstrated based on the ICAO holistic descriptors and language proficiency rating scale (at Level 4 or above).

Language proficiency is not merely knowledge of a set of grammar rules, vocabulary and ways of pronouncing sounds. It is a complex interaction of that knowledge with a number

Language proficiency is not merely knowledge of a set of grammar rules, vocabulary and ways of pronouncing sounds. It is a complex interaction of that knowledge with a number of skills and abilities.

of skills and abilities. In this, it differs substantially in nature from many of the other subjects in school education and in aviation training. Therefore, the users of the Manual on the Implementation of ICAO Language Proficiency Requirements (including licensing authorities, air operators, air navigation service providers, and language training and testing services) have indicated that more detailed guidance on language testing is needed to effectively implement the language proficiency requirements.

International organizations and professional bodies like Eurocontrol, EANPG, ASECNA and COCESNA, developed regional initiatives to meet ICAO language proficiency requirements. These were joined by other initiatives include those of numerous airlines and air navigation service providers on all continents to set up or acquire training and testing programmes. Finally, professional associations such as ICAEA and IALCO have provided fora for the exchange of information and ideas on implementation.

ICAO is leading and has been supporting States in their implementation of language proficiency requirements. Consequential outcomes were the publication in June 2009 of ICAO Circular 318 — *Language Testing Criteria for Global*

Harmonization, Circular 323 — *Guidelines for Aviation English Training Programmes* and a second edition of the ICAO Doc. 9835 - Manual on the Implementation of ICAO Language Proficiency Requirements, in 2010.

To summarize, the SARPs relating to language use for aeronautical radiotelephony communications that were adopted by the ICAO Council on March 2003 are found in Annex 1; Annex 6; Annex 10, Volume II and Annex 11, as follows:

- Annex 10 SARPs clarify which languages can be used for radiotelephony communications;
- Annex 1 SARPs establish proficiency skill level requirements as a licensing prerequisite;
- Annexes 6 and 11 provide for service provider and operator responsibility;
- additional language-related information and guidance material are contained in the PANS-ATM (Doc 4444), Chapter 12, and in the Foreword to Doc 9432.

As a general statement, the purpose of the ICAO language proficiency requirements is to ensure that the language proficiency of pilots and air traffic controllers is sufficient

to reduce miscommunication as much as possible and to allow pilots and controllers to recognize and solve potential miscommunication when it does occur. In short, language should be a tool to identify and help solve a potential problem before it becomes a disaster, rather than being one more attention-demanding obstacle. Rather than language playing a contributing role, the object of ICAO language proficiency requirements is for language to play a problem-alleviating or problem-avoiding role.

However, the ICAO language proficiency requirements are trying to address all sources of miscommunication in radiotelephony communications. Therefore, the goal is to ensure, as far as possible, that all speakers have sufficient language proficiency to handle non-routine situations.

About the Author

Catalin Popa – retired lieutenant-commander, former Romanian CAA's inspector, now Technical Specialist within Operational Safety Section / ANB / ICAO and Continuously involved in military and civil aviation since 1995.

May 2012 – October 2016, joined EUROCONTROL, becoming Romania's representative at EUROCONTROL, with primary task to explore new areas of cooperation, both between Romania and EUROCONTROL and between Romania and the other member states.

In current position, responsible for providing technical advice and services in relation to personnel licensing and flight operations, specifically in the implementation of the Standards and Recommended Practices (SARPs) of Annex 1, Annex 6 - Parts I, II and III, Annex 8 and Procedures for Air Navigation Services — Training (PANS-TRG, Doc 9868). Also tasked to analyze problems raised by States and International Organizations in the field of language proficiency, training and personnel licensing and recommend appropriate solutions.

ICAO actions to assist with safe Humanitarian Operations

by Samir Sajet

In accordance with Assembly resolution **A29-14 regarding Humanitarian Flights**, the International Civil Aviation Organization (ICAO)has been supportive of humanitarian flight operations and has established strong collaboration with other UN organizations like the World Food Programme (WFP). This collaboration involves advising and contributing to the establishment of UN policies and procedures for safe flight operations. ICAO participates in the United Nations Aviation Technical Advisory Group (UN-ATAG) and the WFP Aviation Safety Board, as well as in conferences and humanitarian aviation safety promotional activities. Deliberation at the highest levels where the WFP operates benefits both organizations, and the technical assistance programmes have been implemented to minimize safety risks and to implement ICAO SARPs in a practical manner to reduce operational safety risk.

When roads are impassable, or infrastructure is destroyed, the WFP turns to the skies to quickly bring humanitarian cargo and aid workers to communities in the most inaccessible places on the planet. Whether the cause is flood or earthquake, cyclone or war, the WFP Aviation operates on the front lines of hunger.

The WFP organizes airlifts that deploy life-saving food assistance by plane within 48 hours when situations on land render surface transport impossible. The Aviation team serves the WFP a reliable and cost-efficient means for transporting food and non-food cargo by air, services that are made available to the entire humanitarian community, including UN agencies and NGOs. When necessary, the WFP also performs air drops by flying over designated 'drop zones' and releasing aid cargos from high above, thereby serving remote populations through a rapid and targeted response.

As the world's leading humanitarian airline, the UN Humanitarian Air Service (UNHAS) currently has a fleet of more than 90 chartered aircraft, ranging from large to small aircraft and fixed-wing to helicopters, that are deployed to operations around the globe. Aid workers who are deep in the field, with no other means of transportation, rely on UNHAS to transport them to some of the world's most remote and isolated communities, where commercial airlines do not fly. With air services to more than 250 regular destinations in 16 countries, UNHAS carried more than 250,000 humanitarian passengers.

Passenger safety is at the forefront of all WFP Aviation operations. The WFP's Aviation Safety Unit, which is headquartered in Rome with regional offices in Kenya, South Africa and the United Arab Emirates, is responsible for ensuring adequate levels of safety. All WFP humanitarian air operations are in accordance with United Nations Common Aviation Safety Standards and the ICAO standards and best practices.

About the Author

Captain Samir Sajet is the regional focal point responsible for the World Food Programme (WFP) – Aviation Safety Office (UAE) for Asia, Sudan and the Middle East Regions. Samir serves the World Food Programme in providing the humanitarian community with safe and reliable air transport services during humanitarian emergencies, and in promoting aviation safety worldwide – particularly in developing countries. Currently, Captain Samir works at ICAO HQ in Montreal as s technical officer supporting the operational Safety Section. Samir, who began his UN career in 1998 in Iraq and the World Food Programme in Guinea in 2001 as Chief Air Transport Officer, is no stranger to the emergencies that affect the world's hungry.

Addressing the Lack of Qualified Technical Personnel: the Development of the ICAO Civil Aviation Safety Inspectors Tool (CASI-T)

by Catalin Popa

The Chicago Convention and its supporting nineteen Annexes establish several key obligations for the Contracting States. One of the obligations is oversight of various aviation entities and activities.

To accomplish these obligations, Annex 19 — Safety Management, Appendix 1 identifies eight critical elements (CE).

The ICAO Universal Safety Oversight Audit Programme (USOAP) audits concluded that a lack, or an insufficient number of qualified inspectors or aviation personnel holding highly-specialized technical expertise to perform job functions and tasks, affects the sustainability of safety oversight systems. This lack has been identified as "CE-4" related and it remains one of the main obstacles to the implementation of an effective State safety oversight system.

This deficiency has often been determined as being the root cause of situations leading to the identification of Significant Safety Concerns (SSC) in the State by ICAO. The difficulties of attracting and retaining suitably qualified inspectors able to respond to the challenges inducted by the increased size, scope, complexity and rapid change of the aviation industry have become one of the major issues for the Member States Competent Authorities.

ICAO provisions (e.g. Annex 19, Doc. 8335, Doc. 9734) are addressing the need for qualified personnel, competent to carry out the tasks assigned to them. However, in certain States, training a sufficient number of experts to fill the void is a major challenge. Furthermore, the increase in air transport activities in the coming decades and the limited training capacity offered in these states exacerbate the challenge. For these reasons, ICAO's member States asked for support.
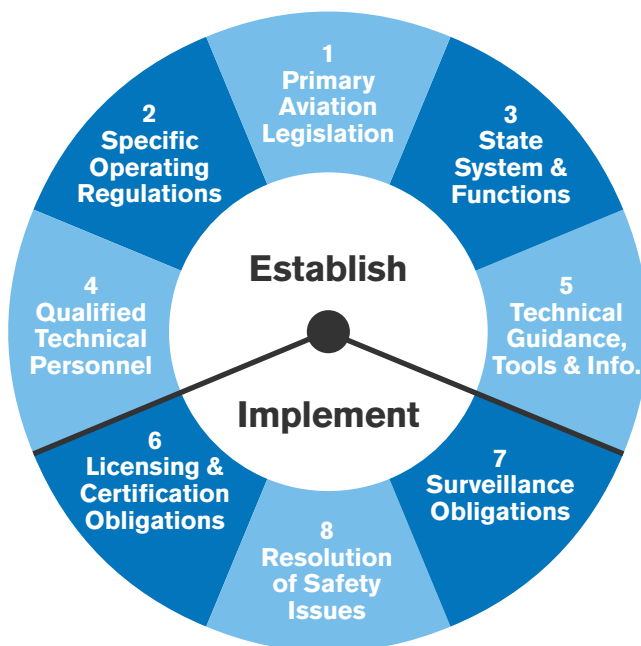
Annex 19, by its standards associated with critical elements, states as follows:

"CE-4 Qualified technical personnel

4.1 The State shall establish minimum qualification requirements for the technical personnel performing safety oversight functions and provide for appropriate initial and recurrent training to maintain and enhance their competence at the desired level.

4.2 The State shall implement a system for the maintenance of training records."

In response, and considering the requirements for support from Member States ICAO initiated a process in 2018 to create a database of highly-qualified and experienced experts capable of performing specialized regulatory tasks and make it available to Member States through a dedicated tool.

The database behind the **ICAO Civil Aviation Safety Inspectors Tool (CASI-T)**, and the tool itself, are based on the concept of collecting relevant data regarding subject matter experts within different civil aviation domains, in line with a set of predetermined tasks' requirements. Second, a professionally developed mechanism will be built and made available by ICAO for its Member States to select from the database of highly-qualified and experienced inspectors those who can complete periodical tasks, by request.

In other words, the tool is designed as a solution for Member States needing experts to complete essential tasks on a short term basis. It will be embedded into the ICAO website.

The concept's complexity and its value reside in the significant number of such experts needed, while the need is multiplied by the large range of aviation domains to be covered.

ICAO has identified examples of the types of highly-specialized skills that are difficult for some Member States to perform. These include but are not limited to:

• Specialized airworthiness inspections, checks, and approvals, including the cross-border transfer of an aircraft;
• Specialized checks and approvals performed by flight operations inspectors during the certification process for issuing air operator certificates; and
• The myriad of checks, inspections and approvals associated with the certification of aerodromes.

Given the complexities of the concept, airworthiness –and cross-border transferability (XBT) activities specifically – were considered selected as an area of initial focus for the development of a CASI-T pilot project. Following the Secretariat's request to support the process, a list of minimum

The ICAO Universal Safety Oversight Audit Programme (USOAP) audits concluded that a lack, or an insufficient number of qualified inspectors or aviation personnel holding highly-specialized technical expertise to perform job functions and tasks, affects the sustainability of safety oversight systems.

requirements was developed by ICAO Airworthiness Panel (AIRP) to define the criteria for an airworthiness expert to be eligible to perform the XBT specific oversight tasks.

ICAO is currently working on creating and populating the database, identifying the applicable criteria, and building the roster of suitable experts within the airworthiness/XBT area.

Once ready for use, when an expert within the database matches a request for a particular task, a direct professional relationship between the envisaged expert(s) and interested Member State (CAA) will be established.

Building on the lessons learned during the demonstration phase of the tool in the airworthiness/XBT area, CASI-T will eventually be extended to cover all oversight activities.

About the Author

Catalin Popa – retired lieutenant-commander, former Romanian CAA's inspector, now Technical Specialist within Operational Safety Section / ANB / ICAO and Continuously involved in military and civil aviation since 1995.

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Aircraft Nationality and Registration

by Tatiana Pak

Regulatory Framework

The concept of nationality for aircraft was adapted from maritime law where the national flag is used to indicate a ship's country of registration[1]. The issues of aircraft nationality and registration were considered during the International Air Navigation Conference held in Paris in 1910. Despite the absence of a final signed agreement at the end of that Conference, the principles of the nationality of aircraft and its registration were formally incorporated into a *Convention Relating to the Regulation of Aerial Navigation*, signed in 1919 ("Paris Convention"). Chapter II – *Nationality of Aircraft* and Annex A to the Paris Convention described the rules and specifications for aircraft nationality and registration.

Nowadays, the principles of aircraft nationality are reflected in the *Convention on International Civil Aviation* ("Chicago Convention"). Pursuant to the Chicago Convention, aircraft have the nationality of the State in which they are registered. All aircraft engaged in international air navigation shall bear appropriate nationality and registration marks in order to permit identification. Annex 7 – *Aircraft Nationality and Registration Marks* sets out Standards and Recommended Practices for the allocation, assignment and display of nationality, registration and common marks. It also sets the format of the certificate of registration.

In accordance with Annex 7, the **nationality mark** is selected by States from the series of nationality symbols included in the radio call signs allocated to the State of Registry by the International Telecommunication Union (ITU). Once the nationality mark is selected, the State notifies ICAO. The **registration mark** is assigned by the State of Registry and comprise of letters, numbers, or a combination of letters and numbers.

Change of Aircraft Nationality

At the time when the Chicago Convention was adopted, commercial aircraft were predominantly purchased directly by their operators who then retained ownership of such aircraft for use during most or all of their useful lives. Changes to aircraft nationality were not common since an aircraft tended to reside within one State for most or all of its useful life. However, over the past three decades aircraft operators have realized substantial capital and operational efficiencies by leasing (rather than owning) a portion of their fleets for various periods of time. According to a Market Research Future (MRFR) analysis, in recent years leasing activities has increased from 2% in 1980 to more than 50% in 2016. According to different studies, the aircraft leasing market will continue to grow.

As a result, aircraft will most likely be transferred from one operator to another and as a result change its nationality multiple times during their useful lives. The change of aircraft nationality or registration from one State to another is referred to as **cross-border transfers of aircraft**. The increase in the number of cross-border transfers of aircraft globally, along with differences in States' regulations, requirements and practices has highlighted certain inefficiencies in a global system that was developed when cross-border transferability (XBT) was relatively uncommon.

The XBT process inherently involves two States: the current State of Registry (the exporting State) and the intended future State of registry (the importing State). This diagram represents a simple process of cross-border transfer of aircraft from one State to another. An aircraft is simply de-registered in one State and registered in another. The simple process does not require moving an aircraft, obtaining a special flight permit or involving other special arrangements.

[1] R.T. Slatter, *Nationality Marks Should Comply with ICAO Annex 7 Specifications*, ICAO Journal, 1992, p. 18.

However, in most cases cross-border transfers of aircraft is not as simple due to significant differences in States' requirements and associated processes. For example, if an aircraft needs to be moved for maintenance from one State to another, the process adds many other additional steps and may involve other States. Another example is when an

aircraft with a valid Certificate of Airworthiness[2] issued by one State is entering on the register of another State; the new State of Registry does not automatically issue a Certificate of Airworthiness. The aircraft needs to comply with the requirements of the new State of Registry, which may be different from those of the previous State of Registry.

XBT Process

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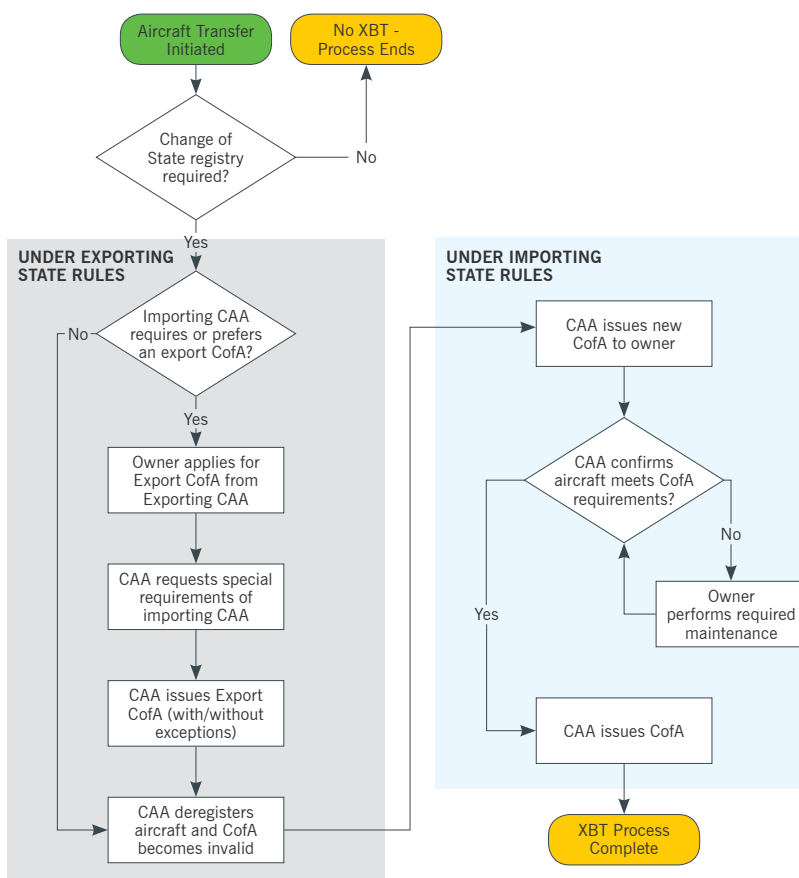
[2] A Certificate of Airworthiness is issued by a State on the basis of satisfactory evidence that the aircraft complies with the design aspects of the appropriate airworthiness requirements.

Annex 7 – *Aircraft Nationality and Registration Marks sets* out Standards and Recommended Practices for the allocation, assignment and display of nationality, registration and common marks.

The increase in cross-border transfers of aircraft, State-to-State variations in regulations, requirements and practices lead not only to complexity of the process but in some cases, it may cause duplications and inefficiencies for all aviation participants, increasing the likelihood of errors and raises associated costs. As the number of cross-border transfers continues to rise, improvements in the process are necessary to maintain or improve the existing safety level by ensuring that resources are not diverted from other safety-related activities of the State.

In 2017, ICAO launched the cross-border transferability initiative with the aim of improving, standardizing and enhancing the efficiency of the cross-border transfers of aircraft and at the same time, ensuring that aviation keeps and improves its remarkable safety record. With the support of subject matter experts from Member States, international organization and industry, ICAO is currently undertaking a structured review of relevant ICAO Annexes, guidance material, various processes and practices established by States in order to identify issues diminishing the effectiveness and efficiency of XBT. Based on the outcomes of the review, mitigation strategies will be developed to address the identified issues.

About the Author

Tatiana Pak is a Technical Officer in the Operational Safety Section of the Air Navigation Bureau. She is currently responsible for the work related to Annex 7 – Aircraft Nationality and Registration Marks, cross-border transferability of aircraft and protection of safety information. Prior to joining ICAO, Tatiana worked for the International Air Transport Association (IATA) and the Government of Kyrgyzstan. Tatiana holds a degree in law and a PhD in political science.

Aerodrome Certification –
Key to Safe and Efficient Aerodrome Operations

by Avner Shilo

Every flight starts and ends at an Aerodrome.

From their humble beginnings as relatively simple landing strips, international aerodromes have evolved into highly complex facilities. A modern international aerodrome's environment is characterized by vast areas, distinct airside (movement area) and landside areas, sophisticated tech-nologies, dozens of square kilometres of runways, taxi-ways, aprons, service areas, a multitude of equipment and integrated systems, and the growing activity of third parties. Added to all of this, today's aerodromes are facing, more than ever, increasing commercial pressures with greater public awareness and expectations on safety and efficiency issues.

ICAO long-term traffic forecasts indicate that global passenger traffic will almost double by 2032, reaching more than 6 billion passengers annually - compared to 3.5 billion in 2016 - and there will be more than 60 million flights. As the number of aerodromes serving international operations is not expected to increase significantly (and certainly will not correlate with the forecast growth in passenger volume and aircraft movements), there is a need for ensuring the sustainable accommodation of this unprecedented growth, while maintaining safety and regularity of operations.

Aerodrome certification has been a requirement in ICAO Annex 14 - *Aerodromes*, Volume I - *Aerodrome Design and Operations* since 2001. It is a proven and effective way of ensuring safe and efficient aerodrome operations, through a defined encompassing process which examines various components of the aerodrome, with an aim to verifying their compliance with international Standards and Recommended Practices (SARPs).

ICAO sets forth an array of provisions that encompass the whole lifecycle of the aerodrome certification process, from the establishment of a dedicated mechanism, to the planning of a certification project and its execution. These include, first and foremost, Annex 14, Volume I which sets the basic, high-level requirements in this area; the PANS-Aerodromes - *Procedures for Air Navigation Services - Aerodromes* (Doc 9981), which details a thorough global procedure for aerodrome certification; and the *Manual on Certification of Aerodromes* (Doc 9774) which provides guidance material supporting the SARPs and the PANS procedures. Furthermore, these three main documents are also supported by more than 20 other manuals which provide further guidance on specific subsets related to the aerodrome certification process, including, among others, aerodrome planning, design, rescue and firefighting, wildlife management, visual aids, obstacles control and more.

During a thorough certification process, aerodrome regu-lators and operators verify that the aerodrome's facilities, design, equipment and operational procedures comply with relevant SARPs, thereby ensuring safe operations and sup-porting optimization of aerodrome capacity and efficiency.
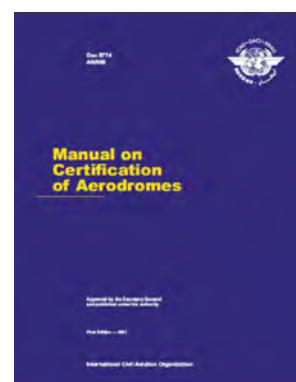
According to Annex 14, Volume I, States shall certify the international aerodromes in the areas under their jurisdiction, through an established mechanism. The certification process is outlined in the PANS-*Aerodromes* (Doc 9981). Generally, it starts with a submission, by the aerodrome operator, of a formal application to the national authority responsible for civil aviation, which includes basic information on the aerodrome operator (to whom the certification will be granted in the end of a successful certification process), the aerodrome itself and its facilities, and the intended operations. It continues with a thorough review by the authority of the aerodrome manual, the key document submitted by the aerodrome operator, which details the day-to-day procedures for the operation of the aerodrome, as well as information pertaining to its planning and design. The process is followed by technical inspections and on-site verification by the authority of the aerodrome facilities and operational procedures, including its safety management system, in order to complete the analysis and ensure compliance with applicable provisions, as well as the appropriateness of operating procedures. The process ends with the granting of the aerodrome certification, which may include details on specific operations-related features or

limitations arising from the certification process, information on major facilities, and the validity of the certificate.

Of particular importance is the conduct, as part of the certification process, of **compatibility studies** and **safety assessments** as outlined in the PANS-Aerodromes, in order to address operational issues in a sustainable way, facilitate the accommodation of new larger or more demanding aircrafts by the aerodrome, and develop operational procedures and operating restrictions, if needed.

ICAO provides ongoing support to Member States in the area of aerodrome certification. This assistance is aimed at capacity building and implementing aerodrome certification worldwide, and primarily includes assistance to States with transposing ICAO provisions into their national regulations, conduct gap analyses, and addressing operational issues revealed in the certification process.

This is done, among others, through continuous dialogue with States, direct support by ICAO regional offices, organization and delivery of regional workshops and seminars on aerodrome certification and operations, and also implementation of aerodrome certification projects by the ICAO Technical Cooperation Bureau (TCB).

About the Author

Avner Shilo is a Technical Officer at the ICAO Airport Operations and Infrastructure Section, responsible for aerodrome operations matters, including aerodrome certification, and the aerodrome operations-related working groups of the ICAO Aerodrome Design and Operations Panel (ADOP). He has 15 years' experience in aviation as an Air Traffic Controller, Aerodrome inspector and manager of an Aerodrome section, involved in aerodrome design, planning, certification, and inspection. He possesses a BA and MA in environmental studies.

The Introduction of ICAO Designators

by Sharron Morin

The Convention on International Civil Aviation (also known as Chicago Convention), was signed on 7 December 1944 by 52 States. Pending ratification of the Convention by 26 States, the Provisional International Civil Aviation Organization (PICAO) was established. It functioned from 6 June 1945 until 4 April 1947. By 5 March 1947 the 26th ratification was received, ICAO came into being on 4 April 1947.[i]

Going back to when ICAO was still PICAO, the importance of being able to identify newly created airlines in flight was already clear. The COM panel of PICAO was the group that provided the groundwork for the Three-letter and Telephony identifiers that we use today.

Initially, there were only telephony designators assigned, as indicated in the final COM report in 1947. The small number of airlines listed is astounding compared to the over 5,800 designators currently listed in our 3LD database today.

As the number of airlines increased it was decided that States would also make requests to ICAO to assign two-letter designators along with a telephony designator. The ICAO two-letter designators for airlines were distributed in "Communication Codes and Abbreviations" (Doc 2560 COM 164).[ii] These designators consisted of a unique two-letter code which could be used in aircraft identification in the flight plan and/or a telephony designator which may be used as part of an aircraft's radiotelephony call sign.

This document then evolved into Doc 506 and then into Doc 6938 and then into the *Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services* (Doc 8585), that is used worldwide today.

In November of 1981 (C-WP/7342), ICAO proposed the change from the old two-Letter designator system to the current **Three-Letter Designator** system due to the increasing number of airlines. The Doc 8585 supplement dated July 1987 is the first appearance in print of the Three-Letter Designators as we know them today.

In Assembly A37 of 2010, (A37-WP/71), ICAO's Technical Commission announced an initial set of safety tools, one of which was the online *Aircraft Safety Information Service* (OASIS), which included the database for *Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services* (Doc 8585). This database and the related print document contained the listing of three-letter and telephony designators assigned by ICAO, including a list of any changes to the designators since the previous issue was published.

[i]   www.icao.int/publications/Pages/doc7300.aspx
[ii] Please note: These ICAO designators are not to be confused with the IATA two letter reservation codes which were at that time used to identify an airline for commercial purposes and were based on the ICAO designators. These IATA codes are no longer in sync with ICAO designators.

In October 2014 State letter 2014/72 announced the new web-based request system for three-letter and telephony Designators called **3LD**. The new online system, which was implemented on 1 November 2014, was a welcome replacement for the slow and antiquated paper-based system of requesting and assigning designators to States.

The 3LD request system (https://www4.icao.int/3ld) allows airlines to request designators themselves directly, and have those requests automatically forwarded to the 3LD Focal Points assigned by each State. An airline can click on **Request New Designator** (under Industry), purchase a PIN, and fill in the form with their suggestions for a Three-letter and Telephony designator, before submitting the request.

The State focal point then receives each new request for review and approval online. The focal point can then forward the request to ICAO to assign the designators by a click of a button. The request is reviewed through ICAO ATM and OPS experts, helping to achieve global suitability and non-duplication of designators. Once assigned, the request follows the reverse path back to the requesting airline.

The transition to an online system provided States with the ability to trace designator requests online and enabled the option for States to receive timely data downloads of the updated designators, an accomplishment which supported ICAO's new strategies to provide safety data as required in a timely and reliable manner.

ICAO is currently looking into ways to expand and improve 3LD's dataset and delivery methods to respond to the increasing demands for safety data globally. Based on ICAO's preliminary compilation of annual global statistics, the total number of passengers carried on scheduled services rose to 4.1 billion in 2017, which is 7.2 per cent higher than the previous year, while the number of departures reached 36.7 million in 2017, a 3.1 per cent increase compared to 2016[iii], a huge change from 1947, when this volume of flights was not even imaginable.

In June of 2019, ICAO will hold its first 3LD User's Forum Meeting to align itself with the future needs of State's 3LD Focal Points in consideration of the upcoming improvements of the online 3LD system.

The expansion of air traffic will only continue, with ICAO at the forefront, ensuring that this expansion will be accommodated in the safest manner possible.

[iii] https://www.icao.int/annual-report-2017/Pages/the-world-of-air-transport-in-2017.aspx

About the Author

Sharron Morin is a Programme Associate and Administrator for the Three-Letter and Telephony Designator database (3LD), producing the ICAO Document 8585, Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services, currently working in the Operational Safety Section of the International Civil Aviation Organization (ICAO). Sharron has worked with ICAO for over 20 years and previously operated the ICAO world-wide aircraft accidents database for 10 years, as well as being an ADREP/ECCAIRS trainer.

The evolution of the airborne collision avoidance system (ACAS) and introduction of ACAS X

by Mie Utsunomiya

The development of airborne collision avoidance systems were initiated in several States across the world, and by early 1970, the first prototypes of an airborne collision avoidance system (ACAS) were developed.

Collisions between passenger aircraft are among the most catastrophic accidents imaginable. The first mid-air collision occurred in 1956 over the Grand Canyon and killed all 128 passengers and the crew of both airliners. As a result, massive research was initiated on schemes to avoid such collisions in the late 1950s. The development of airborne collision avoidance systems were initiated in several States across the world, and by early 1970, the first prototypes of an airborne collision avoidance system (ACAS) were developed. However, it took a number of additional years to validate and further advance the development.

In parallel with the development of the systems, there were many discussions on standardization of those in several ICAO meetings. For example, the 7th Air Navigation Conference was held in 1972, and the conference made a total of 74 recommendations including those related to secondary surveillance radar (SSR) and airborne collision avoidance systems (ACAS). In the1970s, there was an extensive exchange of views regarding the evolution of SSR and ACAS, and in 1981 the Air Navigation Commission (ANC) established the SSR Improvements and Collision

Avoidance Systems Panel (SICASP) with the following terms of reference: "To undertake specific studies … with a view to developing Standards, Recommended Practices (SARPs), procedures and, where appropriate, guidance material concerning … [inter alia] collision avoidance systems."

ICAO first published the Circular 195 Airborne Collision Avoidance Systems in 1985, with the assistance of the SICAPS. In addition to the efforts made by other entities to improve ACAS performance, ICAO initiated a worldwide operational evaluation in the late 1980s and the SICAPS (and its successor) was actively involved in the final evaluation, which was conducted in the early 1990s. After numerous improvements, the ICAO expert group successfully developed the ACAS II provisions as described in ICAO Annex 10 Volume IV.

Today we can proudly say that air travel is incredibly safe. It has been said that "a person who flew continuously on a jet transport aircraft in today's environment could expect to survive more than 11,000 years of travel before becoming the victim of a mid-air collision"[i]. This accomplishment has

[i]   James K. Kuchar and Ann C. Drumm, The Traffic Alert and Collision Avoidance System

been made possible not only thanks to the deployment of ACAS but also thanks to several other similarly successful efforts, such as the development of appropriate operational procedures and training initiatives for flight crews and ATC.

However, we are now facing new challenges to maintain or improve upon this level of safety while supporting increased demand through more and more efficient aircraft operations. The monitoring and assessment of existing ACAS Resolution Advisories (RA) indicates that over 80% of those are triggered by the interactions between the current ACAS alerting criteria and normal ATC procedures during safe operation (where own aircraft and intruder are actually safely separated). These RAs are categorized as unnecessary or nuisance alerts. In addition, the current ACAS logic is not sufficiently flexible to adapt to future operations as described in the Global Air Navigation Plan.

The development of a new and improved ACAS, known as ACAS X, has been initiated to solve operational issues, such as unnecessary alerts, and to accommodate new procedures (such as those supporting 4D trajectory based operations). ACAS X will also enable the use of other surveillance sources, as required to support new aircraft types such as remotely piloted aircraft.

One of the ICAO expert groups, the Surveillance Panel, the successor of the expert group mentioned above, is currently working closely with several other entities to finalize the ACAS X technical provisions for inclusion in Annex 10 Volume IV. The new provisions are based on extensive evaluations which indicated that ACAS X will provide a safety benefit by reducing the probability of certain Near Mid-Air Collisions (NMACs) scenarios by about 20% and also significantly reducing the number of unnecessary alerts and RA reversals. ICAO continues to work with the Surveillance Panel as well as other expert groups and entities in order to maintain and improve the safety of the flying public.

Xa Operational Benefit: Reduction in RAs
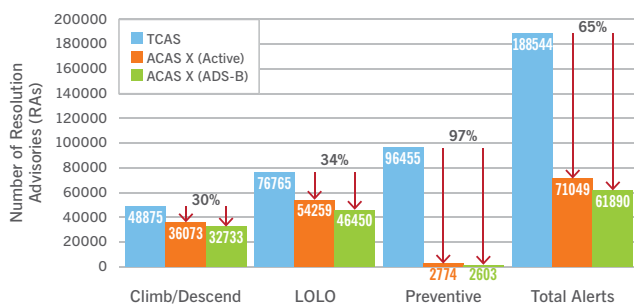
Alerting Comparison between ACAS X V1R0 (RTCA DO-385) and TCAS II v7.1 on TRAMS encounter set (~25,000 observed encounters between October 2008 and July 2016)

Figure Source: U.S. Federal Aviation Administration

Xa Safety Benefit: Reduction in Collision Risk

Risk ratio comparison between ACAS X V1R0 (RTCA DO-385) and TCAS II v7.1 on Lincoln Laboratory Correlated Encounter Model

Notes:
- Induced risk difference due to the prevention of crossing RAs
- Unresolved risk reduction 23%
- Total risk reduction 20% across airspace

$$\text{Risk Ratio} = \frac{P(\text{NMAC with CA})}{P(\text{NMAC without CA})}$$
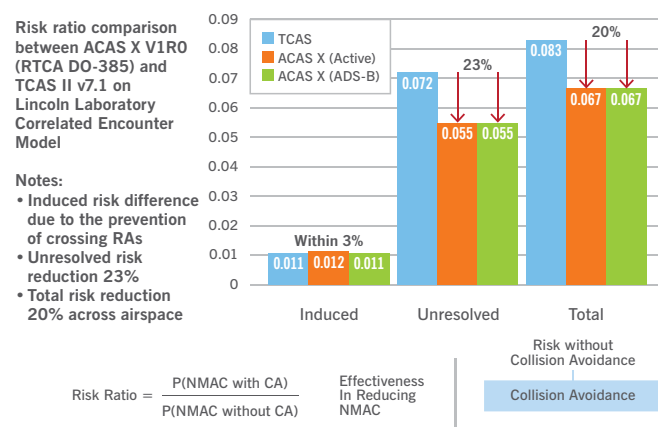
About the Author

Ms. Mie Utsunomiya has been working as a CNS Technical Officer of ICAO HQ since 2011. Since 2015 she has been the Secretary of Surveillance Panel, which undertakes specific studies and develops technical and operational ICAO provisions for aeronautical surveillance systems, airborne surveillance systems, collision avoidance systems and their applications as outlined in the Global Air Navigation Plan. Since 2017, she is working in the area of spectrum management as well.

ICAO provisions for wildlife strikes hazard reduction in aerodromes

by Alexis Clinet

Accidents and incidents between aircraft and wildlife, and more specifically with birds, have been documented since the dawn of aviation. While piloting his airplane on 7 September 1905, Orville Wright had what is believed to be the first collision between an aircraft and a bird, now known as a bird strike. Less than seven years later, on 3 April 1912, in Long Beach, California, Calbraith Perry Rodgers, the first man to make a transcontinental flight across the United States, became the first person to die as the result of a bird strike.

The attention of the international community was drawn to the need for developing detailed airworthiness requirements to enable aircraft to withstand bird strikes in the early 1960s, following two fatal accidents to civil transport aircraft. One of the accidents involved a Lockheed Electra L188 which crashed at Boston Logan International Airport immediately after take-off on 4 October 1960, as a result of engine ingestion of a flock of starlings into three of the aircraft's four engines, causing the aircraft to lose power, stall and crash into the harbour. Sixty-two of the seventy-two passengers and crew members on board perished, in what is believed to be the most deadly bird strike accident to date.

The second accident involved a Vickers Viscount which crashed near Baltimore on 26 November 1962, as a result of failure of the stabilizer when struck by flock of whistling swans *(Cygnus columbianus)* over the State of Maryland, while flying at 6 000 feet. All crew members and passengers on board were killed; the accident raised questions about the design criteria for horizontal stabilizers.

The threat posed by birds on aerodromes was also a subject of concern and, in the early months of 1961, the ICAO Air navigation Commission agreed that studies regarding the reduction of bird hazards on aerodromes should be disseminated. The impact of birds on aerodromes received fairly consistent attention and was discussed in two global meetings at that time: the Seventh Session of the Aerodromes, Air Routes and Ground Aids Division (1962) and the Fifth Air Navigation Conference (1967).

In September 1969, Amendment 23 to Annex 14 – *Aerodromes* to the Chicago convention, recommended that the competent authorities take action to decrease the number of birds representing a hazard to aeroplanes, on or in the vicinity of aerodromes. Guidance materials were also made available to provide effective measures for establishing whether or not birds, on or near an aerodrome, constitute a hazard to aircraft operations, with methods for discouraging their presence.

This requirement was general in nature and contained no provisions for the management of bird attractants in the communities surrounding aerodromes. The provisions found in Annex 14, evolved from this initial recommendation, with the introduction in 1990 of three recommendations which indicated that authorities should assess the bird hazard on, or in the vicinity of, an aerodrome; taking necessary action to decrease the number of birds by adopting measures for discouraging their presence; and preventing the establishment of any site which would attract birds. The recommendations on bird control on, or in the vicinity of, an aerodrome have further been upgraded to Standards with amendments introduced in 2003.

Although the majority of wildlife strikes involve birds, those involving other animals can have severe consequences. In 2009, ICAO extended its provisions to all wildlife (birds and other animals) and included a recommendation for land developments in the vicinity of the aerodrome that may attract wildlife.

To share a common understanding, ICAO started collecting bird strike data as early as 1965 and introduced a reporting system named IBIS (ICAO Bird Strike Information System). ICAO requested Member States to report all bird strikes to aircrafts, with the introduction of a Bird Strike Reporting Form in November 1979. This reporting system has evolved and now includes reporting for all wildlife strikes.
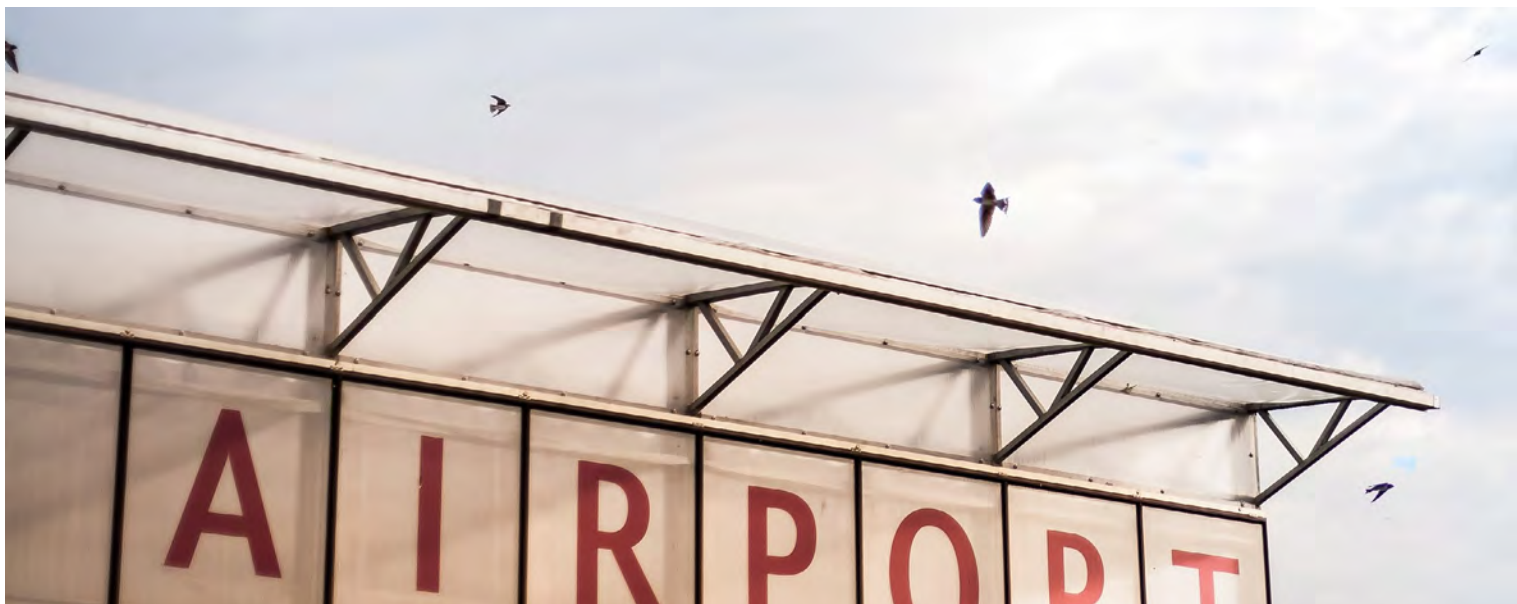
This system allows ICAO to conduct thorough analysis of the wildlife strikes reported and to make the information available to the aviation community. Currently, it is believed that wildlife (bird and other animals) strikes are an increasing safety and economic concern, and have resulted in hundreds of fatalities throughout the years, with an annual loss of over one billion USD to the aviation industry. The statistics issued from the analyses of wildlife strike reports for the years 2008 to 2015, based on 97 751 reports, received from ninety-one States (Electronic bulletin EB 2017/25 available at https://www.icao.int/IBIS refers) shows that 96% of wildlife strikes occurred on or near airports, among which 39% occurred during the take-off run or climb phases and 57% occurred during the decent, approach or landing roll phases.

This analysis was made available and discussed among the aviation community during the ICAO/ACI Wildlife Strike Hazard Reduction Symposium which was held in Montreal, from 16 to 18, May 2017 (Presentations can be accessed at https://www.icao.int/Meetings/wildlife). The symposium successfully increased international awareness on the wildlife strike threat to aircraft operational safety and brought together the international community to exchange ideas, experiences and cooperative efforts. It also provided the opportunity for national civil aviation authorities, aerodrome operators and other stakeholders to formulate effective strategies in preventing and mitigating the risk of wildlife strikes to aircraft.

However, technologies and science are evolving and the future trend in wildlife strike hazard control is expected to combine the traditional methods of habitat management and wildlife control with new surveillance technologies (e.g. avian radar) providing real or near-real time information on birds and helping with habitat management, etc.

In this regards, ICAO is currently revising the *Procedures for Air Navigation Services (PANS) — Aerodromes* (Doc 9981) document, initially developed to complement the standards and recommended practices contained in Annex 14, Volume I with the objective of developing procedures for the management of aerodrome operational issues, which is expected to be applicable in November 2020. The revision will include a chapter on wildlife hazard management, with provisions and procedures relating to the reduction of the risk to aviation safety arising from wildlife, through the proactive management and control of hazardous wildlife at aerodromes and their vicinities. The procedures will detail particular provisions for the establishment of a wildlife hazard management programme (WHMP) at aerodromes, defined as a method for aerodrome operators to adopt reasonable wildlife risk control measures, in order to prevent wildlife from colliding with aircraft.
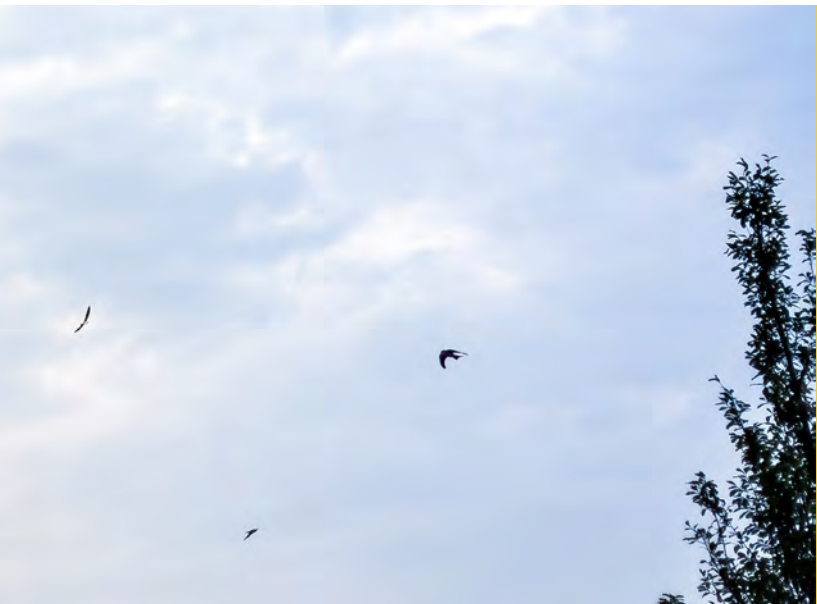
Although the majority of wildlife strikes involve birds, those involving other animals can have severe consequences. In 2009, ICAO extended its provisions to all wildlife (birds and other animals) and included a recommendation for land developments in the vicinity of the aerodrome that may attract wildlife.

The WHMP, as described in the future provisions, will need to be established and tailored to the local environment and commensurate with the wildlife safety risk assessment. It will include procedures and measures for reducing the wildlife strike risk at the aerodrome to an acceptable level. The foundation of an aerodrome's WHMP is habitat and land use management, to limit the attractiveness of sites on, or in the vicinity of, the aerodrome for hazardous wildlife solely. This strategy includes management of specific attractants that include the presence of specific vegetation or water bodies, the use of some dedicated agriculture practices and the limitation of food storage sites. However, management activities should be carefully assessed locally as the decrease of the risk of strikes with some species may increase the risk of strikes with others. The use of wildlife control measures tailored to the locally encountered hazardous wildlife species and adapted to their behaviors are then used to disperse them from high risk areas, using, but not limited to, wildlife patrol, acoustics measures, visual repellents, use of drones and trained predator.

The compliance with national regulations or practices, such as environmental and animal protection regulations, will also be emphasized to ensure that the local WHMP is not conflicting with the objectives of preservation of biodiversity and reduction of environmental impact of air transportation. In this domain multiple, recent, global initiatives have also highlighted the important role aviation plays in ensuring environmental protection, which can be taken into account during the development of a WHMP.

Further guidance is also being developed and will be available in the next edition of the *Airport Services Manual* (Doc 9137), Part 3 — *Wildlife Control and Reduction* (4th edition, 2012) to be consistent with the aforementioned chapter developed for Doc 9981. This new guidance will highlight the importance of developing an WHMP programme specific to each aerodrome, taking into account advancement in technology.

About the Author

Alexis Clinet joined the ICAO Air Navigation Bureau as a technical officer on a two years secondment from the Direction générale de l'Aviation civile (DGAC), FRANCE.

He has been involved in the working group of the ICAO Aerodrome Design and Operations Panel (ADOP).

Introducing the Global Navigation Satellite System in Civil Aviation Use

by Alessandro Capretti

Using the Global Navigation Satellite System (GNSS) to get directions to a destination is a common daily experience for most of us. The navigation applications of virtually all smartphones are based on the Global Positioning System (GPS), which is itself an element of GNSS. But even though we tend to take GNSS for granted today, the introduction of it in the daily lives of billions of people only occurred recently, within the last decade or so. The introduction of GNSS in civil aviation, on the other hand, began much earlier.

Aviation was very quick in realizing the enormous potential of GNSS for safety and efficiency. Already in the late '80s, the work of ICAO's Future Air Navigation Systems (FANS) Committee created global awareness on the important role of GNSS in the future of aviation. The March 1991 edition of the ICAO Journal featured an article about the "coming of age of satellite navigation". And indeed, as early as 1993 (the year in which GPS was declared fully operational), several States had approved the use of GPS guidance for en-route, terminal and non-precision approach operations.

However, even after the early adopter States showed that substantial operational benefits could be gained, acceptance of GNSS navigation by most States was not immediate. While this can be explained in part by the usual reasons militating against prompt adoption of any new CNS technology, such as the cost of equipage, in the case of GNSS there were at least two additional reasons. One was the radical novelty of the technology (satellite navigation being in its infancy at the time) and the other was the diffidence about the use for civil aviation purposes of systems (GPS operated by the United States and GLONASS, operated by the Russian Federation) that had been originally been deployed exclusively or predominantly for military use.

How then did GNSS gain global acceptance by States? Among the many factors that contributed to the process of acceptance, one stands out: ICAO's standardization of GNSS played a crucial role in enabling the use of GNSS by international civil aviation. When, in March 2001, the ICAO Council adopted the first ICAO GNSS Standards, contained in Annex 10, covering both GPS and GLONASS, it officially

endorsed GNSS as one of ICAO standard radio navigation aids, in addition to traditional aids such as instrument landing systems (ILS), very high frequency (VHF omni-directional range (VOR) and distance measuring equipment (DME). With this recognition, the era of GNSS for international civil aviation would effectively start.

The process leading to the adoption of the ICAO GNSS Standards in 2001 was a long and complex one given that it involved ground-breaking steps on both the institutional and technical sides. ICAO was instrumental in making this process possible.

On the institutional side, both the United States and the Russian Federation took the unprecedented initiative of offering to the ICAO Council their respective GNSS systems, GPS and GLONASS, to be available for international civil aviation on a continuous worldwide basis, free of direct user fees. When the ICAO Council accepted the offers (respectively in 1994 and 1996), it effectively sent a message to all States that GNSS was not just a military system, and that it held great promise for civil aviation.

Still, even after surmounting the main institutional hurdle, questions remained on the technical side. Would GNSS be able to meet the demanding civil aviation safety requirements? GPS and GLONASS had not been designed primarily with aviation safety in mind. Their characteristics needed to be analyzed to assess the extent to which they were able to meet safety requirements, and the technical means needed to be devised to augment their performance as required to meet those requirements in full.

This daunting technical task was conducted over several years of intensive work by the ICAO GNSS Panel, that was established in 1993. It resulted in the development of ICAO Standards for a panoply of aviation-specific "augmentation systems" that would complement and enhance the basic navigation service offered by the core GPS and GLONASS constellations to ensure the necessary level of safety. Those augmentation systems (aircraft-based augmentation system (ABAS), ground-based augmentation system (GBAS) and satellite-based augmentation system (SBAS)) are now an integral part of GNSS, making it truly and fully a civil aviation system.

Today, almost three decades after the ICAO FANS Committee first recognized the potential of GNSS, and two decades after the ICAO Council adopted the GNSS SARPs, GNSS has been globally embraced by aviation users throughout the international and domestic air transport fleet and general aviation and constitutes the foundation of the ICAO performance-based navigation (PBN) concept, by providing a ubiquitous navigation capability virtually regardless of ground infrastructure.

But ICAO's work on GNSS is not over. GNSS technology is evolving and offers new opportunities to civil aviation. Two major GNSS developments of global scope are underway and fast approaching completion: Europe's core constellation, Galileo, the fruit of a cooperative effort by European States; and China's own core constellation, the BeiDou navigation satellite system (BDS). Thanks to the introduction of these two advanced systems, the number of individual GNSS satellites available globally will be greatly increased, thereby also increasing the robustness of GNSS as a whole.

Both Galileo and BDS feature a new technology based on the use of two separate frequency bands of operation, as opposed to the single band in use today. GPS and GLONASS are also being enhanced to use two bands. Within ICAO, the Navigation Systems Panel (NSP) is currently developing Standards for this new generation of GNSS, which, being based on the availability of multiple (four) core constellations and the use of dual bands of operation, is referred to as "dual-frequency, multi-constellation" (DFMC) GNSS.

DFMC GNSS will provide increased performance and robustness that will enable the achievement of additional operational benefits and the optimization of the navigation infrastructure. However, just as when GNSS was first introduced, the introduction of DFMC GNSS needs to overcome a number of hurdles, both of an institutional nature (such as acceptance by States of new GNSS elements operated by other States) and of a technical nature (such as additional complexity of the DFMC environment). And just like then, ICAO is engaged today in making that possible by uniting the aviation community in a global effort to achieve the full operational benefits of GNSS.

GNSS has come a long way, but it has a long way to go. ICAO has accompanied its development since the inception of its deployment for civil aviation and will continue to do as GNSS evolves towards ever more advanced and robust navigation performance.

About the Author

Alessandro Capretti is a Technical Officer, Communications, Navigation and Surveillance (CNS) in the ICAO Air Navigation Bureau. He is the Secretary of the ICAO Navigation Systems Panel (NSP).

Forecasting and warning to improve flight safety and efficiency

by Raul Romero

Meteorological threats to the safety of flight have been a primary concern to ICAO since the earliest days of its work. This is reflected in the fact that meteorological standards were among the first to be annexed to the Chicago Convention and in the fact that ICAO has maintained very close cooperation with the World Meteorological Organization throughout its history. ICAO has achieved especially significant progress in this area since the 1980s, with the implementation of two global initiatives: World Area Forecast System (WAFS) and the International Airways Volcano Watch (IAVW).

World Area Forecast System (WAFS)

During the 80s to assist States to concentrate meteorological resources on the improvement of forecasts for terminal areas, since these are considered one of the most critical areas for safe and economic aircraft operations, new provisions related to the introduction of the world area forecast system (WAFS) were introduced in Annex 3-*Meteorological Service for International Air Navigation* in November 1984 following the Communications/Meteorology Divisional Meeting (1982).
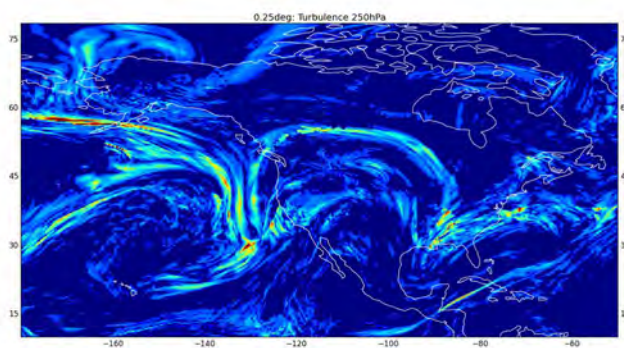
The WAFS was designed as a worldwide system where two world area forecast centres (London and Washington – WAFCs) prepare and provide significant weather and upper-air forecasts directly to States in digital form covering the full globe.

Since their inception the WAFS has been progressively improved through the introduction of updated SARPs in the fourteen subsequent amendments of Annex 3. This has ensured the ongoing provision of high-quality, consistent and uniform forecasts for flight planning and aircraft operations. The global output of the WAFS permitted meteorological watch offices (MWOs) to focus more on weather conditions in their flight information regions (FIRs), and aerodrome meteorological offices to focus more on local aerodrome conditions and forecasting, and to issue warnings of weather conditions that could adversely affect operations and facilities at the aerodrome.

Today, as recommended by the Conjoint ICAO-WMO Divisional Meeting held in Montreal in 2014, the WAFS is being further developed and improved to ensure that it is able to cope with future requirements due to changes in airline business perspectives, flight operations and routes, the increase of data volumes, and to meet developing System Wide Information Management (SWIM) demands.

The currently planned enhancements include the improvement in data resolution from 1.25 degrees Celsius to 0.25 degrees, new data formats, increase in the forecast time steps from 3 hours to every hour, improved data and products covering turbulence, icing and high altitude ice crystals forecasts, and the integration of real-time aircraft systems derived meteorological observational data.

Through these enhancements the global aviation community, and therefore passengers and freight operators, will benefit through the availability of safer route planning in significant weather, improved fuel efficiency, better arrival time predictions, improved passenger comfort, easy to use information for gate to gate planning, and the sharing of meteorological and related information across all aviation domains through SWIM.

Example of global forecast on turbulence from WAFS at 250 hPa with resolution of 0.25 degrees.

The WAFS was designed as a worldwide system where two world area forecast centres (London and Washington – WAFCs) prepare and provide significant weather and upper-air forecasts directly to States in digital form covering the full globe.

This successful system for the provision of meteorological information for flight planning for safe, economic and efficient operations, established more than three decades ago, is now one of the key pillars of meteorological data provision and in the future will continue to bring considerable and increasing operational benefits to global air navigation.

The International Airways Volcano Watch (IAVW)

On 24 June 1982, the global aviation community and much of the world learned of the drama involving a British Airways B747 aircraft that lost power on all four engines while flying at 37 000 ft. from Kuala Lumpur, Malaysia to Perth, Australia.

During the ensuing sixteen minutes, the aircraft descended without power from 37000 to 12 000 ft, at which point the pilot was able to restart three of the engines and make a successful emergency landing at Jakarta, Indonesia.

Suspicion quickly focused on the cause - a volcanic ash (VA) cloud from the erupting Indonesian volcano, Mount Galunggung. Three weeks later another aircraft, a B747 of Singapore Airlines bound for Melbourne, Australia, reported a similar incident losing power on two engines and also successfully diverted to Jakarta.

To meet this newly recognized threat, ICAO developed a set of interim guidelines to assist States in the dissemination of information on volcanic ash to pilots, airlines, and ATS. It also developed preliminary contingency arrangements for the diversion of aircraft around areas affected by volcanic ash.

Formal requirements were introduced, in the relevant Annexes to the Chicago Convention and Procedures for Air Navigation Services (PANS), by the ICAO Council in March 1987. Appropriate guidance materials together with the regular update of these requirements have been introduced to improve the availability of information related to VA for international air navigation.

Important milestones of the IAVW included the designation of nine volcanic ash advisory centres (VAAC) to detect, track, and forecast the movement of VA clouds in their areas of responsibility, and the establishment of the IAVW Operations Group (IAVWOPSG) and the International Volcanic Ash Task Force (IVATF) (established by ICAO to contribute with the European efforts during the Icelandic eruption in April 2010). Currently, the Meteorology Panel Working Group on Meteorological Operations (METP WG/MOG) is responsible for the co-ordination and further development of the IAVW.

The IAVW system has worked very well through the years to reduce the safety risk of volcanic ash to global air navigation. However, one of the main challenges that has impacted improving the effectiveness of the IAVW has been the lack of definition of volcanic ash thresholds that constitute acceptable levels of concentration for safe aircraft operations. The IVATF, established to assist States in response to the disruption of air traffic in Europe caused by the Eyjafjallajokul volcanic eruption in Iceland in 2010, completed an impressive amount of work including the development of a manual on *Flight Safety and Volcanic Ash – Risk management of flight operations with known or forecast volcanic ash contamination* (ICAO Doc 9974). However, due to the embryonic state of the science at

the time, it did not support work on developing modelled volcanic ash concentrations.

Nevertheless, over the last five years, ICAO as part of the MET Work Programme continued work on volcanic ash to further develop the IAVW in line with Global Air Navigation Plan (Doc 9750), as was recommended by ICAO/WMO MET Divisional Meeting in 2014.

This work is progressing well with the assistance of the World Meteorological Organization (WMO), Volcanic Ash Advisory Center provider States, aviation industry stakeholders, science, and academia. Progress includes, much

better understanding of volume and density of volcanic ash particles, volcanic gases along with their potential exposure risks, advances in the numerical modelling of volcanic ash, access to enhanced observations (particularly satellite imagery), introduction of confidence in VA forecasts, state of engine susceptibility science, and so on.

Taking into account the recent and planned future scientific and technological advancements there is a consensus within the aviation operational and scientific sectors involved in the IAVW that continuing work towards quantitative volcanic ash forecasts will greatly support the risk-based, dosage approach.

Current status of ICAO volcanic ash advisory centres (VAAC) - areas of responsibility

The development and use of quantitative volcanic ash contamination information and forecasts is very promising, provided that appropriate operational resources are made available across the aviation industry to enable the transition from scientific research into meteorological operations. This new approach will better serve the purpose of the

IAVW in assisting aircraft remain outside of better defined areas contaminated by volcanic ash, to allow operators the use of a safety risk management, and to have an IAVW system prepared for volcanic eruptions to ensure safety and efficiency of international air navigation is maintained.

About the Author

Raul Romero is a Technical Officer, Meteorology (MET) in the ICAO Air Navigation Bureau.

He is the Secretary of the ICAO Meteorology Panel (METP).

"Urban Air Mobility": Is This a Different Way of Saying "Aviation in Cities"?

by Frédéric Malaud

Introduction

The term "urban air mobility" is increasingly used in media articles, academic papers, and industry publications, often in association with futuristic images of "flying cars" circulating seamlessly over cities, such as in the 1982 film *Blade Runner*.[1] Networks of small, electric powered-lift aircraft are often presented as a solution to enable rapid and reliable urban transportation, with significant savings in commute time. These networks are expected to have significant cost advantages over traditional ground and air transportation, which usually require heavy infrastructure such as roads, rail, bridges, tunnels or airports. The term "flying taxis" which is also used extensively can generate confusion with the term "air taxi service", a type of on-demand air service that has been in existence for decades, and is usually performed by small capacity aircraft on short notice.[2]

Additionally, unmanned aircraft (UA) commonly referred to as "drones" are anticipated to support the development of goods delivery business models, in particular, online sale of products, as well as inspection, monitoring and medical logistics activities. The European UA market is predicted to be worth over EUR 10 billion annually in 2035 and over EUR 15 billion annually in 2050.[3] In the United States, the integration of unmanned aircraft system (UAS) into the national airspace system is forecast to support more than USD 13.6 billion in economic activity in the first three years of integration and the creation of over 100,000 jobs by 2025.[4]

What is urban air mobility?

The U.S. National Aeronautics and Space Administration (NASA) defines urban air mobility as a "system for air passenger and cargo transportation within an urban area, inclusive of small package delivery and other urban unmanned aircraft systems services."[5] The European Aviation Safety Agency (EASA) has recently opened a public consultation to promote innovation and initiate the "development of the regulatory framework to enable the safe operation within cities of small vertical take-off and landing (VTOL) aircraft."[6] According to the industry, urban air mobility is defined as "on-demand and automated passenger and cargo air transportation services, typically without a pilot."[7]

Urban air mobility involves the operation of aircraft

Firstly, any machine that can derive support in the atmosphere from the reactions of the air, other than the reactions of the air against the earth's surface, is an aircraft.[8] This definition covers most, if not all, machines currently envisaged to support urban air mobility operations. Secondly, an unmanned aircraft is described as "an aircraft which is intended to be operated with no pilot on board.[9] Again, most aircraft to be operated as so-called "flying taxis" or small delivery "drones" would fit that definition, as they are to be operated without a pilot on board. Based on these definitions, "urban air mobility" covers a range of activities conducted with aircraft, within cities or suburbs, and which constitute aviation operations.

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[1] Newsweek, 27 May 2019: https://www.newsweek.com/blade-runner-review-ai-flying-cars-elon-musk-678621.
[2] International Civil Aviation (ICAO), *Manual on the Regulation of International Air Transport* (Doc 9626), at V-4-2 (3rd ed. 2018).
[3] SESAR Joint Undertaking, *European Drones Outlook Study*, Nov. 2016.
[4] AUVSI, *The Economic Impact of Unmanned Aircraft Systems Integration in the United States*, March 2013.
[5] National Aeronautics and Space Administration (NASA), *NASA Embraces Urban Air Mobility, Calls for Market Study:* https://www.nasa.gov/aero/nasa-embraces-urban-air-mobility.
[6] European Union Aviation Safety Agency (EASA), *EASA paves the way to enable safe air travel of urban air mobility and air taxi aircraft:* https://www.easa.europa.eu/newsroom-and-events/press-releases/easa-paves-way-enable-safe-air-travel-urban-air-mobility-and-air.
[7] Honeywell, *What is Urban Air Mobility?* https://www.honeywell.com/newsroom/news/2019/01/what-is-urban-air-mobility.
[8] See Annex 1 – *Licensing*, inter alia, to the *Convention on International Civil Aviation*, signed at Chicago on 7 December 1944 and amended by the ICAO Assembly (Doc 7300) [hereinafter Chicago Convention], at *Definitions*.
[9] See Annex 7 – *Aircraft Nationality and Registration Marks* to the Chicago Convention, at 2.2 (6th ed. 2012).

At the global level, States collaborate through the International Civil Aviation Organization (ICAO) to secure the highest practicable degree of uniformity in regulations, standards, procedures and organization in relation to aircraft in all matters in which such uniformity will facilitate and improve air navigation. ICAO's mandate also covers "other matters concerned with the safety, regularity and efficiency of air navigation as may from time to time appear appropriate."[10]

What are key conditions for urban air mobility?

As shown by research, safety is a fundamental condition in order for urban air mobility activities to be accepted by regulators, users and the general public. By definition, there is no pilot on board an unmanned aircraft to "see and avoid" other traffic, to avoid potential collisions with other airspace users, obstacles, severe weather conditions, as well as other dangerous situations. As a consequence, detect and avoid (DAA) capability is one of the key enablers, among many others, for the safe integration of unmanned aircraft into non-segregated airspace.

With respect to aircraft themselves, ongoing so-called "flying taxi" projects are aimed at the development and

introduction within a few years of highly automated UAS available for use as taxis by the general public.[11] Such new types of aircraft designed to carry passengers will require a combination of certification requirements from both manned and unmanned aircraft categories, and considerable work will be required to define the adequate combination of such certification requirements.

Regarding physical infrastructure, tops of parking garages, existing aerodromes and heliports, and even unused land surrounding highway interchanges could form the basis of a distributed network of dedicated operating sites. As the concept for these facilities mature, it will be necessary for decision-makers to plan for the efficient integration of such operating sites within urban ecosystems. In particular, seamless transitions from one transportation mode to another will be required to achieve transport efficiencies and meet changing passenger demands.[12] Among several policy questions which will need to be addressed in the medium term will be the identification, allocation and recovery of costs for the development and deployment of said infrastructure.

In addition, the increasing numbers of aircraft, whether manned or unmanned, planned to operate simultaneously

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[10] See Article 37 of the Chicago Convention.

[11] ICAO *Uniting Aviation*: https://www.unitingaviation.com/strategic-objective/safety/is-there-an-autonomous-flying-car-in-your-future.

[12] Volocopter, *First Air Taxi Volo-Port to be Built by End of 2019:* https://press.volocopter.com/index.php/first-air-taxi-volo-port-to-be-built-by-end-of-2019.

within urban areas will require new approaches to air traffic management. The UAS traffic management (UTM) concept can be described as a system that provides traffic management through the integration of humans, information, technology, facilities and services, supported by air and ground and/or space-based communications, navigation and surveillance. ICAO, building on the work of its UAS Advisory Group (UAS-AG), has recently published its *Common Framework with Core Principles for Global Harmonization*, providing States that are considering the implementation of a UTM system with a framework and core capabilities of a "typical" UTM system.[13]

Conclusion

Urban air mobility activities, which indeed constitute aviation operations, undoubtedly present distinct operational challenges compared to traditional manned aviation, in particular very low altitudes and voluntary proximity to obstacles such as buildings, bridges, and other man-made structures. These operating conditions will likely be at odds with some of the most fundamental principles of aviation, in particular the rules of the air, which consist of general flight rules, visual flight rules (VFR) or instrument flight rules (IFR) and which, inter alia, impose minimum heights over cities

and cruising levels, limit proximity between aircraft, and provide right-of-way rules.[14]

In this context, considerable efforts will be necessary to ensure the development of regulatory solutions enabling the safe deployment of these new aviation activities. ICAO works with its 193 Member States and industry groups to reach consensus on Standards and Recommended Practices (SARPs) for aviation, manned and unmanned. The SARPs developed by ICAO's Remotely Piloted Aircraft Systems Panel (RPASP) support IFR operations in controlled airspace and at controlled aerodromes. The current focus of the RPASP is on airworthiness, operations, operator certification, air traffic management, C2 Link, DAA, safety management and security. The Panel's work will also provide a context within which simplified regulations can be developed for less demanding national operations.

During the Thirteenth Air Navigation Conference held in 2018 (AN-Conf/13) ICAO's Member States also recommended that ICAO "continue supporting the safe and coordinated implementation of aviation activities at very low altitude, particularly in urban and suburban environments, including in the vicinity of, and into, aerodromes.[15]

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[13] ICAO, *UTM – A Common Framework with Core Principles for Global Harmonization*, 2019: https://www.icao.int/safety/UA/Pages/UTM-Guidance.aspx.
[14] See Annex 2 – *Rules of the Air* to the Chicago Convention, at 3.1 and 3.2 (10th ed. 2005).
[15] ICAO Thirteenth Air Navigation Conference (9-19 October 2018): https://www.icao.int/Meetings/anconf13.

About the Author

Frédéric Malaud serves as a Technical Officer in the Remotely Piloted Aircraft Systems (RPAS) Section at the International Civil Aviation Organization (ICAO), which he joined in 2009. As Secretary of the ICAO RPAS Panel, he works with the Organization's Member States and industry groups to safely integrate RPAS and other unmanned aircraft commonly referred to as "drones" into the aviation system. Frédéric has spent

over a decade as an attorney (New York and Paris bars), advising international entities on complex operational, regulatory and legal challenges. He holds a Master's Degree in Law and a Master's Degree in Anglo-American Legal Studies from the University of Paris. He is a licenced commercial pilot and flight instructor with several years of passenger transport experience.

Achieving Effective
Safety Management Implementation

by Elizabeth Gnehm

It is often mentioned that air traffic is expected to double in the next 15 years. That growth combined with rapid technological changes, the increasing complexity of the aviation system and innovative approaches proposed by the aviation industry present challenges to the traditional regulatory approach which is mostly based on the establishment of prescriptive requirements. If we are to enable the rapid evolution of the global air transportation system, the traditional prescriptive approach must be complemented by a performance-based approach as reflected in the provisions of Annex 19 – *Safety Management*. To determine whether we are achieving effective safety management implementation, we need to focus on the activities, processes and tools related to safety performance management as well as State safety programme (SSP) and safety management system (SMS) evaluation.

In the fourth edition of the *Safety Management Manual (SMM)*, Chapter 4, Safety Performance Management, outlines the importance of developing safety objectives that stem from the identification and understanding of the top risks being faced by the State or service provider.

Safety performance indicators (SPIs) and safety performance targets (SPTs) are then derived from the safety objectives and are the main tools for monitoring and measuring safety performance. For a more accurate and useful indication of safety performance, lagging SPIs, that measure events that have already occurred, should be combined with leading SPIs, that focus on processes and inputs that are being implemented to improve or maintain safety. The figure below is from the 4th edition of the SMM and shows the links between lagging and leading indicators.

Examples of links between lagging and leading indicators
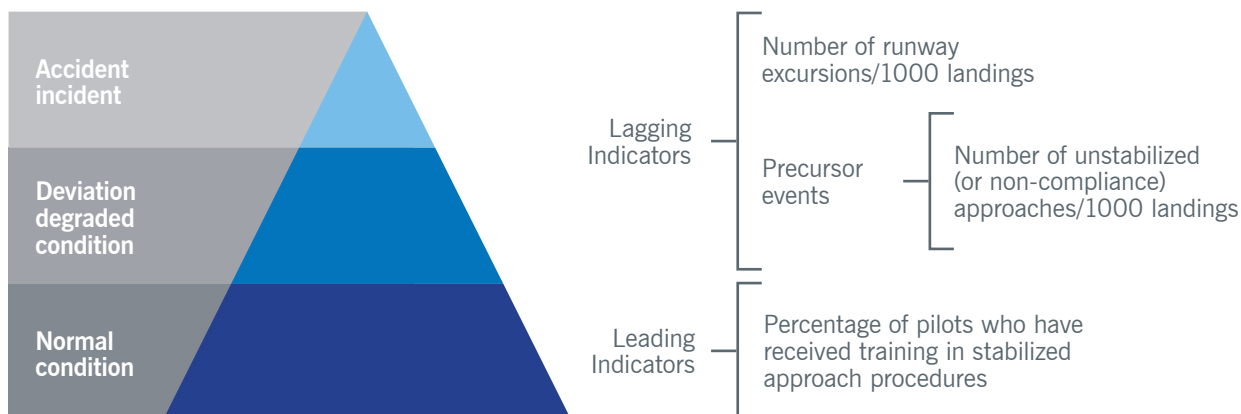
These tools should help us to measure if we are achieving our safety objectives at the service provider, State, regional and global levels. ICAO has put in place an Indicators Catalogue (https://www.icao.int/safety/Pages/Indicator-Catalogue.aspx) to support the sharing of SPIs being used by States and industry and to support the standardization of the indicators through the use of the form provided. In addition, ICAO has developed the Safety Information Monitoring System (SIMS) (www.icao.int/safety/sims), a web-based safety data and information system comprised of different applications which generate indicators, to assist States in the processing and analysis of safety data to monitor safety performance. States interested in joining SIMS are invited to express their interest to their accredited Regional Office. Interested industry stakeholders can become partners to SIMS through the ICAO project-based partnership programme. (https://www.icao.int/about-icao/partnerships/Pages/sims.aspx)

The Global Aviation Safety Plan (GASP) 2020-2022 includes an updated set of goals, targets and indicators to be presented to the 40th Session of the ICAO Assembly for endorsement and is expected to provide inspiration for setting the same or similar at the regional and State levels. The GASP also supports collaboration across the aviation community for the continued improvement in aviation safety.

These activities related to safety performance management should be supported by internal and external audit processes that monitor compliance with safety regulations, the foundation upon which safety management is built, but that also assesses the effectiveness of individual processes and activities as well as the SSP or SMS overall. The tools used to conduct audits typically provide a checklist to be used for the review of each requirement from a binary perspective – Yes/No, Satisfactory/Not Satisfactory. An example question from the Universal Safety Oversight Audit Programme (USOAP) Protocol Questions (PQs) is shown below.

PQ No.	Protocol Question	Guidance for Review of Evidence	ICAO References	CE
1.001	Has the State promulgate primary aviation legislation to enable it to address its obligations as a signatory to the Chicago Convention?	1) Confirm title, date of promulgation and last amendment of all primary aviation legislation. 2) Verify that the primary aviation legislation has been amended as needed following amendments to the Chicago Convention; 3) Verify that the content of the primary aviation legislation is consistent, sufficient (addressing all audit areas as needed) and properly organized.	CC Part I GM Doc 9734 Part A, 3.2	CE-1

To assess whether something is effective, however, requires a performance-based approach which actually reviews whether the activity or process is achieving its intended result. An added benefit of this type of review is that it allows each organization the flexibility needed to implement SSP or SMS in a way that works for their own organization. In addition, it is important to determine if the various processes and activities are appropriately linked (e.g. link between the safety risk management process and the monitoring of safety performance indicators) to enable the achievement of the overall safety objectives of the organization. Although it is usually much easier to implement a prescriptive requirement as well as to audit its implementation, we will not reap the benefits of safety management if treat it as another set of prescriptive requirements.

One approach initially developed by the Safety Management International Collaboration Group (SM ICG) in the SMS Evaluation Tool (Version 1.0 – 1 April 2012)[1] is to provide for the evaluation of the maturity of the SMS which provides four levels to be considered by the auditor/assessor:

Present (P), Suitable (S), Operating (O) and Effective (E). The Management System Assessment Tool published by EASA[2] in September 2017 has followed this model and includes "word pictures" to help the inspector determine the correct level.

1   SAFETY POLICY AND OBJECTIVES
1.1   MANAGEMENT COMMITMENT AND RESPONSIBILITY
The organisation shall define its safety policy which should be in accordance with international and national requirements, and which shall be signed by the Accountable Executive of the organisation. The safety policy shall reflect organisational commitments regarding safety, including a clear statement about the provision of the necessary human and financial resources for its implementation and be communicated, with visible endorsement, throughout the organisation. The safety policy shall include the safety reporting procedures and clearly indicate which types of behaviours are unacceptable and shall include the conditions under which disciplinary action would not apply. The safety policy shall be periodically reviewed to ensure its remains relevant and appropriate to the organisation.

EFFECTIVENESS is achieved when the organisation has defined its safety policy that clearly states its intentions, safety objectives and philosophies and there is visible evidence of safety leadership and management 'walking the talk' and demonstrating by example.

INDICATORS OF COMPLIANCE + PERFORMANCE		P	S	O	E	How it is achieved	Verification
1.1.1	There is a safety policy that includes a commitment towards achieving the highest safety standards signed by the Accountable Executive.						
1.1.2	The organisation has based its safety management system on the safety policy.						
1.1.3	The Accountable Executive and the senior management team promote and demonstrate their commitment to the Safety Policy through active and visible participation in the safety management system.						
1.1.4	The safety policy is communicated to all personnel with the intent that they are made aware of their individual contributions and obligations with regard to Safety.						
1.1.5	The safety policy includes a commitment to observe all applicable legal requirements, standards and best practice providing appropriate resources and defining safety as a primary responsibility of all Managers.						
1.1.6	The safety policy actively encourages safety reporting.						
1.1.7	The safety policy states the organisation's intentions, management principles and commitment to continuous improvement in the safety level.						
1.1.8	The safety policy is reviewed periodically to ensure it remains current.						

ICAO is currently working on the development of a maturity evaluation system, and the technical tools to be utilized for evaluating the level of SSPs implementation, as part of the Universal Safety Oversight Audit Programme (USOAP).

Once the evaluation system and tools are developed, they will be made available to States and assessors will be provided appropriate training to promote standardization in how the tool is used.

ICAO has established the Safety Management Implementation (SMI) website (www.icao.int/SMI) to complement the 4th edition of the SMM and serve as a repository

for practical examples and tools to support our diverse community in the implementation of SSP and SMS. Users who previously found the Appendices in the 3rd edition to be very useful will be pleased to learn that most of that content has been updated and posted on the SMI website. Additional practical examples and tools will be collected, validated and posted on the SMI website on an ongoing basis. I invite you to visit the website and consider submitting a practical example or tool showing how your organization is implementing safety management to share it with the rest of the aviation community. There is a form available for this purpose once you select "Start" and launch the website.

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[1]   https://www.skybrary.aero/index.php/SM_ICG_SMS_Evaluation_Tool
[2]   https://www.easa.europa.eu/document-library/general-publications/management-system-assessment-tool

1   SAFETY POLICY AND OBJECTIVES

1.1   MANAGEMENT COMMITMENT

Annex 19 reference & text

1.1.1   The service provider shall define its safety policy in accordance with international and national requirements.

The safety policy shall:

e) be signed by the accountable executive of the organization

g) be periodically reviewed to ensure it remains relevant and appropriate to the service provider

PRESENT	SUITABLE	OPERATIONAL	EFFECTIVE
There is a safety policy that includes a commitment to continuous improvement, observe all applicable legal requirements, standards and considers best practice signed by the accountable manager.		It is reviewed periodically to ensure it remains relevant to the organisation.	The accountable manager is familiar with the contents of the safety policy.

What to look for
• Talk to accountable manager to assess their knowledge and understanding of the safety policy. • Confirm it meets EU Regulations. • Interview staff to determine how readable and understandable it is.

Corresponding EU/EASA Requirements				
Air Operations	Aircrew	Aerodromes	ATM/ANS	ATCO Training Org.
ORO.GEN.200 'Management system' point (a)(2) and (a)(6) AMC1 ORO.GEN.200(a)(2) 'Management system' - [complex operators] AMC1 ORO.GEN.200(a)(1)(2)(3)(5) 'Management system' point (e) - [non-complex operators]	ORA.GEN.200 'Management system' point (a)(2) and (a)(6) AMC1 ORA.GEN.200(a)(2) 'Management system' - [complex organisations] AMC1 ORA.GEN.200(a)(1)(2)(3)(5) 'Management system' point (e) - [non-complex organisations]	ADR.OR.D. 005 'Management system' point (b)(2) and AMC1 ADR.OR. D.005 'Management system' point (b)(2)	ATS.OR.200 'Safety management system' Point (1) AMC1 ATS.OR.200(1) (i) Safety management system SAFETY POLICY — COMPLEX ATS PROVIDERS AMC1 ATS.OR.200(1); (2); (3) Safety management system GENERAL [non-complex ATS providers]	ATCO.OR.C.001 'Management system of training organisations 'point (b) AMC1 ATCO.OR.C.001(b) Management system of training organisations SAFETY POLICY

About the Author

Ms. Elizabeth Gnehm is responsible for the Safety Management Programme at ICAO and her duties include serving as the Secretary of the Safety Management Panel, which has developed proposals for the first and second editions of Annex 19 – Safety Management, and leading a team to support the implementation of State safety programmes (SSP) and safety management systems (SMS) worldwide. Ms. Gnehm also spent 9 years working in the ICAO Universal Safety Oversight Audit Programme (USOAP) as Technical Coordinator, Team Leader and Airworthiness Auditor and has participated in over 50 ICAO USOAP missions. Prior to joining ICAO in 2002, she worked for the US Federal Aviation Administration and the Boeing Company under various airplane programmes. She holds a BS and a MS in Aerospace Engineering from Texas A&M University.

Challenges the Aviation Industry is Facing

It is projected that global air transport passenger traffic will increase from 4.3 billion in 2018 to approximately 7.8 billion in the next 20 years. The aviation industry needs to prepare for a near doubling of traffic growth. Continued growth points to opportunities for aviation but also poses challenges in terms of network expansion and for aviation capacity, efficiency and safety. The aviation industry is also facing a multitude of emerging issues such as cyber resilience, unmanned aircraft systems/remotely piloted aircraft systems (UAS/RPAS) and operations below flight level 1 000 ft as well as challenges stemming from the escalating dependence on information and communications technology.

Innovation in Aviation Introduces New Challenges

New technologies and concept of operations are rapidly becoming available across the aviation industry. These innovations carry significant potential in improving aviation safety across the globe. They can also lead to more efficient and streamlined aviation regulatory processes.

During the past five years, there has been a significant increase in the pace of development and application of new technologies and concept of operations within the aviation industry. Milestones that have been reached during this period include:

- The circumnavigation of the globe by a solar plane;
- The delivery of packages by drones which include humanitarian and medical supplies;
- The successful suborbital flight carrying a "test participant";
- Multiple successful tests of flying taxis with people on board;
- The deployment of unmanned aircraft systems (UAS) traffic management systems; and
- The provision of regular communication services from platforms on high-altitude balloons.

In many instances, these developments are improving aviation safety, security, sustainability, accessibility and affordability. Some of these advancements also introduce new challenges such as the escalating dependence on information and communications technology.

ICAO as a Global Forum for Innovation

Some Member States brought innovations, and their over-sight thereof, to the attention of the aviation community through a number of ICAO fora including the Thirteenth Air Navigation Conference (AN-Conf/13), the Remotely Piloted Aircraft Systems (RPAS) and Drone Enable Symposia, and various other events. Innovation has indeed become a very common theme for all ICAO events.

Given that innovation in this field is expected to increase, it is important for the global aviation community to develop new regulatory policies in order to evaluate them in a timely manner. These policies would provide a high-level frame-work though which innovations can be assessed and, where relevant, be brought under global polices and standards.

Based on the outcomes of those deliberations, the theme for the upcoming fifth edition of the ICAO World Aviation Forum (IWAF/5) was set as "Innovation", as was the request to hold an innovation fair prior to the 40th Session of the ICAO General Assembly.

The Challenges of a Digital Transformation of the Global Civil Aviation System

In 1944 it was necessary to establish ICAO in order to harness aviation for peaceful purposes and guide the evolution of a rapidly developing system. In the 21st century we are at a similar juncture, only this time the civil aviation system itself is being rapidly transformed by waves of digital technologies that hold great promise, but could also expose the aviation system to new threats and risks which need to be managed.

Certain aspects of the digital transformation of the aviation system must be guided to ensure that it generates ever higher levels of global interoperability and safety. To address this challenge it is necessary to go back to fundamental principles. It is necessary to establish a system of identity and trust that integrates the wisdom of the Chicago Convention into the digital world which is already overtaking the aviation industry.

The Fundamental Notion of Identity and Trust

In 1944 the Chicago Convention established a governance process that allowed States to agree to international standards that served as a basis to issue certificates to aircraft, flight crew, and eventually operators. These certificates established the legal identity of aircraft and could be traced back to a Contracting State. The fact that the certificates were issued based upon ICAO standards, allowed for mutual recognitions and an established level of trust which permitted global operations to flourish. In the digital world of the 21st century, such a system of certificates, registration, and recognition would be called a "Trust Framework".

The governance systems of ICAO are clearly relevant to the challenges posed today by this digital revolution, but the mechanisms must be revised to adapt to current reality. The concept of a trust framework accomplishes that in a fairly conventional way. It suggests that provisions be developed regarding digital identity and trust, which States would then use to establish a mechanism to issue digital certificates. Platforms or entities that need to be trusted would require a digital certificate to gain access to the aviation system to exchange information for the execution of their specific mission. Digital certificates could be issued for manned and unmanned aircraft, aircraft components, electronic flight bags, air navigation services providers (ANSPs), airport operators and ground handlers, manufacturers, repair stations, commercial spacecraft, and other players interacting in the aviation realm.

Currently, such digital certificates are already in use for a variety of different purposes all over the world. There is a massive and mature global system which exists that enables digital certificates to be issued, revoked, recognized and exchanged. A trust framework concept for aviation would not only take advantage of this mature system, but would apply more robust standards of governance that are consistent with the construct of the Chicago Convention. In the commercial world, digital certificates are issued by companies known as Certificate Authorities (e.g., Microsoft, Comodo, VeriSign). These companies are considered the source of trust. In the international civil aviation trust framework, while such companies could perform the routine issuance and management of digital certificates, they would have to do so under the authority of a Member State. It is that connection to a sovereign authority, and the application of ICAO standards, that will permit global recognition and ensure global interoperability.

Operationalizing a Trust Framework

The issuance and maintenance of a system of digital identities and certificates is extremely important, but alone it is not sufficient to ensure interoperability, safety, and resiliency. To achieve that, ICAO will have to develop a private aviation Domain Naming System (DNS) that could be applied across the aviation ecosystem. It would define
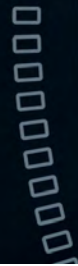
naming conventions for all the items that will be connected to an aviation trust network now or in the future. This is very conventional ICAO work, and in many ways it could be considered a "digitization of Annex 7 — *Aircraft Nationality and Registration Marks*", but applied to other components of the aviation system. This naming schema would have to address all of the operational components of the global aviation system that would communicate securely on a network. Once established, the aviation DNS would operate as a private service. This means that a web search on the public internet could not send an uncertified user to an aviation operational server or an airline operation center. This would reduce exposure to a variety of potential attacks and improve the efficiency of the aviation telecommunications network. This is a proven approach used by many States, global corporations, and the SWIFT/IBAN financial network.

To make this new private aviation DNS function, ICAO would have to ensure that a system of redundant and geographically-dispersed aviation DNS servers are in place to support operations. It would also have to ensure that a central exchange service is put in place to allow digital certificates issued under the authority of one State to be exchanged and recognized by others in real time. Fortunately, these functions are not technologically challenging, and a variety of mechanisms exist to provide these services. These decisions can be taken incrementally, using the normal ICAO governance processes, as the critical work progresses.

Enhancing Resiliency against Cyber Threats and Network Performance

The best practices of industry and financial institutions suggest that ICAO should pursue an additional layer of protection for aviation networks on behalf of all of its users. A private aviation DNS makes it difficult for external users

to stumble into the aviation network, but a private Internet Protocol version 6 (IPV6) address block reserved for aviation would provide another powerful layer of protection when using the public internet infrastructure. For such an addressing block to be allocated to aviation, a request would need to be made to the Internet Corporation for Assigned Names and Numbers (ICANN). The reduction in the threat surface and enhanced resiliency contributed by this action cannot be overstated. Once this block is allocated, commercial routers all over the world would incrementally update their firewall rules to ensure that traffic being directed to this private address block, from sources outside the aviation community, would be automatically dropped. Effectively, this private aviation addresses allocation would result in a massive army of free sentries defending the perimeter of the aviation network. With the use of this private address block, airlines, airports, ANSPs and the new entrants to the aviation community that have to protect themselves against daily intrusions, would be able to reduce the number of attacks by several orders of magnitude. ICAO is intent on pursuing this level of protection on behalf of the global aviation community.

The Consequences of Inaction

It is critical to understand that the digital transformation of the aviation system is happening now, and will continue to take place. The question is whether this transformation proceeds in a coordinated fashion that enhances interoperability and reduces the threat surface or not. Telecommunication service providers, aircraft manufacturers, and avionics producers are all putting in place their own systems of identity and trust as a matter of necessity. This means that in the near future, an aircraft may need different digital certificates to communicate with its satellite communications provider, retrieve data from the airline operations center, update its

avionics, download engine monitoring data and other functions. The potential number of proprietary secure links is nearly endless. This patchwork of disparate efforts to reduce the threat surface to air and ground operations will add complexity to the system that will be costly to maintain and will offer a myriad of gaps for adversaries to exploit.

Similar problems are already being encountered on the ground as ANSPs, airports, and other service providers attempt to exchange information as outlined in the Global and Regional Air Navigation Plans (GANP/ANP) through system-wide information management (SWIM). States and regions that have mature SWIM implementation plans are putting in place their own internal systems of identity and trust to allow them to operate. These systems will not be able to connect to internal or external entities to the aviation community unless ICAO puts into place mechanisms for certificates to be exchanged and recognized at a global level.

It is also important to note the opportunity that is about to be lost regarding the new entrants into the system. Across the world, several Civil Aviation Authorities are responding to the massive influx of UAS. Many are putting in place registry systems and there are ongoing debates around the possibility of an electronic identification system. In the absence of direction from ICAO, manufacturers and States will take different approaches. If ICAO outlines a globally acceptable system of identity and trust, it is likely to be embraced by many or all. This would, in turn, channel the innovation necessary to drive this emerging industry in the direction of interoperability and increased levels of safety in a connected environment.

Another long-term consequence of inaction would be a tacit shift of authority from States to industry. The digital certificates which will make the aviation network secure

and functional may be issued and revoked without the knowledge or participation of States that approve the aircraft designs, maintenance and services. If ICAO acts soon, and in cooperation with the internet governing bodies, the processes used by industry and States will naturally converge and become supportive of one another. For example, an aircraft that is registered in one State may not be authorized a digital certificate by another State. Early action would offer the opportunity to strengthen and modernize the fundamental mechanisms of the Chicago Convention; whereas inaction would cause those mechanisms to be overshadowed.

Implications of Action

There are many aspects of the concept of a trust framework that appear daunting, and it will take years for the full operational vision to be realized. However, substantial benefits will be realized long before the system becomes fully operational. At this moment, the entire aviation community is responding to the increase in cyber threats with different and uncoordinated actions. This divergence, and its effect on interoperability, is crucial for the aviation system. It is envisioned that this divergence will begin to reverse itself when ICAO announces its intentions, rather than when the system goes into operation. Once it is clear that ICAO will put in place systems to establish and share trust, a domain naming system, and an addressing system, industry will start planning and architect their systems to accommodate this more rational and efficient approach. Convergence will begin when the end-point is agreed to, and States have already expressed agreement that ICAO should lead the way.

New Entrants in
Lower Level Airspace

The unmanned aircraft system (UAS) industry continues to expand at the speed of innovation. Economic prospects as to how unmanned aircraft (UA) operations enhance business, enhance safety during precarious operations, or how they facilitate relief during natural disasters add to the growing list of potential uses for the industry, and there are many more. The challenge for all UA operations is that this burgeoning potential surpasses the ability of ICAO and civil aviation authorities to provide the regulatory framework necessary to enable operations in all classes of airspace.

It has taken years to build the safe and reliable global aviation system we know today which focuses on manned aviation. ICAO is working to integrate remotely piloted aircraft systems (RPAS) into this traditional environment, an activity focused on expanding without disrupting the carefully organized aviation system.

Concurrently, the far more rapid development of UAS conducting low-level operations must be addressed. This includes recreational drones as well as the vast numbers that conduct professional and commercial operations. This poses the question of how do we step up our ability to forge UAS integration in a way that respects our aviation heritage, yet enables UAS operations in a dynamic new environment?

One step is to segment low and medium risk UAS operations from those presenting a higher risk to third parties. From UA to supersonic aircraft, whether manned or remotely piloted, all are expected to comply with published requirements when operating in airspace where such requirements have been established. Yet, a portion of UA operations occur at lower altitudes. These operations facilitate many activities with limited impact to manned aviation or to people and property on the ground. Alignment with performance-based standards and assessments that lessen or mitigate associated risks could render a process that enables certain low-level unmanned operations.

By identifying operations that meet the criteria for low risk operations in lower level airspace, harmonized guidance material can be issued with limitations similar to those commonly provided for model aircraft. Examples include recreational flying, agricultural applications or infrastructure inspections where third parties, in the air or on the ground, are not affected. Medium risk operations might include infrastructure inspections where third parties may be in close proximity or beyond visual line-of-sight (BVLOS) operations in remote areas, such as delivery of humanitarian supplies at low level where little aviation occurs. The concept of operations (CONOPS) for each and every operation will be essential in describing the activity and for the Civil Aviation Authority (CAA) to determine the level of risk and whether adequate mitigations have been put in place.

This does not infer a free-for-all operational environment without scrutiny. For example, in humanitarian deliveries, safety requirements for the carriage of hazardous cargo must be followed. This type of operation will require a review by the CAA as well as necessary authorization.

The guidance material, however, for low-to-medium risk operations in lower level airspace can allow flexibility and will ensure safe operations.

Other challenges for full integration of unmanned aircraft remain for future consideration. "Flying taxi" operations (urban air mobility), operations of unmanned aircraft over crowds or cargo operations in densely populated areas will require careful evaluation and are likely to be fully regulated.

Until the requirements for full integration of higher risk UAS operations are matured and implemented through the development of SARPs, ICAO will continue its work to build an efficient system that identifies and tracks UA in the airspace providing a viable framework for unmanned aircraft at large. This effort will ensue until optimization is completed. In the short term, enabling low-to-medium risk operations as previously described is a reasonable first step. This will, in turn, assist Member States by not only providing direction, but support the formulation of national UAS regulations.

Notes:

ICAO

International Civil Aviation Organization
999 Boulevard Robert-Bourassa
Montréal, QC, Canada
H3C 5H7

Tel.: +1 514-954-8219
Fax: +1 514-954-6077
Email: info@icao.int

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