Accident Prevention Strategies

By Accident Classification Task Force (ACTF)

Disclaimer

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MANAGE SAFETY IN AVIATION

IATA remains focused on its top safety priorities, which include Runway Excursions, Controlled Flight into Terrain (CFIT), Loss of Control–In-flight (LOC-I), Mid-Air Collision (MAC), among others, while continuing to promote the implementation of new safety initiatives. Based on analyses of accident data for commercial air transport operations, IATA and the ACTF have developed recommendations to address:

Restart of Operations

Loss of Control — In-flight (LOC-I)

Controlled Flight into Terrain (CFIT)

Mid-Air Collisions (MAC)

Runway Excursions (RE)

Unstable Approaches

Ground Damage

Tail Strikes

Human Factors

In-Flight Decision-Making

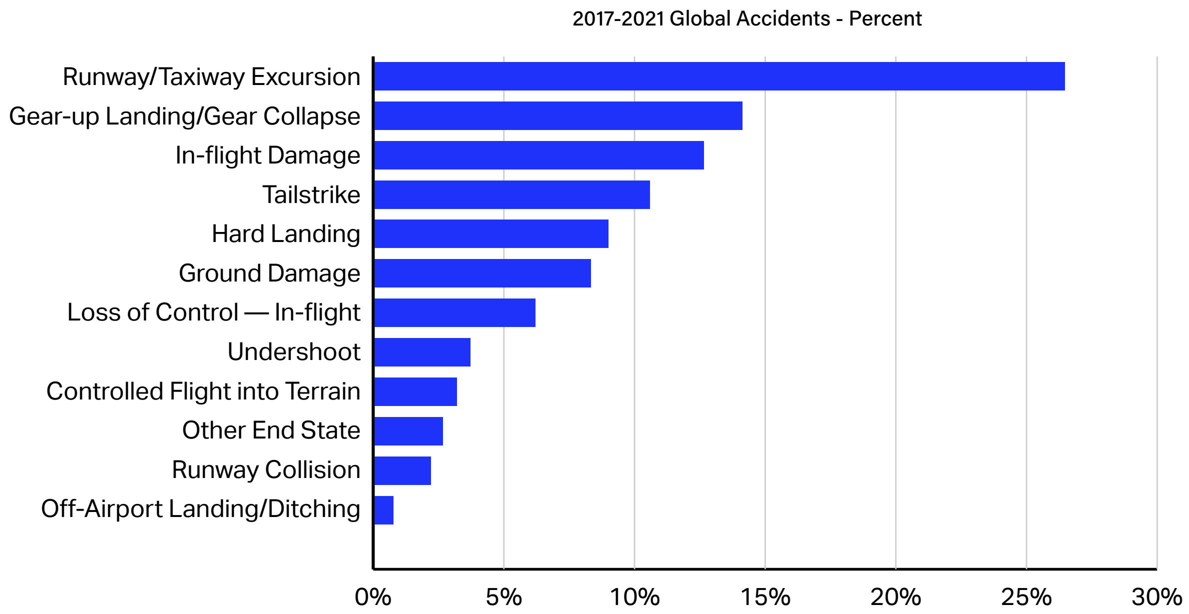
This section has been extracted from the original 2021 IATA Safety Report - Edition Chapter 8 into a stand-alone document. This document is intended to be a living document that will be evaluated and updated on yearly basis, as required, to cover subsequent five- and ten-years' periods.

The recommendations would be followed up by a reporting activity, in which progress on the actions is evaluated and documented. Through close monitoring of the implementation of these recommendations, IATA and ACTF would make adjustments to the document and its initiatives.

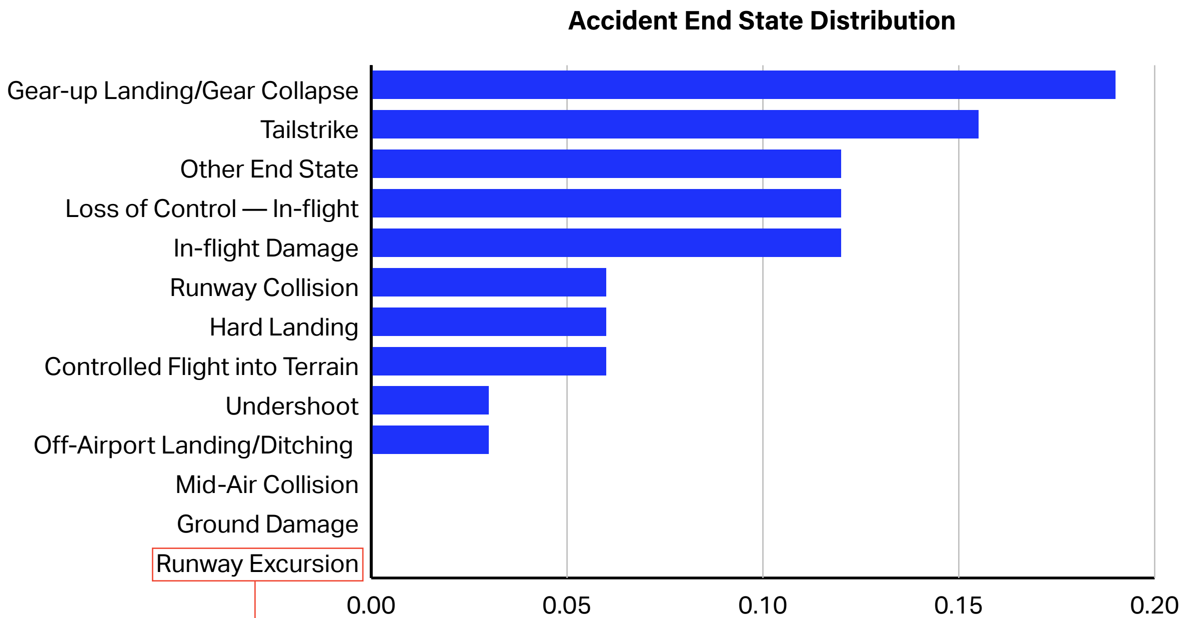
ACTF Accident Prevention Strategies

TOP FINDINGS: 2017-2021

Covering a five-year period, the 2017-2021 Accident End State Distribution, as a percentage of the total, as assigned by the ACTF, was as follows:



The Accident End State Distribution, as a percentage of the total of the 26 accidents that occurred in 2021, as assigned by the ACTF, was as follows:



Runway Excursion	0
Runway Excursion Lateral	0
Taxiway Excursion	0

The accident end states with associated fatalities in 2021 were:

- LOC-I (3) with 75 fatalities
- CFIT (2) with 32 fatalities
- Other End State (2) with 14 fatalities

With a full breakdown of each accident end state, the table below provides an overview of 2021's performance compared to the five-year average:

2021 vs 2017-2021

	2021	Comparison vs 5Y	5 Y Average (2017-2021)
Number of accidents	26	▼	44
Fatality Risk	0.23	▲	0.14
% of accidents involving IATA members	31%	▼	36%
% of fatal accidents	27%	▲	17%
% aircraft propulsion - Jet	50%	▼	64%
% aircraft propulsion - Turboprop	50%	▲	36%
% type of operations - Passenger	62%	▼	78%
% type of operations - Cargo	38%	▲	22%
% Hull losses	31%	▲	24%

COVID-19 – RESTART OF OPERATIONS

COVID-19 has led to a different risk landscape that has introduced new or amplified operational challenges and safety hazards. In addition, the pandemic has revealed gaps that need to be addressed across the aviation supply chain to increase efficiency and improve decision-making. To better understand the operational impacts of COVID-19 and the challenges that can be faced by airlines and air navigation service providers (ANSPs), IATA, along with the Civil Air Navigation Services Organization (CANSO), the International Federation of Air Traffic Controllers' Associations (IFATCA), and the International Federation of Air Line Pilots' Associations (IFALPA) started an initiative in 2020. The initiative included collaborative safety risk assessments (SRAs) in the context of the COVID-19 environment. The SRAs were used to shape educational webinars that were organized with experts representing the different organizations. A document capturing the outcomes of the SRAs and webinars in 2020 and 2021 was developed to provide general considerations for airlines, ANSPs and airports during restart and recovery to normal traffic levels. The guidance document, Considerations for Navigating the Restart and Recovery of Air Traffic, is available online. The main focus areas of the SRAs and guidance document are explained in the following sections. The detailed recommendations can be found in the online document.

Occupational Health and Safety

Given the high complexity of the current public health crisis, States are applying different mitigation measures to manage public health risks. While some governments have issued vaccine mandates, others have not; however, vaccination remains highly recommended by health authorities and encouraged. Nevertheless, the workforce in a given organization may include a mix of vaccinated and non-vaccinated staff. This means requirements for wearing masks, contact tracing, testing, and physical distancing will likely continue for some time. This may also have an impact on staff rostering and corporate policies for health measures, applied even to vaccinated staff. Constant communication and training will continue to be needed to ensure a good understanding by operational staff about residual risks after vaccination and when returning to work. Additionally, regular risk assessment will be needed to evaluate the effectiveness of the multi-layered defense against infection outbreaks to avoid operational interruptions caused by outbreaks among staff. Specifically, during recovery to normal operations, contingency plans should be reviewed to ensure appropriate measures are available in case of an outbreak of COVID-19 infection among operational staff.

Human Factors During Restart of Operations

COVID-19 has been impacting human factors due to rapid and continuous changes in health requirements in the workplace and increasing levels of stress and anxiety specifically due to job uncertainty. Where needed, staff training and validation were postponed. At the same time, after a prolonged period of dealing with the COVID-19 pandemic and all its consequences, there are emerging signs of demotivation to follow recommended protective behaviors, which has been characterized as pandemic fatigue. It is recommended that organizations perform additional risk assessments, considering pandemic impacts of human performance. Education and awareness of operational staff on fitness for duty, self-care, and the availability of support programs will be key during restart and recovery to normal operations. Each type of operation is unique and must address the specific risks related to potential skills decay.

Maintaining Competency and Training

As traffic levels and complexities continue to be dynamic because of the impacts of COVID-19, bringing back Air Traffic Control Officers (ATCOs), pilots and dispatchers who have experienced prolonged absences can require additional attention to training and competency levels. After an extended period away from the flight deck, pilots are often surprised by what knowledge and skills have been retained and which have degraded. Some skills return quickly while others return and develop more slowly.

The following resources are available to support maintaining training and competency during COVID-19:

- Guidance for Post-COVID Restart of Operations: CBTA Training Solutions - IATA
- Guidance for Managing Pilot Training and Licensing During COVID-19 Operations - IATA
- White Paper - ATO-AOC Partnership Including Instructor Provisioning - IATA
- White Paper - Ensuring the quality of training when classroom instruction is delivered via virtual classroom - IATA
- Training Considerations for Return to Operations - IFALPA
- Return to Flying Checklist for Pilots - IFALPA
- Coping with COVID-19 Guide - IFATCA
- Returning to Normal Crew Training - ICAO

Change and Organization Management

The aviation system includes multiple layers of processes, technologies, and people all working together according to global standards that are based on over 100 years of flying experience. The system is complex and includes many actors along the different phases of flight. It takes all processes, technologies, and people working together to ensure a flight can safely take off and arrive at its destination. COVID-19 has disrupted many established procedures across the aviation supply chain, necessitating flexibility and increased awareness.

The 'new normal' created by COVID-19 is challenging some of the assumptions regarding how many functions of the supply chain are carried out. Airlines, ANSPs, and other stakeholders in the aviation supply chain may face difficulty in resource planning and staff/crew scheduling. Airlines and the aviation supply chain will need to adapt and be agile, where possible, to ensure a safe operation during recovery to normal traffic levels. At the same time, the industry is seeing an unbalanced reliance on technology in safety critical tasks, which may result in negative outcomes. This is especially the case as traffic starts ramping up again while operational staff may not have been using parts of their cognitive functions that are normally applied in their jobs. Therefore, there will be a need for operational and safety performance assessments against set KPIs/SPIs with a focus on areas that had reliance on automation since the outbreak of the pandemic.

Interface between Air Traffic Controllers and Crew

As airlines and aviation supply chain actors work together on restarting operations, several considerations need to be made with regard to the effects of training, recency and human factors on both flight crews and ATCOs as they interact with each other. In addition, varying traffic levels after periods of reduced operations could increase the magnitude of certain operational challenges for both airlines and ANSPs. The combination of new and amplified risks and challenges can affect the safety of operations as traffic levels build up.

It will be critical to understand the stressors and challenges on both sides. As air traffic ramps up, it is important for flight crews and ATCOs to take time to make sure that they understand each other, and that any ATC clearance is clearly understood. During periods of low traffic, it was possible to introduce more efficient routes and some operational improvements. During recovery, it may not be possible for ATCOs to continue granting requests for direct routing, for example, because of the increasing traffic levels and additional capacity constraints. Airlines and ANSPs should always work together to achieve system and operational improvements.

The Impact of COVID-19 on Airport and ATM Operations

As traffic levels ramp up, the availability of airport infrastructure may have an impact on traffic management. At the same time, the additional requirements to ensure the biosafety and health of passengers, crews, and staff could affect time spent on the ground, which will impact overall network performance. Ground handling agents across all regions have been experiencing different impacts of COVID-19, including impacts on their staff.

Therefore, it is recommended that airports develop local restart plans that are aligned with airline restart plans. Such plans should be continuously reviewed due to the dynamic operational environment. Airports should also refresh their local risk assessments of the changing environment and promote additional measures and procedures that will be needed to ensure safe operations during recovery. Training and re-training of staff, especially after call back, will be required.

Mental Health and Wellbeing

COVID-19 and its associated restrictions have had a significant influence on the mental health and wellbeing of both passengers and aviation workers, and potentially jeopardize operational safety. Multi-sector collaboration is required to promote the mental wellbeing of aviation personnel and to aid passengers in their trip preparations to deliver a psychosocially safe and supportive aviation environment. The ICAO has published an Electronic Bulletin (EB 2020/55) on Promoting, Maintaining, and Supporting Mental Well-Being in Aviation During the COVID-19 Pandemic, which describes:

- Harsh quarantine rules.
- Home or hotel isolation between flight patterns.
- Increased workload due to intensive cargo operations.
- Long and irregular working hours, reduced rest opportunities, and potential fatigue.

All of these factors have an impact on the state of wellbeing of aviation staff. Safety performance is related to the manner in which people perform their roles, and overall performance relies on sound individual and collective states of wellbeing. Pilot wellbeing programs support pilots during personal crises and/or stresses in their lives, which may impact relationships, health, or professional performance.

Pilot assistance programs provide peer support to fellow pilots, offering referrals to professional resources when appropriate, while upholding strict confidentiality. For other staff groups, Employee Assistance Programs (EAP) work in a similar manner.

The United States FAA, the EEASA, IFALPA, airlines, etc. advocate for peer support programs to be built on SMS principles.

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LOSS OF CONTROL — IN-FLIGHT

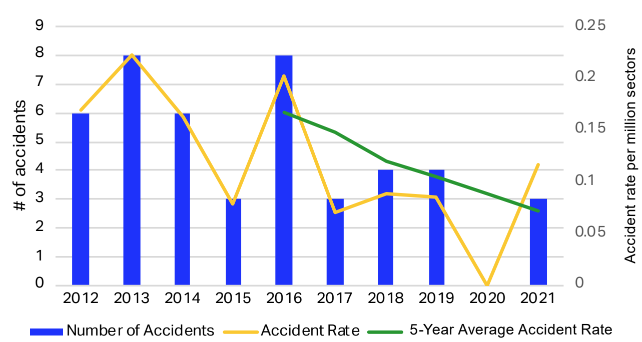
Background

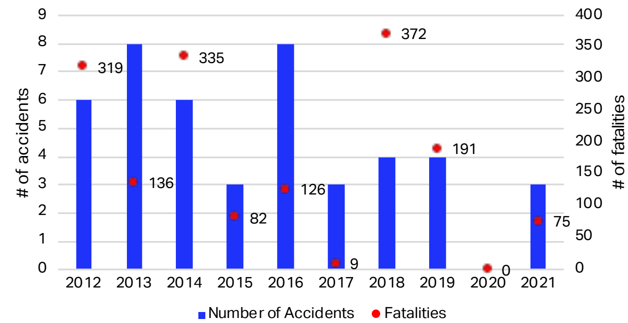
Loss of Control — In-flight (LOC-I) refers to accidents in which the flight crew was unable to maintain control of the aircraft in flight, resulting in an unexpected deviation from the intended flight path. LOC-I can result from a wide range of contributing factors that include, among others, system/component failures (engine and non-engine), hazardous weather conditions (e.g., icing, windshear), inappropriate energy management (stalls), poor automation management and monitoring (autopilot, autothrottle), incorrect maintenance, spatial disorientation, as well as other human and technical factors. Reducing this accident category through understanding of contributing factors and intervention strategies is an industry priority.

Discussion

Although the LOC-I category represented only 8% of all accidents during the last 10 years (2012-2021), it resulted in the highest percentage of fatal accidents (46%) and fatalities (63%). 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 is gradually adding protections to the flight envelope that help pilots prevent and reduce the likelihood of LOC-I accidents. When looking at the rolling average of the LOC-I accident rate for the five years going back to 2012-2016 in the IATA ADX database, the average LOC-I accident rate recorded was 0.17 accidents per million sectors. For the next five years (between 2013-2017), the accident rate was 0.15. In the graph below, it is apparent that the rolling average five-year accident rate continues to trend downwards. Today, the average five-year (2017-2021) accident rate is 0.07 per million sectors. However, the 2021 LOC-I accident rate is 0.12, which is above the five-year average rate.





To assist the commercial aviation industry's awareness of LOC-I hazards and risks, IATA has developed an accident analysis report using data from LOC-I accidents. The risks of 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 high pilot competency standards through training that includes Crew Resource Management (CRM) and basic manual flying skills, including during hazardous weather conditions, is the most effective barrier against LOC-I accidents. 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) using Full Flight Simulator (FFS) training modules, 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 simulator as well as in-aircraft 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 Flight Simulation Training Devices (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 or recover from LOC-I accidents by taking the following actions:

- Increase awareness of the precursors leading to an upset or stall.

- Take definitive and decisive actions to recover from an upset.

- Increase awareness of the flight phases where poor monitoring can be most problematic.

- Strategically plan workload to maximize monitoring during AOV.

- Emphasize the briefing on pre-flight and, in certain phases, impending night or Instrument Meteorological Conditions (IMC) entries that complicate situational awareness and recovery.

- Increase awareness and understanding of certain controls and displays, such as the Flight Modes Annunciator (FMA) on the Primary Flight Display (PFD)/Electronic Attitude Director Indicator (EADI).

- Maintain constant awareness of the stall margin throughout all phases of flight.

- 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.

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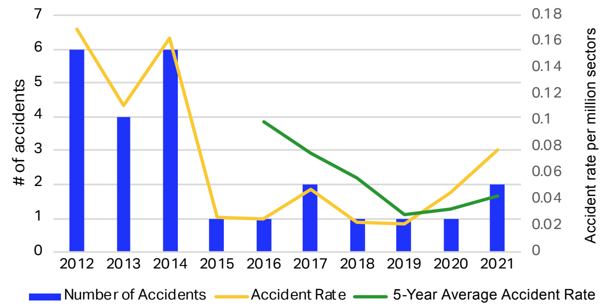
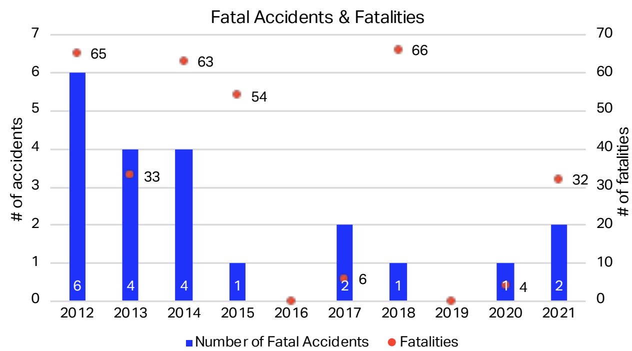
CONTROLLED FLIGHT INTO TERRAIN

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 323 fatalities. When looking at the rolling average accident rate for the five years going back to 2012-2016, the average accident rate recorded was 0.10 accidents per million sectors. During the next five years (between 2013-2017), the accident rate was 0.07. The rolling five-year average accident rates continue to trend downwards. Today, the five-year (2017-2021) average accident rate is 0.04 per million sectors. However, the CFIT accident rate in 2021 is 0.08, which is above the five-year average.





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 EGPWS or 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

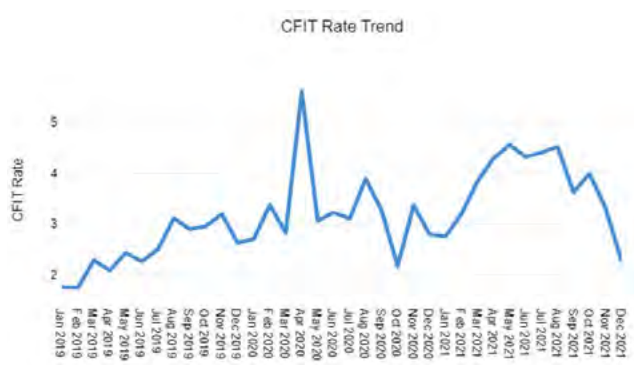
- Updating EGPWS software and Terrain/Obstacle/Runway database in a timely manner

- 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 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 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 2017 to December 2021. 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 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 2012-2021 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 thereof ▪ Absent or deficient safety management ▪ Technology and equipment not installed ▪ Absent or deficient flight ops SOPs and checking
Threats	▪ Meteorology, including poor visibility/IMC ▪ Ground-based navigation aid malfunction or not available ▪ Lack of visual reference
Undesired Aircraft States	▪ Aircraft handling ▪ Unstable approaches ▪ Controlled flight towards terrain ▪ Vertical/lateral/speed deviation ▪ Unnecessary weather penetration
Errors	▪ Failure to cross-verify (automation) inputs ▪ Failure to follow SOPs ▪ Intentional deviation by flight crew ▪ Manual handling errors ▪ Omitted takeoff, descent, or approach callouts
Counter-measures	▪ Overall crew performance ▪ Monitor/Cross-check ▪ In-flight decision-making/contingency plan ▪ FO Is Assertive When Necessary and is able to take over as leader ▪ Captain shows leadership and coordination of flight deck activities ▪ Automation management

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, OEMs, international organizations and other relevant stakeholders to see they are applied. This DIP, which can be found here.

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

What Is Required from Operators?

Safety Management System
- Dedication and commitment from leadership and all industry stakeholders.
- Establish a positive safety culture.
- Encourage operators to use FOQA data to monitor proper responses by flight crew to EGPWS events.

- Increase awareness and visibility of the implications of deviating from established procedures.

- Consult with and promote the performance assessment of EGPWS Guidance Material (GM) and its recommendations.

Training

- Training departments should perform gap analysis against the latest EGPWS training GM available from IATA, EASA, FAA, ICAO, OEMs, and others.

- Enhance flight crew training by implementing CBTA to include an EBT program.

- Consult with the performance assessment of EGPWS GM and its recommendations.

Flight Operations

- Use of terrain display and access to latest information on weather conditions to enhance full situational awareness and ensure timely and appropriate pilot response.

- Encourage pilots and operators to report instantly to the relevant ATC units and authorities all incidents related to GPS or radio altimeter anomalies.

- Encourage flight crew to immediately respond to an EGPWS warning.

- Consult with and promote the performance assessment of EGPWS GM and its recommendations.

Technical Operations (Engineering and Maintenance)

- Ensure the EGPWS software/terrain database are kept up-to-date and highlight the safety benefits that can be obtained by keeping the software/database up-to-date.

- Ensure the use of GPS/GNSS for the position source to EGPWS.

- Consult with the performance assessment of EGPWS GM and its recommendations.

What Is Required from the Manufacturers' Perspective?

- Ensure the timely update of the EGPWS software and Terrain/Obstacle/Runway database.

- Consult with and promote the performance assessment of EGPWS GM and its recommendations.

What Is Required from Pilots?

- The EGPWS is NOT to be used as a primary reference for terrain or obstacle avoidance and does NOT relieve the pilot from the responsibility of being aware of the surroundings during flight. Situational awareness must be maintained at all times.

- Pilots are directly responsible and are the final authority as to the operation and safety of the flight. They are responsible for terrain, other aircraft, and obstacle clearance and separation.

- Once the pilot is cleared to conduct a visual approach, the pilot has full responsibility to maintain separation from terrain and obstacles. Safe separation from the terrain, obstacles and other aircraft must be maintained throughout the flight by using accurate navigation, especially during takeoff, decent and final approach, including briefings and proper checks. If pilots are unable to maintain terrain/obstacle clearance or separation, the controller should be advised and pilots should state their actions.

- Through thorough briefing, the flight crew would be able to know:

  - The main features of the departure route, descent, approach and missed approach.

  - Terrain and hazard awareness, including weather conditions.

- Briefings should include:

  - Significant terrain, obstacles and other hazards, such as weather along the intended departure route.

  - Standard Instrument Departure (SID) and Minimum Safe Altitude (MSA).

- The approach briefing should include:

  - Descent profile management and energy management.

  - Terrain awareness and approach hazard awareness, including weather.

  - Elements of unstable approach and missed approach procedures.

  - MSAs and other applicable minimums (visibility, runway visual range, cloud base).

  - Go-around altitude.

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

Recommendations

- Ensure EGPWS software and Terrain/Obstacle/Runway database are kept up-to-date.

- Ensure GPS/GNSS is used as a position source for the EGPWS.

- Ensure a policy is in place that at least one pilot selects terrain display during critical phases of flight (such as climb and descent below MSA) for additional situational awareness. If weather is not a threat, then both pilots could decide to select terrain display.

- Establish a training program to ensure flight crew is trained to respond to EGPWS alerts effectively.
- Airlines should have procedures to ensure EGPWS equipment always remains activated and serviceable.
- Pilots and operators should promptly notify the respective authorities of the interference location and the relevant ATC if they experience GPS or radio altimeter anomalies.
- Consult the [IATA/Honeywell Performance assessment of pilot response guidance material (GM) and recommendations]

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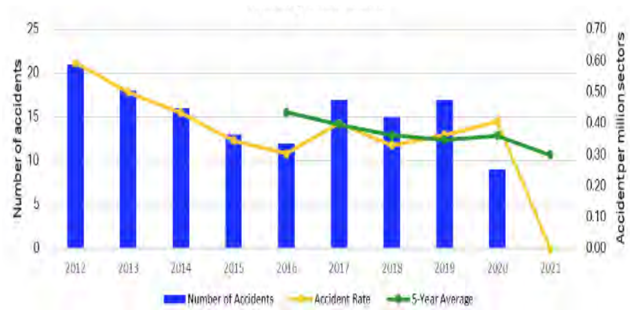
RUNWAY/TAXIWAY EXCURSIONS

Background

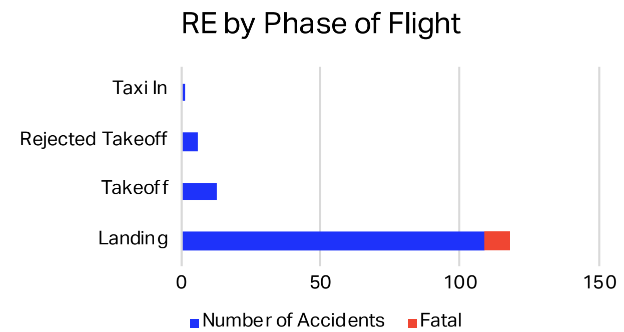
Runway excursions are the result of an aircraft rolling beyond the end of a runway or veering out of its lateral limits. Historically, this category accounts for the most common end state in the accident database. While there are many factors involved in any accident, runway excursions often include factors related to weather or a high energy state when approaching the runway. Either on takeoff or landing, slippery runways with poor braking action due to contamination from snow, rain or ice, often associated with gusting winds, make aircraft control difficult and, as such, are often cited as threats in runway excursions. Long, floated, bounced landing is the undesired aircraft state most commonly cited, indicative of a high energy state while approaching the runway and may be suggestive of landings continued out of unstable approaches.

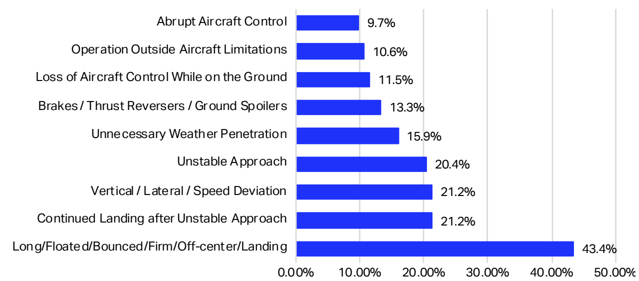
Discussion:

Analyzing the data from the last 10 years (2012-2021), Runway Excursion (RE) is marked as the most frequent accident category with 138 accidents and the third most frequent cause of fatal accidents with 9 accidents, resulting in 93 fatalities. These accidents occurred while the aircraft was taking off or landing, and involved many factors ranging from unstable approaches to the condition of the runway.

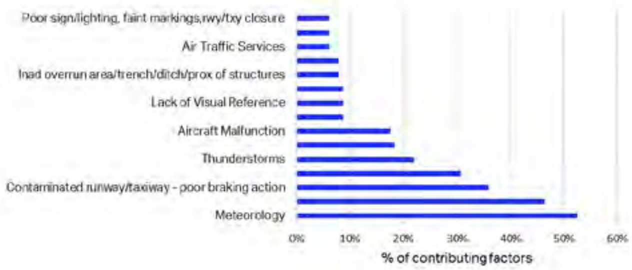


In 2021, there were zero RE accidents, and the rate of RE accidents has steadily decreased in the database over the past 10 years. However, for the past five years, the rate has plateaued in a range between 0.30 and 0.40 per million sectors. Despite there being zero accidents in 2021, the trend indicates that RE will continue to be a concern.





Overwhelmingly, the data indicates that 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. While the rate of runway excursions has reduced, there are still a significant number of accidents due to unstable approaches. It is important that realistic and appropriate stabilized approach gates be set for the operation and recommended best practices for stabilized approach criteria be implemented, such as recommended by IATA/CANSO/IFATCA/IFALPA in the [Unstable Approaches: Risk Mitigation Policies, Procedures, and Best Practices]. Incorporating these recommendations along with effective CRM practices into SOPs is more effective when accompanied by a culture of compliance. 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. Training for both Pilot Flying (PF) and Pilot Monitoring (PM) should reflect best practices, making crews not only aware of what the stabilized approach criteria are, but how to fly within parameters, recognize situations leading to unstable approaches, and when and how to properly conduct a go-around. Incorporating technology such as Runway Overrun Awareness and Alerting Systems into the aircraft to help alert crews when an insufficient amount of runway remains for a safe landing would further aid the crew in decision-making.



Meteorology was the most common threat identified in RE accidents by the ACTF along with related threats of windshear/gusty winds, runway contamination, and thunderstorms. 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. Using Digital Automatic Terminal Information System (D-ATIS) would help in distributing and updating reports as opposed to the already difficult 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 or thunderstorm.

Furthermore, the runway environment itself should be considered to make excursion accidents more survivable. 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 sufficient overrun 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:
The Global Action Plan for the Prevention of Runway Excursions (GAPPRE), which includes a series of consensus-based recommendations that represent best practices and interventions that go beyond regulatory compliance, has been developed with the aim of preventing runway excursions. The Global Runway Safety Action Plan (GRSAP), which was developed to provide recommended actions for all runway safety stakeholders, with the aim of reducing the global rate of runway excursions and runway incursions is being updated. As pertains to runway excursions, the ICAO Runway Safety Tool kit provides links to access more reference material. Recommendations are highlighted and summarized below.

- All stakeholders should participate in runway excursion safety information sharing to further identify risks and best practices.
- SOPs should be developed, in accordance with OEM guidance and regulations, to clearly define safe approach planning, stabilized approach criteria, go-around, safe landing and bounced landing to include crosswind limitations by runway condition.
- SOPs and policies should:
  - Implement TEM strategies and SOPs on takeoff, landing and go-around phases of flight.
  - Include training that emphasizes, among others, the role of effective and active PM, and clearly defines actions for both PF and PM, including performance-based reactions to include PM intervention.
  - Require pilots to always be go-around-prepared and go-around-minded.
  - Include rejected takeoff/landing policy that defines all scenarios that may require the discontinuation of an approach or takeoff and encourages pilots to perform them, if necessary.
  - Adopt, as a minimum, the defined limits set by the OEMs for deviations from approach parameters.
- Review recommendations from available resources to identify ways to increase awareness of weather and airport surface conditions by pilots. A procedure should be in place to perform the landing performance calculation considering a deterioration of the forecasted weather conditions at the time of the arrival.
- Empower flight crew to advise ATC when unable to comply with an instruction or a clearance that would decrease safety margins.
- Support flight crew to use the most suitable or appropriate level of automation at busy airports until Decision Height/Minimum Decent Altitude (DH/MDA), and a visual reference for the runway is in sight.
- Ensure TEM strategies and SOPs are included in flight crew training programs, taking advantage of methods such as CBTA, including EBT. Training may include, but not be limited to, the following:
  - Assessment and analysis of non-normal situations not covered by SOPs.
  - Effective use of current and new technologies to determine landing distances in all weather conditions.
  - Planning and conducting approaches with appropriate contingency plans.
  - Preparing for a go-around in the event of deterioration of weather conditions.
  - Bounced landings that are specific to each aircraft type, following OEM guidance.
  - Scenario-based training to develop pilot competencies for effective TEM to prevent runway excursion (e.g., contaminated runway, last minute change of runway, deterioration of weather conditions).

- TEM pre-departure and arrival briefings.
- Effective determination of the takeoff and landing performance calculation and emphasis on the resulting runway safety margin.
- Effective usage of the ICAO GRF.

▪ A culture that stimulates safe behavior, encouraging risk averse decision-making, should be fostered by promoting a non-punitive go-around policy, use of alternates and compliance with stabilized approach criteria.

▪ Responsible Flight Data Monitoring programs should identify runway excursion risks for monitoring by a robust SMS.

▪ Technology should be implemented as available to monitor and alert flight crews to insufficient runway remaining, risk of runway excursion and high-energy approaches (such as Runway Overrun Awareness and Alerting Systems).

▪ Runways should be constructed with clear distance markings, water shedding to promote better braking, and sufficiently safe clear areas.

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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) 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, 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 non-punitive 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.

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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).

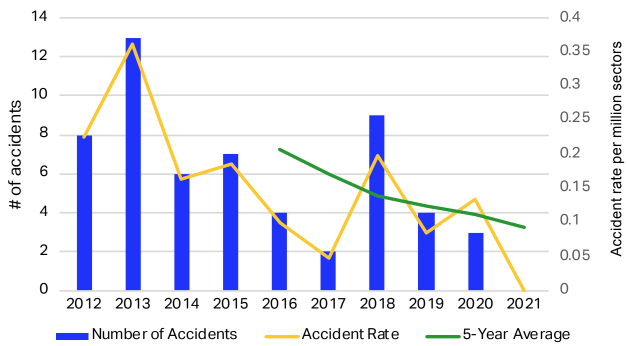
Discussion
When aircraft are taxiing to or from an active runway, they have to successfully navigate through designated paths, following and respecting the instructions given to them and using the signs and markings. Complex regulations, processes and procedures are put in place by regulators and airport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

Threats	Environmental	▪ Meteorology ▪ Air traffic services
	Airport	▪ Airport facilities ▪ Poor signs/lighting/ markings ▪ Rwy/twy closure
	Traffic	▪ Airport traffic ▪ Vehicles
	Airline	▪ Aircraft malfunction ▪ Brakes
	Flight Controls	▪ Ground events
	Psychological/ Physiological	▪ Optical illusion ▪ Misperception
Errors	Procedural	▪ SOP adherence/cross-verification
	Communications	▪ Crew-ramp ▪ Crew-ground control
	Aircraft Handling	▪ Manual handling
Undesired Aircraft States	Gnd. Navigation	▪ Ramp movements ▪ Loss of aircraft control on ground ▪ Wrong twy, ramp, rwy, gate, hot spot
	Incorrect Aircraft Configuration	▪ Brakes, engine, thrust reverses, ground 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 IGOM, ISAGO and IATA 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 SPIs and SPTs to manifest and measure ground safety performance.
- Develop a package of Safety Performance Indicators and Safety Performance Targets 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.

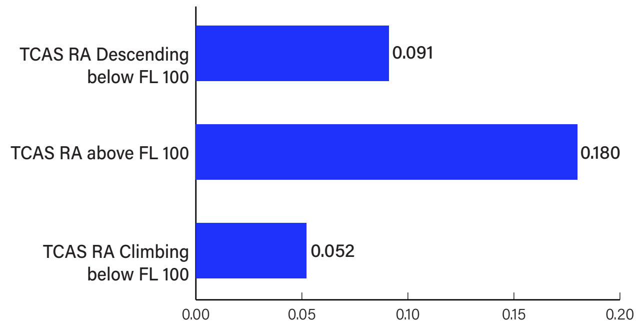
MID-AIR COLLISION

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 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 ACTOs 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.

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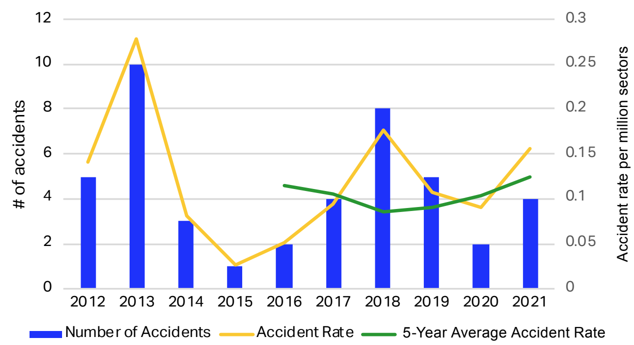
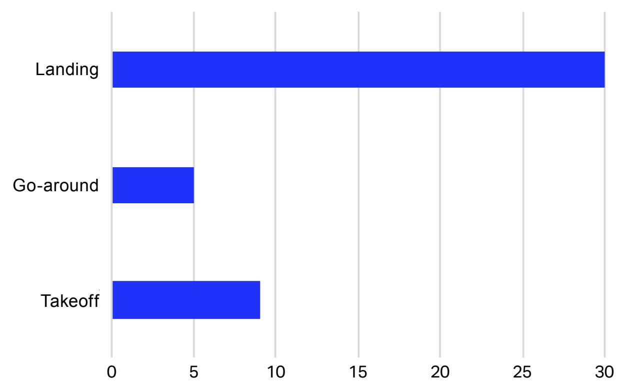
TAIL STRIKES

Background

While statistics show tail strike accidents can be a surprising threat during takeoff and go-around, they are much more common on landing. They can cause serious damage to aircraft and cost operators millions to repair. Tail strike accidents occur when the attitude of the aircraft is such that the tail makes contact with the runway in a way that causes substantial damage.





Discussion

Most tail strike accidents over the past 10 years occurred on landing. The most common threats cited are centered around weather conditions: meteorology and wind/windshear/gusty winds. Landing in gusty wind conditions is a difficult task. Higher approach speeds are required to maintain a safe margin from stall and rapid corrective control inputs are necessary as wind gusts displace the aircraft from the intended path. These factors result in arriving at the runway in a higher energy state, which contributes to the most commonly cited undesired aircraft state of long/floated/bounced landings followed closely by the undesired states of abrupt aircraft control and vertical/lateral/speed deviations. While these factors have been identified in tail strike accidents on landing or go-around, they are often mitigated in successful landings given similar conditions. 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, go-arounds, pilot monitoring, and gusty crosswind landings.

Tail strike accidents on takeoff are less frequent and often due to errors in calculating performance. These calculations have to account for the actual weight of the aircraft, the runway used, and current weather conditions. Errors due to documentation, weight and balance or dispatch paperwork are often cited in tail strikes on takeoff. Procedures must be in place to ensure proper performance calculations are made and communicated to flight crews. Training should be conducted to ensure the correct performance numbers are loaded and used for takeoff, including methods to mitigate errors when a change in runway or weather conditions occurs.

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 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.
- Training should be conducted to make flight crews aware of risks and limitations of tailwind operations, as indicated in IFALPA's publication Tailwind Operations | IFALPA.
- 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 (iata.org).
- Policies and training should be implemented on the role of effective and active Pilot Monitoring (PM) to clearly define actions for both Pilot Flying (PF) and PM, including performance-based reactions to include PM intervention.
- Training should include realistic, evidence and competency-based scenarios requiring TEM 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.
- 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.
- When the runway used for takeoff or landing is changed, reliable procedures and guidance should be implemented to verify that accurate performance is changed and used appropriate to the new runway.
- 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.
- Ensure TEM strategies and SOPs are included in flight crew training programs, taking advantage of methods such as CBTA, including EBT. Training may include, but not be limited to, the following:
  - Initiating scenarios with early or late flare.
  - Preparing for a go-around in the event of deterioration of weather conditions.
  - Using the most suitable or appropriate level of automation at busy airports until DH/MDA, and a visual reference for the runway is in sight.
  - Bounced landings specific to each aircraft type, following OEM guidance.
  - TEM pre-departure and arrival briefings.

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HUMAN FACTORS IN ACCIDENTS

Background:
As understanding aviation accidents is sometimes difficult, owing to the inherent complexity of how accidents come about within elaborate sociotechnical systems, we will focus on human factors on this section. ICAO defines human factors as the scientific study of the interactions between people, machines, and each other (ICAO, 2003).

The FAA further defines human factors as the multidisciplinary effort to generate and compile information about human capabilities and limitations and apply that information to produce safe, comfortable, and effective human performance. Another definition of human factors established by the Health and Safety Executive (HSE) is that human factors refer to environmental, organizational and job factors, as well as human and individual characteristics, which influence behaviors at work in a way that can affect health and safety.

Accident data analyzed from 2012-2021 shows that:

- Aircraft handling (37%) had the highest percentage of causal factors in undesired aircraft states.
- Aircraft handling, unstable approaches, unnecessary weather penetration were causal factors in many aircraft accidents.
- Environmental threats where present in 34% of accidents.
- Runway/Taxiway excursion is the accident category with the highest number of accidents.

Discussion:
Human factors were identified in most of the accident data. Human factors have been widely recognized as critical to aviation safety and effectiveness. Sustainable long-term improvements in aviation safety will come primarily from human factors solutions (e.g., research and development, analysis, and application of human factors methods in airline operations).

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

The modern interdependencies of errors, the tightness of aviation component coupling, and the high consequences of errors require extending human-system capabilities to enhance performance and 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 recommendations below are not exhaustive, as each organization should develop human factors strategies and interventions based on their unique organizational needs.

1) Managing patterns of failure:
Managing human failures is about predicting how people may fail through errors or intentional behaviors 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 control measures. The management of human error includes error prevention and interventions for disallowing errors 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. Risk assessments and incident investigations are SMS elements of managing human performance.

Risk assessments should consider the critical elements of human failure, its implications, and ensure the associated Performance Shaping Factors (PSFs) are understood and the appropriate controls are defined.

The desired safety outcomes of risk assessments:

- Controls reflect limitations of human performance and consider task, personal and organizational factors.
- Systems and processes are designed to be tolerant of human performance failings.
- Performance-shaping factors are optimized.

Furthermore, incident investigation should consider the critical elements that enable understanding of performance variability, operator sensemaking, and allow human performance failings to be identified and root causes to be addressed. Event investigations conventionally focus on what went wrong, but the same methods can also be applied to what made sense to the operator and how many events went well before. 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 an organization's classification schemes and taxonomies are likely to be needed.

The desired safety outcomes of the incident investigations should be to establish:

- Conditions that allowed performance variability to reach the brittleness boundary
- Conditions that allowed human failings to occur
- That system failings are corrected
- Designing systems that are tolerant of human performance failings
- Capturing the resilient capability of the actors when things go well for organizational and individual learning

2) Procedures:
Procedural noncompliance, or procedural drift, has been a causal factor in many aviation accidents. Procedural drift refers to the gap between work as prescribed and work as done.

Procedures include method statements, work instructions, SOPs, flight profiles, company guidance, etc. Incomplete, incorrect, unclear, or outdated procedures can lead to shortcuts and human failures. Procedures should be managed and use a format, style, and level of detail appropriate for the user and the task, and consider the consequence of failures. Procedures should:

- Consider the critical elements that are linked to (safety-critical tasks).
- Be selected, designed, and managed to promote human reliability.
- Be designed in a way that is easy to understand.
- Be kept up-to-date.
- Be easy to access.

The application of human-centered design and systems methods in procedure design is an effective method for taking into consideration work-as-done principles with the goal of closing the gap between work-as-imagined, work-as-prescribed, and work-as-done.

The desired safety outcomes:

- Procedures are implemented where they are needed and contain correct scope-actions-tasks, including emergency actions and sufficient detail.
- Tasks are executed safely and consistently with the intended design of the procedure, resulting in standardization.

- Procedures, checklists, and paperwork are established, and crews are trained in one consistent, predictable way, applying the company's basic operating philosophy.

- Standardization serves as an intervention against human error.

3) Training and Competency:
Studies and data have demonstrated that many of the causal factors identified in aviation accidents are related to human factor lapses in group decision-making, ineffective communication, inadequate leadership and lapses in flight deck management. Hence, the importance of CRM and training in enhancing safety in aviation operations.

Industry should consider the critical elements of enhancing flight crew training by implementing CBTA. Under a CBTA program, such as EBT, the pilot competencies encompass what was previously known as technical and non-technical skills to include the CRM skills of workload management, situational awareness, decision-making, communication and leadership, which are of utmost importance to ensure flight safety.

Given the essential contributions of the instructors/evaluators (IE) to flight safety, IATA led the definition of a pilot IE competency set that was endorsed by ICAO and EASA. Under CBTA, TEM is naturally and fully embedded in the training curriculum. The pilot and IE competencies provide individual and team countermeasures to threats and errors to avoid a reduction of safety margins during training and operations. CBTA is applicable to the whole spectrum of pilot training, from pilot aptitude testing, pilot initial licensing training, IE training and operator training.

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. (see "Fatigue in Aviation: Safety Risks, Preventive Strategies ...") Some of the main airline accidents identify chronic fatigue, sleep loss, and desynchronosis (jet lag) as three "human factors" that contributed to unsafety.

Fatigue refers to issues that arise from excessive working time or poorly designed roster patterns. It can lead to human failures, slower reaction times, reduced ability to process information, memory lapses, absent-mindedness, and loss of attention.

Fatigue management should consider the following critical elements:

- Roster patterns and duty hours are designed and managed to control crew fatigue levels.

- Flight crews are aware of fatigue, and rest periods are utilized effectively to get the required restorative sleep.

- Fatigue of crews is monitored and managed such that system safety is not compromised.

- Crew member fatigue is acknowledged as a hazard that predictably degrades various types of human performance and can contribute to aviation accidents and incidents.

- As fatigue cannot be eliminated, it should be managed.

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. In this effort the Fatigue Management Guide for Airline Operations marks the collaboration between IATA, ICAO, and IFALPA to jointly lead and serve the industry in the ongoing development of fatigue management, using the most current science. It presents the common approach of pilots, regulators, and operators to the complex issue of fatigue. For more information, contact FRMS@iata.org

5) Organizational Culture:
Setting expectations, leading by example and decision-making that takes safety into consideration are essential in creating a strong safety culture. This means taking personal accountability for safety. The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an 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 promotes safe behaviors and discourages unsafe behaviors.

Organizational culture should consider the following critical elements:

- Management of hazards is consistent within the business

- Production/safety conflicts are managed responsibly

- Risks are understood across the business

- Crew members are empowered to act safely

The desired safety outcomes are that organizational culture supports safe flight operations. The positive outcomes are timely risk recognition and management as well as effective TEM.

The operator should consider a systems thinking approach to safety. A 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 ...").

Developed by IATA, the I-ASC Survey is a solution aimed at addressing the industry's need to measure and continuously improve safety culture, using a standardized methodology and key performance indicators. With I-ASC, airlines can also benchmark their safety culture against their peers across the industry using comparable KPIs. ("IATA - Aviation Safety Culture Survey (I-ASC)").

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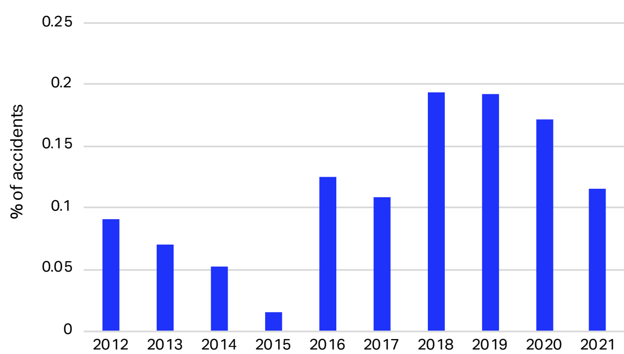
IN-FLIGHT DECISION-MAKING AND CONTINGENCY MANAGEMENT

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 in-flight 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.

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