IATA Annual Safety Report - 2022

Recommendations for Accident Prevention in Aviation

DISCLAIMER

The content, data and information (the “Content”) contained in this publication (“Publication”), is provided for information purposes only and is made available to you on an “AS IS” and “AS AVAILABLE” basis.

IATA has used reasonable efforts to ensure the Content of this Publication is accurate and reliable. We, however, do not warrant, validate, or express any opinions whatsoever as to the accuracy, genuineness, origin, tracing, suitability, availability or reliability of the sources, completeness, or timeliness of such Content. IATA makes no representations, warranties, or other assurances, express or implied, about the accuracy, sufficiency, relevance, and validity of the Content. IATA’s observations are made on a best efforts and non-binding basis, and shall not be deemed to replace, interpret, or amend, in whole or in part, your own assessment and evaluation or independent expert advice. Nothing contained in this Publication constitutes a recommendation, endorsement, opinion, or preference by IATA.

IATA has no obligation or responsibility for updating information previously furnished or for assuring that the most up-to-date Content is furnished. IATA reserves the right to remove, add or change any Content at any time. Links to third-party websites or information directories are offered as a courtesy. IATA expresses no opinion on the content of the websites of third parties and does not accept any responsibility for third-party information. Opinions expressed in advertisements appearing in this publication are the advertiser’s opinions and do not necessarily reflect those of IATA. The mention of specific companies or products in advertisements does not imply that they are endorsed or recommended by IATA in preference to others of a similar nature which are not mentioned or advertised.
This Publication is not intended to serve as the sole and exclusive basis for assessment and decision making and is only one of many means of information gathering at your disposal. You are informed to make your own determination and make your own inquiries as you may deem necessary and suitable. You shall independently and without solely relying on the information reported in this Publication, perform your own analysis and evaluation regarding the nature and level of information you may require, based upon such information, analyses, and expert advice as you may deem appropriate and sufficient, and make your own determination and decisions pertaining to the subject matter under consideration.

This Publication is the property of IATA and is protected under copyright. This Publication and its Content are made available to you by permission by IATA, and may not be copied, published, shared, disassembled, reassembled, used in whole or in part, or quoted without the prior written consent of IATA. You shall not without the prior written permission of IATA: re-sell or otherwise commercialize, make mass, automated or systematic extractions from, or otherwise transfer to any other person or organization, any part of this Publication and its Content in whole or in part; store any part of this Publication, or any Content, in such a manner that enables such stored Content to be retrieved, manually, mechanically, electronically or systematically by any subscriber, user or third-party; or include it within, or merge it with, or permit such inclusion in or merge with, another archival or searchable system.

TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAW, IATA DISCLAIMS ANY REPRESENTATION OR WARRANTY (I) AS TO THE CONDITION, QUALITY, PERFORMANCE, SECURITY, NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OF THIS PUBLICATION AND CONTENT; OR (II) THAT THE ACCESS TO OR USE OF THIS PUBLICATION (INCLUDING ANY AUTOMATED FEEDS OR OTHER DELIVERY MODES) OR ANY CONTENT SUPPLIED OR CONTRIBUTED TO THIS PUBLICATION BY THIRD PARTIES, WILL BE UNINTERRUPTED, ACCURATE, THE MOST UP TO DATE, COMPLETE OR ERROR-FREE. IATA EXCLUDES ALL LIABILITY (TO THE EXTENT PERMITTED BY APPLICABLE LAW) FOR ANY COSTS, LOSSES, CLAIMS, DAMAGES, EXPENSES OR PROCEEDINGS OF WHATEVER NATURE INCURRED OR SUFFERED BY YOU OR ANY OTHER PARTY ARISING DIRECTLY OR INDIRECTLY IN CONNECTION WITH THE USE OF THIS PUBLICATION OR ANY CONTENT CONTAINED OR ACCESSED THEREFROM, OR DUE TO ANY UNAVAILABILITY OF THIS PUBLICATION IN WHOLE OR IN PART.

The name and corporate identification of IATA are registered trademarks of IATA.

© International Air Transport Association, 2023. All Rights Reserved. No part of this publication may be reproduced, recast, reformatted or transmitted in any form by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system, without the prior written permission from:
Senior Vice President
Operations, Safety & Security
International Air Transport Association
800 Place Victoria, P.O. Box 113
Montreal, Quebec
CANADA H4Z 1M1

Contents

Acronyms

ACTF	Accident Classification Task Force
ADX	Accident Data eXchange
AHM	Airport Handling Manual
ANSPs	Air Navigation Service Providers
APV	Vertical Guidance
ATC	Air Traffic Control
ATCOs	Air Traffic Control Officers
CANSO	Civil Air Navigation Services Organisation
CAST	Commercial Aviation Safety Team
CBTA	Competency-Based Training and Assessment
CDFA	Continuous Descent Final Approach
CICTT	Commercial Aviation Safety Team/ICAO Common Taxonomy Team
CRM	Crew Resource Management
D-ATIS	Digital Automatic Terminal Information System
DIP	Detailed Implementation Plan
EASA	European Aviation Safety Agency
EBT	Evidence Based Training
EGPWS	Enhanced Ground Proximity Warning System
FAA	Federal Aviation Administration
FBW	Fly-by-wire
FDA	Flight Data Analysis
FDM	Flight Data Monitoring
FDX	Flight Data eXchange
FMS	Flight Management System
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
GRF	Global Reporting Format
GRSAP	Global Runway Safety Action Plan
GSPs	Ground Service Providers
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFALPA	International Federation of Air Line Pilots' Associations
IFATCA	International Federation of Air Traffic Controllers' Associations
IGOM	IATA Ground Operations Manual
IMC	Instrument Meteorological Conditions
ISAGO	IATA Safety Audit for Ground Operations
LOC-I	Loss of Control — In-flight
MAC	Mid-Air Collision
MSA	Minimum Safe Altitude
NOTAM	Notice to Airmen
OEMs	Original Equipment Manufacturer
PBN	Performance Based Navigation
PF	Pilot Flying
PFD	Primary Flight Display

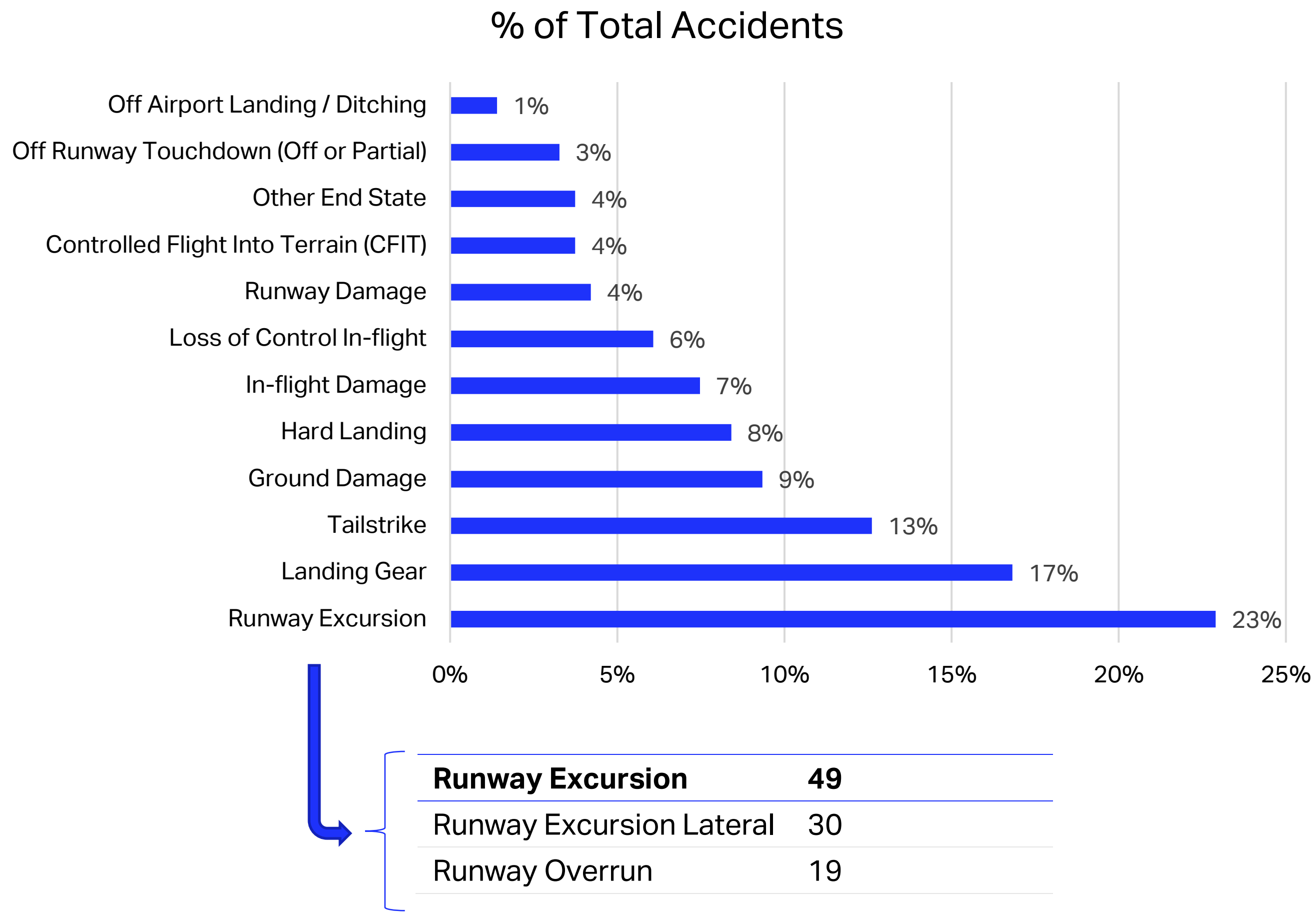
PM	Pilot Monitoring
PSFs	Performance Shaping Factors
PTTF	Pilot Training Task Force
RA	Resolution Advisory
REs	Runway Excursions
SEs	Safety Enhancements
SMS	Safety Management System
SOPs	Standard Operating Procedures
SPIs	Safety Performance Indicators
SPTs	Safety Performance Targets
SVS	Synthetic Vision Systems
TA	Traffic Advisory
TAWS	Terrain Avoidance and Warning System
TCAS	Traffic Collision Avoidance System
TEM	Threat and Error Management
UA	Unstable Approaches
UPRT	Upset Prevention and Recovery Training
VASIS	Visual Approach Slope Indicator System
VGSI	Visual Glideslope Indicator
WMO	World Meteorological Organization

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.

Top Findings: 2018-2022

Covering a five-year period, the 2018-2022 Accident End State Distribution, as a percentage of the total, as assigned by the ACTF, was as follows: 2018-2022 Global Accidents –



Runway Excursion	**49**
Runway Excursion Lateral	30
Runway Overrun	19

The accident end states with associated fatalities in 2022 were:

- Other End State[1] (3) with 138 fatalities
- Off Runway Touchdown (Off or Partial) (1) with 19 fatalities
- Runway Excursion (1) with 1 fatality

With a full breakdown of each accident end state, the table below provides an overview of 2022's performance compared to the five-year average:

2022 Vs. 2018-2022 accidents

	2022	Comparison vs 5y	5Y Average (2018-2022)
Number of accidents	39	▼	43
Number of fatal accidents	5	▼	7
Number of fatalities	158	▼	231
Accident rate	1.21	▼	1.26
Fatality risk	0.11	▼	0.13
% of accidents involving IATA members	28%	▼	38%
% of aircraft propulsion – Jet	64%	▼	67%
% of aircraft propulsion – Turboprop	36%	▲	33%
% of type of operations – Passenger	77%	▼	80%
% of type of operations – Cargo	23%	▲	20%
% hull losses	26%	▲	22%

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

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

In this document, ACTF Members have updated recommendations for Loss of Control Inflight (LOC-I), Controlled Flight into Terrain (CFIT), Runway Excursions (Res), Tail Strike, and Human Factors.

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

Loss of Control — In-flight (LOC-I) Accidents

Background

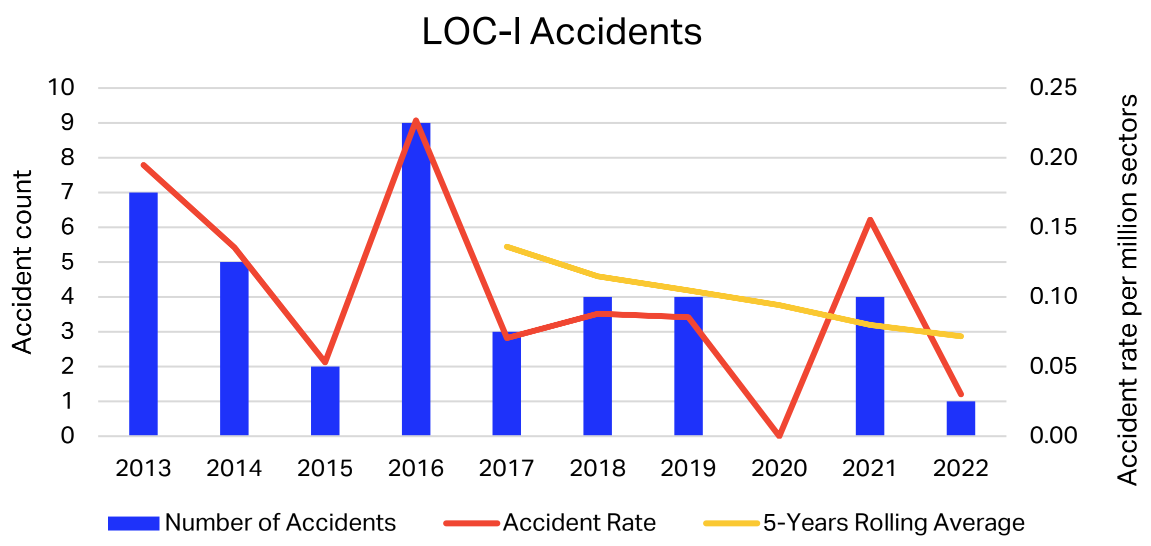
Loss of Control — In-flight (LOC-I) refers to accidents resulting from a loss of aircraft control while, or deviation from intended flightpath, in flight. LOC-I can result from a wide range of contributing factors that include, among others, system/component malfunctions, engine failures, hazardous weather conditions (e.g., icing, windshear, lack of visual reference,…), maintenance event, inappropriate energy management, deficiency in automation management and in monitoring, spatial disorientation, as well as other human performance factors. Reducing this accident category through understanding of contributing factors and implementation of proper intervention strategies is an industry priority.

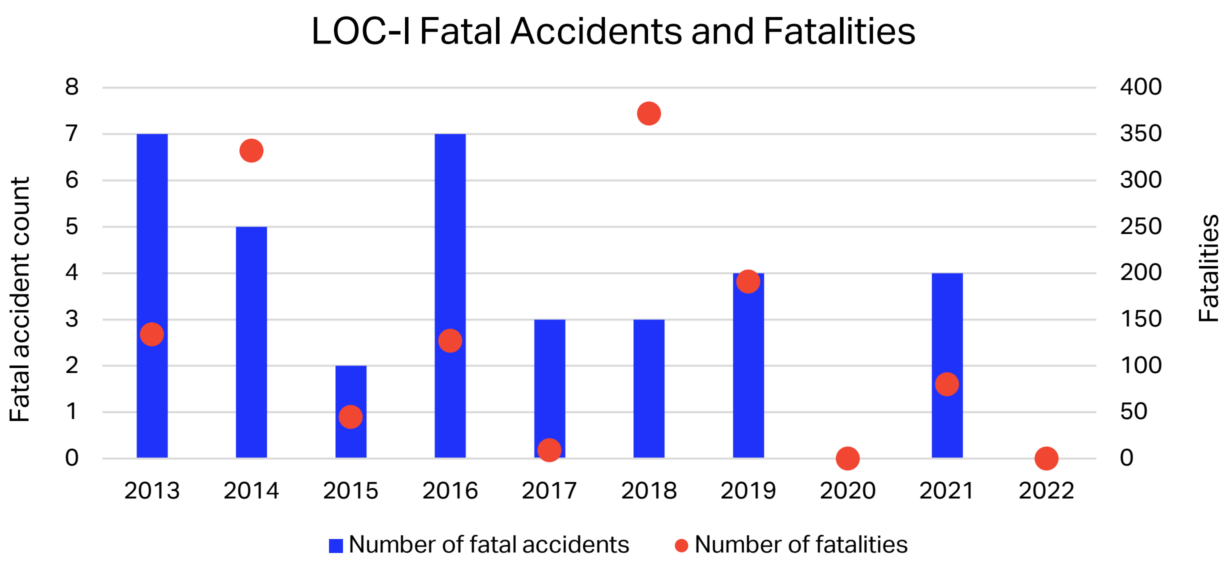
Discussion

Although the LOC-I category represented only 7% (39) of all accidents during the last 10 years (2013-2022), it resulted in the highest percentage of fatal accidents 49% (35) and fatalities 57% (1,290). Among all accident end states, LOC-I is the greatest factor leading to fatalities. LOC-I prevention, because of the variety of possible contributing factors, does not benefit from a single system/equipment solution. Therefore, it deserves the highest attention that the commercial aviation safety sector can pay to it.

Nevertheless, the introduction of flight by Wire (fbw) is gradually adding protections to the flight envelope that help pilots prevent and reduce the likelihood of LOC-I accidents. FBW technology with flight envelope protection function has had a great positive impact in the prevention of LOC-I accidents, thus it is not yet a guarantee to never experience a LOC-I event. The industry has still seen a couple of LOC-I accidents during flight operations with fbw-aircraft, so it is still advisable to identify, implement and train recovery strategies. Great progress over the last years was achieved by training pilots in prevention, recognition and recovery of aircraft upset conditions (UPRT). Nevertheless, IATA still sees, that improvements can be achieved in this area, for example by further including the pilot monitoring in the recovery process (e.g. adequate callouts) and maybe even more by implementing technology, which helps the pilot flying to fly the aircraft out of the undesired aircraft state. This could be for example aural alerts and / or visual indications on the Primary Flight Display (PFD) how to steer the aircraft out of the UAS. An already existing approach could be the enhancement of Synthetic Vision Systems (SVS) in a way, that such systems are able to display a model of the real world in an easy-to-understand way to the flight crew – 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. Further down the route even modifications of aircraft flight control laws are thinkable.

When looking at the rolling average of the LOC-I accident rate for the five years going back to 2013-2017 in the IATA ADX database, the average LOC-I accident rate recorded was 0.14 accidents per million sectors. For the next five years (between 2014-2018), the accident rate was 0.11. In the graph below, it is apparent that the rolling average five-year accident rate continues to trend downwards. Today, the average five-year (2018-2022) accident rate is 0.07 per million sectors. However, the 2022 LOC-I accident rate is 0.03, which is below the five-year average rate of 0.07.





To assist the commercial aviation industry's awareness of LOC-I contributing factors, IATA has developed an accident analysis report using data from LOC-I accidents. The risks contributing to LOC-I can be mitigated, and it is hoped that the contents of the interactive LOC-I Accident Analysis Report will help achieve the goal of building pilot awareness of the conditions that can lead to loss of control. In addition, it should be mentioned that maintaining pilots to high level of competency standards through training is one of the most effective barriers against LOC I accidents. This training should include Crew Resource Management (CRM), Flight path management using different levels of automation and manual control under various adverse weather conditions. The report presents data from 64 LOC-I accidents that occurred over 10 years, spanning from 2009 to 2018.

Recommendations

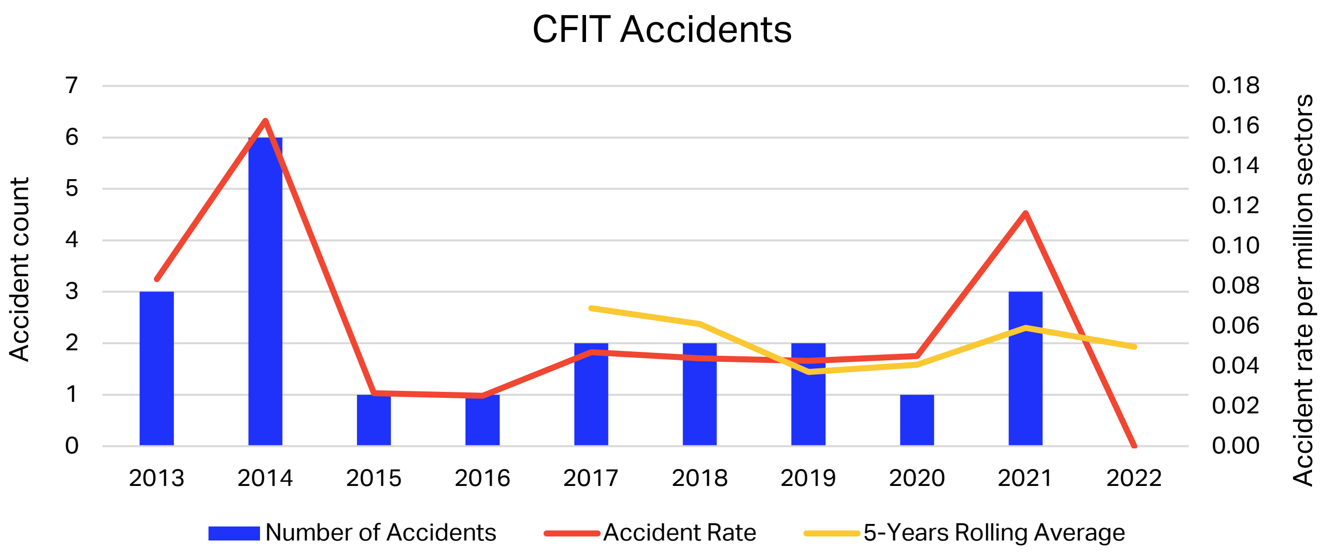
Some of the recommendations from the LOC-I Accident Analysis Report for operators to consider are:

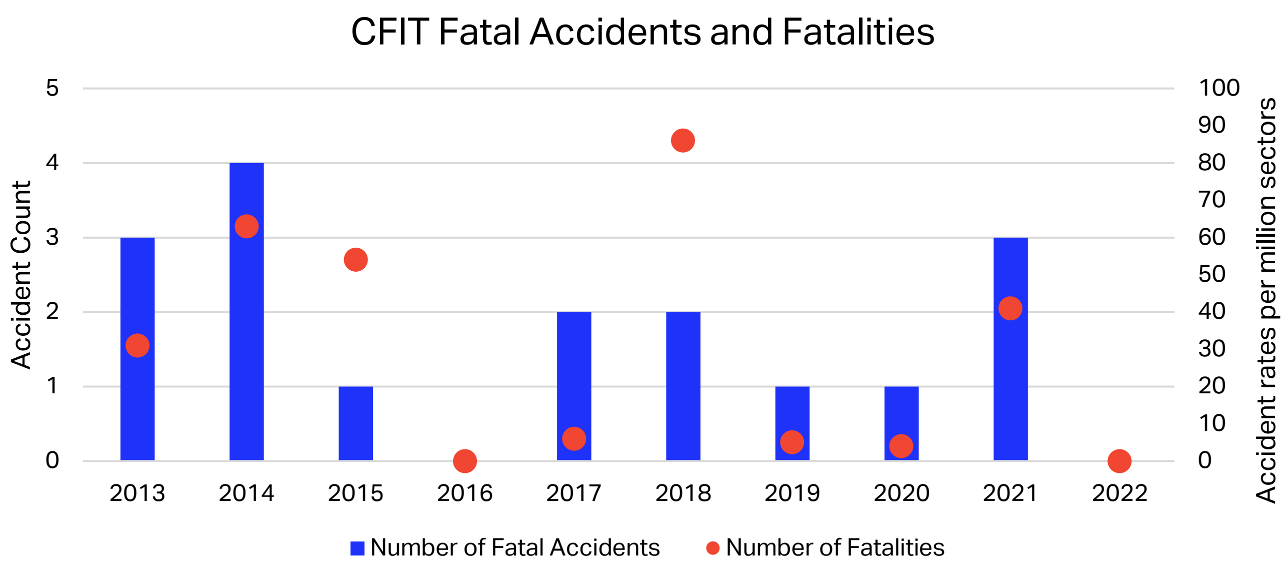
- Conduct training on energy management in a variety of scenarios and flight phases, including but not limited to, engine failure, thrust loss, and abnormal engine configurations.
- Institute Upset Prevention and Recovery Training (UPRT) as recommended in ICAO AC-RASG-AFI-01, 2018, Model AFI Advisory Circular on Loss of Control — In-flight (LOC-I) and Upset Prevention and Recovery Training.
- Provide classroom and Flight Simulation Training Devices (FSTD) training to flight crew on a regular basis that provides a positive experience considering the flight characteristics and performance of the aircraft being flown by the pilots, including during hazardous weather conditions.
- Include and emphasize training for pilots to monitor the aircraft flight path and system, and encourage manual intervention, as appropriate.
- Reinforce workload management as well as task allocation and prioritization to maximize monitoring during Areas of Vulnerability (AOV).
- Ensure training is completed within the validated training envelope of the FSTD.
- Refer to IATA Guidance Material and Best Practices for the Implementation of Upset Prevention and Recovery Training (REV 2).
- Consult the 3rd edition of the Airplane Upset Prevention and Recovery Training Aid (AUPRTA), which emphasizes both recognition and prevention.
- Incorporate, where applicable, the Commercial Aviation Safety Team (CAST) safety enhancements (SEs). All SEs, including 192-211 on Airplane State Awareness, are available on Skybrary.
- While not an exhaustive list, pilots can prevent LOC-I accidents by taking the following actions:
  - Proactively review and refer to the operational manual, and maintain awareness about (but not limited to):
    - The operational threats and errors that could lead to LOC-I,
    - Upset prevention and recovery procedures,
    - Primary flight display indications and the different levels of automation that can be used to manage the flight path,
    - The importance of monitoring, the role of the Pilot Flying (PF) and the Pilot Monitoring (PM) and the prioritization of PF & PM duties depending of the Area Of Vulnerability (AOV).
- During, ground and flight operations apply systematically the Threat and Error management principles to anticipate and mitigate the threats, to detect and correct errors that could lead to unrecoverable deviation from intended flightpath.
- 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.

Controlled Flight into Terrain (CFIT) Accidents

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 290 fatalities. When looking at the rolling average accident rate for the five years going back to 2013-2017, the average CFIT accident rate recorded was 0.07 accidents per million sectors. During the next five years (between 2014-2018), the accident rate was 0.06. The rolling five-year average accident rates continue to trend downwards. Today, the five-year (2018-2022) average accident rate is 0.05 per million sectors. However, the CFIT accident rate in 2022 is 0.00.





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

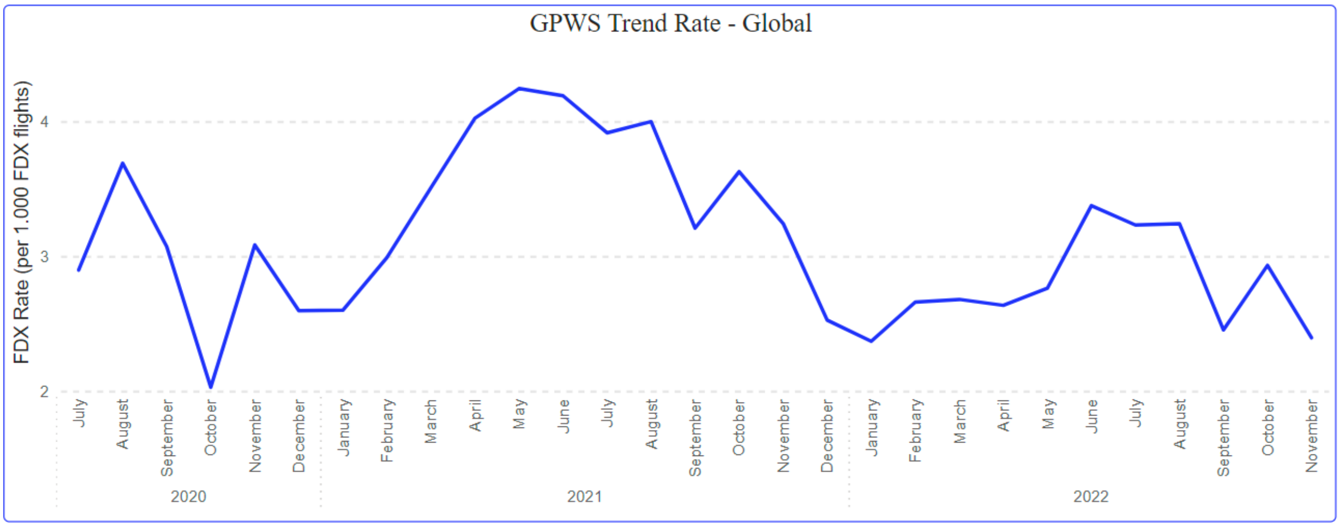
The industry is aware that the mandate of EGPWS and the immediate response to EGPWS warnings has been proven to be a great barrier to prevent CFIT accidents when used as intended.

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. Such action would decrease the number of unwanted warnings experienced and thus increase the integrity and reliability of the EGPWS and the likelihood of timely pilot response. IATA is 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 the IATA/Honeywell guidance on performance assessment of pilot response to EGPWS.

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. FDX is an aggregated de-identified database of Flight Data Analysis/Flight Operational Quality Assurance (FDA/FOQA)-type events that allows IATA to identify commercial flight safety issues that may not be visible to an airline with a dataset limited to its own operations.

The chart below shows the event rate of CFIT/TAWS trend from January 2020 to September 2022. The FDX Event Rate is represented by the number of eventful flights per 1,000 flights in the FDX program.



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.

To summarize, CFIT data from 2013-2022 shows that:

- While CFIT accidents are much lower than a decade ago, they continue to occur.
- CFIT ranked as the second-most common fatal accident category.
- The number of aircraft that have landed safely after an EGPWS warning is growing.

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 operations SOPs and Checking •
Threats	• Meteorology, including poor visibility / instrument meteorological conditions (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, takeoff, 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

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 Manufacturer (OEMs), international organizations and other relevant stakeholders to see they are applied. This DIP, which can be found here. The objective of the DIP is to

- Facilitate the execution of the proposed recommendations
- Identify and communicate with the concerned resources for the execution of the plan
- Report progress against the plan
- Measure the implementation and the effectiveness of the plan

Recommendations

Policy and procedures

- Aviation executive should demonstrate safety leadership and strong commitment to a positive safety culture; and should use FOQA data to monitor proper responses by flight crew to EGPWS events
- Operators should implement a Threat and Error Management (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.
- Operators should consult the IATA/Honeywell Performance assessment of pilot response guidance material (GM) and recommendations
- Operators should have procedures to ensure that
  - at least one pilot selects terrain display during critical phases of flight (such as climb and descent below Minimum Safe Altitude [MSA}) for additional situational awareness. If weather is not a threat, then both pilots could decide to select terrain display,
  - EGPWS equipment always remains activated and serviceable,
  - Pilots promptly notify the respective authorities of the interference location and the relevant Air Traffic Control (ATC) if they experience Global Positioning System (GPS) or radio altimeter anomalies
  - EGPWS software and Terrain/Obstacle/Runway database are kept up-to-date,
  - GPS/ Global Navigation Satellite System (GNSS) is used as a position source for the EGPWS.

Training policy and programs

- Operators should:
  - Enhance flight crew training by implementing CBTA to include an EBT program,
  - Establish a training program to ensure flight crew is trained to respond to EGPWS alerts effectively,
  - 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,
  - Provide awareness to flight crew on the importance to immediately respond to an EGPWS warning.

Runway Excursion Accidents

Background

Runway excursions (REs) are the result of an aircraft, after landing or on takeoff, continuing beyond the end of a runway (overrun) or veering out of its lateral limits (lateral excursion). Such accidents can cause significant damage to the aircarft, and surrounding areas. It can also lead to serious injuries or death to passengers and/or crews. RE accidents are amongst the high-risk categories in aviation. Statistics gathered from 2013 to 2022 show that 23 percent of commercial aviation accidents are from runway excursions. Of those, 86% occurred on landing. RE is the third leading cause of fatal accidents. The nature of the land surrounding the runway excursion contribute to the consequence of the accident.

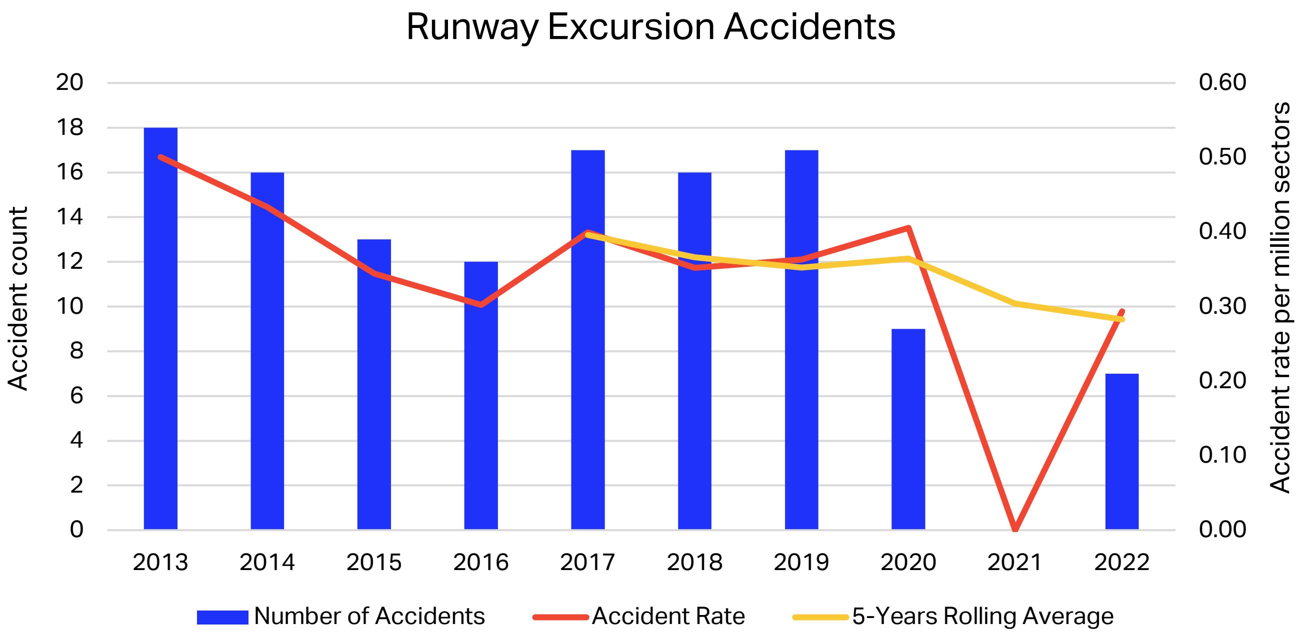
The risk of RE accidents depends on a number of factors involving different stakeholders including operators, airports, aircraft manufacturers and air navigation service providers (ANSPs). Mitigating the risk of RE is best done cooperatively among the stakeholders. Examples of such collaboration are 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.

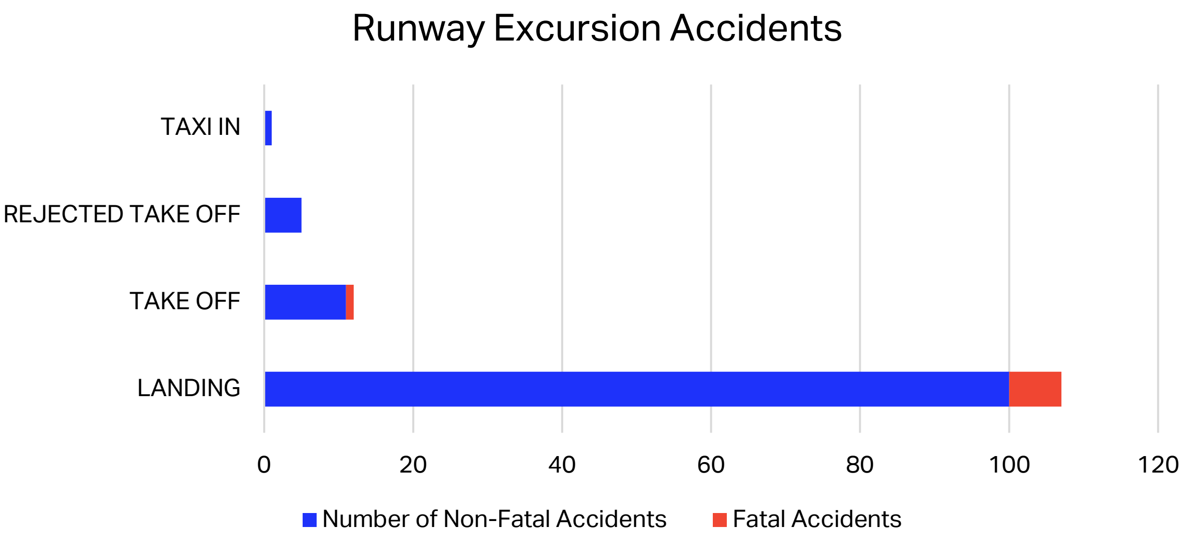
In support to the GAPPRE and GRSAP, IATA is developing a DIP to address RE accidents. This DIP also identifies some recommendations and actions to reduce the risk of REs. Some of these actions are related to collecting, analysing, and sharing runway excursion data, compliance with SOPs, deployment of technology that may reduce the possibility of REs, collaboration with stakeholders to better understand operational difficulties. Sharing information on safety mitigations, such as RE, is the best method to being about industry wide change.

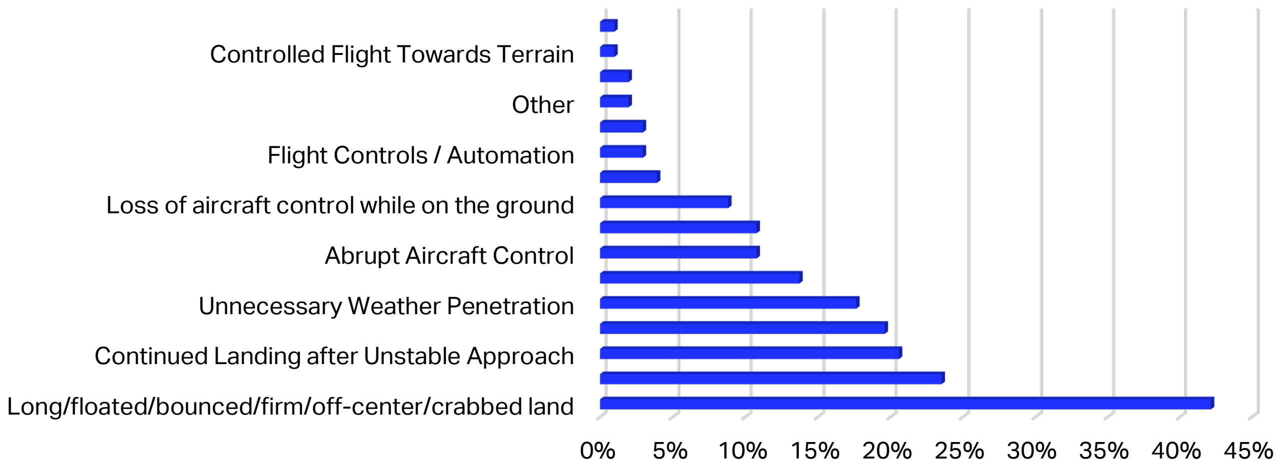
Discussion

Analyzing the data in ADX from the last 10 years (2013-2022), RE is marked as the most frequent accident category with 125 accidents and the third most frequent cause of fatal accidents with 8 accidents, resulting in 88 fatalities. Of those runway excursions, 39% were overruns, 57% were Lateral excursions, and 4% could not be specified.

In 2022, the IATA Accident Classification Task Force (ACTF) recorded 7 RE accidents (5 lateral excursions and 2 overrun) 5 of which were on landing and 2 takeoff excursions. The rate of RE accidents has steadily decreased in the database over the past 10 years, however, for the past five years, the rate has plateaued in a range between 0.30 and 0.40 per million sectors. In 2021, zero RE was recorded, but 2022 has shown the trend remains and the industry cannot lose sight of these events as a major concern.


Runway Excursion Accidents
Accident count
Accident rate per million sectors
20
18
16
14
12
10
8
6
4
2
0
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Number of Accidents
Accident Rate
5-Years Rolling Average


Runway Excursion Accidents
TAXI IN
REJECTED TAKE OFF
TAKE OFF
LANDING
0
20
40
60
80
100
120
Number of Non-Fatal Accidents
Fatal Accidents



Overwhelmingly, the data indicates most runway excursions occur in the landing phase of flight with common undesired aircraft states of long/floated/bounced landing and/or landing from an unstable approach. Stable approach criteria have been adopted by most operators and included into SOPs. The continuation of approaches where the aircraft is in an unstable condition is an area of concern which operators and regulators should exam further. 20% of runway excursion accidents are associated with unstable approaches (UA). It is important realistic and appropriate stabilized approach gates be set for the operation, best practices for stabilized approach criteria, and SOPs be implemented, such as recommended by IATA / Civil Air Navigation Services Organisation (CANSO) / International Federation of Air Traffic Controllers' Associations (IFATCA) / IFALPA Unstable Approaches: Risk Mitigation Policies, Procedures, and Best Practices. Incorporating the recommendations mentioned in this guidance, along with effective CRM practices into SOPs is more effective when accompanied by a culture that requires adherence and leadership backing. Flight crews are expected to perform a go-around when arriving at a mandatory stabilized approach gate out of parameters and should feel comfortable doing so by flight planning with adequate fuel reserves. A non-punitive policy regarding go-arounds together with adequate training using various scenarios will increase flight crew confidence in their handling of the maneuver and will improve their go-around decision-making. A healthy flight monitoring program and SMS should monitor stabilized approach criteria to determine the effectiveness of policy and tailor training as appropriate to maintain a safe operation. The operators' positive safety culture should reward and recognize adherence, proactive planning and utilization of best practices. Training for both PF and PM should reflect best practices, awareness of stabilized approach criteria, how to fly within parameters, recognition of situations leading to unstable approaches, recognition of and planning for adverse runway conditions, and when and how to properly conduct a go around.

It is worth noting UA is not only a factor contributing to runway excursion accidents but a factor to other accident categories, including Hard Landings, CFIT, and Tail Strikes. In 2020, analysis of data during the downturn in air transport activity revealed a sharp increase in the proportion of unstable approaches. IATA has formed a team made up of operators, regulators and pilots unions to investigate this increase and provide further RE mitigation strategies.

The realization of UA contributing to several accident end states, 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 scope of this project was to evaluate the effectiveness of current industry practices that have been implemented to reduce the UA rate; provide recommendations to enhance their effectiveness; and determine where new recommendations for filling identified gaps could be developed.

The full report of the recommendations and the outcomes of the UA Analysis project can be found in this document titled "Examining Unstable Approaches - Risk Mitigating Efforts". One of the findings was the lack of an industry accepted definition of "high risk" UA, that might help operators focus activities to achieve effective improvements in the UA rate, is to develop an industry standard for Risk Classification of Unstable Approaches ("high risk"). IATA is inviting operators to share their UA definitions, processes, or methodologies that they have implemented in their airlines to effectively identify and tackle "high risk" unstable approaches.

Delayed or incorrect flight crew action when using stopping devices, and less than adequate awareness of minimum equipment list items and their effect on braking performance can significantly increase the likelihood of a runway excursion. 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.

Meteorology is one of the most common factors identified in RE accidents by the ACTF along with related threats of windshear/gusty winds, thunderstorms, and low visibility. Other factors may include pilot decision-making ability (Go/No-go decision, land/no-land decision) or understanding of aircraft performance limitations related to landing in a crosswind together with hazardous conditions such as a contaminated runway surface can contribute to a RE accident.

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.

To mitigate these threats, pilots need accurate information to use for calculating performance and in-flight decision-making. Use of the Global Reporting Format (GRF) standardizes reports of contamination and allows operators to develop procedures to guide crews in determining performance calculations and crosswind parameters for takeoff and landing based on the conditions. These reports should be easily and readily available. Operators and regulatory authorities should explore means which make this information readily and easily available to aircrews. Operators should also explore making use of this information a part of SOPs for their aircrew along with providing digital tools (software etc.) to their aircrews to make inflight decision making more automated. This would also necessitate setting hard limits to aid making decision such as diversion or requesting a different runway.

Using Digital Automatic Terminal Information System (D-ATIS) would help in distributing and updating reports as opposed to the already difficult notice to airmen (NOTAM) system. Accurate wind reporting for the runway in use would also aid in assessing the amount of crosswind or even when a tailwind is present. These factors all contribute to runway performance calculations, and all too often change adversely with a fast-moving weather system. Again, incorporating technology to aid crews in making decisions could be a step forward in mitigating the effects of rapid changes in weather conditions. The use of tools incorporating Artificial Intelligence (AI) could, in the future, help automate decision making when incorporated in to SOPs.

Furthermore, the runway environment itself should be considered to make excursion accidents more preventable and reduce the chances of human injury and aircraft damage. A crowned, grooved runway clearly marked and free from rubber deposits allows for shedding of water and generally improved braking action to slow the airplane. A level clear area surrounding the runway, including adequate runway end safety area (RESA) or Engineered Arresting Material, allows aircraft to dissipate energy safely as opposed to an environment with structures or steep drop-offs near the runway, which may cause significant damage to an aircraft in the event of an excursion.

Recommendations

- Consult with the GAPPRE, and GRSAP, As pertains to runway excursions, the ICAO Runway Safety Tool kit provides links to access more reference material.
- Consult with the IATA / IFALPA / CANSO / IFATCA Risk Mitigation Policies, Procedures and Best Practices (GM) – Reference Unstable Approaches Project Analysis Report.
- Encourage the development of industry standard for Risk Classification of Unstable Approaches ("high-risk").
- 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 to clearly define stabilized approach, landing and go-around polices in their operations manual, in accordance with regulations requirements and manufacturers guidance.
- Operators to implement, as part of the accident prevention and flight safety program, a comprehensive Flight Data Monitoring (FDM) program that includes and monitors aircraft parameters, in accordance with Commercial Aviation Safety Team/ICAO Common Taxonomy Team (CICTT).
- Operators are encouraged to use root-cause analysis of SOP non-compliance in order to improve adherence

Airline policy and associated procedures

- Integrating TEM principles where the pilot competencies represent the flight crew countermeasures* (See also Appendix A).
- Emphasizing the proper use of stopping devices, especially when runway conditions are unfavourable
- Recommending the flight crew to execute a go-around at any point during the approach, when there any doubt on a safe continuation of the approach or the landing.
- Mandating the flight crew to apply the TEM model as a tool to increase safety margins in operations by providing to flight crew strategies and tactics to manage potential threats and errors (example See Appendix B)
- Addressing recovering techniques for bounced landings which are specific to each aircraft type, following manufacturing guidance.
- Addressing the conditions requiring a rejected take-off.
- Addressing landing techniques that are aligned with GRF and manufacturer's guidance for all runway states and environmental conditions.
- Describing 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.
- Mandating an assessment of the arrival landing performance (distinct from the conditions forecast prior to departure), that includes landing distance at the time of arrival adding an additional safety margin.
- Allowing the use of appropriate level of automation during the approach, landing and go- around. Likewise, manual flying during operations in good weather.

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,
  - techniques for stabilized approach, flare, touchdown and stopping devices.

  - Practical training on the following:
    - Scenarios based training to enhance 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…),
    - Effective usage of the GRF,
    - 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…).
- Empower and train flight crew to advise Air Traffic Control when unable to comply with an instruction or a clearance that would decrease safety margins.
- Industry to incorporate appropriate methods and technologies that aid in minimizing runway excursions.
- Operators should review their SMS and affirm they are implementing a positive safety culture that rewards adherence to and requires adherence to established minima and stated limits.
- Explore advanced technologies such as AI-based systems which can aid aircrew in obtaining information, and making rapid decisions.

Tail Strike Accidents

Background

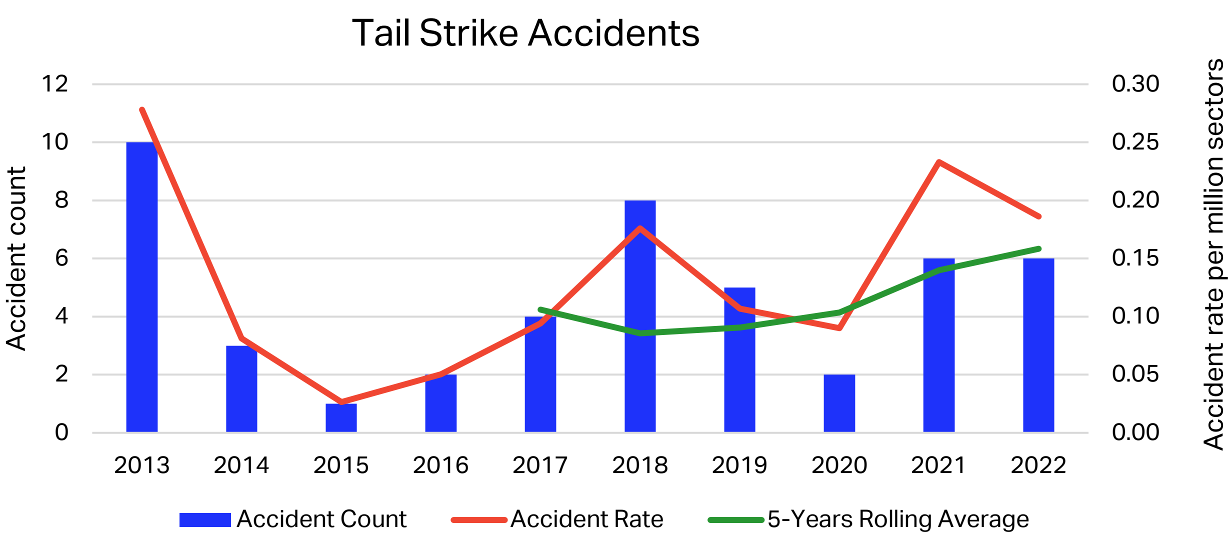
Tail strike accidents occur when the attitude of the aircraft is such that the tail makes contact with the runway, during takeoff or landing or even go-around, resulting in substantial damage. In 2022, there were a number of accidents and incidents that were classified as tail strike events.

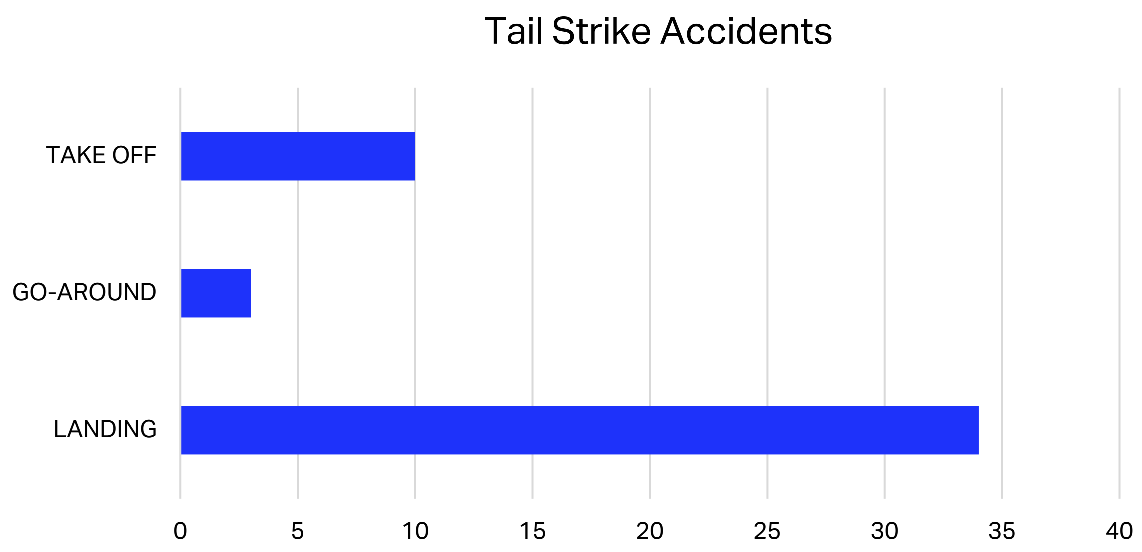
According to ADX, 9% (47) of all accidents over the 10-year period (2013-2022), suffered a tail strike event. In full year 2022, 15% (6) of accidents were as a result of tail strike. While there is typically a low fatality risk, these occurrences can cause serious damage to aircraft and cost operators millions in repairs and lost revenue. When a tail strikes the runway while landing, the damage is typically more severe than when it occurs during takeoff. The worst-case scenario involves the tail striking the runway before the landing gear touches down, damaging the aircraft pressure bulkhead.

Tail strikes can be avoided if flight crew are aware of their contributing factors and adhere to the established standard procedures, that should be reinforced by training programs on proper takeoff and landing procedures.

Discussion

Most tail strike accidents occurred on landing. According to ADX, 79% of all tail strike accidents, over the period of 10 years (2013-2022), occurred on landing and during go-around. Common factors contributing to landing tail strikes include 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 an higher angle of attack and lower tail clearance. With regards to flare technique, too high flare can induce airspeed decrease and long flare leads to pitch increase, with associated tail clearance reduction.





Weather conditions such as high 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.

As mentioned above, 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 takeoff are less frequent and typically less severe. Often pilots may not be aware that a tail strike has happened.

According to IATA ADX, 21% of all tail strike accidents, over the same period, occurred on takeoff. According to a study from Boeing, common factors that increase the likelihood of a tail strike during takeoff, including: mistrimmed stabilizer; incorrect rotation techniques and improper use of the flight director.

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 takeoff 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 "V1" 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 ADX database 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 takeoff, stabilized approaches, bounced landings and go-arounds to validate the effectiveness of policies and recommend changes to training, as appropriate to maintain safe operations.

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 takeoff 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 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 crews aware of risks and limitations of tailwind operations, as indicated in IFALPA's publication Tailwind Operations.

Human Factors

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 people and people have their cognitive capabilities. These capabilities are applied in the day-to-day operations but as well in the planning, design, procurement, and the maintenance of the aviation system.

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.

Discussion

Human Factors were identified in many of the accident data in the International Air Transport Association Accident Data eXchange (IATA ADX). 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.

Recommendations

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

1) 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 Safety Management System (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 defined.

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. 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.

2) 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. Procedures should 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.

3) 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 Competency-based Training and Assessment (CBTA) to include Evidence Based Training program (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.

4) 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 is 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. 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.

5) 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 crew members are empowered to act safely.

The desired safety outcomes are that organizational culture supports safe flight operations. With the positive outcome of timely risk recognition and management and effective threat and error management.

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 has developed the Safety Leadership Charter to support industry executives in evolving a positive safety culture within their organizations. The Charter is geared towards strengthening organizational safety culture through highlighting this critical element as a driver for continuous improvement in safety performance, by proposing commitment to key leadership principles and supporting practical actions. For more information about the IATA Safety leadership Charter and how to get involved contact: safety@iata.org.

6) 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).

During the recovery to normal flight operations after the prolonged covid-19 pandemic, the challenges and workload have shifted dramatically and continue to change almost daily in the dynamic aviation environment. 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, AEP, GP, AME, 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.

A look from 2021 Accident Prevention Strategy

Unstable Approaches

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 ADX indicates that Unstable Approach (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.

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, 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.

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 - 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.

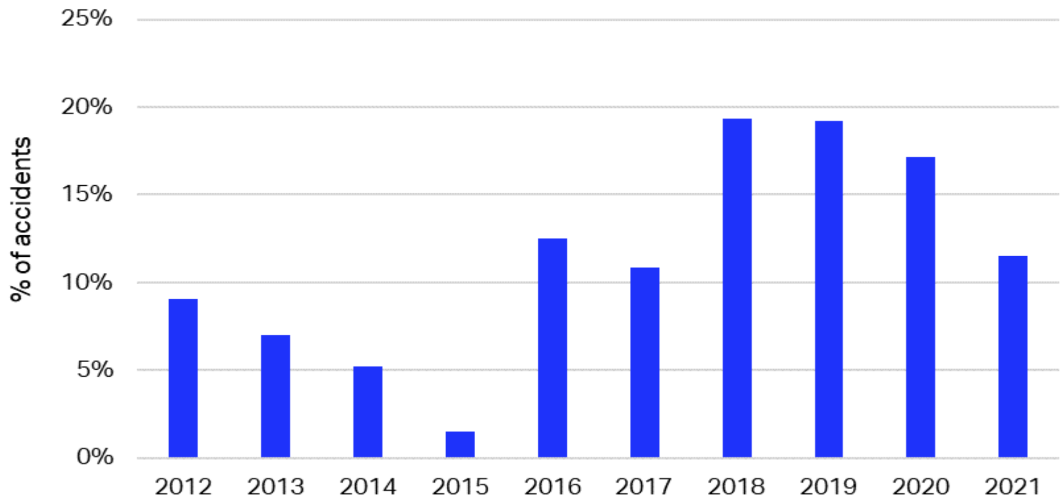
In-Flight Decision-Making and Contingency Management

Background

With increasing financial pressure on airlines and airports, and airspace becoming more congested and severe weather phenomena becoming more frequent, the chance of a diversion from the original destination airport will grow.

In-flight Decision-making 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 maintain situational awareness, 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 unwanted outcome.

In-flight decision-making was a contributing factor in 10% (62) of all accidents from 2012-2021. The ACTF taxonomy added proactive In-flight Decision-making and reactive Contingency Management as Flight Crew Countermeasures in 2019. Missing or insufficient in-flight decision-making significantly increases the risk of accidents. A number of events had already raised concerns about many of the approach and landing accidents, giving rise to recommendations. The chart below shows the percentage 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 inflight decision-making is a factor in a number of accidents. Refer to the following table:

End State	2021	2012-2021
Runway/Taxiway Excursion		22 (29%)
Hard Landing	1(4%)	9 (10%)
Loss of Control – In-flight		9 (12%)
Controlled Flight Into Terrain	1(4%)	7 (10%)
Tail Strike		6 (9%)
In-flight Damage		3 (7%)
Gear-up Landing/Gear Collapse		2 (3%)
Other End State		2 (4%)
Off-Airport Landing/Ditching		1 (3%)
Undershoot	1 (4%)	1 (4%)

Good pilot judgment and sound in-flight decision-making 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.

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 crews on a regular basis during training.

However, very few strategies can be found for normal operations in terms of giving the crews 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, crews may find themselves in conditions that are the same or even worse than at the original destination, but now with considerably less fuel.

The difference between a legal alternate and a sound valid alternate option is often not considered by crews when diverting, nor is this trained. This may end up in a cul-de-sac situation with minimum fuel or, in the worst case, in a hopeless situation with no fuel. 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.

Recommendations to Operators

Create, document, and train a proactive model for in-flight decision-making during normal daily operations. These models should ensure a solid guideline that allows crews to have a stringent and timely strategy for diversion airport assessment.

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.

Enable operational control centers or dispatch to have access to relevant enroute conditions, alternate airport databases and means to transfer this information to flight crews enroute in a timely manner.

Ensure that a reactive decision model is documented and trained to flight crews on a regular basis.

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.

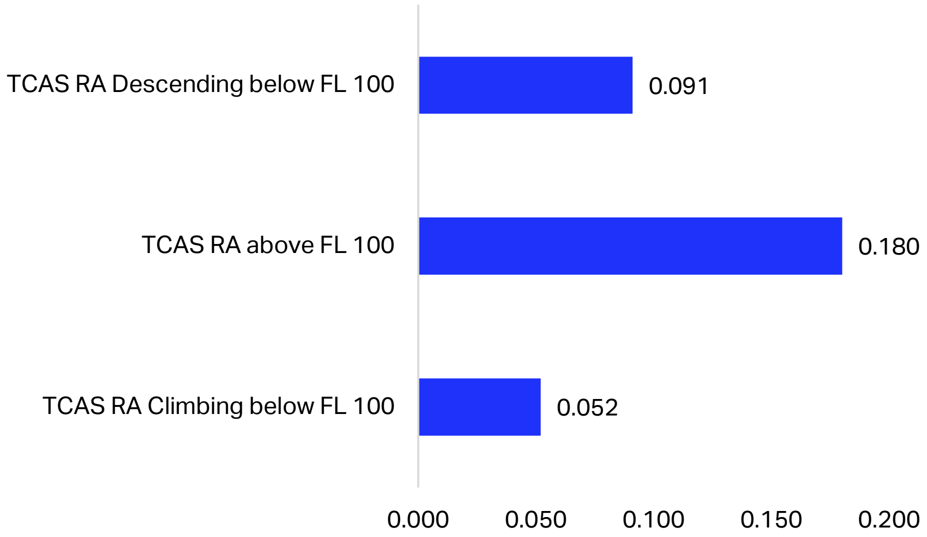
Mid-Air Collision (MAC)

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 fatalities.

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).



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.

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.

Ground Damage

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).

Discussion

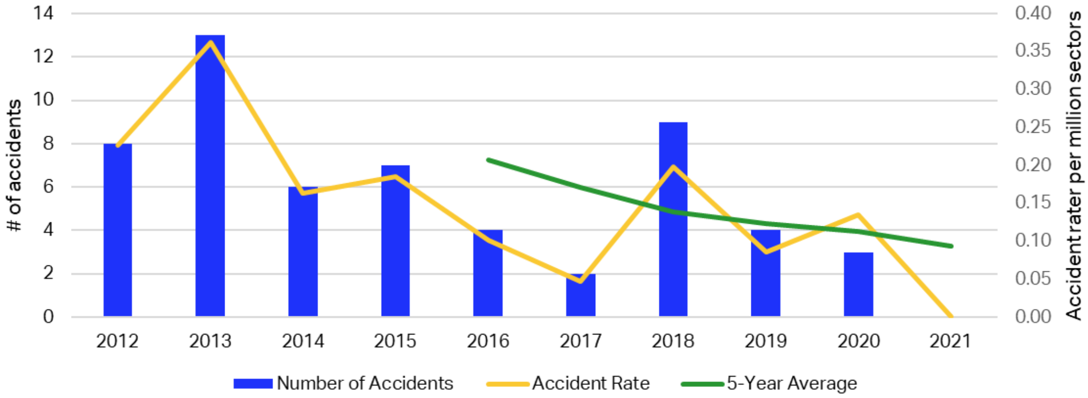
When aircraft are taxiing to or from an active runway, they have to successfully navigate through designated paths, following and respecting the instructions given to them and using the signs and markings. Complex regulations, processes and procedures are put in place by regulators and airport operators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

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 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.

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 Global Reporting Format (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]

Appendix "B" Example of airline policy on TEM

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 Area of Vulnerability (AOV)
  - Prioritization PF and PM duties depending on AOVs

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

<table>
<tr><td colspan="2">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</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td>Pilot Flying role</td><td>Pilot Monitoring role</td></tr>
</table>

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.