IATA Annual Safety Report - 2024 Recommendations for Accident Prevention

61st Edition

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1. Acronyms

ACTF	Accident Classification Task Force
AFM	Aircraft Flight Manual
AHM	Airport Handling Manual
AI	Artificial Intelligence
AIP	Aeronautical Information Publication
AIRAC	Aeronautical Information Regulation and Control
ANSPs	Air Navigation Service Providers
AOV	Areas of Vulnerability
AP	Autopilot
API	Application Programming Interface(s)
APV	Approaches with Vertical Guidance
ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air Traffic Control
ATCOs	Air Traffic Control Officers
ATS	Air Traffic Service
CANSO	Civil Air Navigation Services Organisation
CAST	Commercial Aviation Safety Team
CBTA	Competency-Based Training Assessment
CBT	Computer Based Training
CDFA	Continuous Descent Final Approach
CFIT	Controlled Flight into Terrain
CG	Centre of Gravity
CICTT	Commercial Aviation Safety Team/ICAO Common Taxonomy Team
CRM	Crew Resource Management
CRPA	Controlled Reception Pattern Antennas
CTOL	Collision with Obstacle(s) during Take-Off and Landing
D4S	Data for Safety
DIP	Detailed Implementation Plan
EASA	European Aviation Safety Agency
EBT	Evidence Based Training
EFB	Electronic Flight Bag
EGPWS	Enhanced Ground Proximity Warning System
EMAS	Engineered Materials Arresting Systems
FAA	Federal Aviation Administration
FCOM	Flight Crew Operating Manual
FDM	Flight Data Monitoring
FDX	Flight Data eXchange
FMS	Flight Management System
FOD	Foreign Object Debris
FOQA	Flight Operational Quality Assurance
FSTD	Flight Simulation Training Devices
GAPPRE	Global Action Plan for the Prevention of Runway Excursions
GM	Guidance Material
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRASP	Global Runway Safety Action Plan

GRF	Global Reporting Format
GSPs	Ground Service Providers
HCD	Human-Centered Design
HF	Human Factor
HFTF	Human Factors Task Force
HP	Human Performance
I-ASC	Aviation Safety Culture Survey
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDM	Inflight Decision-Making
IFALPA	International Federation of Air Line Pilots' Associations
IFATCA	International Federation of Air Traffic Controllers' Associations
IGOM	Ground Operations Manual
ILS	Instrument Landing Systems
IOSA	IATA Operational Safety Audit
IRS	Inertial Reference Systems
ISAGO	IATA Safety Audit for Ground Operations
ITAR	International Traffic in Arms Regulations
LOC-I	Loss of Control In-flight
LOSA	Line Operations Safety Audit
MAC	Mid-Air Collision
MSA	Minimum Safe Altitude
NOTAM	Notice to Airmen
OEM	Original Equipment Manufacturer
OFP	Operational Flight Plan
OIPR	Opposite Initial Pilot Response
OSNMA	Open Service Navigation Message Authentication
PBN	Performance-Based Navigation
PF	Pilot Flying
PFD	Primary Flight Display
PM	Pilot Monitoring
PTTF	IATA Pilot Training Task Force
QRH	Quick Reference Handbook
RA	Resolution Advisory
REs	Runway Excursions
RFI	Radio Frequency Interference
RNAV	Area navigation
SARPS	Standards and Recommended Practices
SBT	Scenario-based training
SID	Standard Instrument Departure
SMS	Safety Management System
SOPs	Standard Operating Procedures
SPIs	Safety Performance Indicators
SPT	Safety Performance Targets
SRA	Safety Risk Assessment
SVS	Synthetic Vision Systems
TA	Traffic Advisory
TAWS	Terrain Avoidance and Warning System
TCAS	Traffic Collision Avoidance System

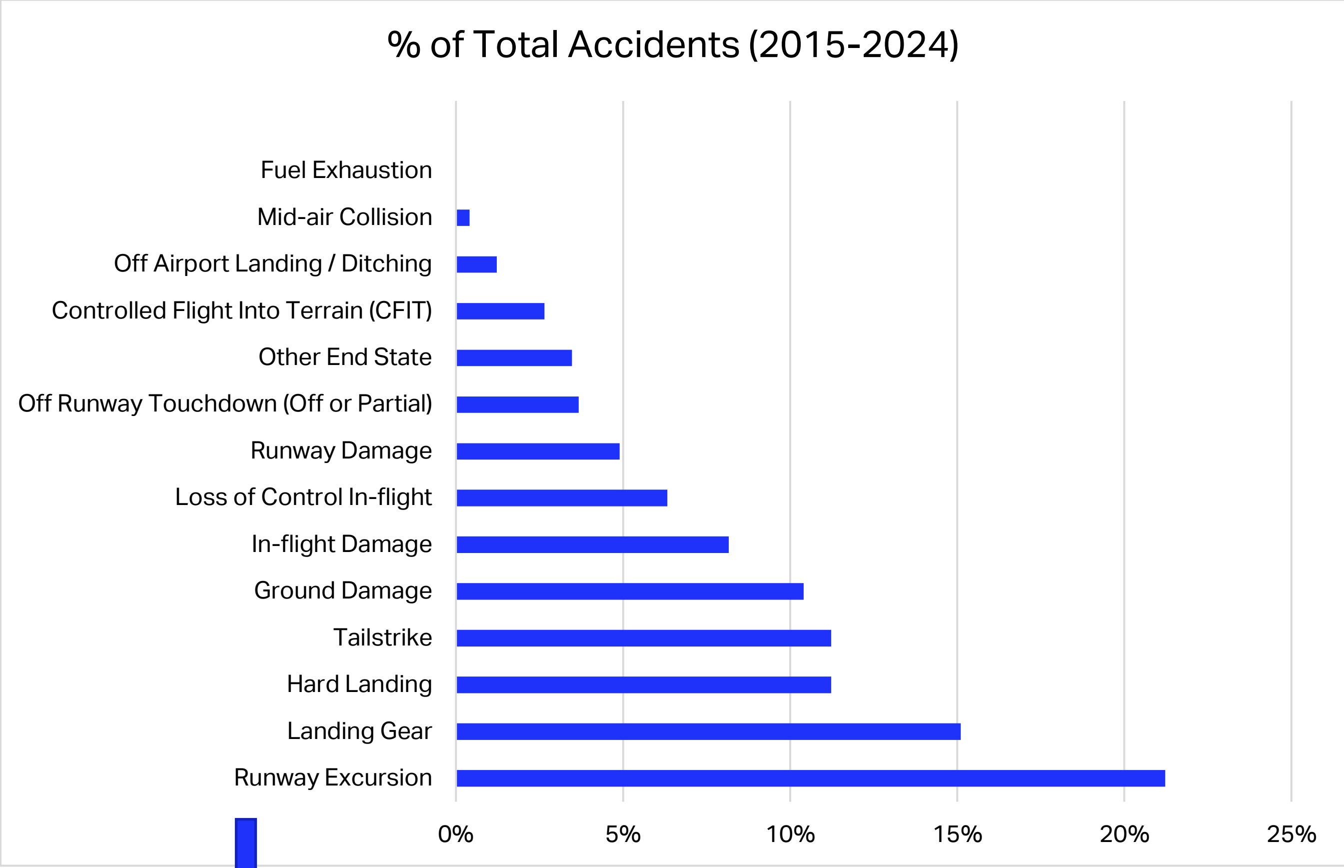
TDB	Terrain DataBase
TEM	Threat and Error Management
UAs	Unstable Approaches
UAS	Undesired Aircraft State
USOAP	ICAO's Universal Safety Oversight Audit Programme
UPRT	Upset Prevention and Recovery Training
VASIS	Visual Approach Slope Indicator System
VGSI	Visual Glideslope Indicator
WMO	World Meteorological Organization

2. Overview

This document, which contains recommendations on certain end states and contributing factors, was developed by the International Air Transport Association Accident Classification Task Force (IATA ACTF). This document comprises recommendations to minimize the likelihood of an accident. It contains background information and explanations to support the recommendations.

2.1. Top Findings: 2015-2024

Covering 10 years, the 2015-2024 Accident End State Distribution, as a percentage of the total, as assigned by the IATA ACTF. The highest percentage of accidents from 2015-2024 was Runway Excursions with 21% of total accidents.



Runway Excursion	**104**
Runway Excursion Lateral	54
Runway Overrun	47
Unknown	3

The accident End States with associated fatalities in 2024 were:

- Other End State[1] (4), claiming 182 on-board fatalities. This accident category also includes on-board fatalities with minor damage
- Loss of Control In-Flight (1), claiming 62 on-board fatalities
- Runway Damage (1), claiming 5 Other fatalities
- Mid-Air Collision (1), claiming 2 Other fatalities

With a full breakdown of each accident end state, the table below provides an overview of 2024's performance compared to the five-year average:

2.2. 2024 Vs. 2020-2024 accidents

	2024	Comparison vs 5y	5Y Average (2020-2024)
Number of accidents	46	▲	39
Number of fatal accidents	7	▲	5
Number of total onboard fatalities	244	▲	144
Accident rate	1.13	▼	1.25
Fatality risk	0.06	▼	0.10
% of accidents involving IATA members	54%	▲	45%
% of aircraft propulsion – Jet	76%	▲	70%
% of aircraft propulsion – Turboprop	24%	▼	30%
% of the type of operations – Passenger	72%	▲	71%
% of the type of operations – Cargo	28%	=	28%
% hull losses (jet and turboprop)	20%	▼	22%

[1] **The Other End State is used where:**

- **Information available at the ACTF meeting was not enough to determine the accident end state. For example:**
  - **Aircraft is missing,**
  - **The investigation is still ongoing or report not available and the ACTF is unable to assign an end state classification**
- **The End State does not fit into other categories**

In this document, IATA ACTF members have updated recommendations for Loss of Control In-flight (LOC-I), Controlled Flight into Terrain (CFIT), Runway Excursions (REs), Tail Strike, Hard Landing, Off Runway Touchdown (Off or Partial), In-flight Decision Making (IDM) and Contingency Management, and Human Factors. Additionally, new recommendations have been added for Off Airport Landing/Ditching, Runway Damage, In-Flight Damage, and Landing Gear. The End States in the following sections are not presented in any particular order.

Please note that this document is periodically updated to ensure that the most current information and practices are in place.

3. Loss of Control In-flight (LOC-I)

3.1. Background

LOC-I represents a critical category of aviation accidents, characterized by the loss of aircraft control while inflight or deviation from the intended flight path. LOC-I accidents are particularly concerning due to their potentially severe consequences, emphasizing the critical need for comprehensive safety measures and preventive strategies within the aviation industry.

Various factors contribute to LOC-I. These factors can range from mechanical failures, adverse weather conditions, maintenance events, or human performance deficiencies such as but not limited to: inappropriate energy management, inappropriate automation management, spatial disorientation, weakness in monitoring, etc. Understanding the nature of these factors is crucial for developing effective strategies to mitigate the risk of LOC-I accidents.

IATA recognizes the importance of mitigating LOC-I accidents and is prioritizing the development and implementation of effective intervention strategies.

3.2. Discussion

Despite accounting for a relatively small percentage (6% or 31) of all aviation accidents (490) over the past 10 years (2015-2024), LOC-I is a significant contributor to fatal accidents and fatalities. This category, accounting for 41% (27) of all fatal accidents (66), 55% (995) of total onboard fatalities (1,825), and 11% (8) of other fatalities (72), stands out as the leading cause of fatal accidents among all accident end states. The statistics underscore the critical need for focused attention on LOC-I prevention.

In 2024, there was one fatal LOC-I accident, resulting in 62 fatalities, where the aircraft crashed in Vinhedo, São Paulo State, Brazil. Figure 1 depicts the number and rates of fatal and non-fatal LOC-I accidents, while Figure 2 presents the LOC-I fatal accidents and the associated number of fatalities over the last 10 years.

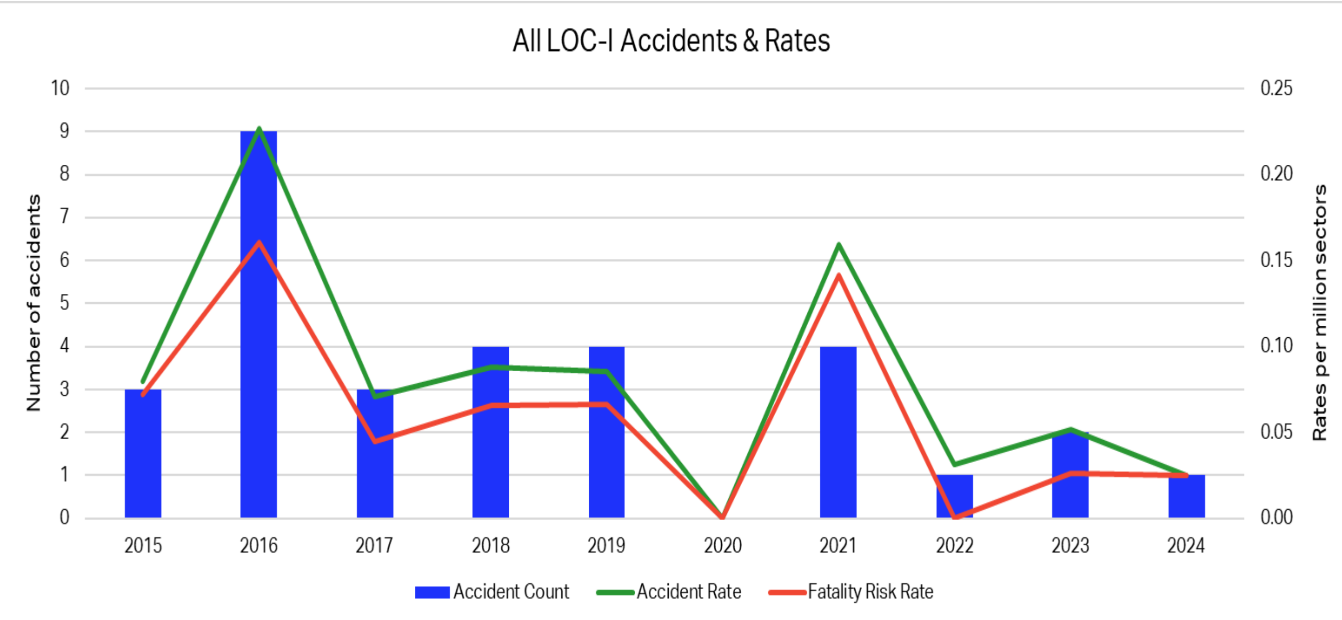


Figure 1: LOC-I Accidents

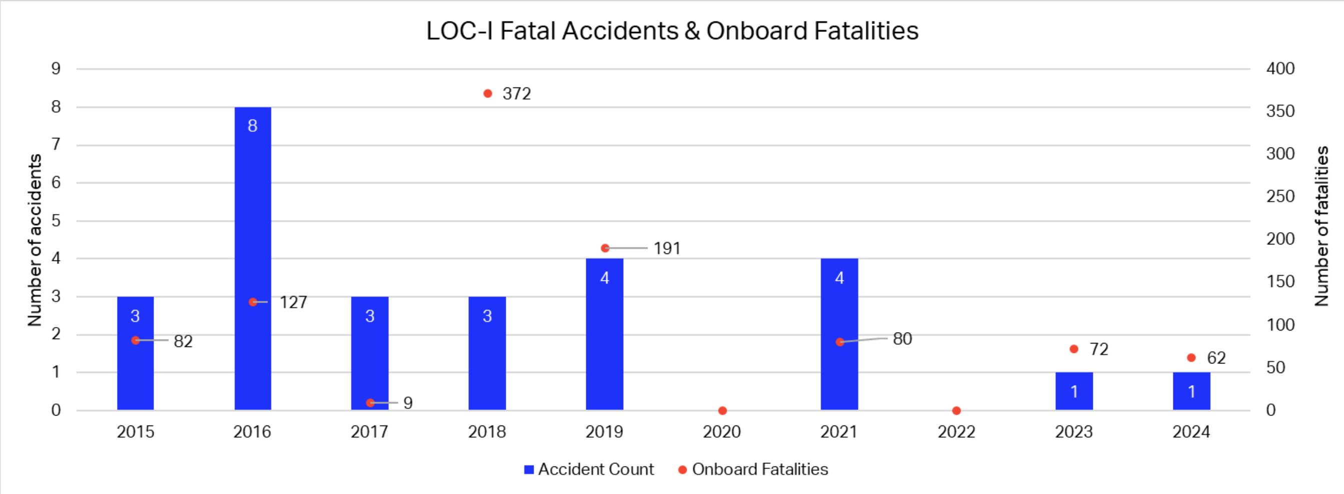


Figure 2: LOC-I Fatal Accident & Onboard Fatalities

Great progress over recent years was achieved by training pilots in the prevention, recognition, and recovery of aircraft upset conditions. The Upset Prevention and Recovery Training (UPRT) represents an essential mitigation measure to address and reduce LOC-I accidents. Although these accidents are known to be low in numbers, they are indeed the leading cause of fatalities in commercial aviation. Recognizing the severity of LOC-I, IATA strongly recommends that the regulators and the industry to consistently implement International Civil Aviation Organization (ICAO) UPRT provisions and IATA best practices accessible here.

While acknowledging the expansion of the UPRT requirements within the States' regulations, IATA recognizes that there is still room for improvement in upset situation prevention and recovery. For instance, emphasizing flight path management monitoring for both pilot flying and pilot monitoring during all phases of flight is essential for upset prevention, applying the standard call out if a flight path deviation occurs is essential for upset recognition and recovery. Moreover, improvements could be made by implementing technologies that assist pilots in recovering the Undesired Aircraft State (UAS). This could involve features such as aural alerts and/or visual indications on the Primary Flight Display (PFD), guiding the pilot on how to fly the aircraft out of the UAS.

An already existing approach could be the enhancement of Synthetic Vision Systems (SVS), whereby such systems are able to display a representation of the real-world situation, in real-time, in an easy-to-understand way – also beyond the normal flight envelope or even in airplane upset situations. A beneficial effect of this should be the prevention of LOC-I situations or at least a successful recovery.

Due to its diverse range of potential contributing factors, LOC-I does not have a one-size-fits-all solution. Recognizing the severity of the issue, the aviation industry must prioritize comprehensive strategies, encompassing training, technology, and procedural enhancements.

In 2024, IATA conducted a comprehensive study in collaboration with industry partners to review LOC-I accident data and available industry materials. The group convened virtually numerous times to analyze the contributing factors to LOC-I events, categorizing them into three distinct categories. Recognizing the importance of this topic, the group adopted a phased approach, initially focusing on environmental conditions and human factors. This study led to the publication of the Loss of Control - Environmental Conditions Safety Risk Assessment (SRA).

The categorization of the contributing factors is the following:

- The Environmental Conditions:
  - Aircraft operates in adverse weather conditions;
  - Aircraft encounters severe thunderstorm/convective activity/windshear;
  - Turbulence;
  - Operating in cold weather conditions – incorrect de-icing (including incorrect de-icing fluid application and use of incorrect fluid type), in-flight procedure for encountering icing conditions;
  - Operating in hot conditions – low air density at high altitude;
  - Equipage of aircraft – advanced weather radar – fitment and how flight crew use;
  - Provision of weather information from Meteorological Service Providers – issues with accuracy / completeness;
  - Obsolete/old technology in Air Traffic Service (ATS) units for weather forecasting and sometimes old technology on board aircraft.

- The Systemic /Human Performance
  - Flight crew - human performance, fatigue, mindset (cognition) – Situational Awareness. (perception, comprehensive, projection), operational pressure ;
  - Incorrect handling of the aircraft not in accordance with Standard Operating procedures (SOPs) / Aircraft Flight Manual (AFM) / Flight Crew Operating Manual (FCOM) E.g. Autopilot (AP) disconnected intentionally during severe turbulence;
  - Pilot and flight management monitoring;
  - Transition between manual / automated flight;
  - Flight crew become incapacitated (medical or due laser illumination);
  - Limitations of Computer Based Training (CBT) training vs classroom training – how is effectiveness monitored;
  - Competency (Knowledge, Skills, and Attitude) – emphasis also on accurate competencies during the recruitment phase.

- Aircraft Technical
  - Cockpit design that induces flight crew errors / Substitution errors (or Cockpit confusion) (e.g. flap / gear lever position);
  - Aircraft departs with mass/balance (CG) out of limits (loading/load distribution)
    - Erroneous or incomplete data entered into the Flight Management System (FMS);
  - Aircraft departs with blocked pitot tubes (insects/covers) leading to incorrect or misleading airspeed displayed to flight crew;
  - Aircraft experiences significant technical failure in flight (related to flight surfaces, flight controls);
  - Single/Dual/Multiple In-Flight Engine Shut Down;
  - Maintenance Practice;
  - Modern envelope protection or smaller operators that may have not implemented UPRT or other recommendations
    - To what extent has UPRT been implemented? How effective is it?
    - Regulatory framework does not contain the UPRT requirements, and some States have not yet introduced those at rule level,
    - Regulatory framework does contain the UPRT requirements, but the operators have not (or badly) implemented the UPRT requirements.

3.3. Recommendations

3.3.1 Operator Safety

- Implement an effective Safety Management System (SMS), including procedure for hazards identification and mitigations.
- Implement and monitor Flight Data Monitoring (FDM) trigger to predict a LOC-I trend.
- Enable and evolve a positive Safety Culture including a robust just culture.
- Complete a risk assessment for Loss of Control, tailoring IATA's generic risk assessment to airlines' own operation, and regularly review it.
- Consult with the LOC-I SRA and its recommendations.

3.3.2 Operator Training

- Implement the latest best practices regarding Upset Recovery and Prevention Training (UPRT).
- Provide ground training as well as flight training in Flight Simulation Training Devices (FSTD) to flight crew on a regular basis to maintain flight crew awareness about:
  - The causes and contributing factors to upset and LOC-I;
  - The flight crew countermeasures to prevent and recover from upset;
  - Environmental hazards;
  - Aircraft aerodynamics;
- Perform scenario-based training and maneuver training focusing on:
  - Flight path management manual control and automation management;
  - Energy management;
  - Adverse weather conditions management;
  - Aircraft system malfunctions management including engine failures;
  - Flight path monitoring including flight path deviations recognition and intervention;
  - Upset recovery procedures;
- Use FSTD to train flight crew to manage the risks associated with various environmental hazards, including adverse weather.
- Provide theoretical and practical training to flight crews in the effective use of weather radar systems applicable to their type of aircraft, including advanced weather radar functions and its limitations.
- Use scenario-based training (SBT) in FSTDs representing their specific operational environment.
- Describe in the airline operations manual a Threat and Error Management (TEM) based decision-making process to be applied by the flight crew in operations.
- For SBT as part of competency-based training and assessment (CBTA) and evidence-based training (EBT), operators should use operational and training data (including Flight Operational Quality Assurance [FOQA]/FDM data) to create realistic training scenarios, considering the FSTD fidelity, flight crew feedback, and human performance aspects.
- Consult with the LOC-I SRA and its recommendations.

Note: The FSTD training should be completed within the validated training envelope of the FSTD equipped with Extended Envelope Package (EEP) features or approved for UPRT.

3.3.3 Airline Operations

3.3.3.1 Airline Operations (Flight Standards)

- The operator policy should define:
  - The TEM concept and mandate its application by the flight crew during all the phases of the flight. The systematic application of TEM should enable the flight crew to anticipate and mitigate the threats, to detect and correct errors that could lead to undesirable aircraft states precursor to LOC-I;
  - The pilot flying (PF) and pilot monitoring (PM) roles regarding the flight path monitoring and their tasks allocation and prioritization depending on the Areas of Vulnerability (AOV);
  - The conditions (workload, weather, recency etc.) under which the manual flight is encouraged.

Appendix "B" shows an example of airline policy on TEM

3.3.3.2 Airline Operations (Pilots)

- Beyond the training provided by the operator, the pilots should proactively review by referring to the operation manual:
  - Primary flight display indications and the different levels of automation that can be used to manage the flight path;
  - Role of the PF and the PM;
  - Prioritization of PF & PM duties depending on the AOV.
- Consult with the LOC-I SRA and its recommendations.

3.3.3.3 Airline Operations (Dispatchers/Flight Planners)

- The operator should ensure that the Dispatchers/Flight Planners:
  - Have the necessary competence to adapt to any route changes pre-flight, including adjusting at short notice to fuel, weight and balance, and departure/arrival times, based on available and reliable Air Traffic Control (ATC) and weather information.
  - Can provide contingency routes for dynamic rerouting to avoid environmental hazards if required.
  - Are using tools and databases which are valid and adequate for operations.
- The operator should ensure that all dispatch and flight planning programs are included into their SMS.
- Consult with the LOC-I SRA and its recommendations

3.3.4 Air Navigation Service Providers

- Air Navigation Service Providers (ANSPs) should be aware of the provision of alternative departure and arrival routings for operators, whenever possible, in advance of weather developments, traffic patterns, or congestion.
- ANSPs should consult with the LOC-I SRA and its recommendations

4. Controlled Flight into Terrain (CFIT)

This section covers the Enhanced Ground Proximity Warning Systems (EGPWS) system, and how the spoofed Global Positioning System (GPS) signal compromises EGPWS.

4.1. Background

Controlled Flight into Terrain (CFIT) refers to an in-flight collision with terrain, water, or obstacle without indication of loss of control. Analyzing data over the last 10 years, CFIT is the second-most frequent cause of fatal accidents, resulting in 215 on-board fatalities and 35 other fatalities. When looking at the rolling average accident rate for the five years going back to 2011-2015, the average accident rate recorded was 0.13 accidents per million sectors. Today, the five-year (2020-2024) average accident rate has improved to 0.04 per million sectors. It is worth noting the CFIT accident remained at zero in 2024. Figure 3 illustrates the number and rates of CFIT accidents, while Figure 4 presents the CFIT fatal accidents and the associated number of fatalities over the past 10 years.

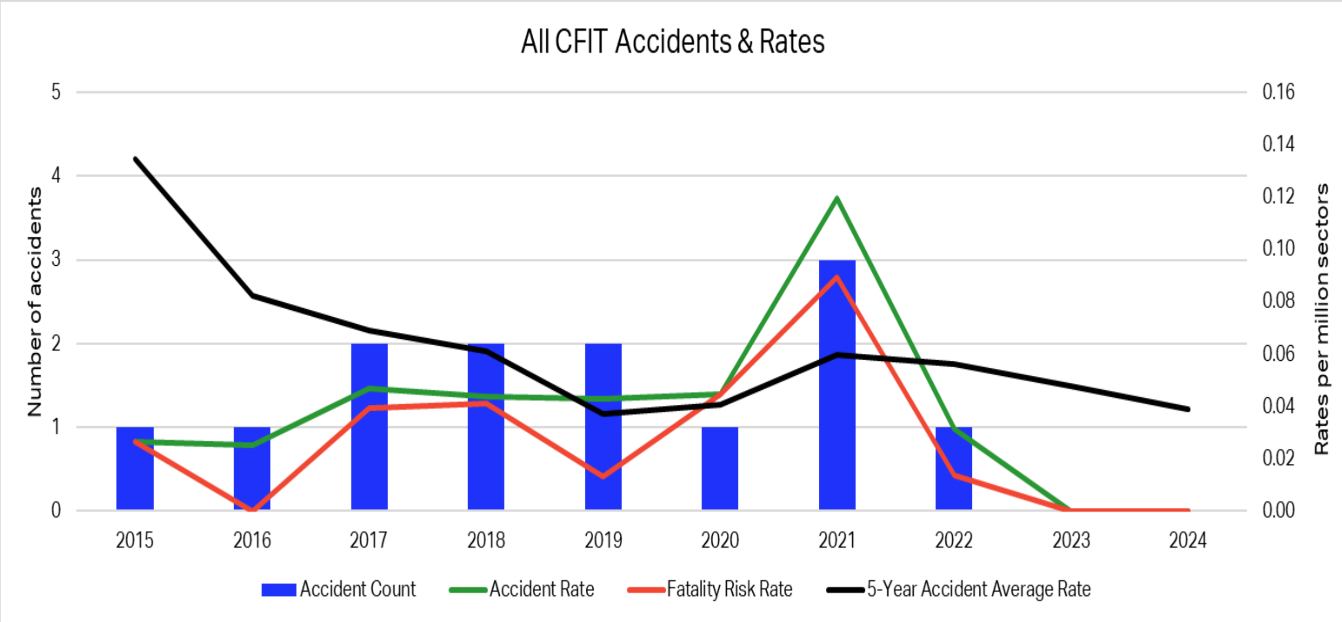


Figure 3: CFIT Accidents

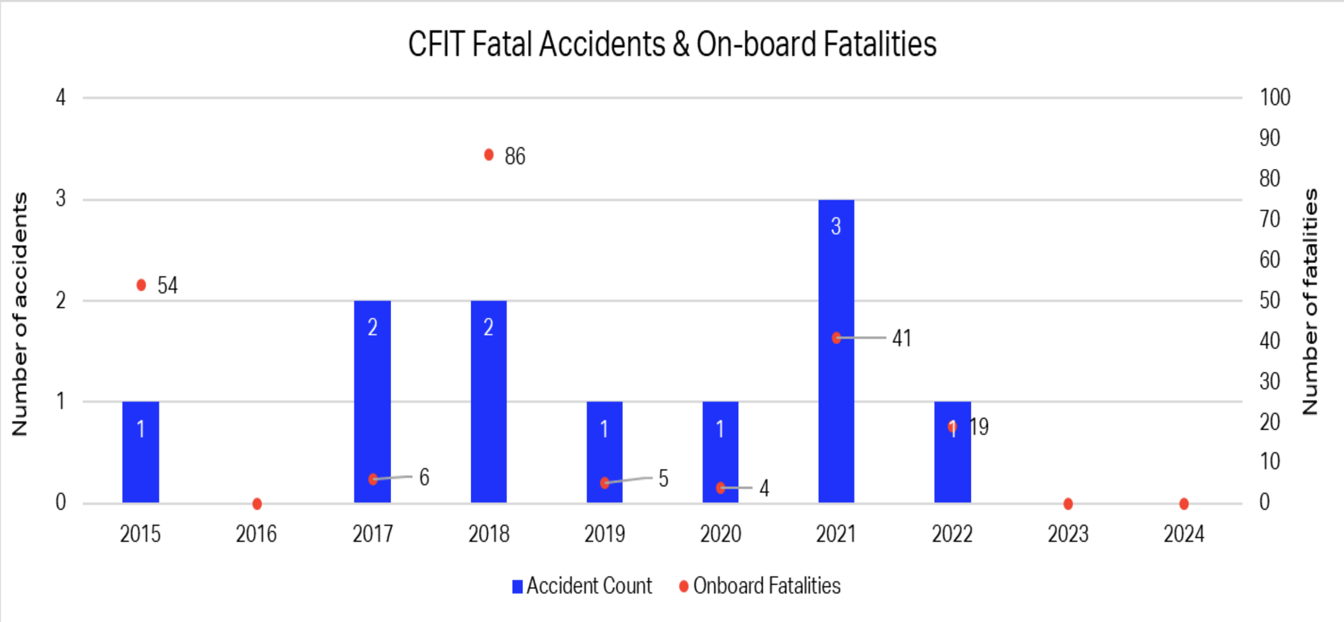


Figure 4: CFIT Fatal Accident & Onboard Fatalities

Today, accident data shows that CFIT accidents are less frequent than a decade ago, and the number of aircraft that have landed safely after an EGPWS or a Terrain Avoidance and Warning System (TAWS) alert is growing every year. Nevertheless, CFIT accidents may continue to occur. Dedication and commitment from leadership and all industry stakeholders, establishing a positive safety culture, as well as technological advances, such as EGPWS and TAWS, have played a role in the reduction of CFIT accidents. These alone do not prevent CFIT accidents; however, the reduction of this accident category requires:

- Efficient flight training to enable better crew performance;
- Enhanced crew resource management;
- Increased situational awareness (including weather conditions);
- Immediate response to EGPWS warnings;
- Updating EGPWS software and Terrain/Obstacle/Runway database in a timely manner;
- Good decision-making and execution.

The industry is aware that the mandate of EGPWS and the immediate response to EGPWS warnings have been proven to be an effective barrier to preventing CFIT accidents when used as intended.

Evidence shows that to obtain the greatest safety benefit from EGPWS and ensure the system remains effective, a call for action by the operators is needed to ensure they update their systems, a task that can be achieved at very little cost. Outdated EGPWS equipment results in persistent nuisance and unwanted EGPWS warnings that could be avoided if the equipment was updated to the latest EGPWS software and Terrain/Obstacle/Runway database available. Recognizing the paramount importance of maintaining up-to-date EGPWS software and Terrain Data Bases (TDB) for aviation safety, IATA took strategic measures and addressed potential risks associated with outdated information. IATA developed a comprehensive Safety Risk Assessment (SRA) to evaluate the validity of the EGPWS database. As a result of this SRA, notable recommendations emerged, including:

- incorporation of the IATA Operational Safety Audit (IOSA) recommended practice FLT 4.2.7 into the standard framework (IOSA Standard Manual). This emphasizes the periodic review of the EGPWS database validity;
- engagement in a collaborative effort with EGPWS manufacturers and avionics suppliers to facilitate easy access to the latest software releases and terrain databases. In 2024, IATA published an informative document "Enhance Access to EGPWS/TAWS Database Information guide", aiming at providing valuable insights to the aviation community that includes:
  - How and where to find the latest EGPWS/TAWS TDB;
  - TDB release schedules;
  - How to view what has changed in the TDB;
  - The link to download the TDB.

IATA has also focused its efforts on increasing awareness of pilot response to EGPWS with guidance material that aims to improve the pilot response rate to EGPWS warnings and reduce further CFIT accidents. Refer to IATA/Honeywell guidance on performance assessment of pilot response to EGPWS.

4.2. Discussion

Although CFIT accidents are relatively few in number, their outcomes are almost always catastrophic, often resulting in a high number of fatalities. Consequently, IATA will continue to identify risks through its Flight Data eXchange (FDX) and other monitoring programs; and contribute to reducing the number of accidents by raising awareness of the precursors and promoting safety measures.

Accident data indicates that a significant number of CFIT accidents occur during the approach and landing phases of flight. Implementing precision approaches or Performance-Based Navigation (PBN) approaches are effective methods to reduce the risk of CFIT accidents. Therefore, authorities and operators are encouraged to comply with ICAO recommendations and guidelines regarding PBN implementation, particularly Approaches with Vertical Guidance (APV).

Installation of lighting systems such as a Visual Glideslope Indicator (VGSI) or a Visual Approach Slope Indicator System (VASIS) are other methods to promote a Continuous Descent Final Approach (CDFA) technique that will help contribute to a stabilized approach.

Additionally, as more baro-VNAV approaches are flown, IATA has recognized the elevated risk of CFIT due to altimeter mis-set. When the altimeter setting is incorrect, it can guide the actual aircraft altitude below what is indicated on the altimeters in the flight deck. The vertical deviation indication may show zero deviation while the actual aircraft altitude can be significantly below the designed approach path.

The most common contributing factors are:

Latent conditions	Deficient regulatory oversight or lack of thereof Absent or deficient safety management Absent or deficient flight ops SOPs and Checking Technology and equipment not installed
Threats	Meteorology, including poor visibility / IMC Lack of visual reference Air Traffic Services Ground-based navigation aid malfunction or not available
UAS	Controlled flight towards terrain Unnecessary weather penetration Vertical / lateral / speed deviation Unstable approach
Errors	SOPs non-compliance Not executing a go-around Manual handling errors Lack of callouts including omitting departure, take-off, approach, or handover briefing
Countermeasures	Monitor / cross-check Inflight decision-making/contingency plan Overall crew performance Leadership, captain should show leadership, and First Officer should be assertive when necessary

Incorrect altimeter settings or signal interference with onboard navigation systems have also been cited as contributing factors to aircraft altitude or position errors that may lead to CFIT.

In support of the IATA/Honeywell guidance on performance assessment of pilot response to EGPWS guidance document, IATA has developed a CFIT Detailed Implementation Plan (DIP) and is working with airlines, Original Equipment Manufacturers (OEMs), international organizations and other relevant stakeholders to see they are applied. This DIP can be found here:

- Facilitates the execution of the proposed recommendations;
- Identifies and communicates with the concerned resources for the execution of the plan;
- Reports progress against the plan;
- Measures the implementation and the effectiveness of the plan.

4.2.1 What Is Required from Operators?

4.2.1.1 Safety Management System

- Dedication and commitment from leadership and all industry stakeholders;
- Establish a positive safety culture;

- Encourage operators to use FOQA data to monitor proper responses by the flight crew to EGPWS events;
- Increase awareness and visibility of the implications of deviating from established procedures;
- Consult with and promote the Performance assessment of EGPWS Guidance Material (GM) and its recommendations.

4.2.1.2 Training

- Training departments should perform gap analysis against the latest EGPWS training GM available from IATA, European Aviation Safety Agency (EASA), Federal Aviation Administration (FAA), ICAO, OEMs, and others;
- Enhance flight crew training by implementing Competency-Based Training Assessment (CBTA) to include an Evidence-Based Training (EBT) program;
- Consult with the Performance assessment of EGPWS GM and its recommendations.

4.2.1.3 Flight Operations

- Use of terrain display and access to the latest information on weather conditions to enhance full situational awareness and ensure a timely and appropriate pilot response;
- Encourage pilots to report instantly to the relevant ATC units and authorities all incidents related to GPS or radio altimeter anomalies;
- Encourage flight crew to immediately respond to an EGPWS warning;
- Consult with and promote the Performance assessment of EGPWS GM and its recommendations;
- Consult with the "Enhance Access to EGPWS/TAWS Database Information guide", to obtain information on how to access the latest EGPWS/TAWS TDB.

4.2.1.4 Technical Operations (Engineering and Maintenance)

- Ensure the EGPWS software/terrain database is kept up-to-date and highlight the safety benefits that can be obtained by keeping the software/database up-to-date;
- Ensure the use of GPS/ Global Navigation Satellite System (GNSS) for the position source to EGPWS;
- Consult with the Performance assessment of EGPWS GM and its recommendations.

4.2.2 What Is Required from the Manufacturers' Perspective?

- Ensure the timely update of the EGPWS software and Terrain/Obstacle/Runway database.
- Consult with and promote the Performance assessment of EGPWS GM and its recommendations.

4.2.3 What Is Required from Pilots?

- Situational awareness must be always maintained. The EGPWS is NOT to be used as a primary reference for terrain or obstacle avoidance and does NOT relieve the pilot from the responsibility of being aware of the surroundings during flight;
- Pilots are directly responsible and are the final authority as to the operation and safety of the flight. They are responsible for terrain, other aircraft, and obstacle clearance and separation;
- Once the pilot is cleared to conduct a visual approach, the pilot has full responsibility to maintain separation from terrain and obstacles. Safe separation from the terrain, obstacles and other aircraft must be maintained throughout the flight by using accurate navigation, especially during take-off, descent and final approach, including briefings and proper checks;

If pilots are unable to maintain terrain/obstacle clearance or separation, the controller should be advised, and pilots should state their intended actions.

- Through thorough briefing, the flight crew would be able to know:
  - The main features of the departure route, descent, approach and missed approach;
  - Terrain and hazard awareness, including weather conditions.
- Briefings should include:
  - Significant terrain, obstacles and other hazards, such as weather along the intended departure route;
  - Standard Instrument Departure (SID) and Minimum Safe Altitude (MSA).
- The approach briefing should include:
  - Descent profile management and energy management;
  - Terrain awareness and approach hazard awareness, including weather conditions;
  - Elements of unstable approach (UA) and missed approach procedures;
  - MSAs and other applicable minimums (visibility, runway visual range, cloud base);
  - Go-around altitude.

To conduct a safe go-around, advance preparation and a comprehensive crew briefing are essential components of risk mitigation. Operators should encourage flight crews to implement a TEM arrival briefing that includes aspects regarding the prescribed missed approach procedure and any threats, such as at airports surrounded by high terrain (with higher required climb gradients), aircraft performance in case of a one-engine inoperative situation, or a balked landing.

4.3. Recommendations

- Ensure EGPWS software and Terrain/Obstacle/Runway database are kept up-to-date.
- Consult the Enhance Access to EGPWS/TAWS Database Information guide" to obtain information on how to access the latest EGPWS/TAWS Terrain Database.
- Ensure GPS/GNSS is used as a position source for the EGPWS.
- Ensure a policy is in place that at least one pilot selects terrain display during critical phases of flight. (such as climb and descent below MSA) for additional situational awareness. If the weather is not a threat, then both pilots could decide to select terrain display.
- Establish a training program to ensure the flight crew is trained to respond to EGPWS alerts effectively.
- Operators should have procedures to ensure EGPWS equipment always remains activated and serviceable.
- Pilots and operators should promptly notify the respective authorities of the interference location and the relevant ATC if they experience GPS or radio altimeter anomalies.
- Consult the IATA/Honeywell Performance assessment of pilot response to EGPWS guidance material (GM) and recommendations.
- Ensure procedures are in place to minimize incorrect altimeter settings. If possible, incorporate altimeter error alerting system on the flight deck.
- Collaboration among OEMs, and other relevant stakeholders, to standardize the release schedule of the terrain data updates in accordance with the Aeronautical Information Regulation and Control (AIRAC) Cycle, in accordance with ICAO guidance.
- Operators, during aircraft purchase/leasing contract negotiations, should consider including EGPWS database updates (as mentioned above) within the commercial contract.
- Discrepancies between Aeronautical Information Publication (AIP) and TDB content should be immediately notified to service providers.

4.4. Global Navigation Satellite System (GNSS)

Global Positioning System (GPS) spoofing, a form of interference where false Global Navigation Satellite System (GNSS) signals mimic legitimate ones, has emerged as a significant threat to aviation safety. The rapid escalation of spoofing incidents in 2024 highlights its growing prevalence and potential to undermine safety systems such as the EGPWS. By generating false GPS position data, spoofing can mislead navigation and warning systems, increasing the risk of CFIT.

This section outlines recommendations to mitigate the risks of GPS spoofing as it pertains to CFIT.

IATA conducted a safety risk assessment regarding the GNSS to provide a structured approach for evaluating GNSS radio frequency interference safety issues. The assessment proposes actions for IATA and makes recommendations to other stakeholders. It offers a standard description of potential threats and preventive controls. This document serves as a resource to assist airlines in assessing operational risks and limitations associated with the degradation of onboard GNSS functionality. It also helps determine whether airline safety controls effectively mitigate GNSS interference risks or if additional measures are required.

4.4.1 Recommendations

4.4.1.1 Recommendations for all Stakeholders

Long-term solutions to address GNSS spoofing will require efforts that extend beyond the aviation industry alone. Effective technologies to defend against spoofing attacks are critical, with the most promising options currently being directional antennas, such as Controlled Reception Pattern Antennas (CRPA), and navigation signal authentication systems like Galileo's Open Service Navigation Message Authentication (OSNMA).

CRPAs enhance resilience by exploiting spatial diversity—distinguishing between desired satellite signals and unwanted jamming signals based on their direction of arrival. Essentially, they create a spatial filter that blocks signals from specific directions while allowing legitimate signals to pass through. However, their civil use is currently restricted by International Traffic in Arms Regulations (ITAR).

Signal authentication, on the other hand, employs cryptographic keys to generate a unique signature for each navigation signal, enabling users to verify its authenticity and ensure it originates from a legitimate source rather than a spoofer. While this technology shows great potential, it is not yet available for operational use in aviation.

All industry stakeholders should collaborate and actively advocate for the removal of export and civil use restrictions, such as those under International Traffic in Arms Regulations (ITAR), to enable the integration of CRPA into civil aviation. Additionally, efforts should focus on accelerating the availability of signal authentication technologies, such as the Galileo OSNMA, to enhance the resilience of navigation systems against interference and ensure continued aviation safety.

4.4.1.2 Recommendations for Manufacturers

As a medium-term solution, manufacturers should focus on developing algorithms capable of detecting GPS spoofing by assessing the physical plausibility and consistency of derived position data (e.g., eliminating large jumps in position or inconsistencies in GPS-derived time). These algorithms should also cross-check GPS data with other navigation sources to identify and reject spoofed signals. Such measures would help prevent incorrect navigation and reduce the occurrence of false or undue warnings.

Furthermore, manufacturers need to review new spoofing effects as reported by operators and provide updated guidance on observed effects and possible mitigations.

4.4.1.3 Recommendations for Operators

Encountering undue EGPWS alerts triggered by spoofed GPS data can erode pilots' trust in the system, potentially leading to alert fatigue and the future dismissal of valid EGPWS alerts, which could result in a CFIT accident. Additionally, even after exiting a spoofing area and when GPS receivers appear to have fully recovered, there remains a risk that incorrect data may persist within various systems, causing erroneous indications or warnings later in the flight.

Until medium- or long-term technical solutions become available, operators should:

- Review procedures for EGPWS use in known spoofing areas, considering the option to selectively disable the system after a thorough risk assessment to reduce nuisance warnings and alert fatigue.
- Emphasize the use of independent navigation and terrain awareness sources, such as Inertial Reference Systems (IRS), radio navigation aids, and radio altimeters, to help pilots maintain situational awareness.
- Prioritize the use of approach navigation aids that do not rely on GPS data, such as Instrument Landing Systems (ILS), especially following confirmed or suspected spoofing during flight.
- Stay updated on developments in GPS spoofing, including evolving locations and spoofing patterns, and regularly review manufacturers' guidance for mitigating spoofing effects and resetting systems after encountering interference.
- Share newly observed spoofing effects with manufacturers.
- Train flight crews about GPS spoofing, providing them with a thorough understanding of its origins, hotspots, expected effects on their specific aircraft type, and the dynamic nature of spoofing patterns.
- Provide crews with up-to-date information on current spoofing locations, at a minimum through pre-flight briefings, but ideally with live onboard mapping tools or onboard detection systems, such as Electronic Flight Bag (EFB)-based solutions.
- Collaborate with other operators to exchange experiences, effective strategies, and best practices for mitigating the impact of GPS spoofing.
- Develop or update the risk model using the appropriate assessment technique to evaluate the operator's exposure to GNSS radio frequency interference (RFI) hazards across the operational network.
- Establish Safety Performance Indicators (SPI) related to GNSS RFI consequences on aircraft navigation and communication performance degradation, focusing on navigation display alerts in line with OEM technical information that can be tracked using the operator's flight data monitoring program.
- Consult with the SRA regarding GNSS and its associated recommendations.

5. Runway Excursion

5.1. Background

Runway excursion (RE) accidents are the result of an aircraft, after landing or on take-off, continuing beyond the end of a runway (overrun) or veering beyond the runway's lateral limits (lateral excursion). These accidents pose significant risks, resulting in potential damage to the aircraft, surrounding areas, and, more critically, endangering the lives of passengers and crew. RE accidents rank among the high-risk categories in aviation, emphasizing the need for proactive measures to mitigate their occurrence.

Accident data shows that REs remain one of the most common types of accidents worldwide and, currently, the third leading cause of fatal accidents in Commercial Air Transport. Also, Runway Excursions have become one of the main sources of hull losses.

The risk of RE accidents depends on various factors and involves many stakeholders, including operators, airports, aircraft manufacturers, and Air Navigation Service Providers (ANSPs). Collaborative efforts among these stakeholders are crucial for effective risk mitigation. Examples of such collaboration include the Global Action Plan for the Prevention of Runway Excursions (GAPPRE) and the Global Runway Safety Action Plan (GRSAP). Both documents provide recommendations and actions for all runway safety stakeholders, aiming to reduce the frequency and the rate of runway excursions.

In support of the GAPPRE and GRSAP, IATA developed a Detailed Implementation Plan (DIP) to address RE accidents. This DIP also identifies some recommendations and actions to reduce the risk of REs.

5.2. Discussion

Analyzing the data from (2015-2024), RE accidents emerge as the most frequent accident category, comprising 104 accidents (21% of all accidents). While RE accidents typically do not result in fatalities, exceptions do exist. The data highlights 8 fatal excursions, resulting in 80 on-board fatalities, along with 8 additional other fatalities, making RE the fourth leading cause of fatal accidents, following the "Other End State" category. Once accidents categorized under "Other End State" are reclassified, RE will become the third leading accident category.

Breaking down the types of runway excursions, it is revealed that 45% of these accidents were runway overruns, indicating instances where aircraft continued beyond the designated runway length. Lateral excursions, where aircraft veered beyond the lateral limits of the runway, accounted for 52% of runway excursions. Additionally, a small percentage (3%) could not be classified, owing to insufficient information.

In 2024, the IATA ACTF recorded 10 RE accidents (4 lateral excursions and 6 overruns). There were zero fatal accidents in this accident category. The accident rate in 2024 increased to 0.25 accidents per million sectors from 0.05 in 2023. When looking at the rolling average accident rate for the five years going back to 2011-2015, the average accident rate recorded was 0.48 accidents per million sectors. Today, the five-year (2020-2024) average accident rate has improved to 0.18 per million sectors. Figure 5 depicts the number and rates of RE accidents over the 10-year period.

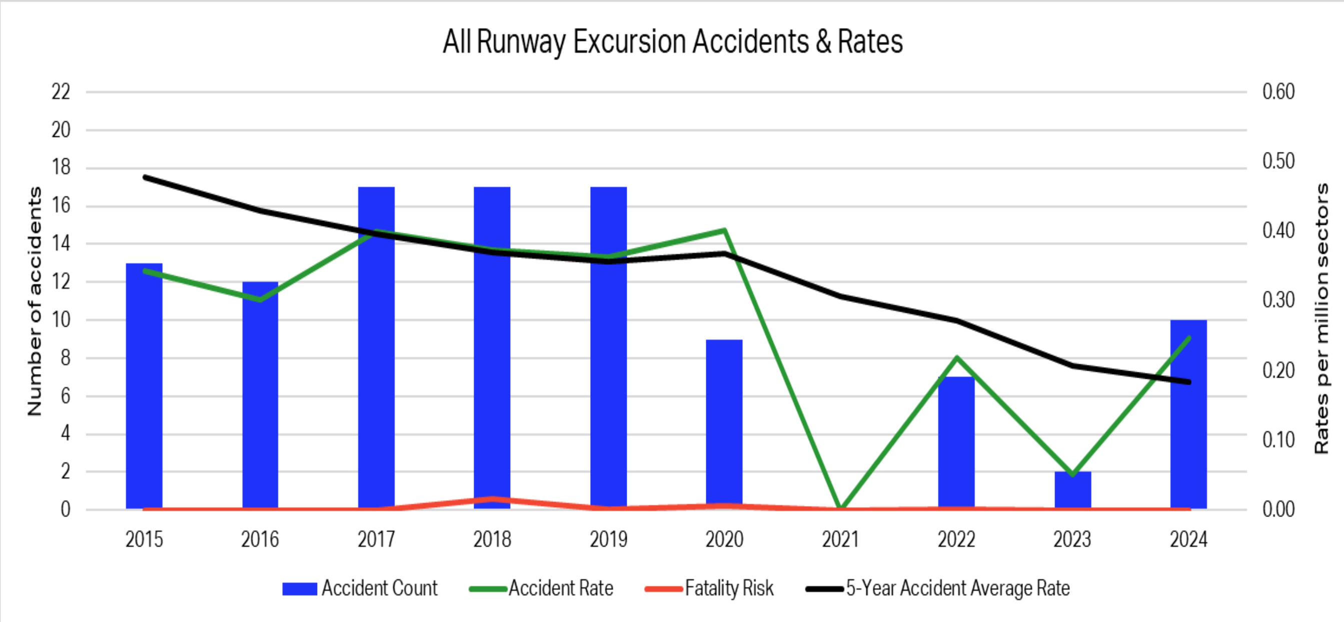


Figure 5: Runway Excursion Accidents

Runway excursions can result from a combination of contributing factors, either acting individually or (more often) in combination. Examining those factors within the scope of TEM, unstabilized approaches (UAs), touching down long and/or fast compounded by the failure to execute a go-around are factors contributing to RE. The continuation of approaches where the aircraft is in an unstable condition is an area of concern that operators and regulators should continue to evaluate and address. It is important to establish realistic and appropriate stabilized approach gates, along with implementing best practices and standardized operating procedures (SOPs), such as recommended by the 3rd edition of the IATA / Civil Air Navigation Services Organisation (CANSO) / International Federation of Air Traffic Controllers' Associations (IFATCA) / International Federation of Air Line Pilots' Associations (IFALPA) Unstable Approaches: Risk Mitigation Policies, Procedures, and Best Practices.

It is worth noting that UAs are not only a factor contributing to runway excursion accidents but also a factor for other accident categories, including hard landing accidents, CFIT, and tail strikes. The broad impact of UAs emphasized the need for comprehensive efforts to identify and address UAs. IATA, together with key stakeholders conducted a study into this matter and developed recommendations to evaluate and address UAs. The full report of the recommendations and the outcomes of the UA Analysis project can be found in this document titled "Examining Unstable Approaches - Risk Mitigating Efforts". One of the findings was the lack of an industry-accepted definition of "high-risk" UA, that might help operators focus activities to achieve effective improvements in the UA rate. This finding is to develop an industry standard for Risk Classification of Unstable Approaches ("high risk"). In 2024, IATA established a group, comprising member airlines and industry partners, to define and categorize high-risk unstable approaches, with the aim of implementing the classification in the Flight Data eXchange (FDX) program for its users. Various Safety Performance Indicators (SPIs) were considered, including the Egregious Unstable Approaches SPI option. In 2025, IATA will continue assessing the appropriate SPIs for high-risk unstable approaches.

Delayed or incorrect flight crew actions when utilizing stopping devices, such as brakes, thrust reversers, and spoilers, coupled with insufficient awareness of minimum equipment list items and their impact on braking performance, pose significant risks and can increase the likelihood of a RE. The reasons here are often not related to aircraft system malfunctions but systemic deficiencies like improper flight crew training, improper or missing SOPs or TEM guidance, or even complacency by flight crews.

Other contributing factors include lack of pilot decision-making, flight crew handling errors (speed and directional control), contaminated runways (wet, icy, etc.), adverse weather conditions including crosswinds/windshear/gusty winds, mechanical failures or gear collapses, and failure to reject take-off before V_1. Factors such as good pilot decision-making and understanding of aircraft performance limitations in challenging conditions play crucial roles in preventing or mitigating RE accidents. Incorporating technology to alert flight crew when an insufficient amount of runway remains for a safe landing would further aid the crew in decision-making. The use of tools incorporating Artificial Intelligence (AI) could, in the future, help automate decision-making when incorporated in to SOPs.

5.3. Recommendations

- GAPPRE and GRSAP contain excellent information regarding RE Prevention. Additionally, the U.S. National Business Aviation Association website under runway excursion includes a depth and breadth of information regarding runway excursion prevention which is applicable to commercial aviation. All of these contain extensive links to additional information. IATA encourages the use of such resources.
- Unstable Approaches are a leading contributor to RE accidents. IATA encourages consultation of IATA / IFALPA / CANSO / IFATCA Unstable Approaches Risk Mitigation Policies, Procedures and Best Practices (GM).

5.3.1 Operator Safety

- Operators should review their SMS and affirm they are enabling and evolving to implement a positive safety culture that requires and rewards adherence to established minima and stated limits.
- Encourage the development, by aircraft operator, of a standard Risk Classification for Unstable Approaches (e.g. “high risk”), along with recommended stringent SOPs and metrics for stabilization of approach, Go-Arounds, etc. The industry should strive to socialize these SOPs within a just safety culture.
- Create an atmosphere of trust, where operator employees are encouraged and confident to openly report safety-related information.
- Active contribution and participation in safety information sharing programs, and regional and local safety groups is essential. This facilitates the free exchange of relevant runway safety information including identified risks, safety trends, and good practices.
- Operators should implement, as part of the accident prevention and flight safety program, a comprehensive FDM program that includes and monitors aircraft parameters in accordance with the Commercial Aviation Safety Team/ICAO Common Taxonomy Team (CICTT).
- Using real- or near-real-time data from low-level windshear detection and alerting systems (where available) is also encouraged.
- Operators are encouraged to use root-cause analysis of SOP non-compliance to improve adherence to airline policy and associated procedures. This should be used as a learning tool for operators and a means to provide further training to crews rather than as a disciplinary tool.

5.3.2 Airline policy and associated procedures

- Integrate TEM principles where the pilot competencies represent the flight crew countermeasures (See also Appendix A).
- Develop organizational metrics using TEM, Line Operations Safety Audit (LOSA) and FOQA for flight crew's initial and refresher training on runway excursion prevention.
- Emphasize the use of all available information and onboard tools, such as EFB, to gather and analyze all available information on runway conditions, and configuration prior to landing as a tool to determine precautions that could be taken.
- Emphasizing the proper setup and use of stopping devices, especially when runway or weather conditions are unfavorable.
- Define clearly stabilized approach criteria and landing and go-around policies in their operations manual in accordance with regulations requirements and manufacturer guidance. Additionally, establish these limits as hardline items which must be followed by flight crew. Rewarding and celebrating the compliance to these limits can assist in the establishment of a strong safety culture.
- Recommend and encourage flight crew to execute a go-around, provided it is safe to do so, at any point during the approach when there is any doubt on a safe continuation of approach or landing.
- Integrate the willingness to accept go-arounds as part of daily operations in operator's safety culture.
- Mandate flight crew to apply the TEM model as a tool to increase safety margins in operations to develop flight crew strategies and tactics. (See Appendix B for an example).
- Address recovery techniques for bounced landings which are specific to each aircraft type, following manufacturing guidance, reinforce the acceptance of go arounds versus continued landing.
- Address the conditions warranting a rejected take-off.
- Address landing techniques aligned with Global Reporting Format (GRF) and manufacturer's guidance for all runway states and environmental conditions as part of the operator's SOP.
- Describe the roles and responsibilities for PF and PM, including intervention strategies with associated procedures and guidance to ensure, when necessary, flight crew to discontinue an approach and execute a go-around in accordance with criteria established by the Operator.
- Emphasize the need to avoid cultural issues which could negate the use of good Crew Resource Management (CRM). Equal opportunity and willingness to call out possible safety issues is vital.
- Mandate an assessment of the arrival landing performance (distinct from the conditions forecast prior to departure), which includes landing distance at the time of arrival adding an additional safety margin.
- Allow the use of appropriate level of automation during the approach, landing and go- around. Likewise, manual flying during operations in good weather. Maintaining manual flying skills is necessary to ensure flight crew competence.

5.3.3 Airline Training policy and associated program should address:

- Negative impact on safety when deviating from SOPs.
- Importance of accurately determining the landing performance to ensure sufficient margins during landing in all weather conditions.
- Development of predictive metrics using LOSA, FOQA, weather and other available data to bolster flight crew training and knowledge to accurately determine safety measures for safe landings.
- Techniques for stabilized approach, flare, touchdown and stopping devices.

5.3.4 Practical training should include:

- Scenarios-based training to enhance pilots' competencies for effective TEM to prevent RE (e.g., contaminated runway, last minute change of runway, deterioration of weather conditions…), and usage of EFB or other tools available in the cockpit.

- Effective usage of the GRF.
- Maneuver training to develop pilots flying, monitoring and intervention skills (e.g. bounce landing, take-off and landing with maximum cross wind, all engines go-around at different stages of the approach, take off.
- Empower and train flight crew to advise ATC when unable to comply with an instruction or a clearance which would decrease safety margins to an unacceptable level.
- Highlight the availability of aircraft arresting systems such as engineered materials arresting systems (EMAS), if available.

5.3.5 Industry initiatives, and research into the following as aids to decreasing RE

- Explore the applicability of Application Programming Interface(s) (API) to integrate tools and applications included as standalone items within the cockpit and EFBs. As API plays an important role in facilitating data exchange and integration among various systems and stakeholders.
- Develop advanced predictive metrics using available data from operators, regulators and others as a means to provide timely information prior to flight or prior to approach to land for RE prevention.
- Conduct research into the use of AI into flight planning, enroute operations and approach procedures to supply flight planners, dispatchers, Air Traffic Controllers and flight crew with definitive and timely information.

6. Tail Strike Accidents

6.1. Background

Tail strike accidents occur when the attitude of the aircraft is such that the tail contacts the runway, during take-off or landing or even go-around, resulting in substantial damage.

According to IATA Annual Safety Report, 11% (55) of all accidents over the 10-year period (2015-2024), suffered a tail strike event. In year 2024, 26% (12) of the accidents were the result of a tail strike. While there is typically a low fatality risk, these occurrences can cause serious damage to aircraft and cost operators millions in repairs and lost revenue. When a tail strikes the runway while landing, the damage is typically more severe than when it occurs during take-off. The worst-case scenario involves the tail striking the runway before the landing gear touches down, damaging the aircraft pressure bulkhead.

To assist air operators in mitigating the risks of tail strikes, IATA has developed an SRA. This assessment provides a structured approach for analyzing tail strikes and helps stakeholders evaluate and manage the associated risks.

6.2. Discussion

Most tail strike accidents occur on landing. According to IATA Safety Report, 82% (45) of all tail strike accidents, over the period of 10 years (2015-2024), occurred on landing and during go-around. In 2023, IATA introduced two subcategories under tail strike: tail strike on landing and go-around, and tail strike on takeoff. Analyzing the data from the last two years, it is revealed that 94% of these accidents were tail strikes on landing and go-around.

In 2024, the IATA ACTF recorded 12 tail strike events (11 on landing and go-around and one on take-off). There were zero fatal accidents in this accident category. The accident rate per million sectors in 2024 went up to 0.30 from 0.16 in 2023. Figure 6 depicts the number and rates of Tail Strike accidents over the 10-year period. It was cited in some accidents that the pitch had exceeded the limits stated in the aircraft operating manual, abnormal runway contact, no go around after bounced landing, wind/windshear and poor crew response and situational awareness contributed to these mishaps.

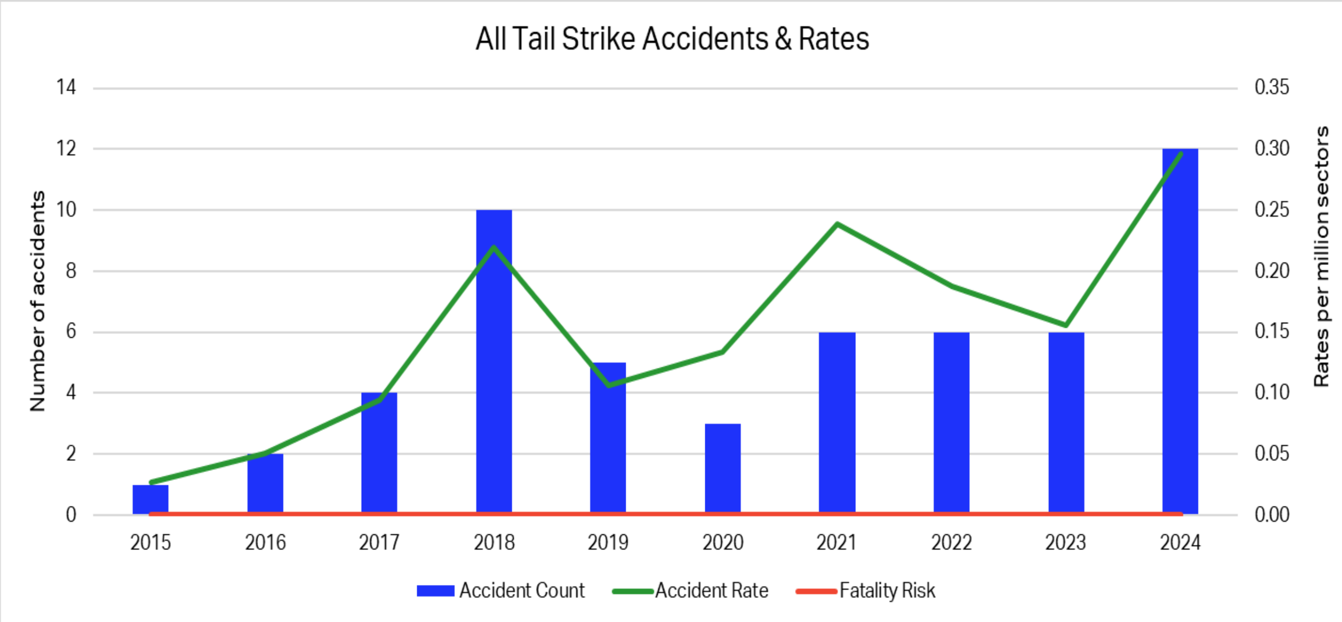


Figure 6: Tail Strike Accidents

As seen above, most tail strike accidents occur during landing and go-around. The common threats or factors that contributed to those landing accidents include poor or incorrect pilot technique, unstable approach and/or arriving at the runway in a higher energy state resulting in long or bounced landings, holding the airplane off the runway in the flare, and mishandling of crosswinds, gusty winds, and turbulence.

Moreover, it was cited a low energy situation (speed decrease before flare due to weather or due to a lack of speed monitoring), implying a higher angle of attack and lower tail clearance. With regards to flare technique, a flare that is too high can induce airspeed decrease and long flare leads to pitch increase, with associated tail clearance reduction.

Weather conditions such as strong crosswinds, gusty winds and turbulence on final approach make landing a challenging handling task. Gusty crosswinds require higher approach speeds which increase the descent rate. Rapid corrective control inputs are necessary as wind gusts displace the aircraft from the intended path may increase the descent rate. If not handled correctly, arresting this descent in the flare can result in extreme touchdown attitude and tail strike.

Another common factor cited in tail strike accidents is a long flare during landing, which is frequently prompted by the desire to accomplish a smooth touch down. Over rotation techniques during go-around, improperly conducting a go-around after a bounced landing and incorrect pitch attitude by trimming the elevator during the flare are also cited as factors contributing to landing tail strikes. Too much trim raises the nose resulting in pitch-up that can cause the aircraft to balloon away from the runway.

Tail strike accidents on take-off are less frequent and typically less severe compared with those during landing. Often pilots may not be aware that a tail strike has happened during take-off. According to the IATA safety report, 16% (9) of all tail strike accidents, over the reporting period (2015-2024), occurred on take-off. The common threats identified that potentially may lead to take-off tail strikes include over rotation or incorrect techniques on take-off, excessive initial pitch attitude and mistrimmed stabilizer usually occurs as a result from using erroneous data, including an error in the performance and trim calculations, the wrong weights, or an incorrect centre of gravity (CG) due to improper aircraft loading. There were also cases reported where the information was accurately provided to the flight crew, but was incorrectly entered into the Flight Management System (FMS) or the stabilizer trim setting itself.

Furthermore, pilots must also implement certain techniques on take-off to prevent a tail strike due to rotation risk factors. It was noted that rotation prior to V_R (rotation speed) is cited as a contributing factor. An incorrect V_R may cause an early rotation, factors causing a rotation prior to V_R can be due to autorotation, suspected pilot error (rotation initiated close to "100kt" or "V_1" call out instead of "Rotate" call out), or the pilot decision to rotate early due to an obstacle on the runway. This will lead to an increase in the pitch attitude at liftoff and, as a result, potentially cause a tail strike. Also, rapid rotation rate can also cause a tail strike. The amount of control input required to achieve the correct rotation rate varies from one aircraft type to another. It is important that when a pilot transitions to a new aircraft type, to become familiar with the proper rotation rate, and to know the tail strike attitude of the aircraft and never rotate beyond it.

Application of training, policies and procedures are often the difference between a successful landing or tail strike accident. Guidance on crosswind limits, stabilized approach criteria and pilot monitoring expectations help to mitigate this risk along with training in bounced landings, and go-arounds. Simulator training should also be conducted regarding the manufacturer's recommended rotation rate, practices for selection of thrust and proper technique for gusty crosswinds.

Note: The tail strike data identified in the IATA Safety Report only represents events that meet the threshold of substantial damage and, as such, do not fairly represent the number of tail strike incidents that occur and may underrepresent this risk factor as a precursor to more significant events. A flight data monitoring program should be used in conjunction with a robust SMS to monitor excessive pitch at take-off, stabilized approaches, bounced landings and go-arounds to validate the effectiveness of policies and recommend changes to training, as appropriate to maintain safe operations.

6.3. Recommendations

6.3.1 Standard operating procedures

- Manufacturers and operators should establish clear parameters and guidance for wind limits, including crosswind, tailwind and wind gusts.
- Similar to the runway excursion recommendation, a realistic stabilized approach criteria should be established as appropriate for the operation, as recommended in the IATA guide to stabilized. approaches Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices, 3rd Edition.
- Similar to the runway excursion recommendation, operators should implement policies and training on the role of effective and active PM to clearly define actions for both PF and PM, including performance-based reactions to include PM intervention.
- Reliable methods and procedures need to be established for performance calculations, including weight and balance, as well as how these numbers are communicated to the pilots and/or loaded into the aircraft as recommended by IATA's FMS data prevention document IATA Teaching Plan.
- Technology should be considered to aid in take-off performance monitoring, such as recommended by IFALPA's Take-Off Performance Monitoring System to possibly include Runway Overrun Awareness and Alerting Systems.
- Similar to the runway excursion recommendation, operators, should ensure that both operator and training policies address TEM as a tool to increase safety margins by providing flight crew strategies and tactics to manage potential threats and errors.

6.3.2 Operator Training

- Operator should implement CBTA including EBT training programs as the pilot competencies provide individual and team countermeasures to threats, errors and potential reduction of safety margins.
- Training may include, but not be limited to, the following:
  - Awareness about tail strike contributing factors;
  - Realistic scenarios or event requiring adequate threat and error management regarding descent planning, stabilized approach, go-around and landing, including bounced landings, crosswinds and contaminated runways. Go-Around, Missed Approach and Balked Landings | IFALPA, Commercial Aviation Safety Team (CAST) SE-198, SAFO15004;
  - The anticipation, the planning and the execution of go around during adverse weather conditions during all stages of the approach, flare and landing;
  - The completion of the aircraft type specific bounced landings procedure as per OEM guidance
  - Appropriate application of TEM during pre-departure and arrival briefings.
- Training should be conducted to make flight crew aware of risks and limitations of tailwind operations, as indicated in IFALPA's publication Tailwind Operations.
- Simulator training usually includes conducting a go-around from below minima. Therefore, thinking about how to conduct a go-around from long flare, different altitudes, and different configurations is vital in preparation for the landing, while also taking terrain, weather, ATC requirements and the traffic environment into consideration.
- If flight crew training schedules have been disrupted for a considerable amount of time, the operator should consider either additional training or restarting the training to ensure the appropriate level of competency and confidence.
- Operators to ensure flight crew are appropriately trained in energy management and state awareness for the aircraft type they operate in, such as pitch and bank awareness on touchdown.
- Operators to ensure flight crew are appropriately trained in manual handling and use of automation for energy management.
- Establish policies and train pilots on pilot monitoring intervention strategies within the CRM (i.e. callouts, communication) to avoid or recover from Undesired Aircraft States (including but not limited to bounces, long landings, tail strikes).

6.3.3 Safety Management

- Develop/update their risk model using the appropriate assessment technique to manage Tail Strike risks.
- Develop controls-based audits according to the risk model and assess the effectiveness of controls in place.
- Create a process to map safety intelligence onto the risk assessment tool such as the proposed bowtie that was developed by IATA.
- Use SPIs to track precursors related to Tail Strike and trigger actions when deviating from the target or reaching the limit of control.
- Establish and track the Top Event - Tail Strike's SPI to monitor its evolution

7. Hard Landing

7.1. Background

Hard Landing widely refers to accidents occurring when an aircraft touches down with a vertical descent speed and force that exceeds the normal operating limit of the aircraft. A hard landing may be outside of the manufacturers' design specifications and consequently result in inspection for damage before the next flight to ensure the aircraft has not sustained damage. Hard landings are usually judged by the flight crew's perception of the sink rate. It can also be evidenced post-flight through an analysis of the flight data recorders, or via analysis of Flight Operations Quality Assurance data.

Hard landings can result from a range of contributing factors that include among others meteorological conditions, in particular, thunderstorms which result in low visibility conditions and wind shear, lack of visual reference, ATS, lack of or unavailable navaids, airport facilities – poor signage, lighting, faint markings, aircraft malfunction, and human factors such as optical illusion/visual misperception due in part to fatigue. Reducing this accident category through understanding the contributing factors and the implementation of proper intervention strategies is an industry priority.

7.2. Discussion

Hard landings are the third largest contributor to accidents, accounting for 11% (55) of all accidents over the past 10 years (2015-2024). While hard landing accidents typically do not result in fatalities, exceptions do exist. Notably, there was a fatal accident in 2019 that resulted in 41 on-board fatalities. In 2024, there were two hard landing accidents. The accident rate per million sectors declined from 0.13 in 2023 to 0.05 in 2024. Figure 7 illustrates the number and rates of Hard Landing accidents. Hull loss and substantial damage to aircraft are the major concerns for airlines arising from hard landing accidents.

Hull loss and substantial damage from hard landing accidents have decreased over the past decade, with 9 hull loss accidents and 46 substantial damage accidents. 2015 was a significant year in terms of hull loss with 0.08 accidents per million sectors and substantial damage with an accident rate of 0.37 per million sectors. Figure 8 presents hard landing accidents hull loss vs. substantial damage.

Hard landing accidents are more prominent in jet aircraft than in turboprop aircraft, with 40 accidents compared to 15 over the 10-year period. In 2024, although there was one hard landing accident each for jet and turboprop aircraft, the accident rate for turboprops in this category was higher than that for jets per million sectors (0.28 vs. 0.03). This is due to the number of sectors flown by each type of aircraft. Figure 9 depicts the hard landing accidents involving jet vs. turboprop aircraft.

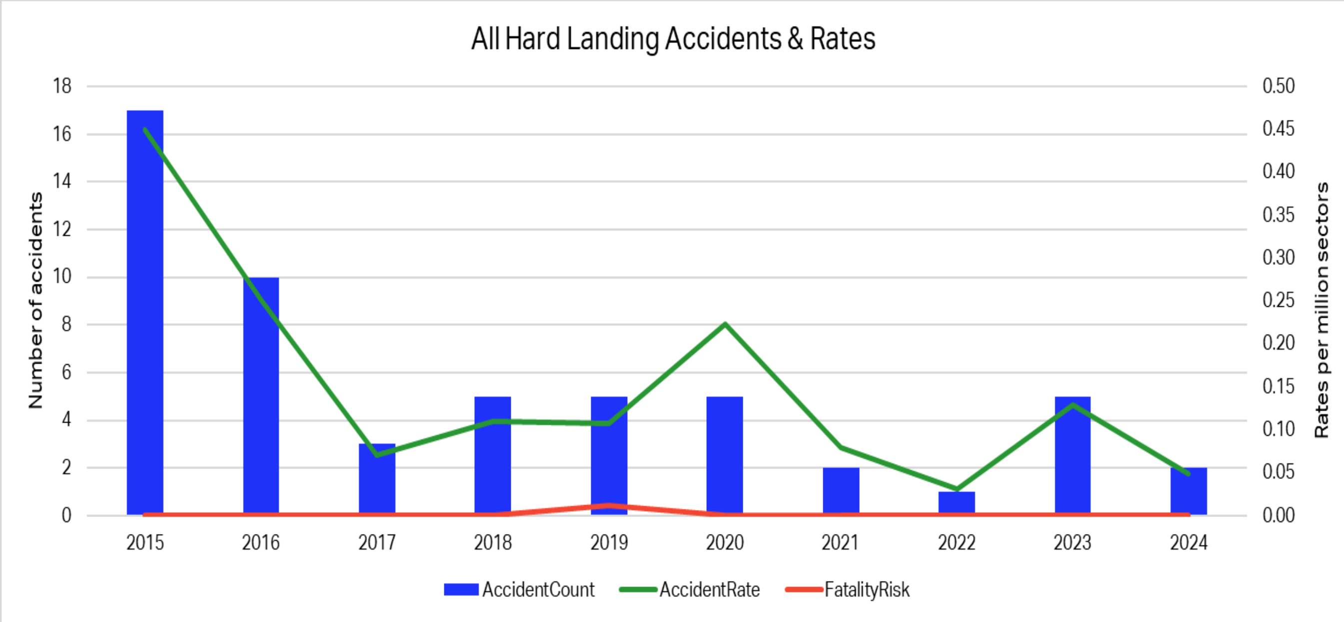


Figure 7: Hard Landing Accidents

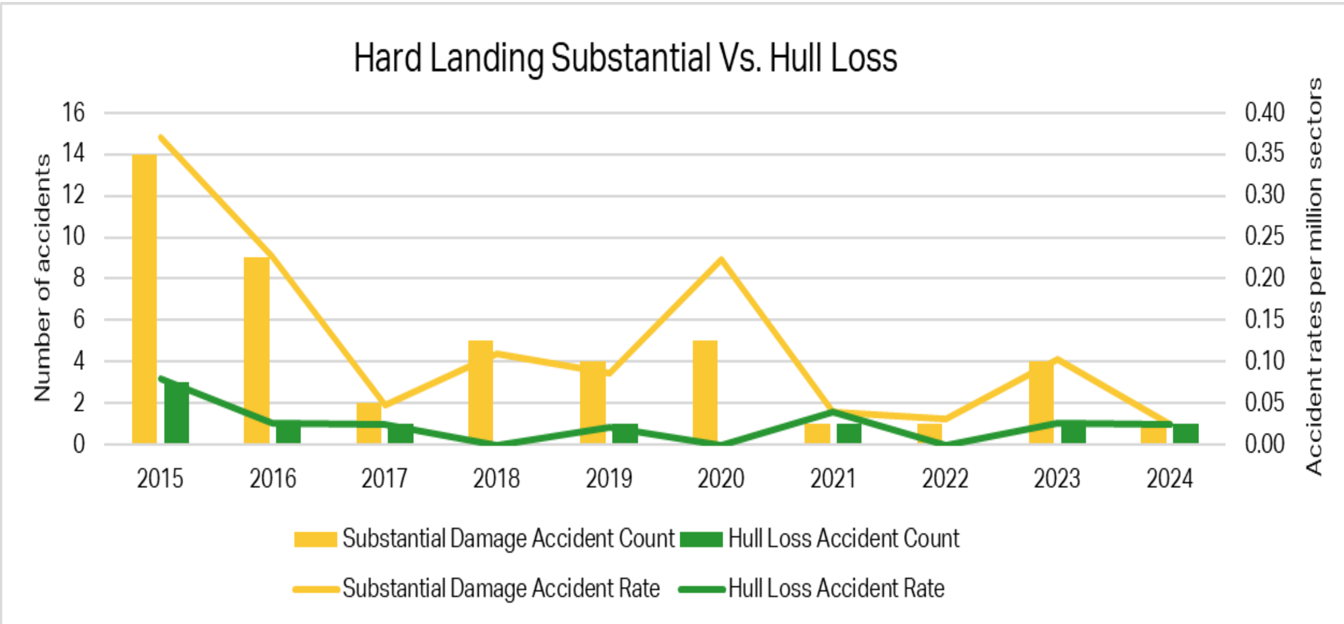


Figure 8: Hard Landing Hull Loss vs. Substantial Damage

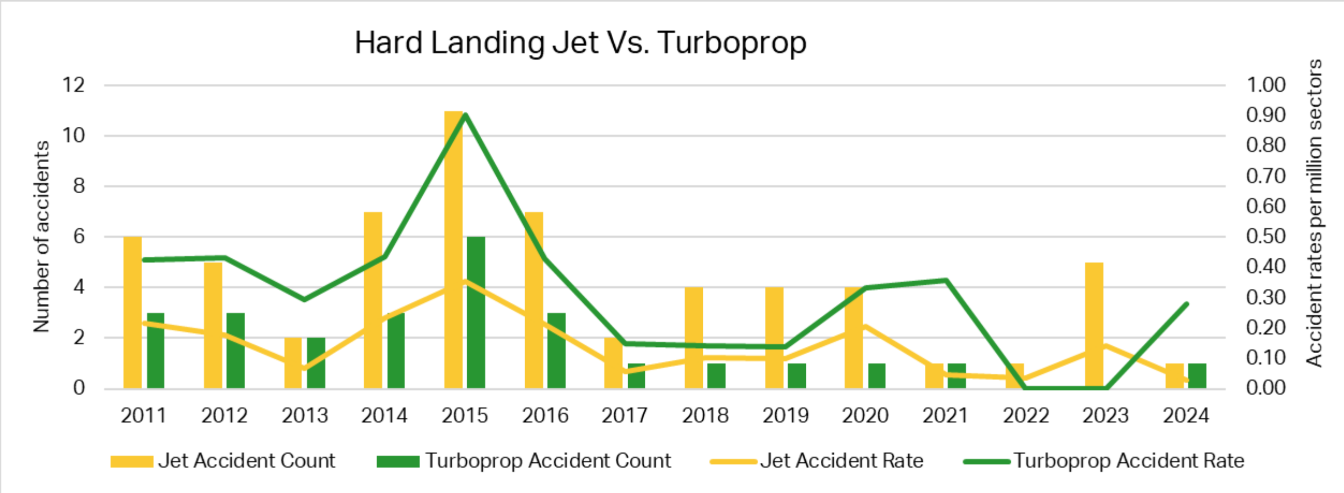


Figure 9: Hard Landing Jet vs. Turboprop

Hard landings, as the name implies, occur at the end of a sector when workload peaks and fatigue may impair crew performance. Most hard landing accidents occur during thunderstorms or in wind shear conditions. These environmental conditions lower the flight crew's visibility and reduce flight crew's perception during the landing phase, impairing the situational awareness of the flight crew. Human factors such as fatigue and pressure to complete the flight sector also contribute to the impairment of the flight crew's situational awareness and response.

Recognizing the conditions a flight crew may find themselves in prior to a hard landing event is key to recognizing the potential for a hard landing and making appropriate decisions. The most common aircraft conditions leading to a hard landing are, manual handling, abnormal runway contact and vertical/lateral/speed deviations, unstable approach, abrupt aircraft control, non-compliance to SOPs, and continued landing after unstable approach leading to abnormal runway contact.

By reviewing the hard landing accidents from the IATA Annual Safety Report, it is believed airlines will understand the primary drivers for the decision-making process that results in a hard landing are human factors related and are, to a degree, manageable. Hard landings primarily have an economic impact on airlines, however, if severe enough they may result in injuries and fatalities. Reviewing, and incorporating discussions on hard landings at the airline operations level can reduce the number of hard landings experienced and reported each year.

By raising awareness of the factors contributing to hard landings, such as adverse weather conditions near airports and the flight crew's workload during landing, it is hoped that airlines will become more aware and engage in discussions on how to mitigate hard landings.

7.3. Recommendations

The primary underlying condition for hard landing accidents is Flight Operation. It is imperative for the aircraft to be established on a stable approach, and considering adverse weather conditions, including wind shear and turbulence, which could destabilize the approach.

Conducting training to quickly realize when an approach has become unstable and prompt decision-making on appropriate actions such as performing a go-around will reduce hard landing events.

The introduction of intervention training (taking-over control or handing-over control), where the trainee is exposed to scenarios that could lead to a hard landing, different altitudes, weights and configurations should be introduced:

- High Flare;
- Long Flare;
- No Flare;
- Overcontrolling roll during flare;
- Misuse of rudder;
- Go - around after bounced landing;
- Go - around below minima;
- Go - around during flare;
- Excessive de-rotation

Discussions at the operator level on human factors and the decision-making process for go-arounds and approaches during adverse weather conditions are recommended to increase awareness of the potential for a hard landing and will also aid in reducing hard landing events.

Operators to establish policies and train pilots on pilot monitoring intervention strategies within CRM (i.e. callouts, communication) to avoid or recover from Undesired Aircraft States (including but not limited to hard landing, bounces, long landings, tail strikes).

Additionally, flight crew should always consider options to execute a go-around or diversion during approach briefing. Use all available resources to aid situational awareness and encourage all flight crew members' participation in the decision-making process.

Operators should define meteorological conditions thresholds, such as lower crosswind limits, for less experienced pilots.

8. Off Runway Touchdown (Off or Partial)

8.1. Background

Off Runway Touchdown (Off or Partial) refers to accidents occurring when an aircraft's touchdown is not on the runway. This accident category includes undershoot (used for occurrences on landing flare), overshoot and lateral touchdown. Off Runway Touchdown (Off or Partial) accidents differ from runway excursion and Off Airport Landing/Ditching accidents in that Off Runway Touchdown (Off or Partial) refers to an accident where the landing gears' first point of contact with the ground is not on the runway (including stop-ways and thresholds), when a landing on the runway is being attempted. Off Runway Touchdown (Off or Partial) can result from a wide range of contributing factors, in particular meteorological conditions such as thunderstorms/convection cells, low visibility/IMC, wind/windshear or turbulence, lack of visual reference, ATS, navaids, airport facilities and human factors such as optical illusion/visual misperception and operational pressure. Typically, this category has seen more financial impact on airlines than fatal accidents, however, the possibility of a fatal or injurious accident can never be discounted when dealing with Off Runway Touchdown accidents.

8.2. Discussion

In the past 10 years (2015-2024), Off Runway Touchdowns (Off or Partial) accounted for 4% of all accidents (18). Of all fatal accidents over the same period, Off Runway Touchdown (Off or Partial) accounted for 2 fatal accidents, resulting in 5 onboard fatalities. This category is one of the lowest contributors to fatal accidents.

With respect to hull loss and substantial damage accidents, Off Runway Touchdowns over the past decade (2015-2024) accounted for 4 hull loss accidents and 14 accidents which resulted in substantial damage to the aircraft. Overall, there was an accident per year from 2015-2018 that resulted in a hull loss, with none recorded since 2019 as illustrated in Figure 10. However, the annual average for Off Runway Touchdowns that result in substantial damage to the aircraft is about 1 per year.

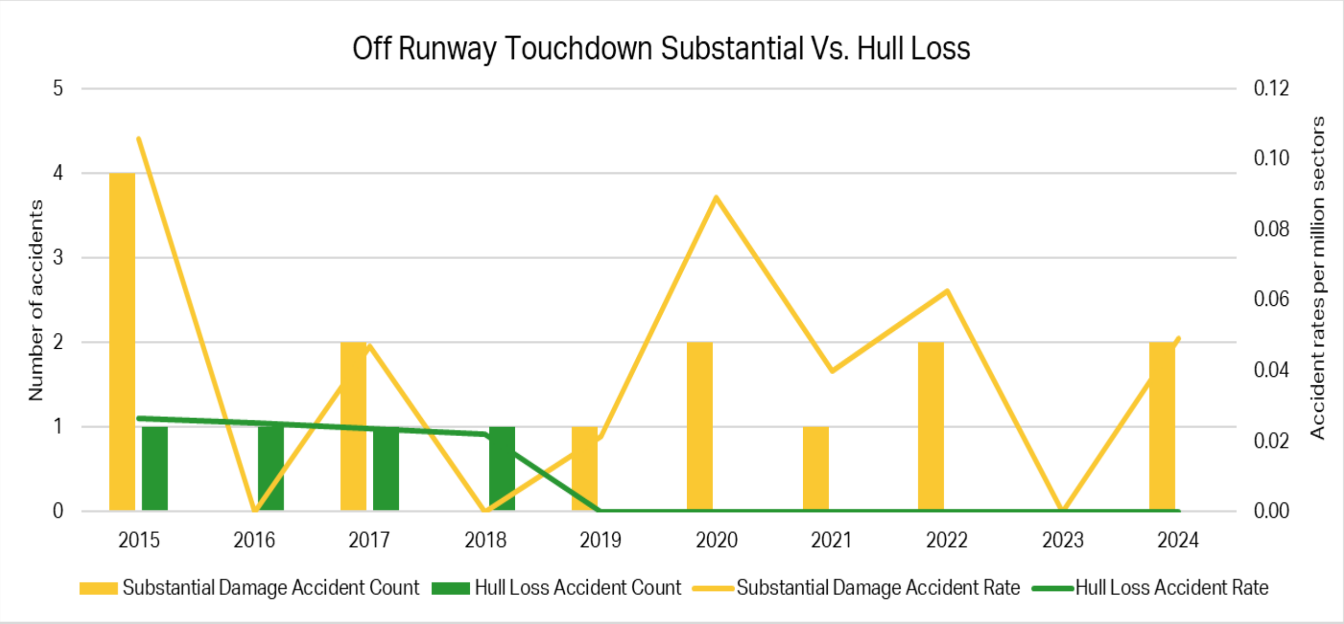


Figure 10: Off Runway Touchdown Accidents Hull Loss vs. Substantial Damage

In terms of jet and turboprop fleets, there is no real trend for either – the frequency of events is random year to year over the past decade (2015-2024). There have been more accidents on the jet fleet (11) versus the turboprop fleet (7) over the recording period, however, the five-year (2020-2024) rolling average accident rate for the jet fleet was 0.03, while for the turboprop fleet was higher at 0.19 accidents per million sectors. Potential reasons for this may include the age of the aircraft, crew workload, and type of flight sector.

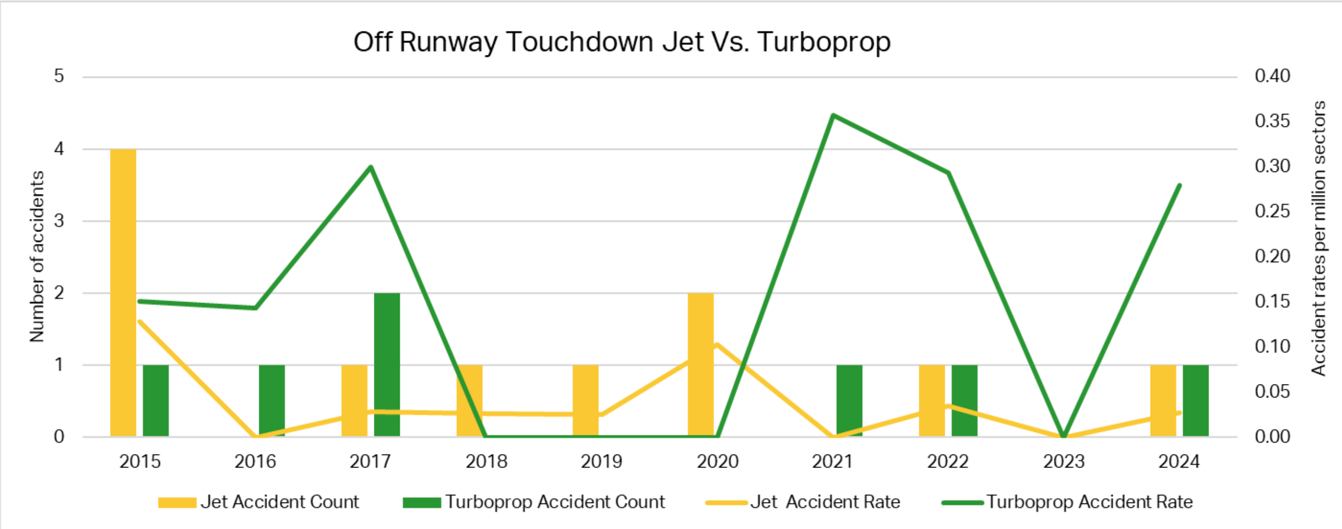


Figure 11: Off Runway Touchdown Accidents Jet vs. Turboprop

Off-runway touchdowns (off or partial) occur at the end of a sector when workload peaks and fatigue may impair crew performance. Over the past decade, adverse meteorological conditions were cited in 72% and may have increased the crew workload due to factors such as degradation or low visibility (50%) and lack of visual reference (33%). Meteorological conditions responsible for Off Runway Touchdowns also include Wind/Windshear/Turbulence (44%), and thunderstorms or other significant convection (22%). Deficient regulatory oversight or lack of thereof and absent (44%) or deficient safety management were also cited in 39% of the Off-runway touchdowns (off or partial) accidents.

Other conditions contributing to an increase in crew workload and degradation of situational awareness that may result in Off Runway Touchdowns include:

- **Air Traffic Services** – lack of or unavailable Navaids (44%);
- **Airport Facilities –** poor signage/lighting, faint markings, or runway/taxiway closures, trenches, ditches or structures in close proximity to runways/taxiways (33%),
- **Physiological Factors** – Optical Illusion/visual misperception (28%).

The increase in crew workload due to the conditions above could lead to deviation in the following areas:

- **Flight Crew –** Manual handling of the primary flight controls, incorrect automation settings and or selections, systems/radios instrument settings, wrong altimeter reference settings and aircraft handling errors;
- **Communication** – crew communication;
- **Procedures** – SOP adherence/SOP cross-verification, go-round not initiated after destabilized approach, callouts

By reviewing the Off Runway Touchdown (Off or Partial) accidents from the IATA Annual Safety Report, it is believed that airlines will understand that the contributing factors for the decision-making process that results in Off Runway Touchdown (Off or Partial) are human factors related and are, to a degree, manageable. Off Runway Touchdown (Off or Partial) primarily have an economic impact on airlines, however, if severe enough they may result in injuries and fatalities. Reviewing and incorporating discussions on Off Runway Touchdown (Off or Partial) at airline level can reduce the number of Off Runway Touchdown (Off or Partial) experienced and reported each year.

It is hoped that, raising awareness on the primary factors behind Off Runway Touchdown (Off or Partial) such as meteorology conditions, ATS, lack of visual references, airport facilities and physiological factors will result in a raised awareness at the airlines and open discussion on how to mitigate off Runway Touchdowns.

8.3. Recommendations

The primary underlying conditions for Off Runway Touchdown (Off or Partial) accidents are increased workload due to situational disorientation caused by meteorological conditions, incomplete ATS, lack of visual-spatial references, and degraded airport landing facilities. It is imperative that an aircraft be always on a stable approach to landing. To counter the above-mentioned situational disorientation drivers, flight crews need to undergo frequent training to recognize when an approach becomes unstable and the correct procedures to safely handle an unstable approach. Flight crews should also be aware of conditions which may result in situational disorientation on landing and should discuss and plan countermeasures prior to initiating a landing when conditions where situational disorientation may arise.

Discussions at the operator level on human factors and the decision-making process for go-arounds and SOP cross-verifications are recommended to increase awareness of Off Runway Touchdown, and how to manage go-arounds to reduce the potential for an Off Runway Touchdown.

9. Off Airport Landing/Ditching

9.1. Background

Off Airport Landing/Ditching is defined as an accident where there is any intentional controlled landing of an aircraft outside of a designated airport area.

9.2. Discussion

Off Airport Landing/Ditching is one of the least frequent types of accident category, ranking 12 out of the 14 accident categories. Figure 12 depicts the ranking of the accident categories. The accident rate for Off Airport Landing/Ditching is 0.02 accidents per million sectors over the past decade.

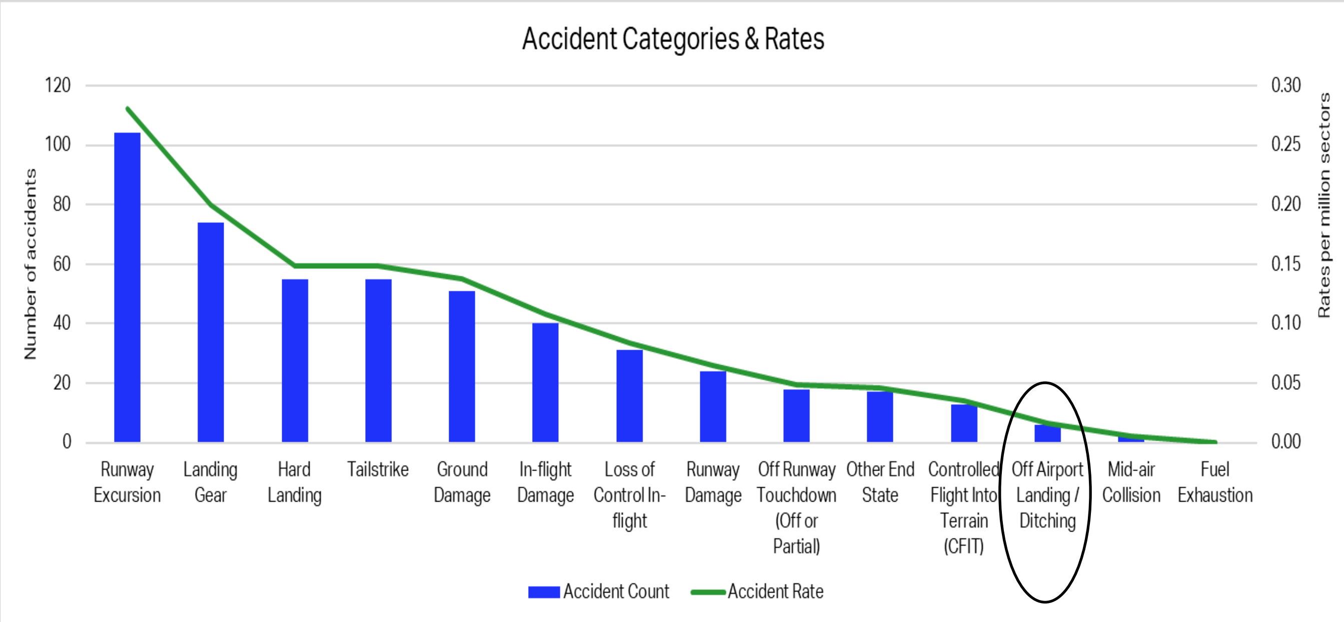


Figure 12: Ranking of Accident Categories

Over the past 10 years (2015-2024), there have been 6 Off Airport Landing/Ditching accidents, all of which resulted in zero fatalities. It should be noted that the rate of these accidents has been increasing, with 5 of the 6 accidents occurring between 2021 and 2023, as illustrated in Figure 13. Despite this increasing trend, the overall number of Off Airport Landing/Ditching accidents remains low. As mentioned above, despite the increase in the accident rate, there have been no fatal accidents over the 2015-2024 period.

Most of the Off Airport Landing/Ditching accidents (4 out of 6) resulted in substantial damage to the aircraft. Between 2015 and 2024, there were 2 jet accidents and 4 turboprop accidents. Notably, both jet accidents resulted in hull losses.

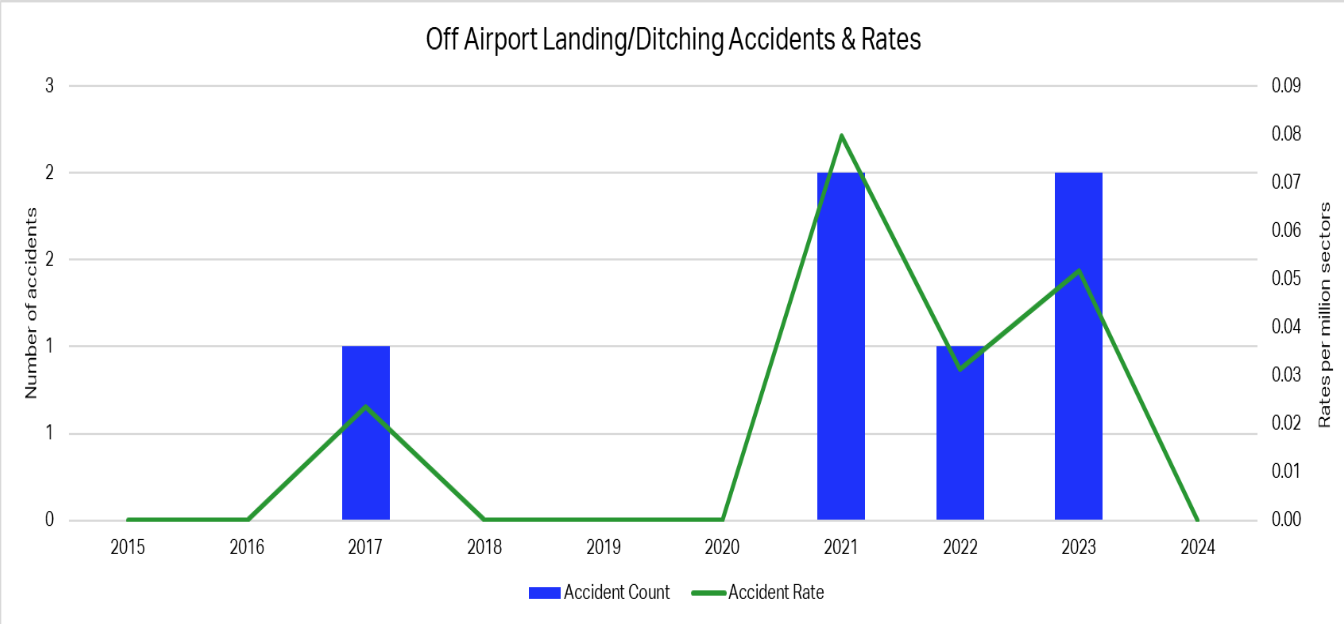


Figure 13: Off Airport Landing/Ditching Accidents

The top drivers of Off Airport Landing/Ditching are:

- Airline related: Aircraft Malfunction – Engine Failure, Hydraulic System Failure, and Operational Pressure;
- Environmental related: Meteorological – low visibility/IMC and Icing conditions;
- Psychological/Physiological related: Fatigue.

Contributing factors for Off Airport Landing/Ditching accidents are predominantly attributed to:

- Aircraft Handling;
- Aircraft Configuration – Engine, Systems (Hydraulic) and Landing Gear;
- Air Navigation – Unnecessary weather penetration.

The top drivers that led to the decision to divert or miss a landing were:

- Procedural – SOP Adherence/SOP Cross-verification (Unintentional and Intentional), Checklists (Abnormal/Non Standard Checklist), Crew Response (inadequate response to warnings and/or alerts, and incorrect performance calculations from the flight crew;
- Flight Crew – Manual handling of primary flight controls, and Systems/Radios/Instruments (settings/selections)
- Communications – Pilot to pilot (crew) communication in the same aircraft

9.3. Recommendations

- Off Airport Landing/Ditching occurs under extreme circumstances when a flight crew has no other option. In almost all cases, Off Airport Landing/Ditching should be avoidable with proper planning and execution. Since the largest driver for Off Airport Landing/Ditching is Engine/System Failure, followed by meteorological conditions such as low visibility, or icing conditions, training in flight planning, communication and proper decision-making techniques can reduce the number of Off Airport Landings/Ditching.

9.3.1 Operator Safety

- Establish a Positive Safety Culture.
- Mitigate known situations where pilots might feel pressured to perform an Off Airport Landing/Ditching such as operational pressures, fatigue.

9.3.2 Operator Training

- Implement training considering the following provisions and best practices:
  - Human Factors and CRM to improve communication and decision-making;
  - Identify situations where an Off Airport Landing/Ditching would be required, such as uncontrollable onboard fire, fuel exhaustion or loss of all engines.
- Perform scenario-based training with a focus on:
  - prepared emergency landings including coordination with relevant parties, such as cabin crew, ATC, company, etc.;
  - flight crew training emphasizing CRM during very complex in-flight procedures with complex checklists;
  - aircraft system malfunctions management that might result in a planned Off Airport Landing/Ditching.

9.3.3 Operator Flight Standards

- Establish a culture where pilots are not pressured to perform flights with constrained fuel or marginal weather conditions.
- Establish memory items for immediate actions in time-critical emergencies.

9.3.4 Recommendations for Pilots

- Pilots should be trained and demonstrate proficiency in:
  - Contents of the Quick Reference Handbook (QRH)
  - Structure of complex emergency procedures
  - Crew coordination procedures, including with cabin crew

10. Runway Damage

10.1. Background

Runway Damage is defined as any occurrence at an airport involving the incorrect presence of an aircraft, vehicle, person or wildlife on the surface designated for the landing and take-off of aircraft and resulting in damage.

10.2. Discussion

Runway Damage is amongst the top 10 frequent accidents and ranks 8 out of the 14 accident categories overall. The accident rate for Runway Damage is 0.06 accidents per million sectors as illustrated in Figure 14.

Over the past 10 years (2015-2024), there have been 24 Runway Damage accidents. These accidents resulted in zero onboard fatalities. However, there have been 3 fatal accidents, resulting in 9 'other fatalities', which are not included in the fatality risk rate. Runway Damage accidents have been sporadic, with 2016 experiencing an unusually high number of accidents (6), as shown in Figure 15.

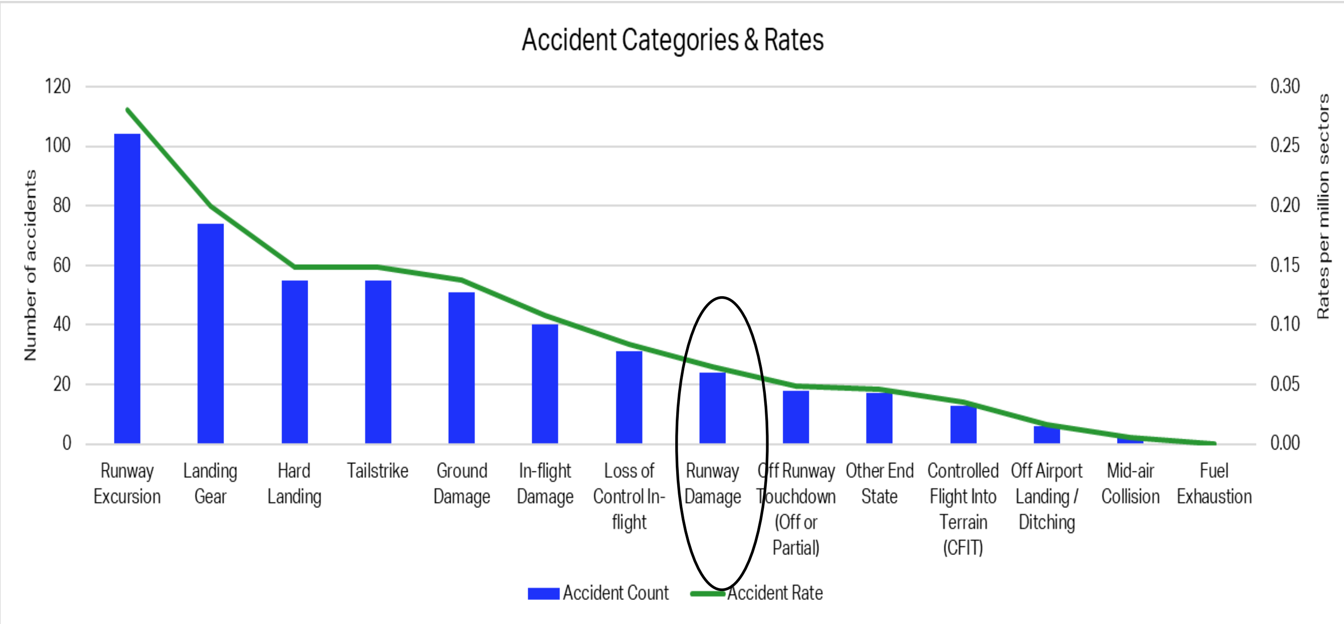


Figure 14: Ranking of Accident Categories

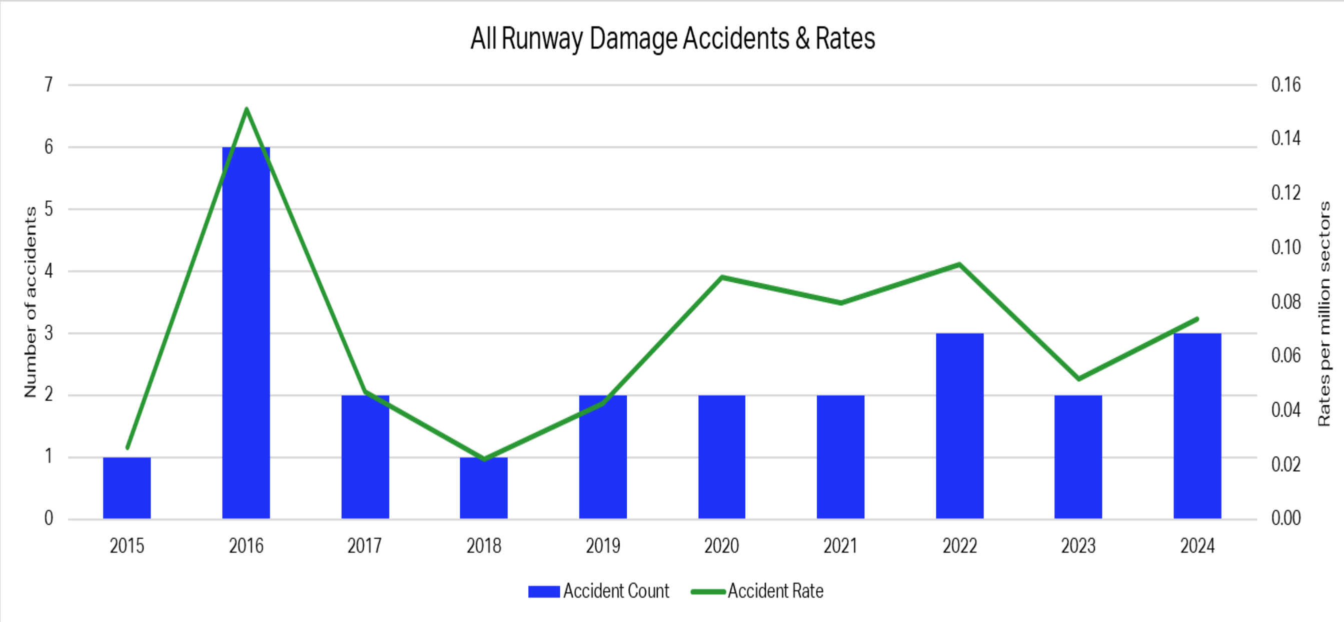


Figure 15: Runway Damage Accidents

Most of the Runway Damage accidents resulted in substantial damage rather than hull loss. There were 4 hull loss accidents over the 10-year period versus 20 substantial damage accidents for the same period. In terms of aircraft propulsion for the same period (2015-2024), there were 17 jet accidents and 7 turboprop accidents.

Looking at the Runway Damage Accidents from the region of operator versus region of occurrence, it is apparent that Runway Damage occurred more at the airports in Asia Pacific (ASPAC), Africa (AFI), and Middle East and North Africa (MENA) than their regions of operator. Figure 16 presents the distribution of Runway Damage Accidents by Region of Operator versus Region of occurrence.

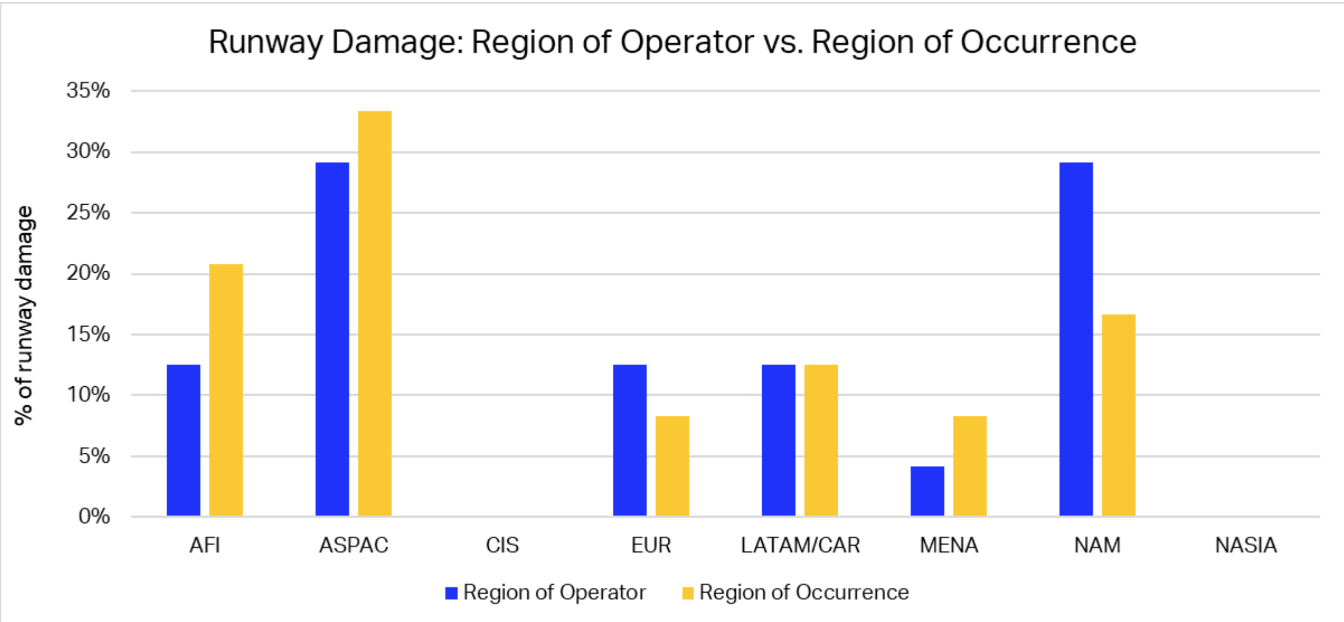


Figure 16: Runway Damage by Region of Operator Vs. Region of Occurrence

The top drivers of Runway Damage are:

- Environmental related: Aircraft Impact by Birds/Foreign Objects, Airport Facilities, Air Traffic Surfaces, Runway Surface Incursion and Meteorology;
  - IATA has produced a generic safety risk assessment for runway incursion, supported by a bow tie model;
- Airline related: Aircraft Malfunction, Operational Pressure, Ground Events.
- Psychological/Physiological related: Optical Illusion/visual misperception.

Contributing factors for Runway Damage accidents are predominantly attributed to:

- Ground Navigation, including runway or taxiway incursion, loss of control on the ground and ramp movement;
- Aircraft Handling, including vertical, lateral or speed deviation.

The top decision drivers involved in runway damage accidents:

- Procedural – Intentional deviation from SOP Adherence/SOP Cross-verification, Callout and Briefings;
- Flight Crew – Manual handling of primary flight controls;
- Communications – Crew to external communication with ATC.

For more information on this section, visit the IATA Annual Safety Interactive Threat and Error Management Tab.

10.3. Recommendations

Runway Damage accidents should be avoidable. With the exception of aircraft system and engine malfunctions, all other drivers of Runway Damage accidents should be avoidable. Additionally, both aircraft system and engine malfunctions should be practiced in training to enhance the pilots' performance in preventing this type of accident. Runway Damage accidents can be reduced by having suitable airport facilities (fencing and Foreign Object Debris [FOD} clearing) installed and maintained in accordance with current international standards. Proper training in SOPs, handling of the aircraft, and enhancing communication (i.e. radiotelephony, standard phraseology) can also reduce the number of Runway Damage accidents.

10.3.1 Operator Safety

- Establish, promote, and follow a Positive Safety Culture.
- Work with airport authorities to establish mitigations and practices to avoid known contributors for Runway Damage.
- Maintain accurate airport facility information on all destination and diversion airports flown into, focusing on airport layout and lighting facilities and updating them as required.

10.3.2 Operator Training

- Implement scenario-based training with ground navigation events and rejected landings due to potential collisions.

10.3.3 Operator Flight Standards

- The operator’s policy should define:
  - Stabilized approaches;

- Sterile cockpit during ground operations;
- TEM and mandate its application by the flight crew whenever necessary. This systematic application of TEM should enable the flight crew to anticipate and mitigate threats;
- The "PF" and "PM" roles regarding monitoring and their tasks allocation and prioritization during landing, missed approach, and ground operations as they pertain to normal and non-normal operations.

10.3.4 Recommendations for Pilots

- The pilots should proactively review (by referring to the Operation Manual) their roles during abnormal and emergency procedures
  - Role of the PF and the PM during critical phases of flight;
  - Route and/or airport briefings to familiarize themselves with known threats;
  - Situations that may arise based on the airport being flown into with known issues identified during airport analysis; for example – wildlife on the active runway due to insufficient airport perimeter control.

11. In-flight Damage

11.1. Background

In 2023, IATA revised its taxonomy, the In-flight Damage is now defined as an accident that has damage occurring while the aircraft is airborne. This type of accident includes weather-related events, technical failures, bird strikes and fire/smoke or fumes. A subcategory of this type of accident – Collision with Obstacle(s) during Take-Off and Landing (CTOL) was introduced. Events while airborne with an Uncontained Engine Failure caused by the ingestion of foreign objects (i.e. drones, birds, hail, etc.) are classified as In-flight Damage accidents.

CTOL accidents include contact with obstacles such as vegetation, trees, walls, snowdrifts, power cables, Telegraph wires and antennae, offshore platforms, maritime vessels and structures, land structures, and buildings. Additionally, CTOL accidents include water obstacles during take-off and/or landing from water (i.e. waves, dead-head logs/trees, ships, and swimmers). Take-off/Landing accidents are classified as CTOL only when the flight crew are aware of the true location of the obstacle, but its clearance from the aircraft flight path was inadequate to avoid the obstacle.

11.2. Discussion

In-flight Damage accidents are the sixth most frequent type of accident category with 40 accidents over the past 10 years (2015-2024), as illustrated in Figure 17. These types of accidents occur at a rate of 0.11 per million sectors flown. Figure 18 depicts the number of In-Flight Damage Accidents and Rates per year. In-flight Damage accidents have accounted for 98 on-board fatalities and one 'other fatality'. As illustrated in Figure 19, most of these fatalities occurred in a single accident in 2020 where an aircraft crashed in a residential area, also claiming a single other fatality. The single fatality in the 'other fatality' category is not included in the calculation of the fatality risk rate.

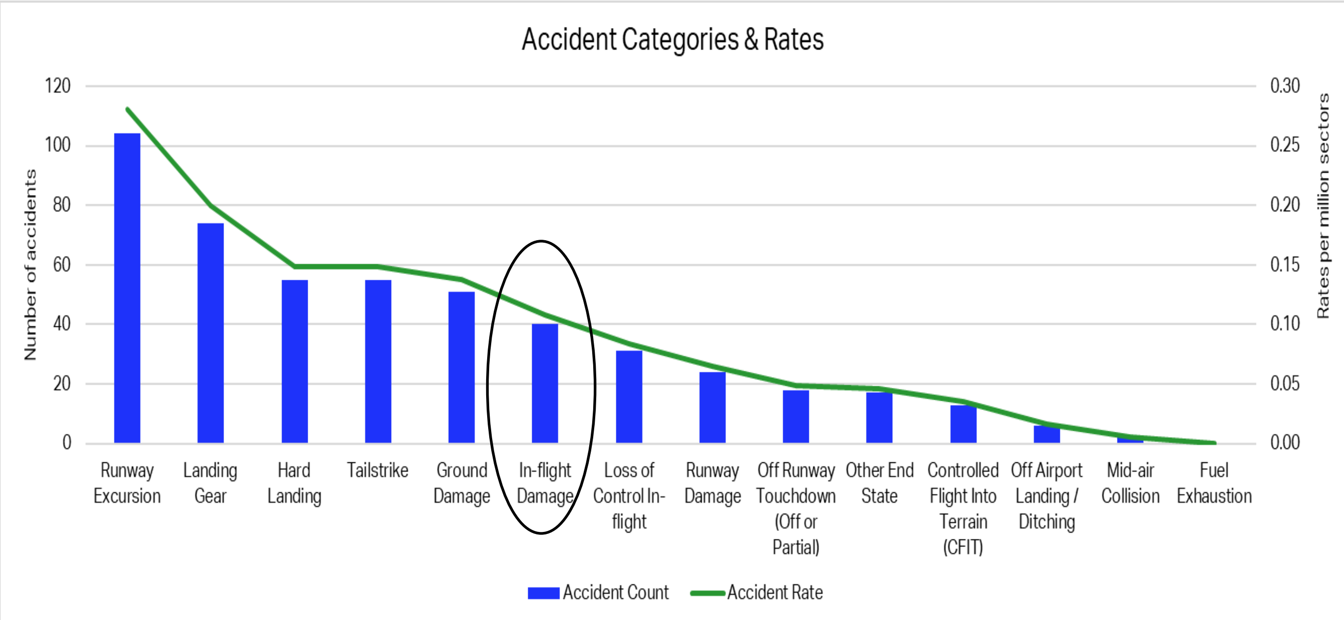


Figure 17: Ranking of Accident Categories

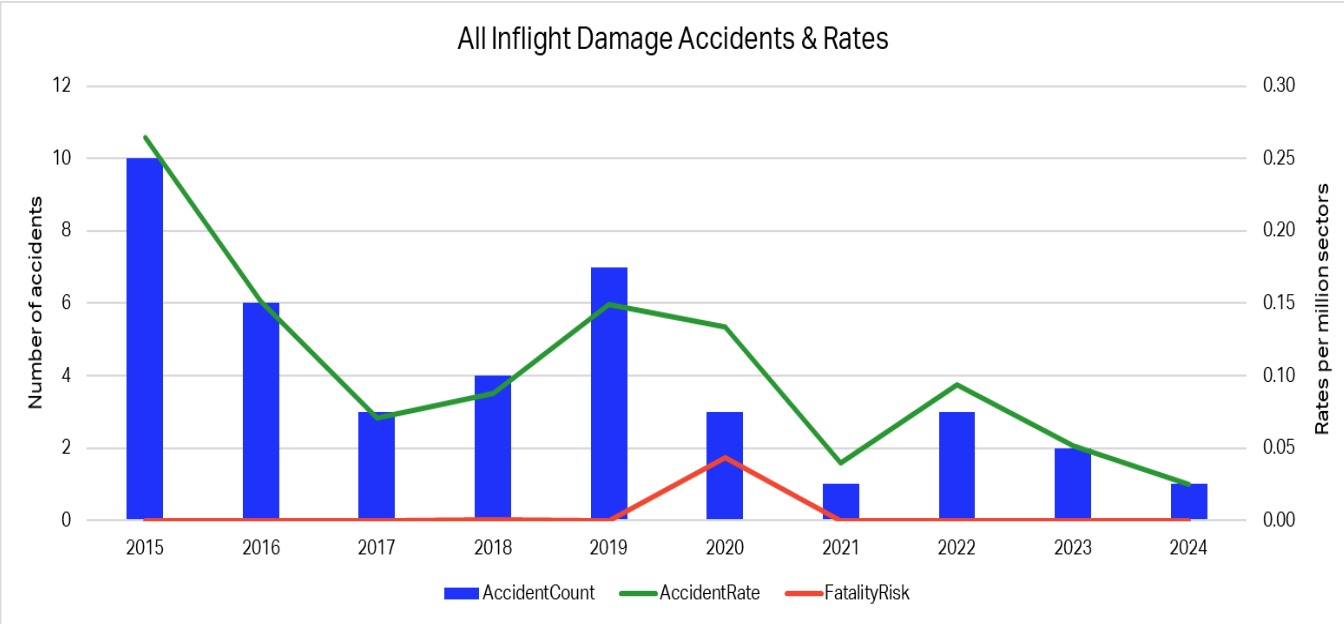


Figure 18: In-Flight Damage Accidents

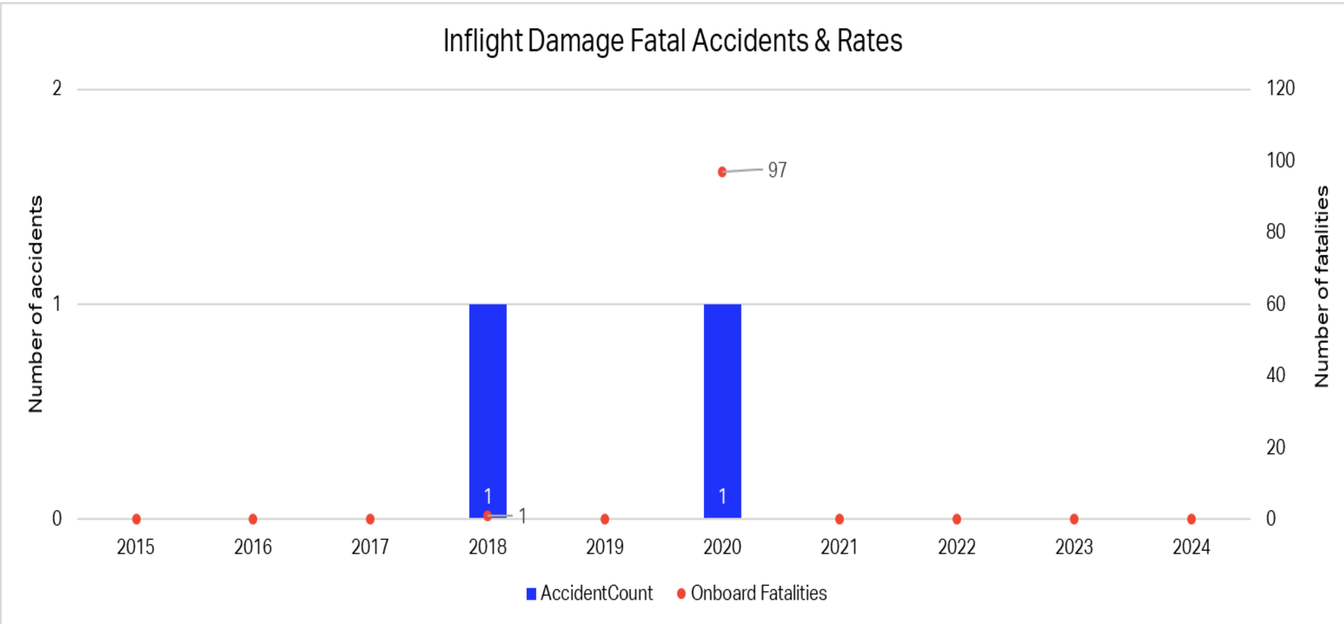


Figure 19: In-Flight Damage Fatal Accidents and Fatalities

Overall, In-flight Damage-related accidents and accident rates have been trending downwards for the period between 2015-2024, and the fatality risk over this period has remained steady at zero except for the fatal accident in 2020.

Out of the 40 accidents over the 10-year period, 5 accidents resulted in hull loss, 4 of which were on jet aircraft. The remaining 35 accidents resulted in substantial damage, 29 of these involving jet aircraft. Figure 20 shows the distribution of Inflight Damage Accidents that resulted in substantial damage and hull loss.

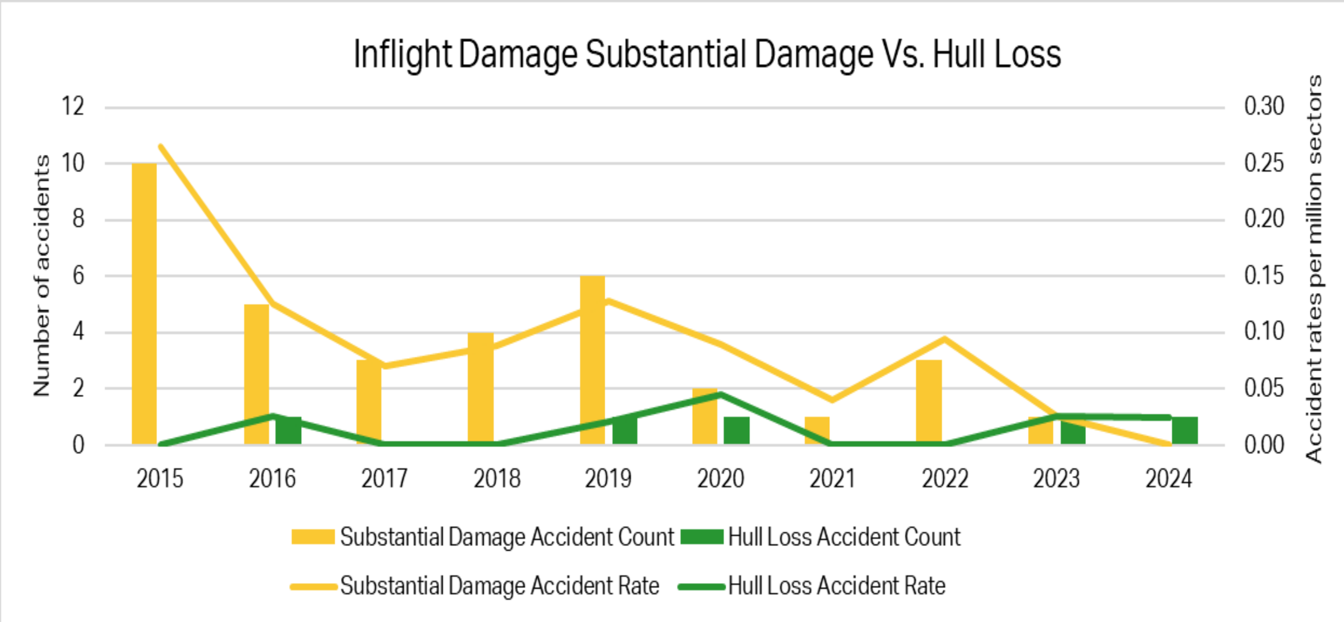


Figure 20: In-Flight Damage Accident Hull Loss Versus Substantial Damage

The top drivers of In-Flight Damage are:

- Environmental such as Meteorology (thunderstorms/convection, hail), Aircraft Impacted by Birds or Foreign Objects, and Airport Facilities (contaminated runway/taxiway which provide poor braking conditions and airport perimeter control/fencing/wildlife control), and
- Airline such as Aircraft malfunction (system failures and uncontained engine failures), Maintenance events and Aircraft fire/smoke (crew, cabin or cargo compartment).

11.3. Recommendations

In-flight Damage accidents happen during a flight. They may be avoidable with proper planning and decision-making. Weather should not be a contributor factor for In-flight Damage accidents if properly planned for and communicated between the flight crew, airline, and airport.

11.3.1 Operator Safety

- Establish and promote a Positive Safety Culture.
- Develop SOPs that are specific to mitigating In-flight Damage (I.e. Proper use of the weather radar).
- Review SOPs ensuring they are up to date and revise them when required.
- Be aware of “trigger events” such as incidents or occurrences, regulation changes, SMS reports (etc.) that warrant a review of the SOPs.
- Maintain the most accurate airport facility information on all destination and diversion airports flown into and update when required.

11.3.2 Operator Training

- Implement training considering the following provisions and best practices:
  - Human factors and crew resource management to improve communication and decision-making;
  - Manual handing of primary flight controls during normal and non-normal procedures;
  - Conducting training to identify an unstable approach and encourage a mitigation strategy, such as a go-around.
- Perform scenario-based training and maneuver training focusing on:
  - flight path monitoring including flight path deviation recognition and intervention;
  - add recognition training for weather and potential unsafe airport conditions.

11.3.3 Operator Flight Standards

- The operator policy should define:
  - Threat and Error Management (TEM) safety management process and mandate its application by the flight crew during all the phases of the flight. This systematic application of TEM should enable the flight crew to anticipate and mitigate threats and errors;
  - Flight path monitoring is the responsibility of both the pilot flying and the pilot monitoring.

11.3.4 Recommendations for Pilots

- Pilots should proactively review their roles during both normal and non-normal situations including:
  - Use of weather radar;
  - Aircraft limitations and technical specifications;
  - The role of the PF and the PM while carrying out normal and non-normal procedures;
  - Improving situational awareness by identifying phases of flight in the operation where a pilot's situational awareness may be reduced. This may include limiting distractions, efficient pre-flight planning, and workload management.

12. Landing Gear

12.1. Background

Landing gear accidents are any gear-up landing/collapse resulting in substantial damage or loss of life. The year 2023 marked a significant revision in the taxonomy. This change led to the creation of two distinct subcategories, allowing for more precise classification and analysis of accidents related to landing gear. The subcategories mentioned above were Gear Collapse and Gear Up Landing. As the names imply, gear-up landings occur when the gear has not extended and locked, or not all gear extends and locks when commanded. Gear Collapse landings occur when the landing gear display shows the gear to be extended and locked in place but subsequently, collapses during the landing. This may occur due to mechanical/systems means or due to the loading placed on the landing gear exceeding the design limits during landing.

12.2. Discussion

Landing Gear accidents are the second most frequent type of accident category with 74 accidents over the past 10 years (2015-2024). Landing Gear accidents occur at a rate of 0.20 per million sectors flown. However, there have been no fatal landing gear related accidents over the same period. Substantial damage and hull loss are the major concern for airlines arising from landing gear accidents.

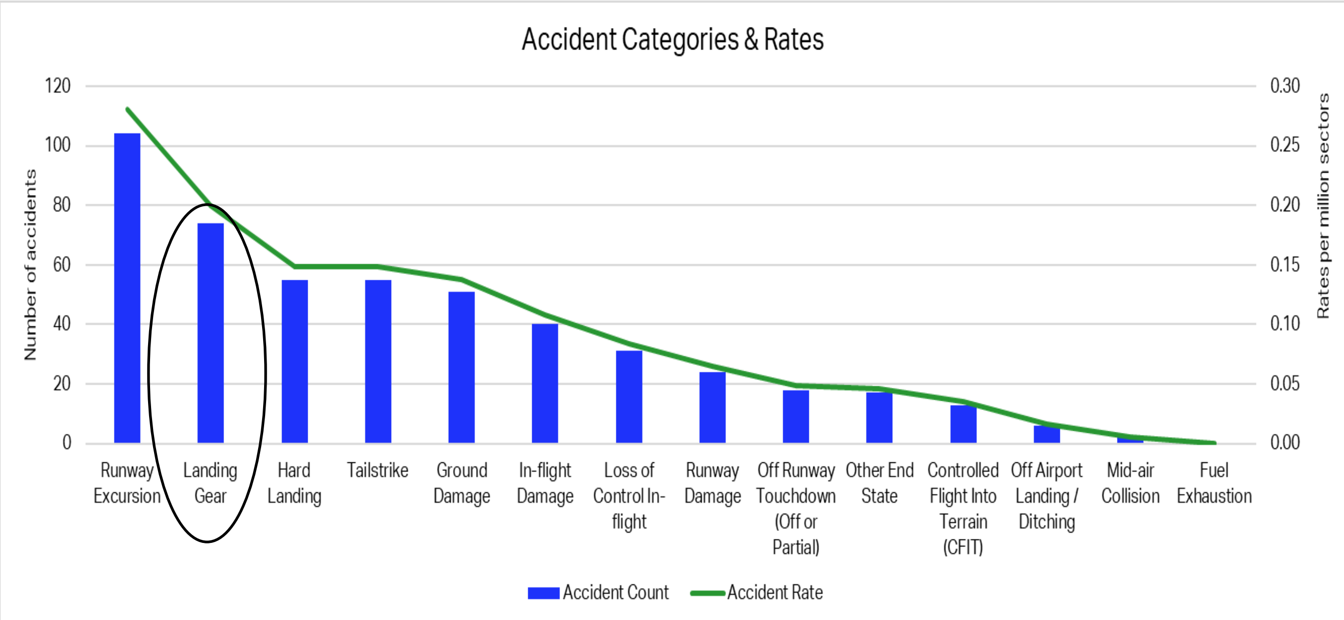


Figure 21: Accident Categories

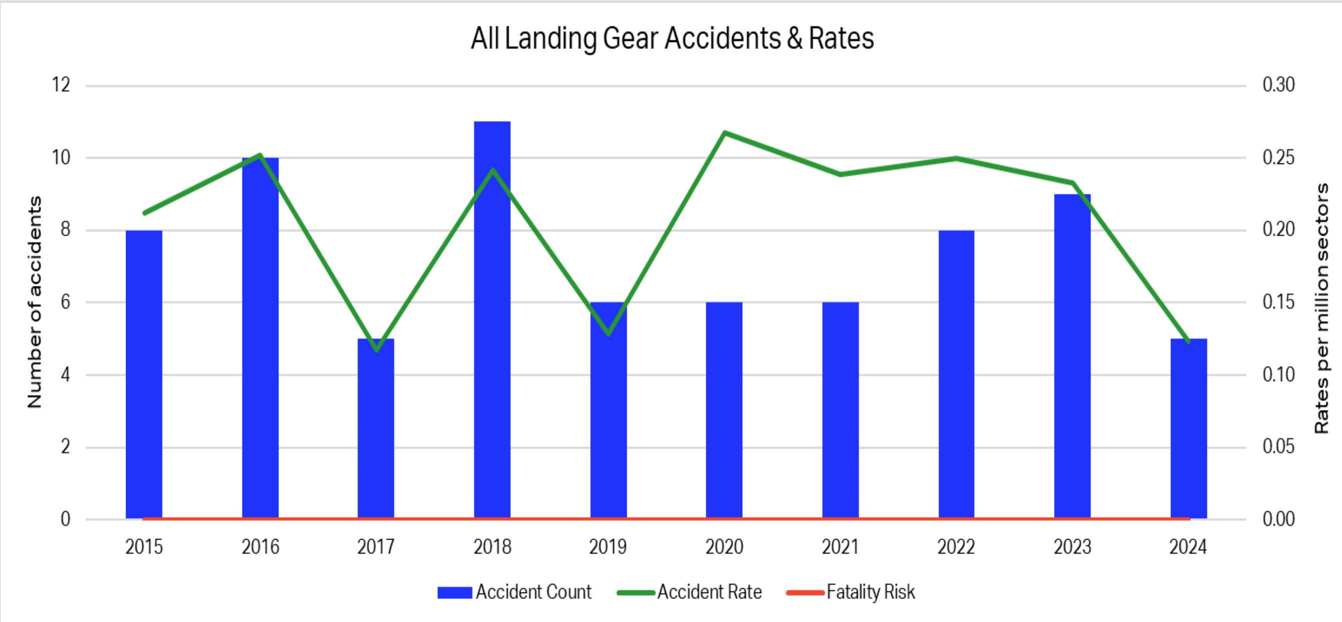


Figure 22: Ranking of Accident Categories

Over the reporting period, 10 aircraft were lost due to landing gear-related accidents, while substantial damage occurred on 64 aircraft. Figure 23 illustrates the distribution of these accidents, highlighting both substantial damage and hull loss.

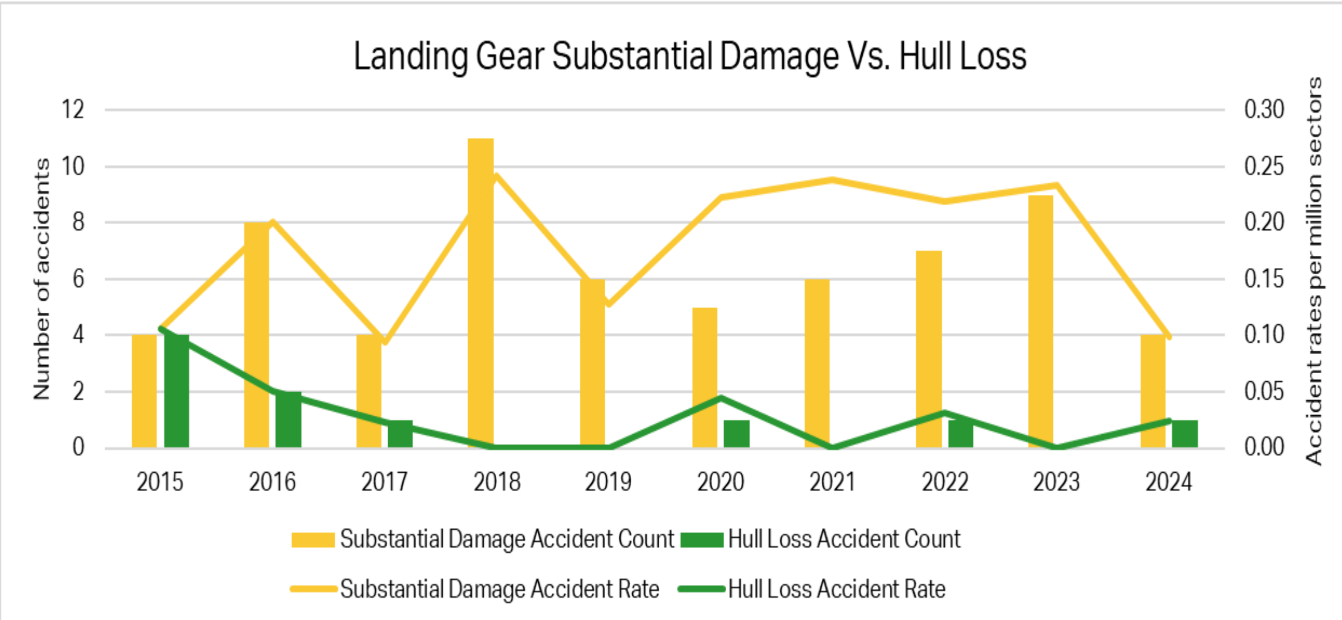


Figure 23: Landing Gear Accident Hull Loss Versus Substantial Damage

Out of the 74 landing gear accidents, 45 were on jet aircraft. The remaining 29 accidents involved turboprop aircraft. Figure 24 illustrates the distribution of these accidents, highlighting both jet and turboprop number of accidents and accident rates. The turboprop accident rate per million sectors rose from 0.55 in 2023 to 0.84 in 2024. The jet accident rate per million sectors went from 0.20 in 2023 down to 0.05 in 2024.

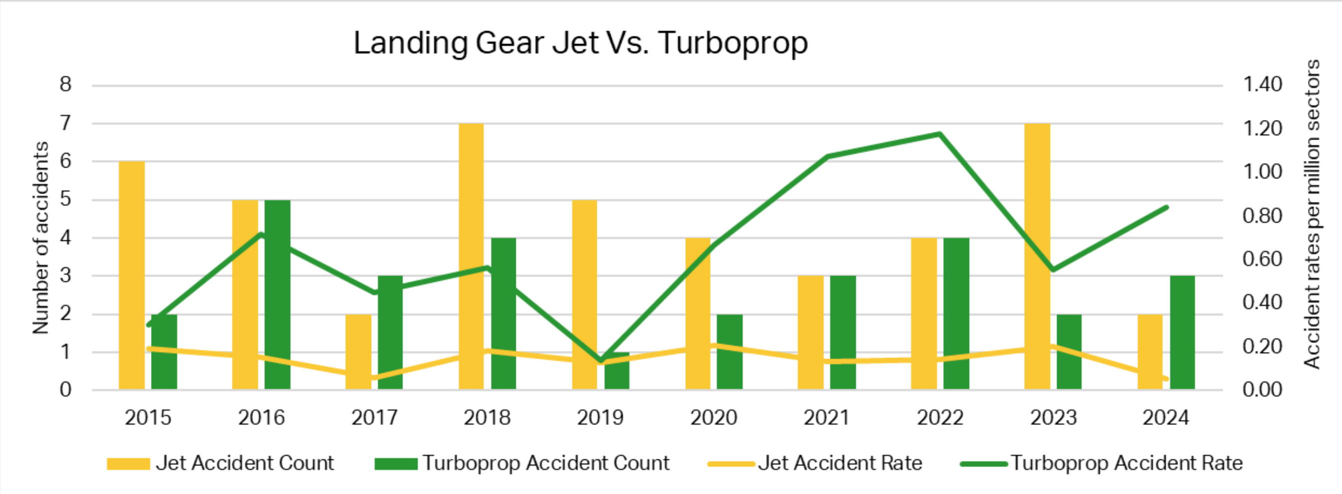


Figure 24: Landing Gears per Aircraft Propulsion

Contributing Factors for landing gear accidents are predominantly attributed to aircraft malfunction system component failure non powerplant (78%), Landing Gear/Tires (77%) with Maintenance Events accounting for 38% with Hydraulic System Failure the top driver at 4%. Other drivers for landing gear accidents are Airport Facilities, Meteorology, Air Traffic Services, Operational Pressure and Dispatch/Paperwork. All these drivers are not significant contributors but do play a part in landing gear accidents.

Landing gear accidents typically occur during the landing phase of a flight. The landing gear is selected 'down' as part of the approach for landing, and the flight crew receives a message indicating a problem with the landing system. In the case of a gear-up accident, alternate means of extending the gear fail, and the flight crew elects to land the aircraft on some of the landing gear or the belly of the aircraft after all alternate means of deploying the landing gear have been exhausted. Typically, it is the nose landing gear that fails to deploy. This may be due to the complexity of the nose landing gear, which not only takes aircraft landing loads but is also used to maneuver the aircraft on the ground. This dual role increases the complexity and number of parts of the component.

In the case of 'Landing Gear Fails to Extend' accidents, the crew is aware of the malfunction and can manage the issue safely. This type of scenario accounts for a number of landing gear accidents, but the largest contributor to landing gear accidents is gear collapse accidents. When the landing gear collapses on landing, the flight crew is typically unaware of a potential malfunction of the landing gear system and is forced to react as the aircraft transfers its mass load (weight) from the wing to the landing gear. In this scenario, the flight crew has virtually no time to plan for the event and must react to the performance of the aircraft as it decelerates to a stop.

Other contributors to landing gear accidents include a mix of system failures, runway conditions, or weather-related factors where the flight crew typically has very little time to react during the landing phase to a destabilizing approach or issues with the runway surface. Fortunately, in all 74 landing gear accidents, the event occurs on the ground, and the majority of the landing forces are absorbed by the aircraft structure, resulting in no fatalities. Unfortunately, when the aircraft structure absorbs these landing forces, the result is significant structural damage to the aircraft or hull loss.

12.3. Recommendations

Due to the nature of the Landing Gear type of accident, there is little the flight crew can do to avoid the event. The Landing Gear system is a complex aircraft component that is a hybrid of structural members and systems, that relies on additional systems to perform its intended function. Where the flight crew are aware, through indication that the Landing Gear has malfunctioned, appropriate measures can be employed to land the aircraft with minimal damage and loss of life.

12.3.1 Operator Safety

- Establish a Positive Safety Culture.
- Establish a maintenance culture that ensures the manufacturer's recommended maintenance is followed.
- Ensure proper oversight at all external Maintenance Repair and Overhaul (MRO) facilities carrying out maintenance on behalf of the operator.

12.3.2 Operator Training

- Implement training considering the following provisions and best practices:
  - Human factors and crew resource management to improve communication and decision-making;
  - The Concept of "The Dirty Dozen" with respect to maintenance (https://www.faasafety.gov/files/gslac/library/documents/2012/nov/71574/dirtydozenweb3.pdf)
- Perform scenario-based training with a focus on:
  - abnormal and emergency procedures including alternate landing gear release;
  - aircraft system malfunctions management including landing gear failures.

12.3.3 Operator Flight Standards

- The operator policy should define:
  - The recommendation to remain on the runway with landing gear malfunctions as appropriate.

12.3.4 Recommendations for Pilots

- Pilots should proactively review their roles during both normal and non-normal situations including:
  - Familiarize themselves with the procedures associated with landing gear abnormalities;
  - Aircraft systems, technical specifications, and limitations.

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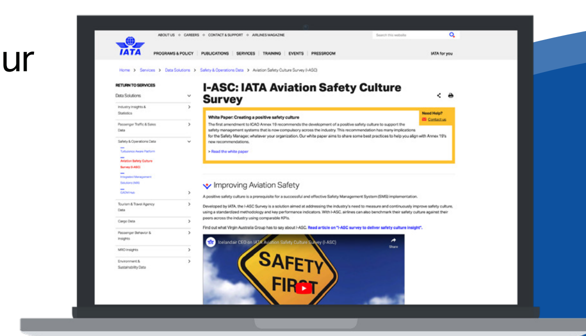


13. In-flight Decision-Making (IDM) and Contingency Management

13.1. Background

With increasing financial pressure on airlines and airports and available airspace becoming more congested more often, the chance of a diversion from the original destination airport is likely to increase. These are, in fact, not the only reasons for the necessity to divert. More frequently occurring adverse weather conditions, an increasing number of illegal drone activities near airports, escalating regional conflicts, activities of civil unrest, to name a few, have shown, that the circumstances for any given flight can greatly change within a matter of minutes, forcing flight crew to alter their routing in order to achieve a safe landing at an alternate airport, where stable conditions and adequate ground handling for passengers, crew and aircraft is granted.

IDM is a systematic approach to the cognitive process of selecting the best course of action by pilots in response to a given set of circumstances. It involves sound decision-making by the pilot during a flight, when operating in a complex operational environment. It requires pilots to continuously collect and process information, maintain situational awareness, have relevant skills and experience. The decision to divert without sacrificing situational awareness, for example, due to weather or other unfavorable flying conditions, usually involves economic consequences, to divert, however, can lead to an even more unwanted outcome.

IDM was a contributing factor in 16% (78) of all accidents from 2015-2024 Missing or insufficient IDM significantly increases the risk of accidents. The number of past events had already raised concerns about many of the approach and landing accidents, giving rise to recommendations. The chart below shows the number of accidents per year that have missing or insufficient In-flight decision-making as a contributing factor.

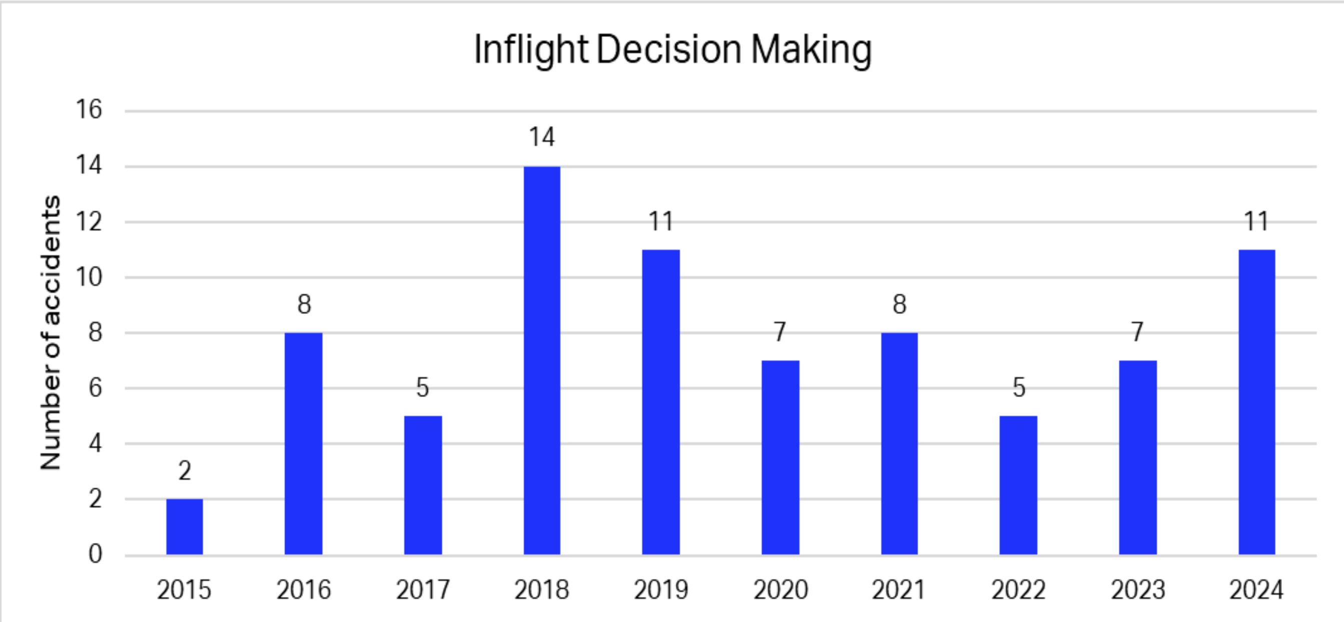


Figure 25: Number of events with in-flight decision-making, a contributing factor

It is apparent in the accident data of the last 10 years that problem solving and decision making is a factor in a number of accidents. Refer to the following table:

End State	2024 46 accidents	2015-2024 490 accidents
Runway/Taxiway Excursion	2 (4%)	22 (4%)
Controlled Flight Into Terrain		10 (2%)
Tail Strike	6 (13%)	10 (2%)
Loss of Control – In-Flight	1 (2%)	9 (2%)
Hard Landing		8 (2%)
Off-Airport Landing/Ditching		4 (1%)
In-Flight Damage		3 (1%)
Ground damage		3 (1%)
In-Flight Damage		3 (1%)
Ground Damage		3 (1%)
Landing Gear	1 (2%)	3 (1%)
Off Runway Touchdown	1 (2%)	3 (1%)
Other End State		2
Runway Damage		1

Good pilot judgment and sound IDM are, therefore, crucial for safe aircraft operations and accident prevention. With good judgment and sound decision-making, the inherent risk in a flight is reduced. It is also important to mention that sound decision-making does not always involve choosing the best solution but making a choice that is adequate to ensure the safety of a flight, rather than eliminating economic consequences.

13.2. Discussion

Many airlines offer strategies to their pilots for reactive decision-making in abnormal conditions and onboard failure cases, such as an unexpected deterioration of weather conditions or a failure of an onboard system. These are sound concepts based on TEM models, well documented and demonstrated to flight crew on a regular basis during training.

However, still only a few strategies can be found for normal operations in terms of giving the flight crew guidelines for a proactive selection of desirable conditions and triggers for an enroute fuel stop or even diversion to an alternate airport. Planned alternate airports are mainly based on official weather minima, but do not consider possible increased traffic flow and runway availability e.g. in case many aircraft arrive at this alternate aerodrome for the same reason and therefore at the same time. In the case of a real diversion, flight crews may find themselves in conditions that are the same or even worse than at the original destination, but now with considerably less fuel. The difference between a legal alternate and a sound valid alternate option is often not considered by dispatchers during the preparation of Operational Flight Plan (OFP) or by flight crews when diverting, nor is this trained. This may end up in a cul-de-sac situation with minimum fuel or, in the worst case, in a hopeless situation with no fuel. In 2024 we have not observed an accident on this category, but just in the recent years our industry has narrowly escaped disasters with some 'close calls'. Often, the airlines' operational control centers do not have all the necessary operational information about possible diversion alternates available. Operational constraints, apart from weather-related threats, are not consistently considered during the decision-making for an alternate airport. Especially emerging conflict zones with developing closures of airspaces and subsequent unavailability of alternate airports have an impact on air traffic. Those areas are often only considered reactive, rather than proactive. Although not the sole solution for any given situation, it has to be said that the amount of fuel available to the crew at any moment in time corresponds directly to their available options. Therefore, IDM has to start already at the dispatch briefing phase of every flight. From then on, the situation has to be monitored within a continuous IDM process by flight crews and the operators mission support team. Conditions (weather, airport and/or airspace availability, fuel burn) that turn into unexpected negative directions have to be picked up at an early enough stage to be able to adapt the conduct of the flight. This could for example mean, that an enroute fuel stop has to be performed or to decide upon diverting to an alternate airport timely enough.

13.3. Recommendations

13.3.1 Recommendations to Operators

Create, document, implement and train a proactive model for IDM during normal daily operations. These models should ensure a solid guideline that allows flight crew to have a stringent and timely strategy for diversion airport assessment. Enable operational control centers or dispatch to have access to relevant enroute conditions, alternate airport databases and means to transfer relevant changes of these information to flight crew enroute in a timely manner. Ensure that a proactive decision model is documented and trained to flight crew on a regular basis. Establish a culture, where flight crews do not hesitate to aim for the timely safe landing at any suitable airport, if unforeseen circumstances occur, that put a safe landing at the planned destination in doubt.

13.3.2 Recommendations to Flight Crew

A valid diversion airport should always have adequate weather conditions, which may be different from legal minima. Operational conditions should be such that the traffic situation as well as system constraints and outages present no threat to a safe landing. The airport layout should allow for more than one landing possibility (e.g., at least a parallel taxiway) to prevent a cul-de-sac scenario. Flight Crews should make use of their best expertise to conservatively anticipate possible deteriorating conditions at their valid diversion airports (e.g. bad WX arears moving into the direction of this airport or possible increased traffic flow to their valid alternate airport causing delay) and avoid flying out all their discretionary fuel to the last possible minute. Performing a diversion to an alternate airport alone increases flight crew workload by itself. Additional pressure resulting from threats like fuel starvation have proven to impair the flight crew decision-making ability and performance.

13.3.3 Recommendations to Industry

Develop and maintain useful and accessible databases for hazards enroute or at specific airports and make them available to airlines and their crews and operational control centers. Develop exemplary models for proactive and reactive decision-making models as a template for airlines and flight crews. Closely monitor regional conflict zones and areas of actual or potential civil unrest, to be able to react instantly if threats arise, which have an impact on the safety of operations. Publish accessible and easy to understand guidelines for dispatchers and flight crews to anticipate short- and mid-term conditions of unfavourable weather development that may negatively affect operations.

Ensure the availability of the latest meteorological information (including updates and amendments) of relevance to the entire flight, including enroute weather conditions and conditions at the origin, destination, and alternate airports.

14. Human Factors

14.1. Background

The understanding of aviation accidents is elaborate, owing to the inherent complexity of how accidents come about within complex sociotechnical systems. Aviation Safety is the responsibility of all the stakeholders in the aviation system. These stakeholders are humans, and human performance is influenced by different factors. Human factors (HF) is concerned with the application of what we know about human beings, their abilities, characteristics and limitations, to the design of equipment they use, environments in which they function and jobs they perform (ICAO Doc. 10151).

The ICAO published Doc 10151 'Manual on Human Performance (HP) for Regulators' (first edition 2021). This manual highlights the importance of integrating Human Performance considerations in the development of ICAO Standards and Recommended Practices (SARPs) and in States associated regulatory activities. It supports regulators to make it easy for people in the aviation system to do the right thing and avoid negative safety consequences. The manual also highlights the human contributions to the global aviation system using a system's perspective on human performance. Human Factors takes a system thinking approach, is design driven and focuses on the outcomes of performance and wellbeing and overall system safety.

14.2. Discussion

Human Factors were identified in many of the accident data in the IATA Safety Report. Human Factors has been widely recognized as critical to aviation safety and effectiveness. Sustainable long-term improvements in aviation safety will come primarily from the human factor's domain such as physical ergonomics, cognitive ergonomics, and organizational ergonomics.

From a safety perspective identifying the sources of human errors is no simple task. Properly investigated and analysed causal factors cannot rely solely on attributions to "human/operator error." It is widely acknowledged that errors are largely a result of confluence of factors (rather than one simple factor), and that these multiple components involve complex processes associated with human performance such as cognition, organizational dynamics, individual differences, and how they interact with system design, tools, and the operational environment.

Over the years, the perception of human error in aviation has also transformed. In the old view, human error was seen as a human problem, with the belief that errors caused problems directly. This perspective led to a focus on identifying and mitigating individual errors. In contrast, the new view recognizes human error as a symptom of deeper system issues. From this perspective, errors are seen as indicators of underlying problems within the system, prompting a more comprehensive approach to identifying and addressing systemic weaknesses.

This shift has driven a more nuanced understanding of safety, where the aim is not only to prevent human errors but to design systems that are resilient to errors and can adapt to and mitigate their consequences effectively.

The modern interdependencies of error, the tightness of aviation component coupling, and the high consequence of error require extending human-system capabilities to enhance performance and to take advantage of technological advances in materials, avionics, data collection, information access, and decision support systems. These technological changes, as well as the expectation of the human to accommodate them, create uncertainties and require additional human performance research to help develop future systems that are error-resistant and error-tolerant.

14.3. Recommendations

The below recommendations are not exhaustive, as each organization should develop human factors strategies and interventions based on their unique organizational needs.

14.3.1 Learning from Normal Work:

Each day in the aviation system people go to work, perform their normal duties and encounter challenges to which they adapt and overcome, all without adverse events. Every day there are opportunities for learning when nothing goes wrong, learning from "normal work".

The everyday work complexities are a vital part of understanding system performance. Adaptive capacity is the system resilience to sustain safe operations despite disturbances. Learning about the precursors of incidents when nothing goes wrong and how people complete the work by adapting to varying challenges and conditions can support the implementation of effective controls and reduce risk. Understanding the system conditions and interactions, talking to the operator at the sharp end, understanding the system constraints, dependencies and flows will support learning from "normal work". Empathy, curiosity and listening are foundations of learning and may support the identification for resilient performance employed by operators in normal work. The use of positive taxonomies may support the analysis of resilient performance, and the use of text analysis from your safety report database is useful in capturing resilient performance from the reporter and feeding this information back into the system.

14.3.2 Managing patterns of failures:

Managing human failures is about predicting how people may fail through errors or intentional behavior within the system. Operational risk assessments need to recognize the limits of human performance and consider the impact of task, personal, environmental, and organizational factors when deciding on barriers and control measures. The management of human error includes the error prevention and the interventions for disallowing an error from adversely affecting system output. Some of those techniques include Human Factors Engineering, Feedback/Feedforward information systems, Ergonomics, Paperwork management, and behavioral safety, among others. It is up to the operator to determine the most suitable approach according to the operational context.

According to the ICAO Doc. 10151 "Manual on Human Performance (HP) for Regulators", 1st Ed. 2021, there are five key factors influencing HP:

- Individuals' performance is influenced by their strengths and limitations;
- Individuals perceive situations uniquely and act in ways that they find logical;
- Individuals adjust their actions to cope with the challenges of a complex and ever-changing work environment;
- Individuals evaluate risks and make compromises accordingly;
- Individuals' performance is affected by their interactions with other people, technology, and their surroundings.

Here we will nominate Risk assessments and Incident investigations as SMS elements of optimizing human performance.

Risk Assessments should consider in addition to 'Hazards' the 'Human Factors', and their implications on human performance. Ensure that the Performance Shaping Factors (PSFs) are understood in how they can influence human performance and that the appropriate barriers and controls are implemented to reduce risk.

The desired safety outcomes of the risk assessments are that the barriers and controls support human performance and consider, task, personal and organizational factors. That the systems and processes are designed to be tolerant of human performance failings, and that the performance shaping factors are optimized. The risk assessment should work through the full hierarchy of control when implementing control measures. IATA provides Safety Risk Management training, Safety risk management is a key component of a successful airline SMS, required to assess the risks associated with identified hazards, and to implement effective mitigation actions.

Furthermore, Incident Investigation should consider the critical elements that enable, understanding performance variability, operator sensemaking, human performance limitations to be understood and allow root causes to be addressed. Event investigations conventionally focus on what went wrong, but the same methods can also be applied to what goes well. Even in the context of adverse event investigations, questions can be asked about what went right during the event, how things usually go well, and why things sometimes go exceptionally well. Introducing modifications into your organization's classification schemes and taxonomies are likely to be needed.

The desired safety outcomes of an incident investigation should be to establish the conditions that allowed performance variability to reach the brittleness boundary, the conditions that allowed human performance failings to occur, that system failings are corrected, and designing systems that are tolerant of human performance failings, furthermore, capturing the resilient capability of the actors when things go well for organizational and individual learning. IATA provides Human Factors in Aviation training; this training focuses on the understanding of human behavior and performance. Human Factors knowledge is used to optimize the fitness between people and the systems in which they work to improve safety and performance.

14.3.3 Procedures:

Procedures include method statements, work instructions, SOPs, flight profiles, Company guidance, etc. Incomplete, incorrect, unclear, or outdated procedures can lead to short cuts and human failures.

Procedural noncompliance and procedural drift have been a causal factor in many aviation accidents. Procedural drift refers to the gap between work as prescribed (baseline performance) and work as done (operational performance).

14.3.4 The Four Ps of SOPs Design

Effective SOP design incorporates four key principles, the "Four Ps":

1. **Philosophy:** This represents management's overarching view on how to conduct operations. It can be a "wide road" philosophy, granting operational personnel discretion commensurate with the situation. This empowers operational personnel to make informed decisions based on real-time circumstances. Alternatively, a "straight-jacket" philosophy provides a highly regimented approach with minimal individual discretion.

Operational personnel are expected to fully abide by SOPs regardless of operational circumstances when performing operational duties.

2. **Policy:** Policy sets out broad specifications for how the organization expects personnel to conduct operations, maintenance, training, and exercise authority. These policies translate the chosen philosophy into concrete guidelines.

3. **Procedures:** Procedures define the specific sequence of actions personnel should take to complete a task. They should be consistent with established policies and outline the "who, what, how, when, and where" of each step. Building on our previous example, a procedure might detail the specific steps involved in a runway incursion: who calls out the incursion, who applies braking, who reduces thrust, and so on.

4. **Practices:** Practices represent what happens in the workplace. These can either reflect adherence to established procedures, or deviations from them. Ideally, procedures and practices should be closely aligned. However, unforeseen circumstances may necessitate deviations.

Effective SOP design includes mechanisms for capturing and analyzing these deviations to inform future revisions of policies and procedures.

Clear procedures and comprehensive training programs are essential for personnel across the aviation industry to effectively manage and mitigate risks. Procedures provide aviation professionals with clear, step-by-step instructions on how to react to various situations, even when hazards arise despite design for minimum risk, incorporated safety devices, and provided warning devices.

- Procedures should also be managed and use a format, style, and level of detail appropriate for the user, task and consider the consequence of errors;
- Procedures should consider the critical elements that are linked to safety critical tasks;
- Procedures are selected, designed, and managed to promote human reliability;
- Procedures are designed in a way easy to understand;
- Procedures are up to date;
- Procedures are easy to access.

A Human-Centered Design (HCD) approach is needed when designing procedures. The application of Human-centered design and systems methods in procedure design involves considering human performance principles that enable the "building in" of safety and the "building out" of hazards. (ICAO, 2023). Its goal is to make it easy to do the "right thing" and reduce the risks of unintended consequences. Procedures that are developed using a human-centered approach result in improved system performance and human well-being.

The desired safety outcomes are that procedures are implemented where they are needed and contain correct scope-actions-and tasks, including emergency actions-and sufficient detail. Tasks are executed safely and consistent with the design intent of the procedure, resulting in standardization. Procedures, checklists, and paperwork are established, and crews are trained in one consistent, predictable way, keeping the company's basic operating philosophy. Standardization serves as an intervention against human error. IATA offers the air transport industry a comprehensive suite of products on a multitude of topics. Ranging from regulations and standards to guidance material, these manuals are designed to promote safety and optimize efficient operations. Airlines, airports, ground service providers, freight forwarders and other key industry stakeholders rely on the IATA guidelines to ensure robust and efficient operations.

14.3.5 Training and Competence:

Many aviation accidents have certain things in common – lapses in group decision-making, ineffective communication, inadequate leadership, and lapses in flight deck management.

Training provides people with new knowledge and skills, but people need to apply and practice these to become competent. Competence is a combination of practical thinking skills, knowledge, attitude and experience. Training and competence can help reduce human failures caused by lack of knowledge and promote behaviors that will keep them safe.

Training should consider the critical elements of enhancing flight crew training by implementing CBTA to include EBT. Consider the competencies of Instructors and Examiners using the standardized competency model developed by IATA Pilot Training Task Force (PTTF).

Training in Crew Resource Management, Team Resource Management and Human Factors in Maintenance is an effective tool in preventing human performance lapses. CRM training considers human performance limiters (such as fatigue and stress), the nature of human error, and it defines behaviors that are countermeasures to error, such as leadership, briefings, monitoring and cross checking, decision making, and review and modification of plans. ("On error management: lessons from aviation") CRM support safe attitudes and behavior, creating safety.

The desired safety outcomes are the resilience in adapting to today's complex yet highly reliable aviation system where the circumstances of the next accident are difficult to predict. IATA led the development of a new training methodology based on evidence collected in operations and training: EBT. An EBT program focuses on the development and assessment of key pilot competencies to better prepare the pilots to manage potentially dangerous situations in flight operations, where the crews can perform normal and emergency procedures consistently to the required competency. IATA provides CRM implementation training, this includes strategies to optimize the use of staff, equipment, and procedures to prevent errors at each phase of flight. This training examines the complex threat and error environments common to today's workplace, providing best practices to increase flight safety.

By adopting an integrated approach to Human Factors training, airlines can create a more cohesive and resilient safety culture, where personnel from different departments (Flight Crew, Cabin Crew, Dispatchers, Mechanics, Ground Operations Staff, Passenger Service Staff and Cargo personnel) work collaboratively to enhance overall aviation safety and operational effectiveness. This approach allows the airlines personnel to work on common problems across operational areas, on topics based on communication, teamwork, workload management, situational awareness, decision-making process, and leadership, among others.

14.3.6 Fatigue Management:

Fatigue poses an important safety risk to aviation. In addition to decreasing performance in-flight fatigue has negative long-term health effects. Some of the main airline accidents identify chronic fatigue, sleep loss, and desynchronization as three "human factors" hazards that contributed to unsafety.

In accordance with ICAO, fatigue is defined as a physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to perform safety related operational duties. It can lead to human failures, for example, slower reaction times, reduced ability to process information, memory lapses, absent-mindedness, and losing attention.

Crew member fatigue is now acknowledged as a hazard that degrades various types of human performance and can contribute to aviation accidents and incidents, as fatigue cannot be eliminated, but can and should be managed. Fatigue management should consider how duty patterns are designed and managed, to reduce the level of crew fatigue. Fatigue management is a shared responsibility. On the one hand, flight crew are aware of the negative effects of fatigue and utilize rest periods effectively to get the required restorative sleep. At the same time, the fatigue levels of crews are monitored and managed such that system safety is not compromised.

The desired safety outcomes are that roster patterns and duty hours are designed to balance the demands of the flight duty with the time for rest and recovery so that personnel are alert when on duty.

Incorporating training on fatigue recognition and management into Human Factors training for operational areas is a critical and recommended practice for airlines. Fatigue can significantly impact the performance and decision-making abilities of individuals in the aviation industry, making it essential to equip personnel with the knowledge and strategies to identify and mitigate fatigue in the daily life, such as sleep hygiene measures.

Implementing Fatigue Management Strategies

To support operator's implementation on fatigue management strategies and FRMS, the IATA Human Factors Task Force (HFTF) has developed the following documents.

- Common Protocol for Minimum Data Collection Variables in Aviation Ops;
- Fatigue SPIs: A Key Component of Proactive Fatigue Hazard Identification;
- IATA FRMS White Paper;
- IATA FRMS Condensed Version of CASA Document on Biomathematical Models;
- IATA FMTF White Paper on Uses and Limitations of Biomathematical Fatigue Models.

Implementation guide for operators

The Fatigue Management Guide for Airline Operations marks the collaboration between IATA, ICAO and the International Federation of Airline Pilots' Associations (IFALPA) to jointly lead and serve the industry in the ongoing development of fatigue management, using the most current science. It presents the common approach of pilots, regulators, and operators to the complex issue of fatigue.

All documents are available for download from the IATA website.

14.3.7 Organizational Culture:

The shift from blaming individuals (the 'old view') to understanding errors as consequences of systemic vulnerabilities (the 'new view') marks a significant evolution in safety philosophy. The new view, supported by contemporary human factors research, posits that errors are not merely the result of individual failings but are often predictable outcomes of interactions within complex systems. This perspective recognizes that human error is inevitable and seeks to understand the conditions and contexts in which errors occur, aiming to design systems that are resilient to these inevitable human shortcomings.

Setting expectations, leading by example and decision making that takes safety into consideration are essential in creating a strong safety culture. This means taking personal accountability for safety. The safety culture of an organization is the product of individual and group value, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, the style and proficiency of and organization's health and safety management.

A 'learning organization' values and encourages learning from its core and other organizations' experience. Learning organizations are characterized by "constant vigilance" and seek out bad news as well as good news. Understanding human factors can turn organizational learning into preventive solutions and using behavioral safety methods as an approach which promotes safe behaviors and discourage unsafe behaviors.

Organizational culture should consider the critical elements that management of hazards is consistent within the business. This means that production/safety conflicts are managed responsibly, that risks are understood across the business and all team members are empowered to act safely.

The desired safety outcomes are that organizational culture supports a safe aviation system. With the positive outcome of timely risk recognition and management and effective TEM.

The operator should consider a system thinking approach to safety. Systemic approach to safety implies considering the system, as well as the interactions and interconnections between its various elements—human, technology, organization, and context—rather than considering single elements in isolation. ("Systems thinking applied to safety culture approach in …"). IATA's Safety Leadership initiative and its Aviation Safety Culture Survey (I-ASC) are noteworthy contributions to advancing the safety culture and overall safety performance within the industry.

14.3.8 Developing and Maintaining a Just Culture

In accordance with Skybrary, one key to the successful implementation of safety regulation is to attain a "just culture" reporting environment within aviation organizations, regulators, and investigation authorities. A just culture, which is one of the main drivers of a broader concept of Safety Culture, plays a significant role as both an enabler and an indicator of a robust Safety Culture. It is fundamental for building trust, enhancing safety reporting, and promoting a continuous improvement mindset within the aviation industry.

Recommended Key Features for Developing and Maintaining a Just Culture: the following list outlines some of the key features that need to be addressed when developing and maintaining a Just Culture in an organization:

- Just Culture policy documented;
- Definitions agreed about what is "acceptable" behavior, and what is "not acceptable". (Note: these will be specific to, and aligned with, values derived from national, organizational and professional cultures);
- Sanctions agreed for unacceptable behavior;
- Process to deal with actions in the "grey area".
- Just Culture policy communicated throughout the organization;
- Reporting systems linked to Just Culture policy;
- Fair treatment being applied;
- Breaches of the policy being monitored (e.g., error punished, or violations excused);
- Reports being followed-up; actions taken to address error-producing conditions;
- Just Culture training provided to all staff;
- Just Culture awareness campaigns addressed to staff at all levels.

14.3.9 Mental Health and Wellbeing:

The aviation system is working 24/7. This constant pressure on the aviation workforce with changing rosters, night shifts, and circadian disruptions can make it challenging to maintain a regular 'healthy lifestyle'. Research suggests that these sources of work-related-stress affect the physical, social, and psychological health of the aviation worker. The aviation worker suffers the same or higher mental health and wellbeing issues as the rest of the population. A systems-based approach to Health is the biopsychosocial view of health. It is a holistic view of health which considers the impact of psychological and social influences. The biopsychosocial model of health correlates the interaction between psychological and biological factors, and one important element is to consider the impact that stress can have. Negative stress can produce general health decline, autonomic dysregulation, and cognitive process; however, the primary concern is its impact on mental health.

"Mental health is a state of wellbeing in which and individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community." (World health organization). Organizations are encouraged to work in preventing work-related mental health conditions by managing psychosocial risks in the workplace. Employers can implement organizational interventions that directly target working conditions and environments Aviation personnel from pilots, Air traffic controllers, Maintenance Technicians, Cabin Crew, support staff etc., experiencing mental health and wellbeing difficulties should be prompted to speak with their Peer Support Officers of the Peer Assistance Network, Employee assistance program counsellor, General Practitioner, Aviation Medical Examiner, family, friends, or colleagues. Removing the stigma and asking for support early is the best option. Aviation organizations should develop and implement in their workplace an integrated approach to mental health and wellbeing with three main areas to focus on: protection, promotion, and support.

Protect and promote mental health at work by offering manager training for mental health, training for workers in mental health literacy and awareness, and interventions for individuals to build skills to manage stress and promote well-being.

Support people with mental health conditions to participate in and thrive at work by offering reasonable accommodation at work and return-to-work programs that combine work-directed care with ongoing clinical care.

Create an enabling environment for change by strengthening leadership and commitment to mental health at work not just focusing on the absence of illness but on the presence of wellness!

Incorporating training on self-care based on "IMSAFE" model (as a reference framework) into Human Factors training is a recommended practice. The "IMSAFE" model is well-known in aviation for assessing a pilot's fitness for flight. It stands for Illness, Medication, Stress, Alcohol and other psychoactive substances, Fatigue, and Nutrition (Eating).

A Look from Previous Accident Prevention Strategy - This Section Has Not Been Updated for the 2024 Edition of the Safety Report

15. Unstable Approaches

15.1. Background

Approach and landing procedures are some of the most complex procedures in flight operations. The approach and landing phase of flight has a critical function in bringing an aircraft safely from airborne to runway, and a stable approach is a key feature to a safe landing. IATA Annual Safety Report indicates that UA was a contributing factor in 26% of the approach and landing accidents from 2016-2020.

The reduction of unstable approaches is an ongoing objective of the aviation industry. Operators have strict criteria that must be met to continue an approach. These criteria are based on a series of 'gates' that normally prescribe speed, aircraft configuration, rate of descent, power settings and the correct lateral and vertical path, taking into account real-time variables such as prevailing wind and weather conditions on the approach. If these criteria are not met at a certain point, a go-around is mandatory.

In 2017, IATA, in collaboration with CANSO, IFALPA and IFATCA, produced the 3rd edition of Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices. The purpose of this guidance is to raise awareness of the elements that contribute to unstable approaches, as well as to state some proven prevention strategies. The guidance also emphasizes the importance of pilots, ACTOs and airport staff working together with regulators, training organizations and international associations to agree on measures and procedures to reduce unstable approaches.

In 2020, during the COVID-19-induced downturn in air transport activity, an analysis of flight operations data revealed a substantial increase in the proportion of unstable approaches. UA was cited as a contributing factor in 29% (10 accidents) ACTF Accident Prevention Strategies of all accidents that happened in that year. At that time, IATA alerted the industry of the increase through the issuance of an Operational Notice that recommended operators review and implement the recommendations found in the 3rd edition of the Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices document.

15.2. Discussion

It is common to think of unstable approaches as a precursor of RE accidents. A deeper analysis of accident data shows UA is one of the most common contributing factors to many accidents, like CFIT, Hard Landings, LOC-I, and Tail Strikes, among others. This realization, coupled with the increase of UA in 2020, gave rise to the UA Analysis Project, led by IATA and CANSO, and with the participation IFALPA, IFATCA, ATR, Boeing, Embraer, CAST, World Meteorological Organization (WMO), ICAO, and many airline members and industry safety partners.

The objective of the UA Analysis Project was to evaluate the effectiveness of current industry practices that have been implemented to improve the UA rate and provide recommendations to enhance their effectiveness or recommend new ones that might be missing. To support this work and its recommendations, a number of steps were taken, which included:

- Industry experts conducted five safety risk assessments (SRAs).
- A survey was conducted to help gauge the state of the industry and the effectiveness of current industry UA strategies, policies, training and communication efforts.

This initiative identified issues that significantly influenced the possibility of UAs, examined their impacts, and showed their importance in preventing UAs. Such issues are:

- Variations were noted across the industry in the implementation of stabilized approach SOPs recommended by aircraft manufacturers.
- Deviations by pilots from the operators' SOPs and industry best practices for stabilized approach criteria, as well as missed approaches and go-arounds.
- Lack of an industry-accepted definition of "high risk" UAs, which might help operators focus resources and achieve effective improvements in the UA rates.
- Lack of participation in industry safety information-sharing programs, and local and regional safety groups, which could produce systematic industry improvements in UA rates.
- Wider use of the 3rd edition of Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices and other industry documents is of paramount importance.
- Punitive safety cultures.
- Ineffective crew resource management.

Collaboration, cooperation, transparency, and communication between all participants, including the operators, manufacturers, state regulators, training organizations, ANSPs, Air Traffic Control Officers (ATCOs) and, of course, the pilots themselves, is required to implement

- procedural changes to systematically reduce the rate of UA at
- runways identified as higher risk.

15.3. Recommendations

To overcome the issues identified by the safety experts, many options were considered by the group to enhance or implement new safety measures. They were weighted based on their effectiveness, cost, implementation time, and efficiency. In the end, the group settled on the following recommendations:

- Develop an industry standard for Risk Classification of Unstable Approaches ("high risk").
- Validate consistency for the use of stabilized approach SOPs in the industry.
- Promote the importance of establishing and actively participating in safety information-sharing programs (e.g., EASA - Data for Safety (D4S), FAA - Aviation Safety Information Analysis and Sharing (ASIAS), IATA – FDX, Asia Pacific RASG - AP Share).
- Improve crew resource management behavior.
- Implement a positive safety culture and employ a nonpunitive approach to reporting and learning from adverse events.
- Improve/implement national regulations to protect safety information and its sources.
- Measure implementation of information-sharing regulations in ICAO's Universal Safety Oversight Audit Programme (USOAP) and rank countries accordingly. Propose to ICAO to highlight safety information protections in their USOAP reports to countries.
- Update and promote the IATA, CANSO, IFATCA, IFALPA 3rd edition of Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices.
- Urge pilots to comply with SOPs and industry best practices for stabilized approach criteria, as well as missed approaches and go-arounds, due to the dangers of a UA.
- A full report with the full set of recommendations will be made available on our runway safety page of the iata.org/safety.

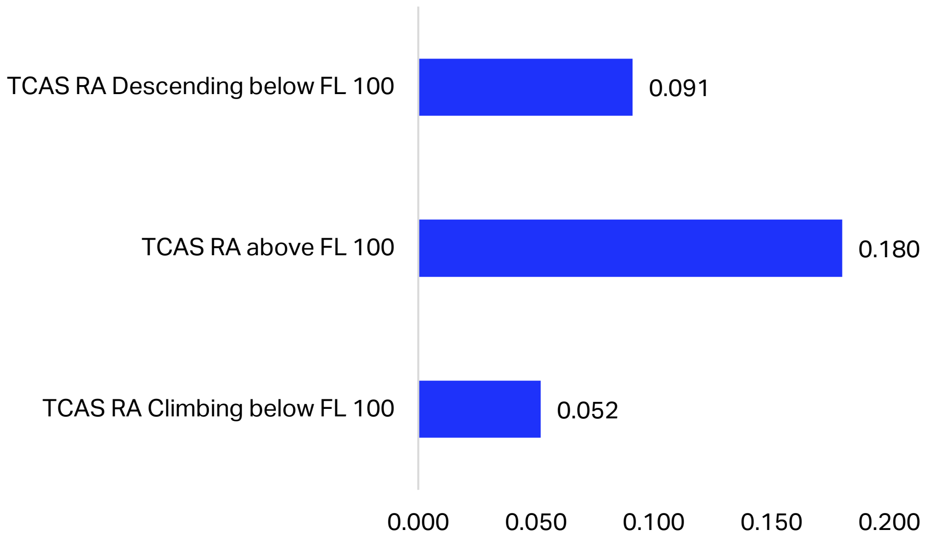
16. Mid-Air Collision (MAC)

16.1. Background

Safety information continues to show that Mid-Air Collision (MAC) remains a high-risk area in aviation. In the IATA Annual Safety Report, two accidents were attributed to MAC in the last 10 years, with zero MAC accidents in 2021. Although in 2021 the air traffic volume still has not reached pre-pandemic levels, the risk of MAC is still present in the industry. The outcome of a MAC accident would most likely be catastrophic with multiple fatalit

16.2. Discussion

Due to the consistent low number of MAC accidents, it is worth taking a close look at other data, especially data on the precursors to MAC, such as Traffic Collision Avoidance System Traffic Advisory and Resolution Advisory (TCAS TAs and RAs). The IATA FDX database and an IATA/EUROCONTROL joint study provides good statistical data that helps to better evaluate the risk of MAC. At the time this report was prepared, the data shows the risk of encountering a TCAS RA between January 2017 and October 2021, excluding corporate jets, was 0.180 per 1,000 flights for the flight phase above FL100. TCAS RAs below FL100 have been split into TCAS Climb RAs (0.052 per 1,000 flights) and TCAS Descend RAs (0.091 per 1,000 flights), as the later are prone to develop additional conflicts (e.g., Ground Proximity).



16.2.1 FDX TCAS Rate (per 1,000 FDX flights)

Introducing TCAS in aircraft has, without a doubt, contributed largely to the low number of MAC accidents the industry has experienced in the last decade. TCAS has proven to be a reliable countermeasure to MAC, but there are shortcomings to be observed. Consistent updates of hardware and software, as well as effective pilot training, are crucial points to keep the system effective. Despite efforts made by the industry over the years, the recent IATA/EUROCONTROL study gave indications about some areas where the industry can still improve.

Opposite Initial Pilot Response (OIPR): It was discovered that, in several cases, pilots reacted to RAs in the opposite vertical direction than required (e.g., initiating a climb when a descent was needed). In most of these cases, the pilots corrected their actions within seconds and subsequently flew the RA in the correct vertical direction. The initial opposite reactions were occurring across a wide range of aircraft types and operators.

The OIPR events may diminish the effectiveness of collision avoidance advice given by TCAS or trigger excessive reactions to correct the RA.

Excessive g-loads while responding to RAs: Occasionally, pilots apply excessive g-loads while responding to RAs. These cases should be captured by RA monitoring and investigated, as excessive g-loads carry a risk of injury to the aircraft occupants and, in some cases, damage to the aircraft.

To further enhance safety within the MAC category, operators must implement a TCAS monitoring program and investigate these types of events. The lessons learned will be fed into their safety promotion program and, when necessary, into their training program. Furthermore, existing procedures should be reviewed to determine whether they are suitable for every situation that can occur in their flight operations.

There are still large areas of airspace where commercial air traffic and general aviation operate in close proximity. In some areas, smaller aircraft are exempted from the use of transponders and see-and-avoid is the main barrier to prevent MAC.

With today's speeds of modern aircraft, this proves increasingly ineffective, as one accident, involving two non-commercial planes (therefore not included in our database), that happened in Denver, CO, in 2021 showed in an impressive manner.

Improved positive safety culture: This includes improving resource management, air and ground communications, training, compliance with TCAS warnings, etc.

16.3. Recommendations:

- Flight crew should always respond to an RA without undue delay, but avoid hasty and abrupt reactions to prevent incorrect maneuvers. IATA recommends that all operators and flight crew consult with the 3rd edition of the IATA/EUROCONTROL Performance Assessment of Pilot Compliance with TCAS using FDM guidance material.
- Flight crew should refrain (except when mandated by SOP or operational guidance) from switching their TCAS to 'TA only' and always use TCAS TA/RA mode, especially during approach in high-density airspaces.
- FSTD manufacturers, airplane operators and ATCOs should work together to develop realistic TCAS training scenarios that provide a variety of real-world TCAS scenarios.
- Existing FSTDs should be upgraded to be able to provide these scenarios.
- TCAS training should be improved to address these realistic scenarios and some special cases (e.g., Low-Level TCAS Descend RA, TCAS scenarios during parallel RWY ops).
- The 'see-and-avoid' principle alone is too weak to be effective, especially combined with the speeds of modern jet aircraft and today's recovering traffic load. Where commercial airline traffic is allowed to be present in an airspace, the regulator should ensure TCAS systems for all traffic are compatible with each other and all traffic is known to ATC. This also applies to UAVs. This is indispensable around commercial airports.
- Pilots have to be able to easily determine in their charts where the boundaries between controlled and uncontrolled airspaces are located.

17. Ground Damage

17.1. Background

This category includes accidents that cause damage to aircraft while on the ground as a result of ground movements, such as taxiing to or from an active runway, or because of ground handling operations when parked on the ramp. In accordance with ACTF taxonomy, it includes:

- Occurrences during (or as a result of) ground handling operations
- Damage while taxiing to or from a runway in use
- Foreign Object Debris (FOD) not on the runway in use
- Fire/smoke/fumes while on the ground

Other events related to this classification are:

- Contact with another aircraft, person, ground vehicle, obstacle, building, structure, etc. while on a surface other than the runway in use.
- Damage while servicing, boarding, loading or deplaning the aircraft.
- Deficiencies or issues related to snow, frost and/or ice removal from the aircraft.
- Pushback/powerback/towing events.
- Jet blast downwash ground handling occurrences.
- Damage while in parking areas (ramp, gate, tiedowns).
- Preflight procedural or configuration errors leading to subsequent events (e.g., improper loading/servicing/secured doors and latches)

17.2. Discussion

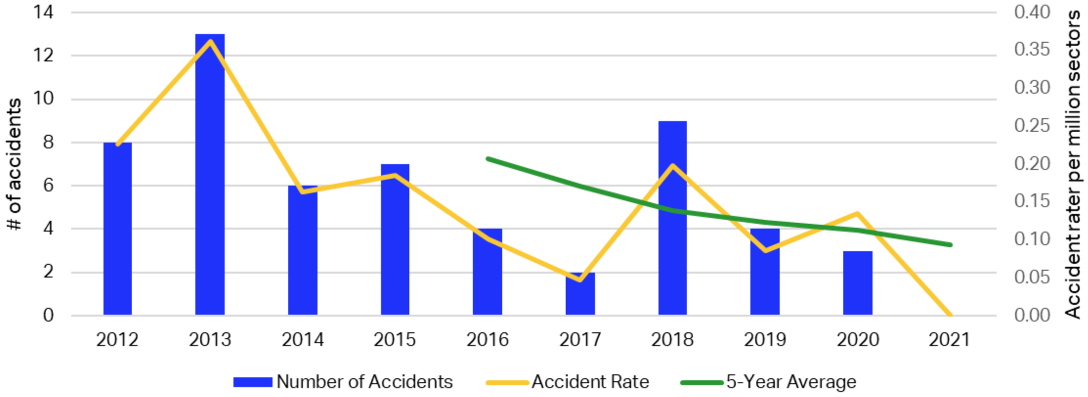
When aircraft are taxiing to or from an active runway, they have to successfully navigate through designated paths, following and respecting the instructions given to them and using the signs and markings. Complex regulations, processes and procedures are put in place by regulators and airport operators to ensure no obstacles or threats pose a risk to aircraft movements.

While on the ramp, aircraft are surrounded by various equipment, ground vehicles, and ground personnel (including ground handling, airport, cargo, maintenance, and security crews, among others), all of which are always on the move and follow precise procedures and timelines to ensure safe and on-time operations. If this choreography of movements is not managed correctly, they can pose a threat to safe operations.

During ground operations, FOD is another concern, as it imposes a significant threat to safety. FOD can damage aircraft during critical phases of flight. The risk of FOD can be reduced by implementing FOD preventive measures and using FOD detection and removal equipment effectively.

ACTF recommends that all stakeholders, including Ground Service Providers (GSPs), airports operators, and aircraft operators implement several measures to reduce ground damage accidents and promote safety culture.

In the last decade, the number of ground damage accidents followed a good downward trend until 2018, when the accident rate reached 0.20 per million sectors, well above the average five-year (2014-2018) accident rate of 0.14. In 2020, we saw another increase in the accident rate, which reached 0.14 per million sectors (above the average five-year (2016-2020) accident rate of 0.11 per million sectors).



Although there were no ground damage accidents reported in 2021, ground damage accounts for 9% (56) of total accidents reported in the IATA Annual Safety Report from 2012-2021. Of the 56 ground damage accidents, we found:

- 50 involved passenger flights and 5 cargo flights
- 43 involved jet aircraft and 13 turboprop aircraft
- No fatal accidents

When categorized by phase of flight, we found the following distribution for the 56 ground damage accidents:

- 39% during taxi in/out
- 27% during engine start
- 18% during pre-flight
- 7% in parked position (post-arrival)
- 5% during ground servicing
- 4% on landing

The results of the ACTF TEM analysis of the same accidents shows the following contributing factors:

Latent Conditions	Contributing Factors	
Threats	Environmental	Meteorology Air traffic Services
	Airport	Airport Facilities Poor sign/lighting/markings Rwy/twy closure
	Traffic	Airport traffic Vehicles
	Airline	Aircraft Malfunction Brakes
	Flight Controls	Ground Events
	Psychological/Physiological	Optical illusion Mis perception
Errors	Procedural	SOP Adherence/cross verification
	Communications	Crew ramp Crew ground control
	Aircraft Handling	Manual Handling
Undesired Aircraft State	Gnd. Navigation	Ramp Movements Loss of acft. Control on gnd. Wrong twy, ramp, rwy, gate, hot spot
	Incorrect acft Config.	Brakes, Engine, Thrust Reverses, Gnd. Spoilers Operation outside aircraft limitations

Actions that can be taken to reduce ground damage accidents while taxiing or on the ramp include:

- Vehicle operators and flight crew must maintain situational awareness.
- Vehicle operators and flight crew must operate in accordance with all company and airport rules.
- Vehicle operators and flight crew must remain vigilant to the potential of other vehicles crossing at designated apron maneuvering areas.
- Flight crew must remain vigilant for a taxi lane that is compromised by another aircraft, vehicle or object.
- Flight crew, when taxiing in gusty wind conditions or at busy airports, must maintain a safe taxiing speed to ensure directional control and have the ability to recognize any potential hazards in time to avoid them.
- To help flight crew determine the wingtip path while taxiing when the wingtips cannot be easily seen from the cockpit, an anticollision aid, such as a camera system, should be installed

17.3. Recommendations

ACTF proposes the following points to be revisited by both service providers and airport management to reduce ground damage accidents:

- to improve safety through ISAGO audit, which aims to improve the safety performance of GHSPs and the reduction of safety risks in ground operations.
- Implement combined training, including regulations, industry standards, best practices, and SMS.
- Follow aircraft ground handling procedures set by international organizations like the IATA Ground Operations Manual (IGOM), IATA Safety Audit for Ground Operations (ISAGO) and IATA Airport Handling Manual (AHM).
- Complete obstruction-free clearance, including FOD on runways, taxiways, and aprons.
- Perform requirements and procedures for regular inspection to detect and remove FOD.
- Hold detailed discussions with risk and safety departments regarding the introduction of any improved safety procedures to examine lessons learned.
- Ensure flight crew are familiar with the airport maneuvering areas and procedures, especially during construction and unusual circumstances.
- Enhance the ground communication between flight crew, ATC personnel and vehicle drivers during aircraft and vehicle operations in the maneuvering areas of airports to ensure greater situational awareness.
- Pay special attention to keep Notice to Airmen (NOTAMs) updated and with clear text.
- Develop a package of Safety Performance Indicators (SPIs) and Safety Performance Targets (SPTs) to manifest and measure ground safety performance.
- Develop a package of SPIs and SPTs to focus on collisions on the ground that are directly related to ground handling activities.
- Train ground personnel on CRM and competencies such as leadership, teamwork, decision-making and problem-solving.
- Focus training on real exercises in situ with abnormal situation simulations rather than on theory.

18. Training: Refer to Appendix "A"

Operators should implement effective training methods such as competency-based training and assessment (CBTA) including Evidence-Based Training (EBT). From a competency-based training and assessment perspective, the pilot competencies provide individual and team countermeasures to threats and errors and undesired aircraft states.

Under CBTA programs, the CRM skills are embedded in the pilot competencies. Therefore, the CRM training supports the development of the competencies as countermeasures in the TEM concept. Additionally, EBT curriculum contains relevant scenarios for pilots to be exposed to runway excursion contributing factors.

- The operator initial and recurrent training programs should include, but not be limited to, the following:
  - Effective usage of the ICAO GRF
  - Effective determination of the take-off and landing performance calculation and emphasis on the resulting runway safety margin
  - Runway excursion contributing factors and risk mitigation
  - **Scenarios based Training** to develop pilots' competencies* for effective threat and error management to prevent runway excursion (e.g., contaminated runway, last minute change of runway, deterioration of weather conditions…).
  - **Manoeuvre training** to specifically develop pilots flying, monitoring and intervention skills (e.g. bounce landing, take-off and landing with maximum cross wind, all engine go around at different stages of the approach, take over…).
- (*) Pilot competencies template

Pilot competencies	
• Application of Knowledge [KNO] • Application of Procedures and Compliance with Regulations [PRO] • Aeroplane Flight Path Management, automation [FPA] • Aeroplane Flight Path Management, manual control [FPM]	• Communication [COM] • Situation Awareness and Management of Information [SAW] • Leadership and Teamwork [LTW] • Workload Management [WLM] • Problem Solving and Decision Making [PSD]

19. Appendix "B" Example of airline policy on TEM

19.1. The way forward

It is recommended that Airline policy covers the following sections:

- **TEM concept** including,
  - Definitions the concept and definition of Threats, Errors and Undesired Aircraft State
  - Role of pilot competencies as countermeasures
  - Applicability of TEM in operations, (all flight phase, briefing, debriefing etc.)

- **Automation and manual flying**, where pilots:
  - Decide level of automation according to operational context (risk assessment)
  - Maintain competence by using all level of automation including manual flying
  - Are ready to change level of automation at all time, if necessary
  - Have clear visibility on operator limitation that could apply

- **Monitoring, including:**
  - Definition of monitoring
  - Definition of the PF and PM roles
  - Definition of AOV
  - Prioritization PF and PM duties depending on AOVs

19.2. Example

Operation Manual
TEM **Definitions** The threat and error management (TEM) is a concept that assists the pilots in understanding, from an operational perspective, the interrelationship between safety and their own performance in the dynamic and challenging contexts applicable to their operations. TEM provides the pilots with tools as well as strategies and tactics to manage potential threats, to limit the risks due to errors and consequently to enhance safety margins in operations. From a human performance perspective, the pilot competencies* represent the individual and team countermeasures to the management of threats and errors and to the recognition and the recovery of potential reduction of safety margins. *Note: pilot competencies* are generally described in the Operator Training Manual*

Implementation

The pilots apply the TEM concept during all the phases of the flight from flight preparation to post flight debriefing.

The pilots continuously and systematically perform a TEM assessment of the operational context of the flight.

The TEM assessment may conduct a specific briefing

The TEM assessment is a pre-requisite to all technical briefing

Level of Automation including manual flying

The pilots should decide the appropriate level of automation to ensure the safety of the flight and the maintenance of their competence.

The flight crew's decision regarding the selection of the level of automation that includes manual flying should be based on:

- the operating limitations*
- the TEM assessment of the operational context,
- the pilots' needs (pilot exposure, recent experience, crew composition…)

The pilots should continuously monitor the automation or flight guidance systems, the deviations from intended flight path, the relationship between the aeroplane attitude, speed and thrust.

The flight crew should review and adapt the level of automation when a potential risk of safety margins reduction has been identified.

**: the operating limitations may be published in different section of the operation manual:*

A. General policy => operating procedures limitations (e.g., specific approach…)
B. Type specific=> Aircraft operating limitations
C. Route/Area and aerodrome limitations=> Regional-Local limitations
D. Training manual=> limitations applicable during LIFUS-IOE

Monitoring

Definition

Monitoring is a cognitive process to compare an actual to an expected state.

Monitoring is embedded in the pilot competencies which serve as countermeasures in the threat and error management model. It requires knowledge, skills and attitudes to create a mental model and to take appropriate action when deviations are recognized.	
Pilot Flying role The pilot flying (PF) primary task is to control and manage the flight path. The secondary tasks of the PF are to perform non-flight path related actions (radio communications, aircraft systems, other operational activities, etc.) and to monitor other crew members.	**Pilot Monitoring role** The pilot monitoring (PM) primary task is to monitor the flight path and its management by the PF. The secondary tasks of the PM are to perform non–flight path related actions (radio communications, aircraft systems, other operational activities, etc.) and to monitor other crew members.
Implementation Pilots must manage distractions and disturbances in such way that their primary tasks are always performed. Cognitive resources being limited, pilots must manage their workload to achieve efficient monitoring. Pilots exercise their competencies to anticipate and intervene if necessary when they detect deviations comparing an actual to an expected state. **Area of Vulnerability (AOV)** There are three types of AOV (Low, Medium and High) depending on the time available to detect and correct a deviation in trajectory, configuration or energy. The three types of AOVs indicate to the pilots (PF and PM) the segment of the flight profile where they should adapt the emphasis on: • task prioritization and distribution • task interruptions and disruptions management • monitoring scanning pace **LOW AOV**: Stable trajectory (e.g., straight-and-level cruise flight) The pilots have sufficient time to detect and correct potential deviations. • The scanning frequency of the trajectory parameters is done at normal sampling rate • Secondary tasks can be performed **MEDIUM AOV**: Moderate responsive flight path	

The pilots have reduced time to detect and correct potential deviations.

- The scanning frequency of the trajectory parameters is done at elevated sampling rate
- Secondary and no time-consuming tasks can be performed by the PM

HIGH AOV: Highly responsive flight path.

The pilots have very little time to detect and correct potential deviations.

- The scanning frequency of the trajectory parameters is done at high sampling rate
- The PM only performs mandatory secondary tasks

Note:
(*) Sampling rate is the frequency with which a pilot directs his visual and mental attention to the various items or indicators that represent the flight path.

A *normal sampling rate* is the equivalent of the scanning frequency required of a pilot when hand-flying an aircraft in straight-and-level flight. This implies a rate sufficient to reliably detect changes, to recognize factors that may affect the flight path, and to anticipate the need to shift to a higher sampling rate.

An *elevated sampling rate* is the scanning frequency required of a pilot when hand-flying an aircraft approaching an imminent change in trajectory or energy (e.g., approaching a turn point, or a descent point, or a configuration change point).

A *high sampling rate* is the scanning frequency required of a pilot when hand-flying an aircraft through the execution of a significant change of trajectory or energy.