IATA Annual Safety Report - 2023

Recommendations for Accident Prevention

60

Celebrating 60 years of the IATA Annual Safety Report

DISCLAIMER

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1. Acronyms

ACTF	Accident Classification Task Force
ADX	Accident Data eXchange
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
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
AUPRTA	Airplane Upset Prevention and Recovery Training Aid
CANSO	Civil Air Navigation Services Organisation
CAST	Commercial Aviation Safety Team
CBTA	Competency-Based Training Assessment
CDFA	Continuous Descent Final Approach
CFIT	Controlled Flight into Terrain
CICTT	Commercial Aviation Safety Team/ICAO Common Taxonomy Team
CRM	Crew Resource Management
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
FDA	Flight Data Analysis
FDM	Flight Data Monitoring
FDX	Flight Data eXchange
FOD	Foreign Object Damage
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
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

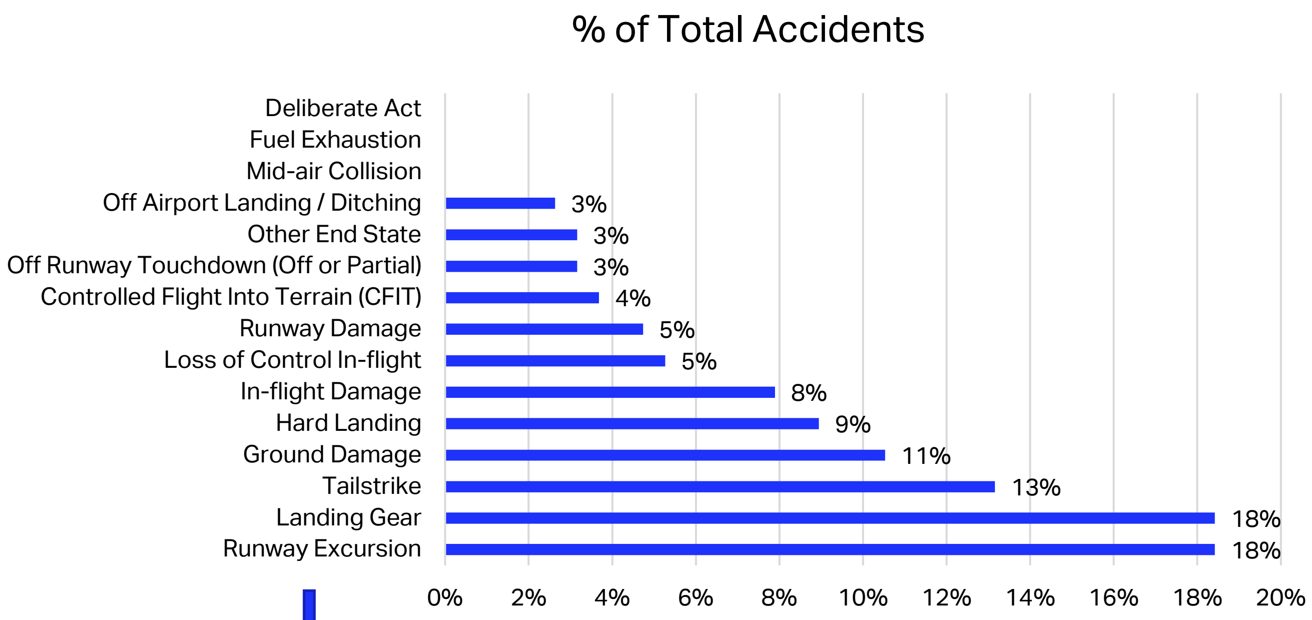
IOSA	IATA Operational Safety Audit
ISAGO	IATA Safety Audit for Ground Operations
LOC-I	Loss of Control Inflight
LOSA	Line Operations Safety Audit
MAC	Mid-Air Collision
MSA	Minimum Safe Altitude
NOTAM	Notice to Airmen
OEM	Original Equipment Manufacturer
OFP	Operational Flight Plan
OIPR	Opposite Initial Pilot Response
PBN	Performance-Based Navigation
PF	Pilot Flying
PFD	Primary Flight Display
PM	Pilot Monitoring
PTTF	IATA Pilot Training Task Force
RA	Resolution Advisory
REs	Runway Excursions
RNAV	Area navigation
SEs	Safety Enhancements
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 Accident Classification Task Force (ACTF). This document comprises recommendations to minimize the likelihood of an accident. It contains background information and explanation to support the recommendations.

2.1. Top Findings: 2019-2023

Covering a five-year period, the 2019-2023 Accident End State Distribution, as a percentage of the total, as assigned by the ACTF, was as follows: 2019-2023 Global Accidents –



Runway Excursion	**35**
Runway Excursion Lateral	22
Runway Overrun	13

The accident end states with associated fatalities in 2023 was:

- Loss of Control Inflight (1) with 72 fatalities

With a full breakdown of each accident end state, the table below provides an overview of 2023's performance compared to the five-year average:

2.2. 2023 Vs. 2019-2023 accidents

	2023	Comparison vs 5y	5Y Average (2019-2023)
Number of accidents	30	▼	38
Number of fatal accidents	1	▼	5
Number of fatalities	72	▼	143
Accident rate	0.80	▼	1.19
Fatality risk	0.03	▼	0.11
% of accidents involving IATA members	67%	▲	42%
% of aircraft propulsion – Jet	77%	▲	64%
% of aircraft propulsion – Turboprop	23%	▼	36%
% of type of operations – Passenger	77%	▼	78%
% of type of operations – Cargo	23%	▲	21%
% hull losses	7%	▼	25%

In this document, ACTF Members have updated recommendations for Loss of Control Inflight (LOC-I), Controlled Flight into Terrain (CFIT), Runway Excursions (REs), In-Flight Decision Making (IDM), and Human Factors. Also new recommendations have been added for Hard Landing, and Off Runway Touchdown (Off or Partial)

Please note, this document may be periodically updated to ensure the most current information and practices are in place.

3. Loss of Control Inflight (LOC-I)

3.1. Background

Loss of Control — In-flight (LOC-I) represents a critical category of aviation accidents, characterized by the loss of aircraft control while inflight, or deviation from the intended flightpath. 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 and 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 proper intervention strategies.

3.2. Discussion

Despite accounting for a relatively small percentage (7% or 33) of all aviation accidents (506) over the past decade (2014-2023), LOC-I is a significant contributor to fatal accidents and fatalities. This category, comprising 47% (29) of all fatal accidents (62) and 56% (1,228) of total fatalities (2,182), stands out as the leading cause of fatal accidents among all accident end states. The alarming statistics underscore the critical need for focused attention on LOC-I prevention.

In 2023, there was only one fatal LOC-I accident, resulting in 72 fatalities. Figure 1 depicts the number of LOC-I accidents and their rates and Figure 2 presents the LOC-I fatal accidents, and the associated number of fatalities over the last 10 years.

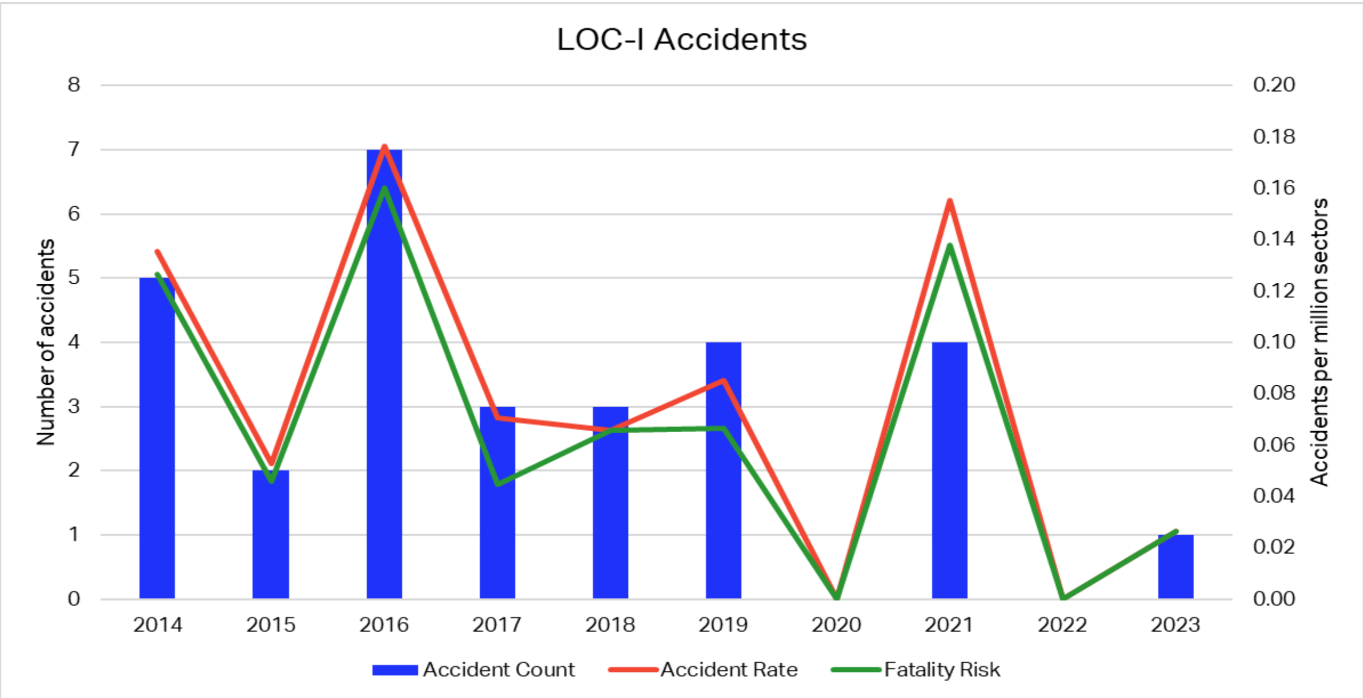


Figure 1: LOC-I Accidents

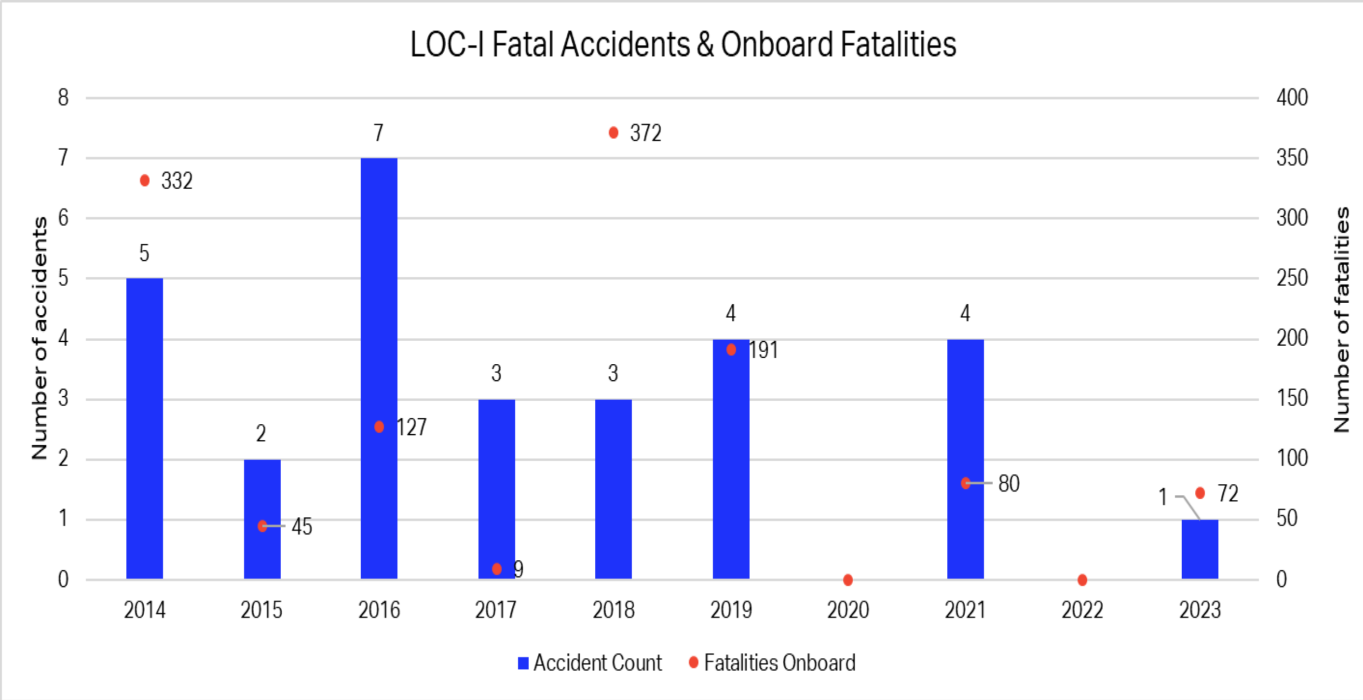


Figure 2: LOC-I Fatal Accident & Onboard Fatalities

Great progress over the 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 the regulators and the industry to implement consistently 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 for upset situation prevention and recovery. For instance, emphasizing the flight path management monitoring for both pilot flying and pilot monitoring during all phase of flight is essential for upset prevention, when 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 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 control 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 a least a successful recovery. In future, even modifications of aircraft flight control laws are conceivable.

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.

3.3. Recommendations

- Download the LOC-I Accident Analysis Report to get an evaluation of the risk factors from LOC-I accidents and information designed to aid the industry in the implementation of mitigation strategies.

3.3.1 Operator Safety

- Implement an effective Safety Management System, 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.

3.3.2 Operator Training

- Implement the training considering the following provisions and best practices:
  - ICAO Doc 9868 (PANS TRG) and the Manual on Aeroplane Upset Prevention and Recovery Training (Doc 10011)
  - Airplane Upset Prevention and Recovery Training Aid-Revision3 (AUPRT-Rev3)
  - IATA Guidance Material and Best Practices for the Implementation of Upset Prevention and Recovery Training (REV 2).
  - Commercial Aviation Safety Team (CAST) safety enhancements (SEs). All SEs, including 192-211 on Airplane State Awareness, are available on Skybrary.
- Provide ground training and 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
  - Aircraft aerodynamics
- Perform scenario-based training and manoeuvre training focussing 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

Note: The FSTD training should be completed within the validated training envelope of the FSTD

3.3.3 Operator Flight Standards

- The operator policy should define:
  - the Threat and Error Management (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 and pilot monitoring 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" Example of airline policy on TEM

3.3.4 Recommendations for Pilots

- Beyond the training provided by the operator, the pilots should proactively review by referring to the operation manual:
  - The Primary flight display indications and the different levels of automation that can be used to manage the flight path,
  - The role of the Pilot Flying (PF) and the Pilot Monitoring (PM)
  - The prioritization of PF & PM duties depending on the AOV.

4. Controlled Flight into Terrain (CFIT)

4.1. Background

Controlled Flight into Terrain (CFIT) is when an aircraft collides during flight with a terrain, water, or an obstacle without indication of loss of control. Analyzing data for the last 10 years, CFIT is the second-most frequent cause of fatal accidents, resulting in 278 fatalities. When looking at the rolling average accident rate for the five years going back to 2010-2014, the average accident rate recorded was 0.17 accidents per million sectors. Today, the five-year (2019-2023) average accident rate has improved to 0.05 per million sectors. However, the CFIT accident rate in 2023 was 0.00 (zero) per million sectors, down from one accident in 2022 with an accident rate of 0.03 accidents per million sectors. Figure 3 depicts the number of CFIT accidents, and their rates and Figure 4 presents the CFIT fatal accidents, and the associated number of fatalities over the last 10 years.

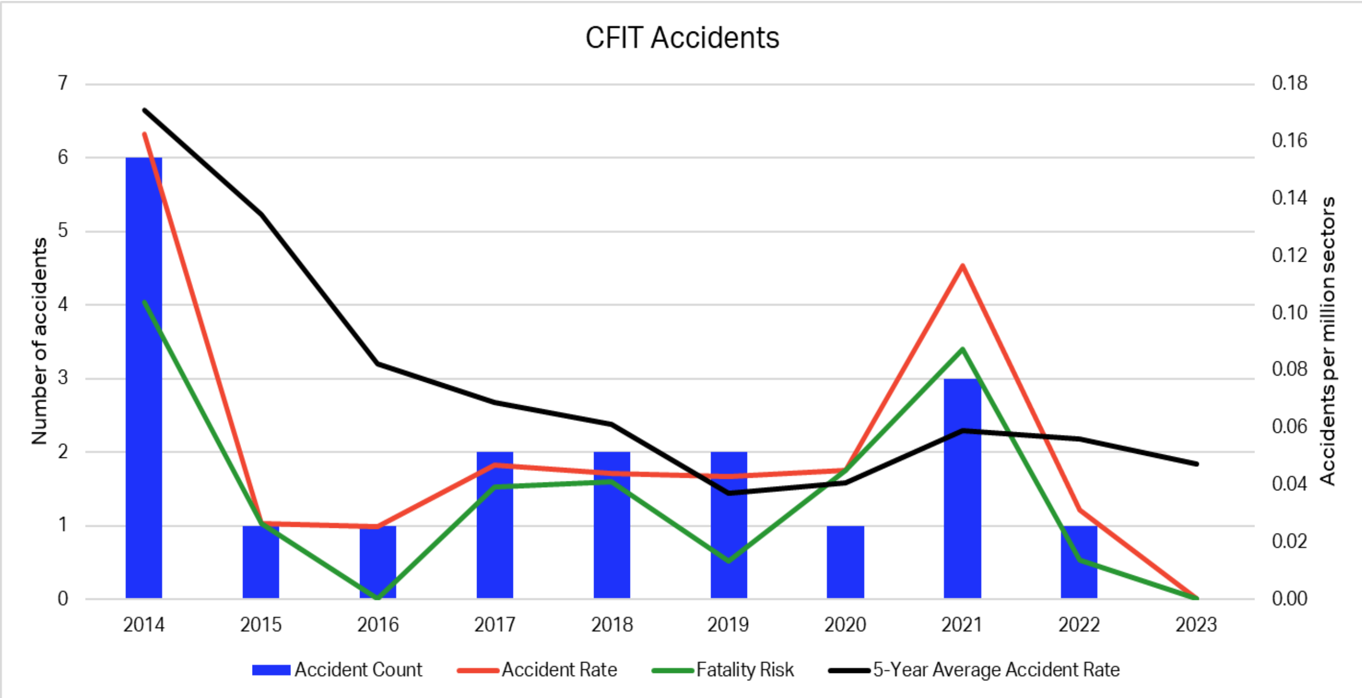


Figure 3: CFIT Accidents

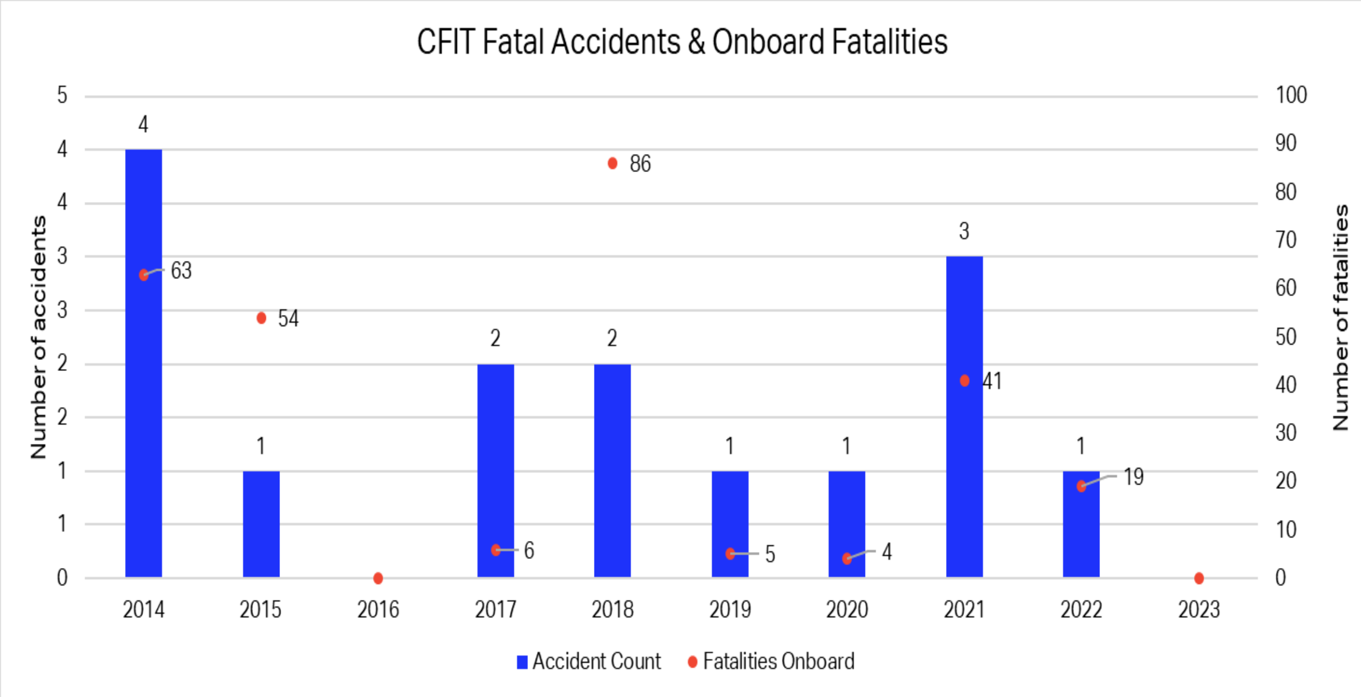


Figure 4: CFIT Fatal Accident & Onboard Fatalities

Today, accident data shows that CFIT accidents are much lower than a decade ago, and the number of aircraft that have landed safely after an Enhanced Ground Proximity Warning System (EGPWS) or Terrain Avoidance and Warning System (TAWS) alert is growing every year. Nevertheless, CFIT accidents 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, 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 has been proven to be a great barrier to prevent CFIT accidents when used as intended.

Evidence shows, 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 has undertaken strategic measures to address potential risks associated with outdated information. In response to this concern, a comprehensive Safety Risk Assessment (SRA) was conducted in 2022 to evaluate the validity of the EGPWS database.

As a result of this SRA, notable recommendations emerged, including the

- incorporation of the IATA Operational Safety Audit (IOSA) recommended practice FLT 4.2.7 into the standard framework (IOSA Standard Manual 16). 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. Looking ahead to 2024, IATA is set to publish an informative document, 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

The outcome of the SRA is aligned with the content of this section.

IATA is also focusing its efforts to increase 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 few in number, the outcome of CFIT accidents is almost always catastrophic, and can cause a high number of fatalities. As such, IATA will continue to identify the 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.

IATA has also published a detailed interactive analysis report on CFIT accidents using 10-year data that can be found here. Data shows that a good number of CFIT accidents occur in the approach and landing phases of flight. Implementation of precision approaches or Performance Based Navigation (PBN) approaches are effective methods to reduce the risk of CFIT accidents. Authorities and operators are, therefore, 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-based area navigation (RNAV) approaches are flown, IATA has recognized the elevated risk of CFIT due to altimeter mis-set. When the altimeter setting is incorrect, it can make the actual aircraft altitude to be 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 ▪ Technology and equipment not installed ▪ Absent or deficient flight ops SOPs and Checking
Threats	▪ Meteorology, including poor visibility / IMC ▪ Ground-based navigation aid malfunction or not available

	▪ Lack of visual reference
UAS	▪ Vertical / lateral / speed deviation ▪ Unstable approach ▪ Continued landing after unstable approach ▪ Operation outside aircraft limitation
Errors	▪ SOPs non-compliance ▪ Intentional deviation by flight crew ▪ 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 FO is assertive when necessary

Incorrect altimeter setting 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, which 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 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 latest information on weather conditions to enhance full situational awareness and ensure timely and appropriate pilot response.
- Encourage pilots and operators to report instantly to the relevant Air Traffic Control (ATC) units and authorities all incidents related to global positioning system (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.

4.2.1.4 Technical Operations (Engineering and Maintenance)

- Ensure the EGPWS software/terrain database are 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 maintained at all times. 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, decent 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.
- 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 weather is not a threat, then both pilots could decide to select terrain display.
- Establish a training program to ensure flight crew is trained to respond to EGPWS alerts effectively.
- Airlines 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 guidance material (GM) and recommendations
- Ensure procedures are in place to minimize incorrect altimeter settings. If desirable, 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, every 56 days as per ICAO guidance.
- Collaboration among OEMs, and other relevant stakeholders, to standardize and improve the information provided to operators - ensuring that the content of the database updates is well defined, with the differences from the previous version clearly articulated. This will enable performance-based updates as permitted by the new ICAO standard.
- 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) (reality) and TDB content should be immediately notified to service providers.

5. Runway Excursion

5.1. Background

Runway excursion (REs) 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 have become one of the most common types of accident worldwide and, currently, the third leading cause of fatal accidents in Commercial Air Transport. Also, REs have become one of the main sources of hull losses.

The risk of RE accidents depends on a number of 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 are 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, with the aim of reducing 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 spanning from (2014-2023), REs emerge as the most frequent accident category, comprising 110 accidents (22% of all accidents). While RE accidents typically do not result in fatalities, exceptions do exist. The data highlights 7 fatal excursions, resulting in 80 fatalities, making RE the third leading cause of fatal accidents.

Breaking down the types of runway excursions, it is revealed that 40% of these accidents were overrun, indicating instances where aircraft continued beyond the designated runway length. Lateral excursions, where aircraft veered beyond the lateral limits of the runway, accounted for 55% of runway excursions. Additionally, a small percentage (5%) could not be classified, owing to insufficient information.

In 2023, the IATA Accident Classification Task Force (ACTF) recorded 2 RE accidents (1 lateral excursions and 1 overrun). There were zero fatal accidents in this accident category. Overall, the rate of RE accidents has steadily decreased over the past 10 years; the RE accident rate recorded in 2014 was 0.43 accidents per million sectors and 2023 was 0.05 accidents per million sectors. Figure 5 depicts the number of RE accidents and their rates over the 10-year period.

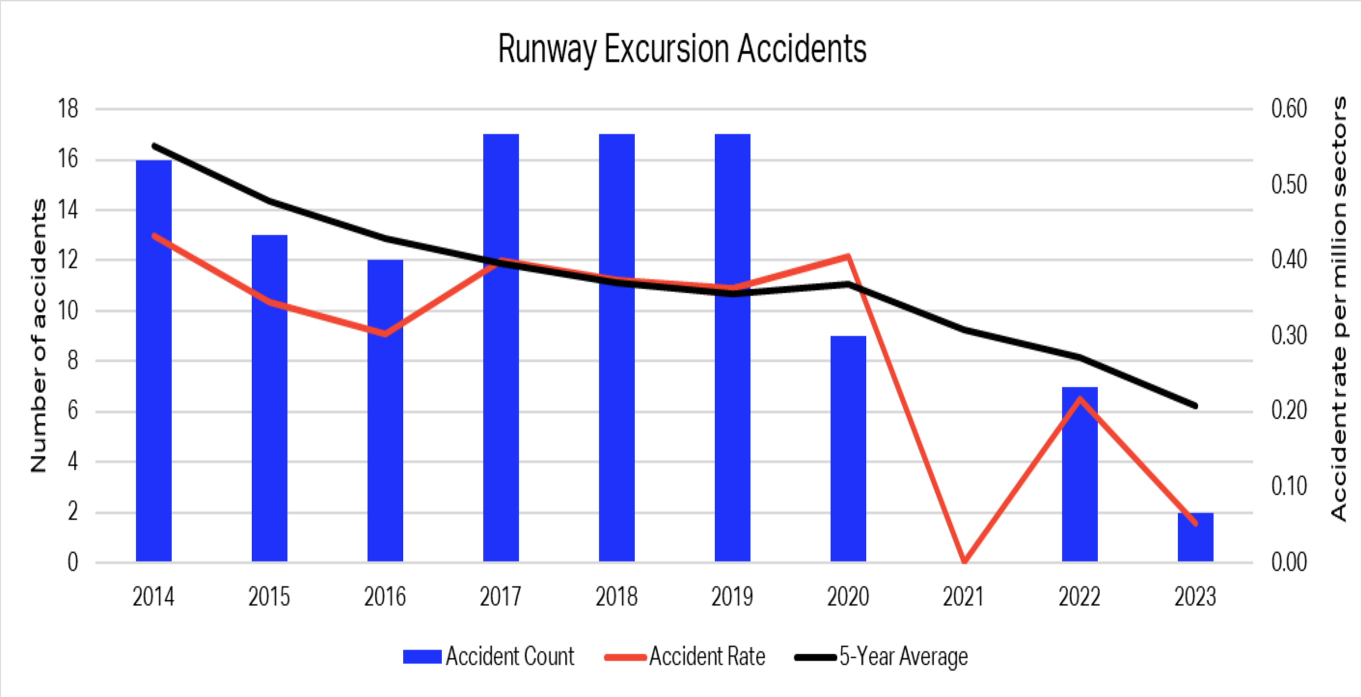


Figure 5: Runway Excursion Accidents

Runway excursions can result from a combination of various 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 which operators and regulators should continue to evaluate and address. It is important to establish a realistic and appropriate stabilized approach gates, along with implementing best practices and standardized operating procedures (SOPs), such as recommended by 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 UA is not only a factor contributing to runway excursion accidents but also a factor to other accident categories, including Hard Landings, CFIT, and Tail Strikes. The broad impact of UA emphasized the need for comprehensive efforts to identify and address UAs. IATA, together with major key stakeholders conducted a study into this matter and developed recommendations to evaluate and address UAs. 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, is to develop an industry standard for Risk Classification of Unstable Approaches ("high risk").

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 like 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, statistical and preventive regarding RE Prevention. Additionally, the U.S. National Business Aviation Association website under runway excursion contains 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. IATA encourages consultation of IATA / IFALPA / CANSO / IFATCA Risk Mitigation Policies, Procedures and Best Practices (GM) – Reference Unstable Approaches Project Analysis Report.

5.3.1 Operator Safety

- Operators should review their Safety Management System (SMS) and affirm they are enabling and evolving implementing a positive safety culture that requires and rewards adherence and requires 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 for socialisation of 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 which includes and monitors aircraft parameters, in accordance with Commercial Aviation Safety Team/ICAO Common Taxonomy Team (CICTT). Usage of 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 in order to improve adherence 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 Electronic Flight Bag (EFB), to gather and analyze all available information on runway conditions, and configuration prior to landing as a tool to determine precautions which 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, landing and go-around polices in their operations manual, in accordance with regulations requirements and manufacturers guidance. Plus posing these limits as hard line items which will be followed by flight crew. Reward and celebrate the following of these limits can assist in the establishment of a strong safety culture.
- Recommend flight crew be encouraged 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 to integrate TEM. (Example See Appendix B)
- 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. 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 include – Awareness on the following:

- 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 on the following:

- 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.
- Manoeuvre training to 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 off.
- Empower and train flight crew to advise ATC when unable to comply with an instruction or a clearance which would decrease safety margins.
- 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 stand alone items within the cockpit and EFBs.
- 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 Artificial Intelligence (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. Hard Landing

6.1. Background

The term Hard Landing refers to accidents occurring when an aircraft touches down with a vertical descent speed and force that exceeds the normal limit of the aircraft. A hard landing may be outside of the manufacturers' design specifications and consequently will result in inspection for damage before the next flight to ensure that the aircraft has not sustained any 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 flight data recorder

Hard landings can result from a wide 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, air traffic service (ATS), lack of or unavailable navaids, airport facilities – poor signage, lighting, faint markings, aircraft malfunction, and human factors such as optical illusion/visual mis-perception due in part to fatigue. Reducing this accident category through the understanding of contributing factors and implementation of proper intervention strategies is an industry priority.

6.2. Discussion

Hard Landings are the third largest contributors to accidents 12% (62) over the past 10 years (2014-2023). They account for the 7h highest percentage of fatal accidents, resulting in 41 fatalities; however, this is misleading since all hard landing fatalities over the past decade occurred during one accident in 2019. Hull loss and substantial damage to aircraft are the major concerns for airlines arising from hard landing accidents.

Hull loss and substantial damage have been trending down over the 2014-2023 period with hull loss due to hard landing accounting for 7 aircraft and substantial damage to 55 aircraft over the same period. 2015 was a significant year in terms of hull loss with 0.08 accident per million sectors and substantial damage with an accident rate of 0.26 per million sectors.

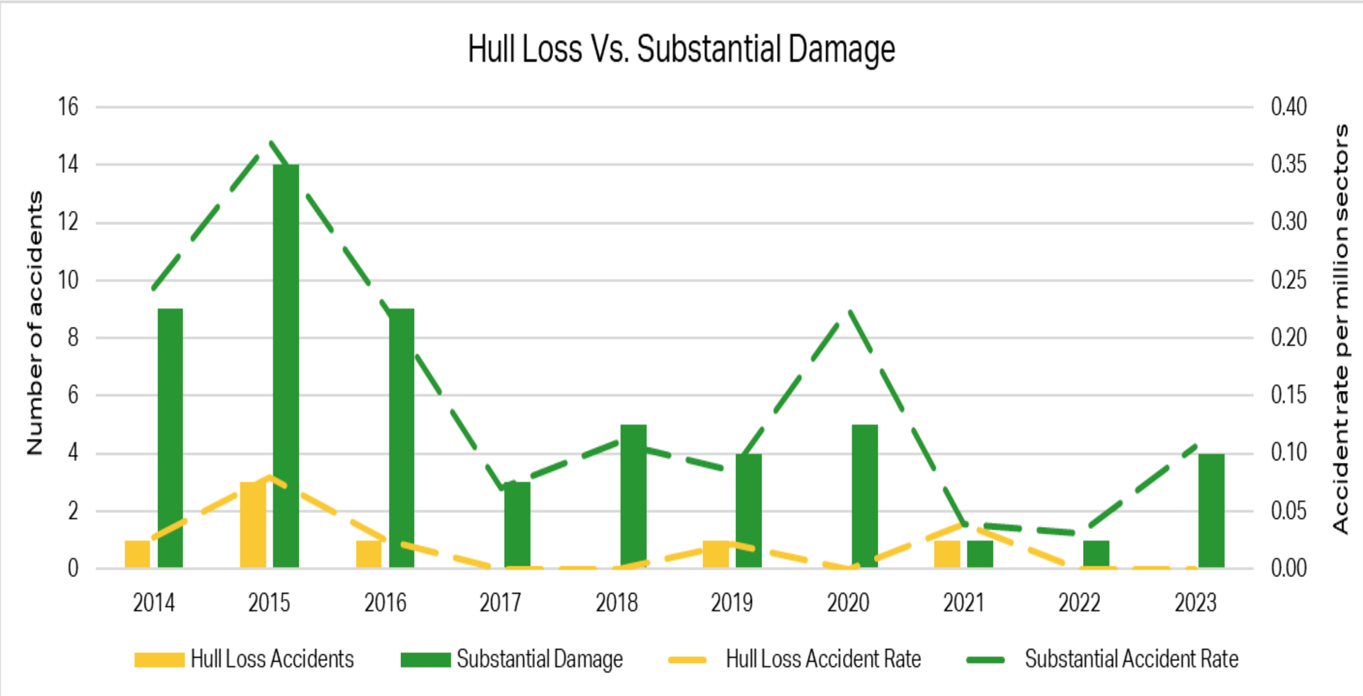


Figure 6: Hard Landing Hull Loss vs. Substantial damage

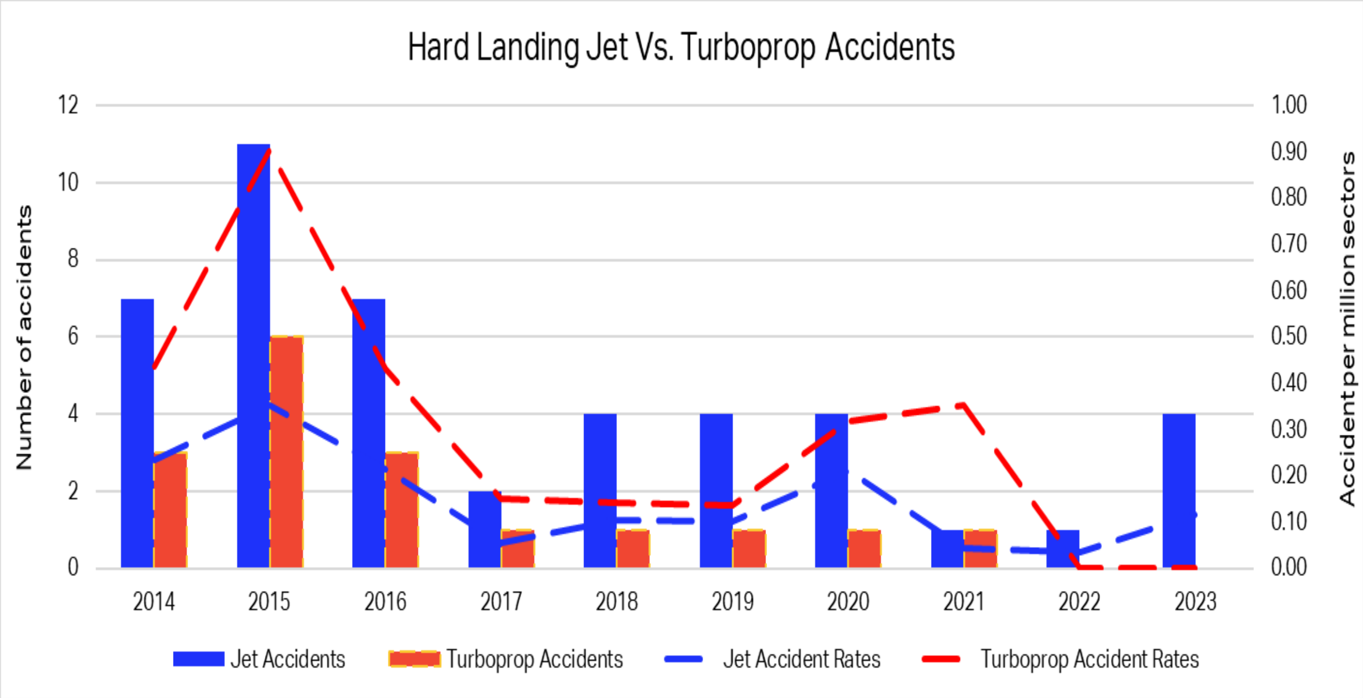


Figure 7: Hard Landing Jet vs. Turboprop

Looking at the hard landing accidents in 2023, there were 4 accidents involving jet aircraft, while there were zero accidents for turboprop aircraft. The 2023 jet accident rate in this accident category was higher than that of turboprop accident rate per million sectors (0.12 vs.0.00). However, looking at the 5-year (2019-2023) rolling average accident rate for both the jet and turboprop aircraft in this accident category, the turboprop accident rate per million sectors was higher than the jet accident average rate (0.16 vs 0.10). Potential reasons for this may include age of the aircraft, crew workload, and type of flight sector.

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 the flight crew 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 the appropriate decisions. The most common aircraft conditions that lead to a hard landing are vertical/lateral/speed deviations, unstable approach, abrupt aircraft control, and continued landing after unstable approach leading to abnormal runway contact. When flight crew find themselves faced with these situations the most common errors made to correct the situation are manual handling of the primary flight controls, No Go-around performed, failure to adhere to SOP and failure to enact SOP Cross-verification, and No Go-around after recognizing a destabilization on approach.

By reviewing the hard landing accidents from the IATA Annual Safety Report, it is believed that airlines will understand that 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 level can reduce the number of hard landings experienced and reported each year.

It is hoped that by raising awareness on the contributing factors behind hard landings such as adverse weather at and in the vicinity of airports immediately prior to landing as well as flight crew workload during landing will result in a raised awareness at the airlines and open discussion up on how to mitigate Hard Landings.

6.3. Recommendations

The primary underlying conditions for hard landing accidents are Flight Operation related. It is imperative that an aircraft be on a stable approach to landing. Adverse weather conditions, including wind shear and turbulence, can destabilize an 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 aide in reducing hard landing events.

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 cross wind limits, for less experienced pilots.

7. Off Runway Touchdown (Off or Partial)

7.1. Background

Off runway touchdown (off or partial) refers to accidents occurring when an aircraft's touch down 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 stopways 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 condition 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 to airlines than fatal accidents, however, the possibility of a fatal or injurious accident can never be discounted when dealing with off runway touchdown accidents.

7.2. Discussion

In the past 10 years (2014-2023), off runway touchdowns (off or partial) accounted for 3% of all accidents (17). Of all fatal accidents over the same time period, off runway touchdown (off or partial) accounted for 2 fatal accidents, resulting in 5 fatalities. This 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 (2014-2023) accounted for 4 hull loss accidents and 13 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. However, the annual average for off runway touchdowns that result in substantial damage to the aircraft is 1 per year.

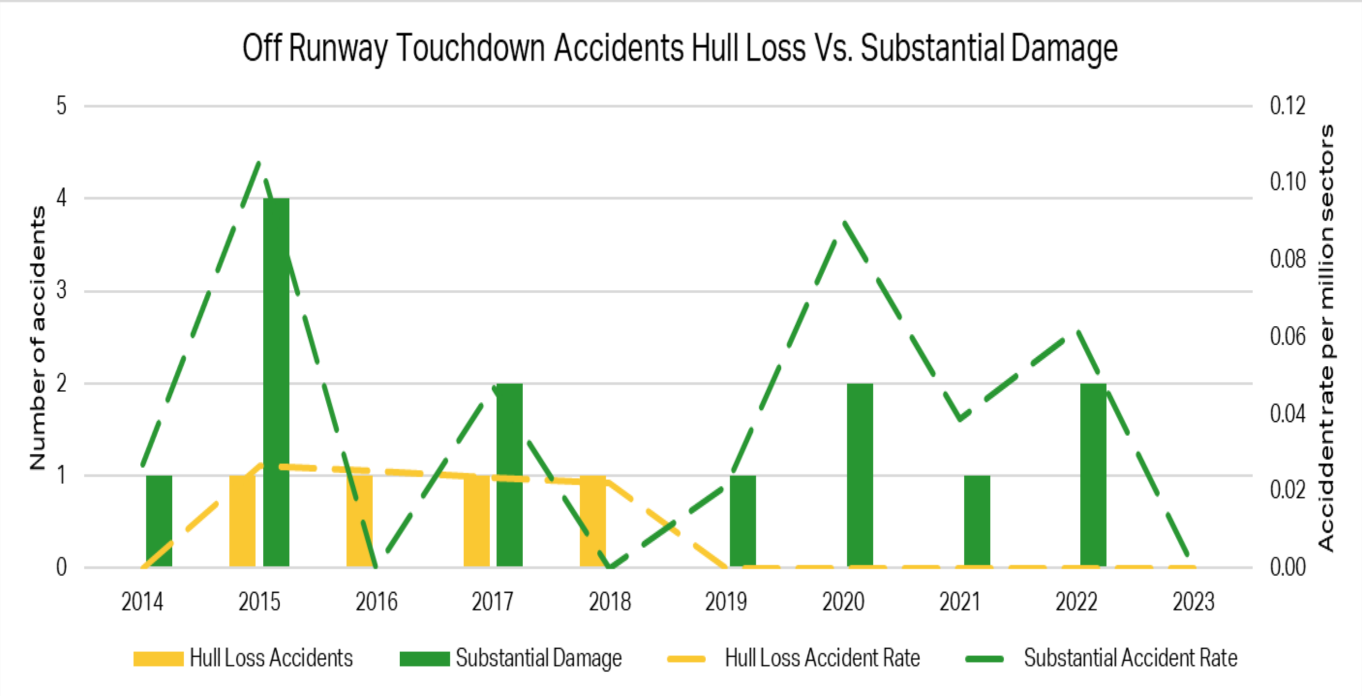


Figure 8: Off Runway Touchdown Accidents Hull Loss vs. Substantial Damage

In terms of jet and turboprop fleets, there is no real trend for either – frequency of events is random year to year over the past decade (2014-2023). There have been more accidents on the jet fleet (10) versus the turboprop fleet (7) over the recording period, however the five-year (2019-2023) rolling average accident rate for jet fleet was 0.03, while for turboprop fleet was higher at 0.13 accidents per million sectors. Potential reasons for this may include age of the aircraft, crew workload, and type of flight sector.

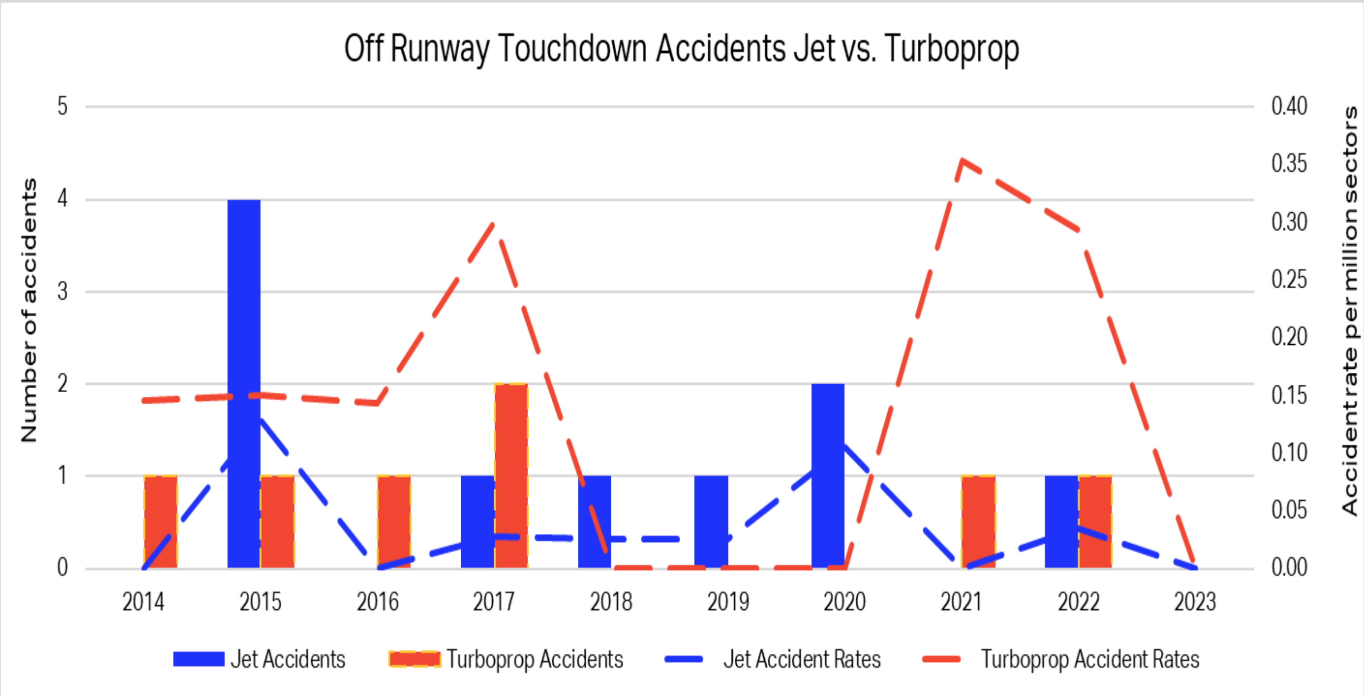


Figure 9: Off Runway Touchdown Accidents Jet vs. Turboprop

Off runway touchdowns (off or partial) occur at the end of a sector when workload peaks and fatigue may impair crew performance. Meteorological conditions may increase the crew workload due to degraded or lack of visual reverence and are a contributing factor in almost 71% of all off runway touchdowns (off or partial) accidents. Meteorological conditions responsible for off runway touchdowns include Low Visibility/IMC (47%), Wind/Windshear/Turbulence (41%), and Thunderstorm or other significant convection (18%).

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 (47%);
- **Lack of visual reference** (29%);
- **Airport Facilities** – poor signage/lighting, faint markings, or runway/taxiway closures, trenches, ditches or structures in close proximity to runways/taxiways and contaminated runways that result in poor braking action (29%), and;
- **Physiological Factors** – Optical Illusion/visual mis-perception (29%), and Operational Pressures (12%)

The increase in crew work loading due to the conditions above lead to the following decision-making deviations which ultimately may result in an off runway touchdown:

- **Flight Crew Processes** – 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; and

- **Procedures –** SOP adherence/SOP cross-verification, go-round not initiated after destabilized approach, call-outs

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 the airline level can reduce the number of off runway touchdown (off or partial) experienced and reported each year.

It is hoped that by 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 up on how to mitigate off Runway Touchdowns.

7.3. 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 refences, 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 counter measures 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. Operational pressures should not be a factor when training and preparing flight crews for situations where Off Runway Touchdowns may arise.

8. Tail Strike Accidents

8.1. Background

Tail strike accidents occur when the attitude of the aircraft is such that the tail makes contact with the runway, during take-off or landing or even go-around, resulting in substantial damage. In 2023, there were a number of accidents and incidents that were classified as tail strike events.

According to IATA Annual Safety Report, 9% (45) of all accidents over the 10-year period (2014-2023), suffered a tail strike event. In full year 2023, 17% (5) of accidents were as a result of a tail strike accident. 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 a SRA. This assessment provides a structured approach for analyzing tail strikes and helps stakeholders evaluate and manage the associated risks.

8.2. Discussion

Most tail strike accidents occur on landing. According to IATA Safety Report, 82% (37) of all tail strike accidents, over the period of 10 years (2014-2023), occurred on landing and during go-around. According to the IATA Safety Report and the SRA, the common threats or factors that may potentially contribute to landing tail strikes 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.

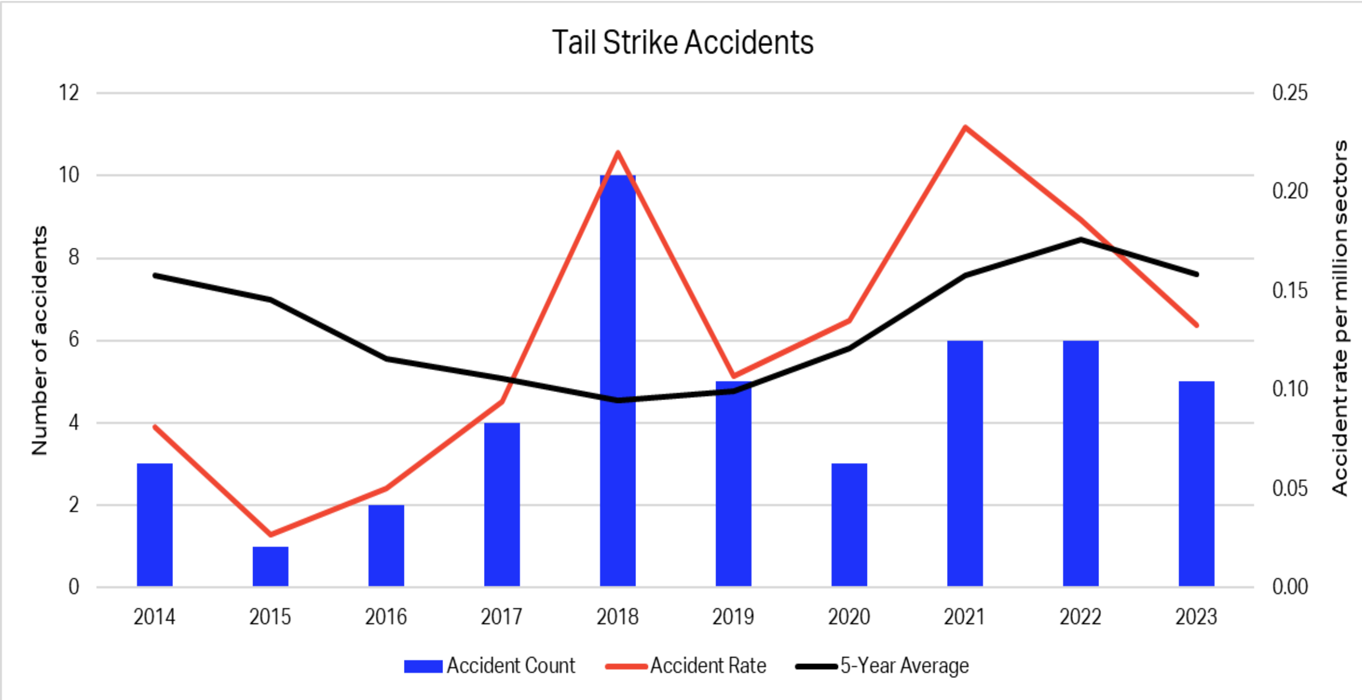


Figure 10: Tail Strike Accidents

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 further increasing 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 IATA safety report, 18% (8) of all tail strike accidents, over the same period, 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 Vr is cited as a contributing factor. An incorrect Vr may cause an early rotation, factors causing a rotation prior to Vr 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 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.

8.3. Recommendations

- 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 | IFALPA to possibly include Runway Overrun Awareness and Alerting Systems.
- Similar to the runway excursion recommendation, operators, should ensure that both operator and training policies are addressing TEM as a tool to increase safety margins by providing to flight crew strategies and tactics to manage potential threats and errors.

- 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 in regard to descent planning, stabilized approach, go-around and landing, including bounced landings, crosswinds and contaminated runways. Go-Around, Missed Approach and Balked Landings | IFALPA, 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 selection of the most suitable or appropriate level of automation for the approach until DH/MDA, and a visual reference for the runway is in sight
  - 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.

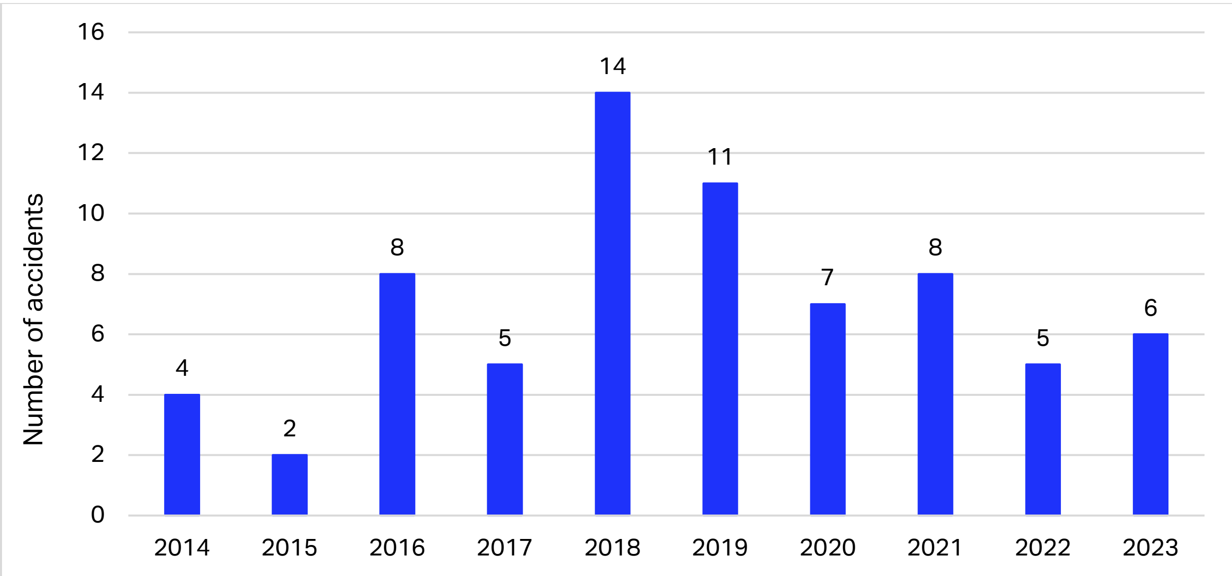
9. In-Flight Decision-Making and Contingency Management

9.1. 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.

In-flight Decision-making (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. Choosing not to divert, however, can lead to an even more unwanted outcome.

IDM was a contributing factor in 14% (70) of all accidents from 2014-2023. 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.



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	**2023** 30 accidents	**2014-2023** 506 accidents
Runway/Taxiway Excursion		22 (4%)
Controlled Flight Into Terrain		10 (2%)
Hard Landing		9 (2%)
Loss of Control – In-flight	1 (3%)	8 (2%)
Tail Strike	1 (3%)	5 (1%)
Off-Airport Landing/Ditching	1 (3%)	4 (1%)
In-flight Damage	1 (3%)	3 (1%)
Ground damage	2 (7%)	3 (1%)
Landing Gear		2
Other End State		2
Off Runway touchdown		2

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.

9.2. 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, very 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 a diversion to an alternate airport. Planned alternate airports are mainly based on official weather minima. In the case of a real diversion, flight crew 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 crew 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. 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.

9.3. Recommendations

9.3.1 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 this 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.

9.3.2 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.

9.3.3 Recommendations to Industry

Develop and maintain 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. Closely monitor regional conflict zones and areas of actual or potential civil unrest, in order to be able to react instantly if threats arise, which have impact on the safety of operations.

10. Human Factors

10.1. 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 refers to the discipline that applies knowledge about human beings and their abilities, characteristics and limitations, equipment design, task design and the environment in which they perform.

International Civil Aviation Organization (ICAO) published Doc 10151 'Manual on Human Performance (HP) for Regulators' (first edition 2021). This manual highlights the human contributions to the global aviation system using a system's perspective on human performance. Human Factors takes a systems thinking approach, is design driven and focuses on the outcomes of performance and wellbeing and overall system safety.

10.2. 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 factors), 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.

The modern inter-dependencies 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.

10.3. Recommendations

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

10.3.1 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.

10.3.2 Managing patters 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. 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 organisation’s classification schemes and taxonomies are likely to be needed.

The desired safety outcomes of the incident investigations 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 behaviour and performance. Human Factors knowledge is used to optimize the fit between people and the systems in which they work in order to improve safety and performance.

10.3.3 Procedures:

Procedural noncompliance and procedural drift has 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).

Procedures include method statements, work instructions, Standard Operating Procedures (SOPs), flight profiles, Company guidance, etc. Incomplete, incorrect, unclear, or outdated procedures can lead to short cuts and human failures. A Human-Centered Design (HCD) approach when designing procedures is needed. 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 they 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

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-centred 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.

10.3.4 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, and experience. Training and competence can help reduce human failures caused by lack of knowledge and promote behaviours 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 Maintenance Human Factors 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 behaviours 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 behaviour, creating safety.

The desired safety outcomes is 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.

10.3.5 Fatigue Management:

Fatigue poses an important safety risk to aviation. In addition to decreasing performance in-flight (chronic) fatigue has negative long-term health effects. ("Fatigue in Aviation: Safety Risks, Preventive Strategies ...") Some of the main airline accidents identify chronic fatigue, sleep loss, and desynchronosis as three "human factors" that contributed to unsafety.

In accordance to 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, so as 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.

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 industry in the ongoing development of fatigue management, using the most current science. It presents the common approach of crew members, regulators, and operators to the complex issue of fatigue. For more information, contact FRMS@iata.org.

10.3.6 Organizational Culture:

Setting of 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 behaviours.

Organizational culture should consider the critical elements that management of hazards is consistent within the business. 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 systems 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 safety culture and overall safety performance within the industry. For more information about the IATA Safety leadership Charter and how to get involved contact: safety@iata.org.

10.3.7 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 organisations, 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 organisation:

- Just Culture policy documented.
- Definitions agreed about what is "acceptable" behaviour, 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 behaviour.
- Process to deal with actions in the "grey area".
- Just Culture policy communicated throughout the organisation.
- 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.

10.3.8 Mental Health and Wellbeing:

The aviation system is working 24/7. This constant pressure on the aviation workforce with changing rosters, night shifts, 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).

After the recovery form the pandemic new stressors emerged that may have an impact in Mental health and Wellbing. People react differently to these stressors and the risks are that these stressors may negatively shift the individual on the mental health spectrum from flourishing to moderate or even a languishing mental health state, the impact on human performance can affect all stakeholders in the aviation system. A salutogenic approach to mental health and illness is proposed. It encourages the accessing of advice and support, without necessarily needing therapeutic intervention for a disease. Help and support should be available and should be clearly signposted by the organizations. 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.

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.

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 accommodations 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.

A look from 2022 Accident Prevention Strategy

11. Unstable Approaches

11.1. 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 Accident Data eXchange (ADX) 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.

11.2. Discussion

It is common to think of unstable approaches as a precursor of RE accidents. A deeper analysis of IATA ADX 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.

11.3. 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.

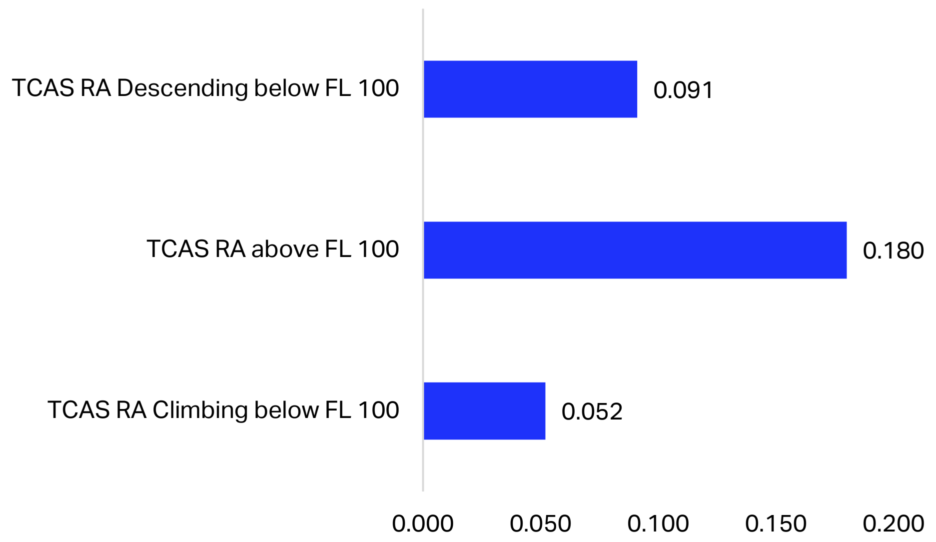
12. Mid-Air Collision (MAC)

12.1. Background

Safety information continues to show that Mid-Air Collision (MAC) remains a high-risk area in aviation. In the IATA ADX, 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

12.2. 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).



12.2.1 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.

12.3. 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 Air Traffic Control Officers (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.

13. Ground Damage

13.1. 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 Damage (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)

13.2. Discussion

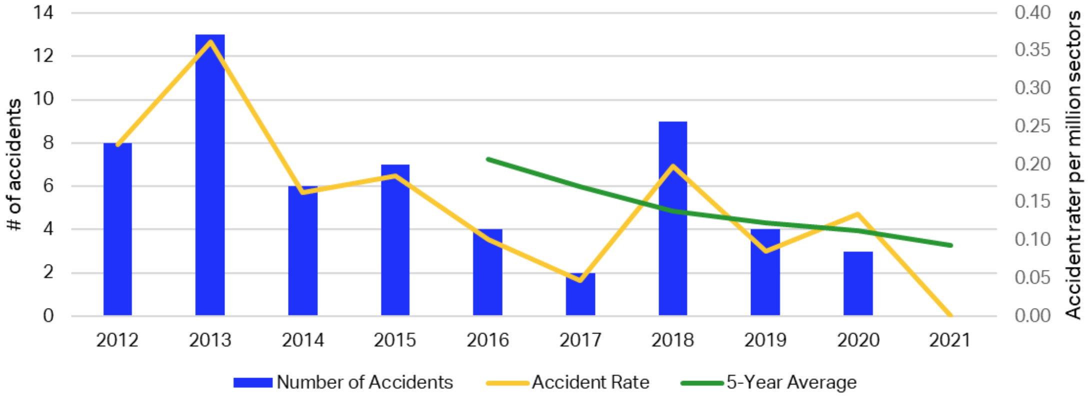
When aircraft are taxiing to or from an active runway, they have to successfully navigate through designated paths, following and respecting the instructions given to them and using the signs and markings. Complex regulations, processes and procedures are put in place by regulators and airport operators 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 ADX 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

13.3. Recommendations

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

- Improve quality via a common audit program that could meet targets from GSPs and airlines.
- 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 competences such as leadership, teamwork, decision-making and problem solving.
- Focus training on real exercises in situ with abnormal situation simulations rather than on theory.

14. 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]

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

15.1. 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

15.2. 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	Pilot Monitoring 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.	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.