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Airbus

A Statistical Analysis of Commercial Aviation Accidents 1958 - 2021

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Safety Publications

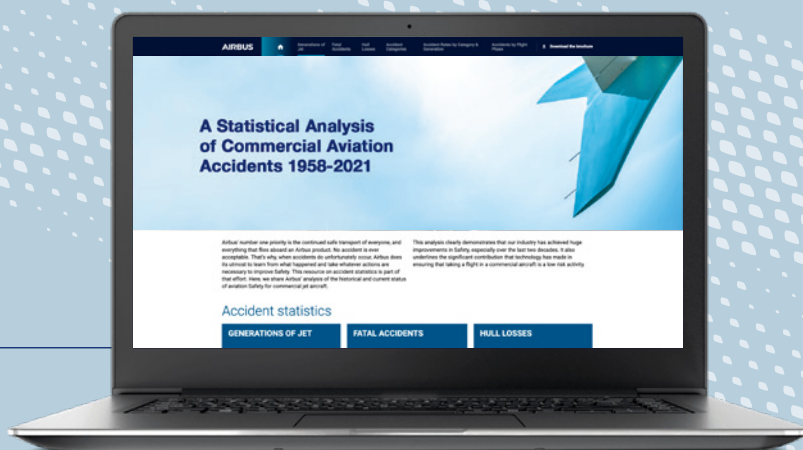
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Scope & Definitions

This publication provides the Airbus annual analysis of aviation accidents, with commentary on the year 2021, as well as a review of the history of the safety record for commercial aviation.

This analysis clearly demonstrates that the commercial aviation industry has achieved huge improvements in safety over recent decades. It also underlines the significant contribution that technology has made in ensuring that taking a flight in a commercial jet aircraft is a low-risk activity.

The goal of any review of aviation accidents is to help the industry further enhance the level of safety, therefore, an analysis of forecasted aviation macro trends is also provided. This highlights the key factors influencing the industry's consideration of detailed strategies for the further enhancement of aviation safety across the air transport system.

Scope of the Brochure

• **All Western-built commercial air transport jets that carry over 40 passengers (including cargo aircraft):**

- Airbus: A220, A300, A300-600, A310, A318/319/320/321, A330, A340, A350, A380
- Boeing: B707, B717, B720, B727, B737, B747, B757, B767, B777, B787
- Bombardier CRJ series
- British Aerospace: Avro RJ series, BAe 146
- British Aircraft Corporation BAC-111
- Convair 880/990
- Dassault Mercure 100
- De Havilland Comet
- Embraer: E170, E175, E190, E195, ERJ 140, ERJ 145, ERJ 145XR
- Fokker: F28, F70, F100, VFW 614
- Hawker Siddeley Trident
- Lockheed: L-1011
- McDonnell Douglas: DC-8, DC-9, DC-10, MD-11, MD-80, MD-90
- Sud-Aviation Caravelle
- Vickers VC-10
- Sukhoi Superjet

Note: Non-Western-built jets are excluded* due to lack of information, and business jets are not considered due to their particular operating environment.

*except Sukhoi Superjet

• **Since 1958**, the first year with regularly scheduled transatlantic flights using commercial jet aircraft.

• **Revenue flights**

• **Operational accidents**

• **Hull loss** and **fatal** types of accidents

Source of Data

• The accident data was extracted from official accident reports, as well as ICAO, Cirium, and Airbus databases.

• Flight cycle data was provided by Cirium for all aircraft. Cirium revises these values on an annual basis as further information becomes available from operators.

Definitions

- **Revenue flight:** A flight involving the transport of passengers, cargo or mail. Non revenue flights such as training, ferry, positioning, demonstration, maintenance, acceptance and test flights are excluded.
- **Operational accident:** An accident taking place between the time any person boards the aircraft with the intention of flight until the time all such persons have disembarked, excluding sabotage, military actions, terrorism, suicide and the like.
- **Fatal accident:** An event in which at least one person is fatally or seriously injured as a result of:
 - being in the aircraft, or
 - direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
 - direct exposure to jet blast.

This excludes the injuries that are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally accessible by the passengers and crews.

- **Hull loss:** An event in which an aircraft is destroyed or damaged beyond economic repair. The threshold of economic repair decreases with the residual value of the aircraft. Therefore, as an aircraft ages, an event leading to damage that was economically repairable years before may be considered a hull loss.

Definition of accident categories

The accident categories described are based on standard ICAO definitions.

The seven categories listed below are the accident types that are the cause of most accidents.



Runway Excursion (RE)

A lateral veer-off or longitudinal overrun off the runway surface, and not primarily due to SCF or ARC.



Undershoot/Overshoot (USOS)

Touchdown off the runway surface in close proximity to the runway. It includes offside touchdowns.



Loss of Control In-flight (LOC-I)

Loss of aircraft control while in flight, and not primarily due to SCF.



System/Component Failure or Malfunction (SCF)

Failure or malfunction of an aircraft system or component, related to its design, the manufacturing process, or a maintenance issue, and which leads to an accident. SCF includes those related to powerplant (SCF-PP) and those which are not powerplant-related (SCF-NP).



Controlled Flight Into Terrain (CFIT)

In-flight collision with terrain, water, or obstacle without indication of loss of control.



Abnormal Runway Contact (ARC)

Any takeoff or landing involving abnormal runway contact, and not primarily due to SCF, leading to an accident. Hard landings and tail strikes are included in this category.



FIRE (F-NI and F-POST)

Fire or smoke inside or outside of the aircraft, in flight or on the ground, and regardless of whether the fire results from an impact (F-POST) or not (F-NI).



01

2021 & Beyond

Traffic and Accidents in 2021

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Traffic and Accidents in 2021

The number of flights globally increased by 4 million in 2021 compared with 2020, but this is 40% below the number of flights recorded in the years prior to the pandemic.

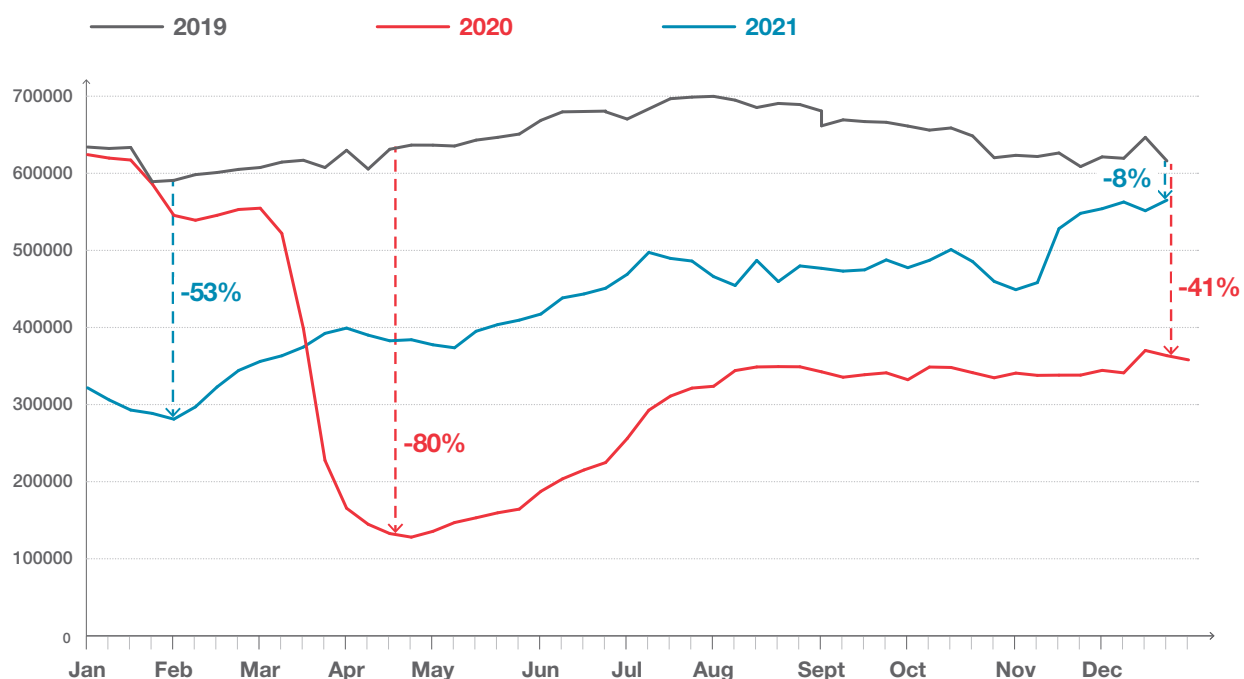
The industry as a whole was tested throughout 2021, but there are some positive signs of recovery even though the Covid-19 crisis continues. Despite staggered periods of recovery and relapse experienced in different regions, the number of flights globally increased by 4 million in 2021 compared with 2020. However, this is 40% below the number of flights recorded in the years prior to the pandemic.

An industry-wide focus on addressing risks related to periods of inactivity versus rapid return to service showed how safety vigilance is necessary to avoid a crisis on top of a crisis for aviation.

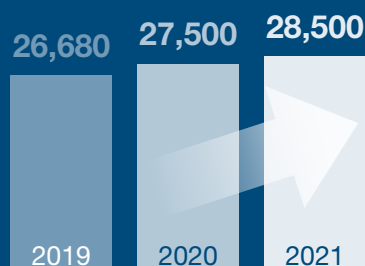
There was 1 fatal with hull loss and 4 hull loss accidents recorded in 2021, which was less than the 3 fatal with hull loss and 3 hull loss accidents the previous year. 2021 was a year with one of the lowest number of accidents and fatalities. However, due to the reduced number of flights over the last 2 years, these numbers alone do not provide an accurate indication of the overall safety performance or trends.

This statistical analysis of commercial aviation accidents uses accident rates calculated as a 10 year moving average to provide a more consistent comparison across industry growth and cycles.

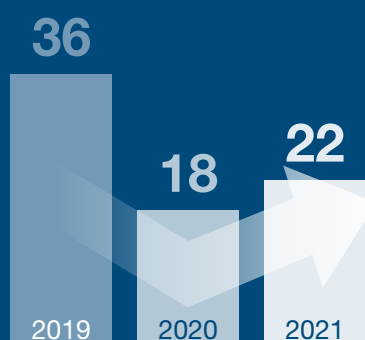
World traffic in flight cycles per week



Fleet & Traffic Evolution

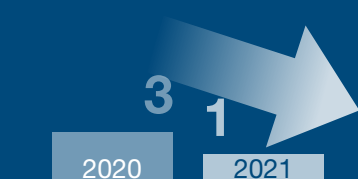


In-Service Fleet Aircraft
(including stored aircraft)



Flight Departures
(in millions)

Fatal Accidents



Fatal Accidents



Yearly Fatal Accident Rate
(per million flights)

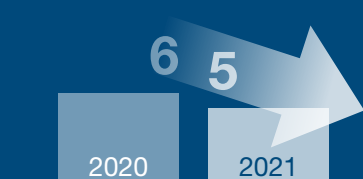


Gen3 Fatal Accident Rate
10yr Moving Average
(per million flights)

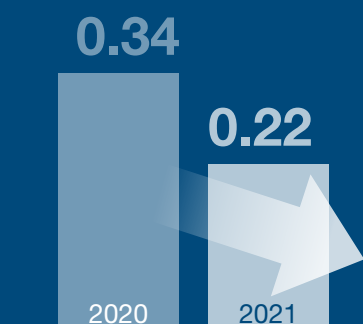


Gen4 Fatal Accident Rate
10yr Moving Average
(per million flights)

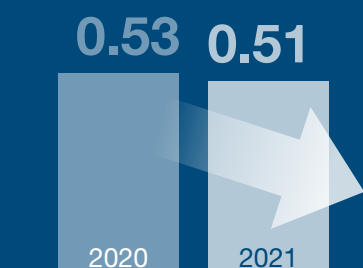
Hull Loss Accidents



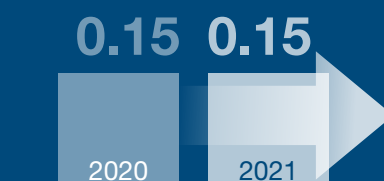
Hull Loss Accidents



Yearly Hull Loss Accident Rate
(per million flights)



Gen3 Hull Loss Accident Rate
10yr Moving Average
(per million flights)



Gen4 Hull Loss Accident Rate
10yr Moving Average
(per million flights)



Outlook for 2022 and Beyond

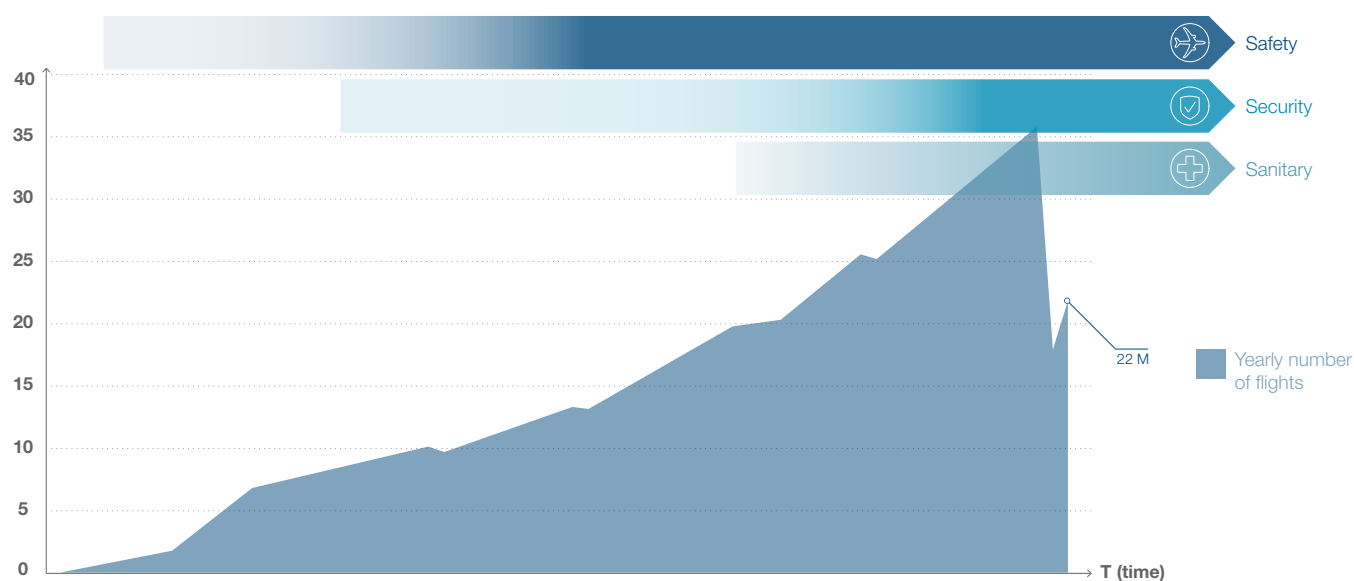
There are major lessons learned for the industry, including the values of strong safety governance to adapt to the rapid changes brought about by the global crisis, and how to manage the risks.

The aviation industry showed resilience in 2021 with its sustained response to the crisis caused by the pandemic. The considerable and multiple consequences of the Covid-19 crisis have put the sanitary threats to commercial aviation in the spotlight, which must now be considered in addition to managing any safety and security risks.

This has focused the industry on all aspects of the end-to-end travel experience and adopting the sanitary measures necessary to make the entire journey safe and healthy.

There are major lessons learned for the industry, including the values of strong safety governance to adapt to the rapid changes brought about by the global crisis, and how to manage the risks. The overall success of this approach is seen in the safe return to service throughout 2021 by managing all threats in all domains of the air transport system such as maintenance engineering, flight operations, and training.

Ensuring that safety, security, and sanitary threats can be managed consistently will increase the resilience of the entire air transport system to face any future crisis or challenge across the air transport system.





02

Commercial Aviation Accidents 1958-2021

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Evolution of the Number of Flights and Accidents

The number of accidents today is significantly lower than a comparable year more than 15 years ago.

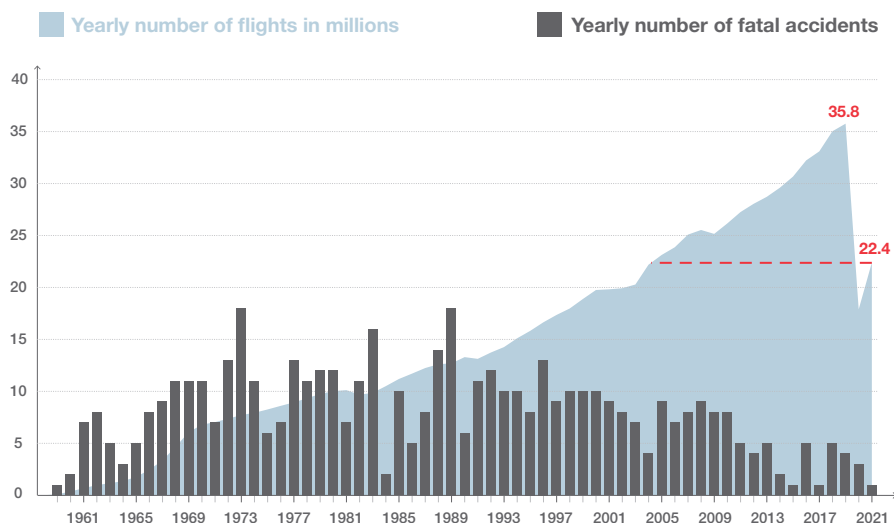
The number of flights on commercial jet aircraft was continuously growing prior to the effects of the pandemic. In spite of this growth, the number of accidents was decreasing each decade.

The number of flights in 2021 was still 40% lower than the flights operated in 2019. There were 5 commercial jet hull loss accidents recorded and 1 of these had fatalities.

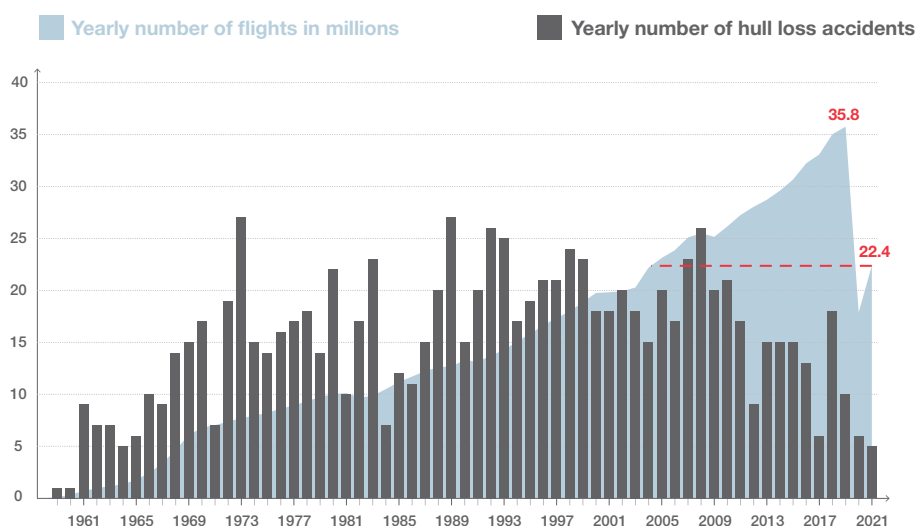
This is a slight improvement when compared with the previous years, which indicates the industry resilience to maintain a level of safety despite the challenges of the ongoing Covid-19 crisis. However, with the number of flights still lower than pre-pandemic levels, it is not possible to say if it shows sustained improvement of the overall safety performance.

As the number of accidents and flights will vary each year, accident rates are more relevant than reviewing the number of accidents per year when analyzing trends.

Fatal



Hull loss



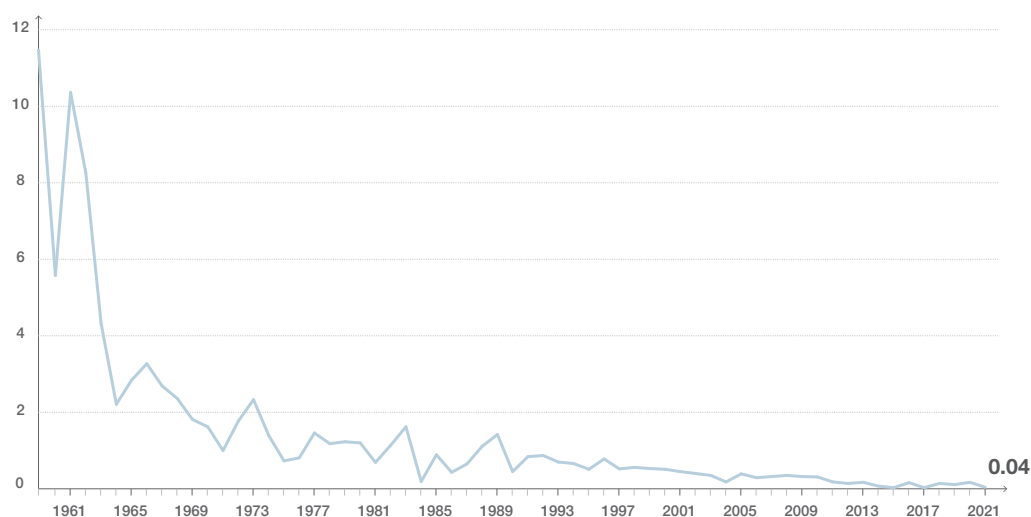
Evolution of the Yearly Accident Rate

The rate of fatal accidents and hull losses is steadily decreasing over time.

There were far fewer flights in the 1960s, but a peak in the accident rates is shown due to the lower number of flights and the higher number of accidents recorded during this period. However, the volume of flights over recent decades is sufficient to show that the accident rate is continually decreasing.

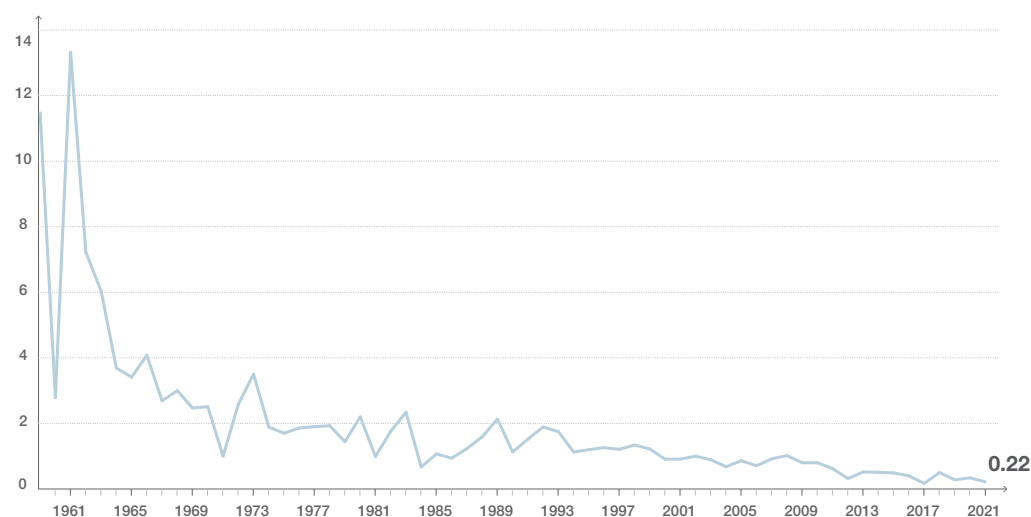
Fatal

Yearly fatal accident rate per million flights



Hull loss

Yearly hull loss accident rate per million flights



Four Generations of Commercial



Caravelle

Early Commercial Jets

From 1952

Dials and gauges in cockpit, early autoflight systems

Comet, Caravelle, BAC-111, Trident, VC-10, B707, B720, DC-8, Convair 880/990

1st Generation



A300-600

Glass Cockpit, FMS & TAWS

From 1980

Electronic displays, Flight Management System (FMS), and Terrain Awareness and Warning System (TAWS) reduced CFIT accidents
A300-600, A310, Avro RJ, F70, F100, B717, B737 Classic, B737 NG, B737 MAX, B757, B767, B747-400/-8, Bombardier CRJ,
Embraer ERJ, MD-11, MD-80, MD-90

3rd Generation

Jet Aircraft



A300

More Integrated Autoflight

From 1964

More elaborate autopilot and autothrottle systems

Concorde, A300, Mercure, F28, BAe146, VFW 614, B727, B737-100/-200, B747-100/-200/-300/SP, L-1011, DC-9, DC-10

2nd Generation



A320

Fly-By-Wire

From 1988

Flight envelope protection enabled by fly-by-wire technology reduced LOC-I accidents

A220, A318/A319/A320/A321, A330, A340, A350, A380, B777, B787, Embraer E-Jets, Sukhoi Superjet

4th Generation

Evolution of Commercial Jet Aircraft

Airbus aircraft flew 75% of the flights made by fourth-generation commercial jet aircraft in 2021.

There were around 22 million flight departures in 2021, but this remains 40% lower than the almost 36 million flights in 2019 before the pandemic. 12 million flights were made by fourth-generation jets, 9 million of which were Airbus aircraft.

The largest percentage of flights in recent years were made using the latest fourth-generation commercial jets, which have the lowest accident rate. As the percentage of these flights increases over the next decade, this should help to sustain further decreases in the overall accident rate for commercial air transport. The continual reduction in accident rates shown on the previous pages has been achieved by an ongoing commitment of the commercial aviation industry to enable a safe aircraft to be safely operated in a safe air transport system.

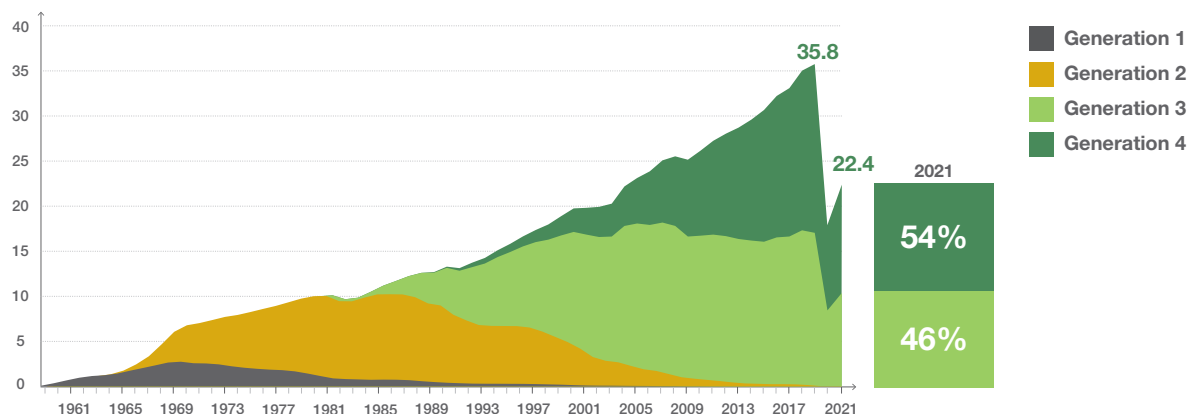
A notable part of this success is due to effective regulation, a strong safety culture, and improvements in training. Technological advances are also a crucial enabler for enhancing the level of safety. In particular, technologies introduced in aircraft systems intentionally evolved with improving safety as their aim.

The first generation of commercial jet aircraft were designed in the 1950s and '60s with system technologies, which were limited in their capabilities by the analog electronics of that era. A second generation of aircraft quickly appeared with improved autoflight systems.

The third generation of aircraft was introduced in the early 1980s. This generation took advantage of digital technologies to introduce glass cockpits with flight management systems and navigation displays, which significantly improved navigation capabilities and position awareness. Combined with the Terrain Awareness and Warning System (TAWS), these evolutions were key to reducing Controlled Flight Into Terrain (CFIT) accidents.

The fourth and latest generation of commercial jet aircraft first entered into service in 1988 with the Airbus A320. Fourth-generation aircraft use fly-by-wire technology with flight envelope protection functions. These functions protect against Loss Of Control In-flight (LOC-I) accidents. Fly-by-wire technology is now the industry standard and it is used on every currently produced Airbus model, Boeing B777 and B787, Embraer E-Jets, and the Sukhoi Superjet.

Yearly number of flights per aircraft generation (in millions)



Evolution of Accident Rates by Aircraft Generation

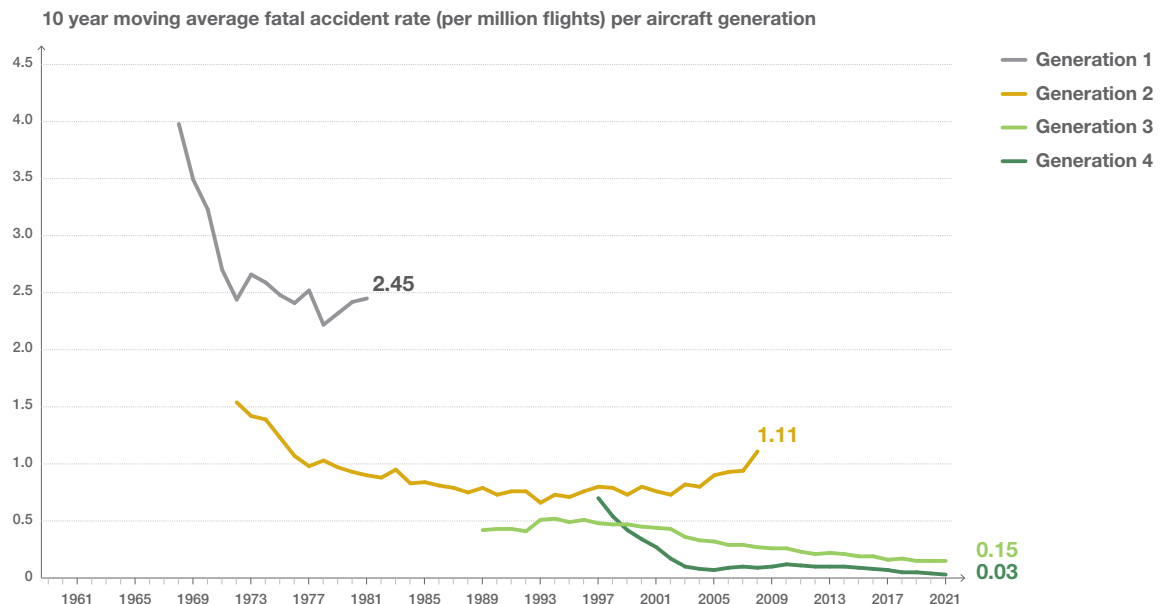
Advances in technology have helped to reduce accident rates for each generation.

Calculating the 10 year moving average accident rate provides a clearer picture of an overall trend. The data shows when an aircraft generation has recorded more than 1 million flights in a year and begins from the tenth year after the entry into service of each generation.

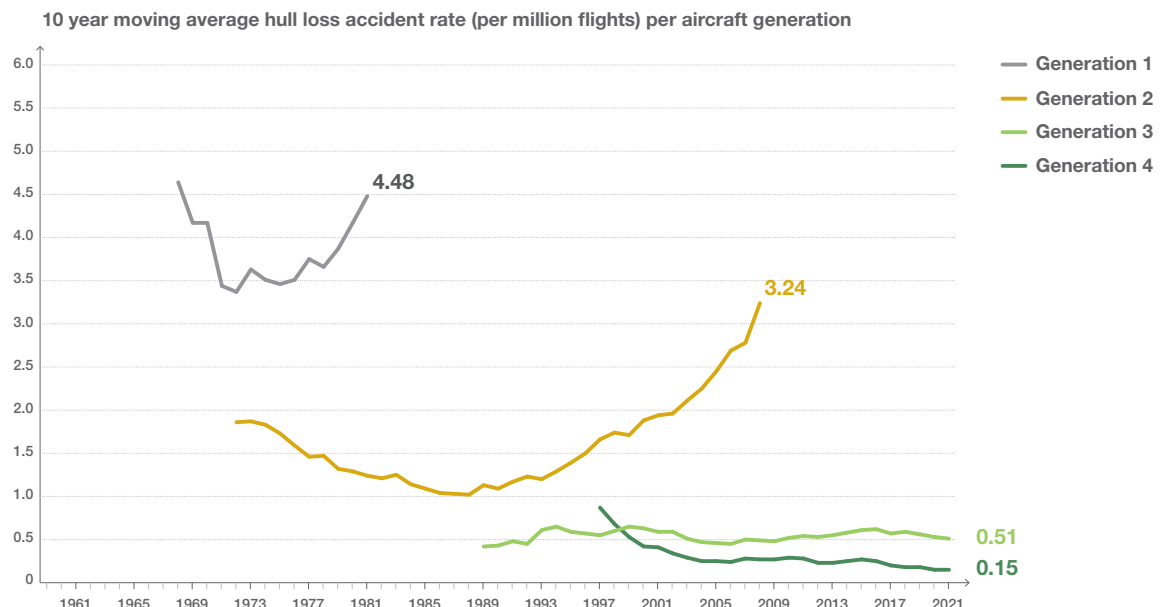
For example, the 10 year moving average accident rates for the fourth-generation commercial jet aircraft are shown from 1997, which was the tenth year in service for the A320 aircraft.

The 10 year moving average accident rates for today's fourth-generation aircraft are more than three times lower than the rates recorded for the third-generation aircraft.

Fatal



Hull loss

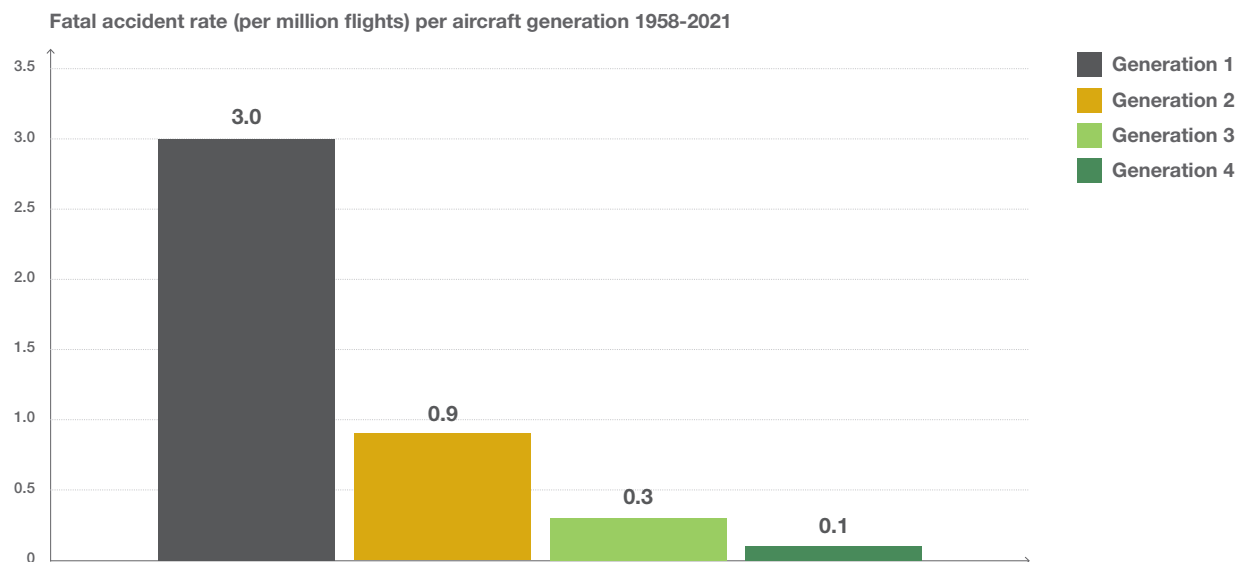


How Technology Helped Reduce Accidents

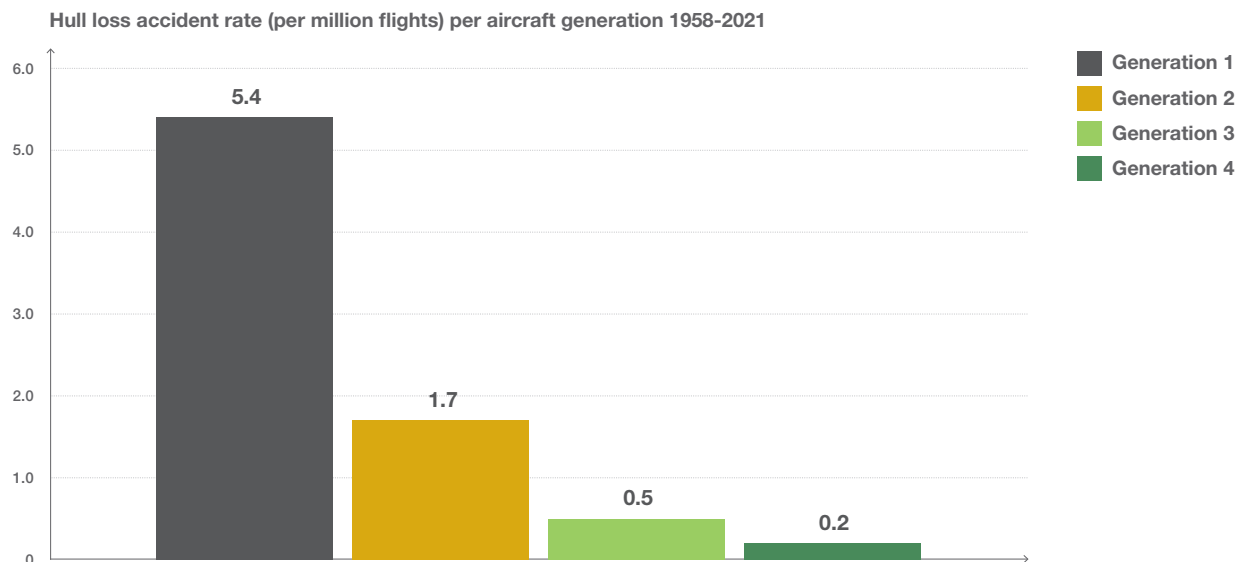
Statistics over the life of each aircraft generation show a significant improvement in the level of safety, notably since the introduction of third-generation aircraft, and further enhanced by the latest fourth-generation aircraft.

Comparison of accident rates by generation of aircraft provides a clear illustration of the value of commercial aviation industry investments in technology to improve safety.

Fatal



Hull loss



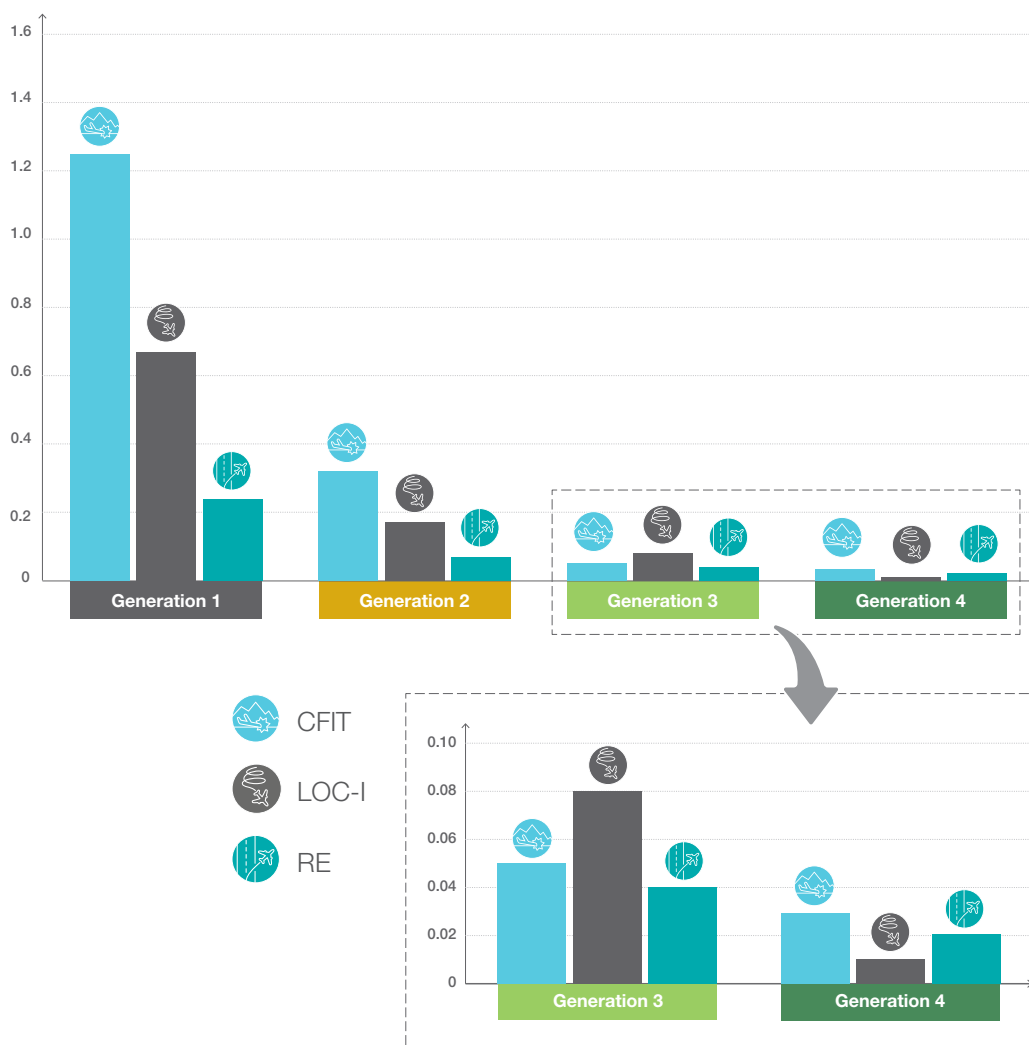
How Technology Addressed the Major Causes of Accidents

Accident rates were further reduced with the introduction of new technologies on each generation of aircraft.

The introduction of Flight Management System (FMS), improved navigation displays, and the Terrain Awareness and Warning System (TAWS) with the third-generation aircraft significantly reduced the number of CFIT fatal accidents when compared to the previous first and second-generation aircraft.

The benefits of fly-by-wire technologies and energy management systems, which were first introduced on the fourth-generation aircraft, show a lower rate of LOC-I and RE accidents when compared with the previous third-generation aircraft. More detailed analysis about the influence of these technologies on reducing the accident rate is introduced in section 3.

Average fatal accident rate (per million flights) per accident category 1958-2021



-86%

CFIT accident rate from second to third generation



-89%

LOC-I accident rate from third to fourth generation



03

Commercial Aviation Accidents Over the Last 20 Years

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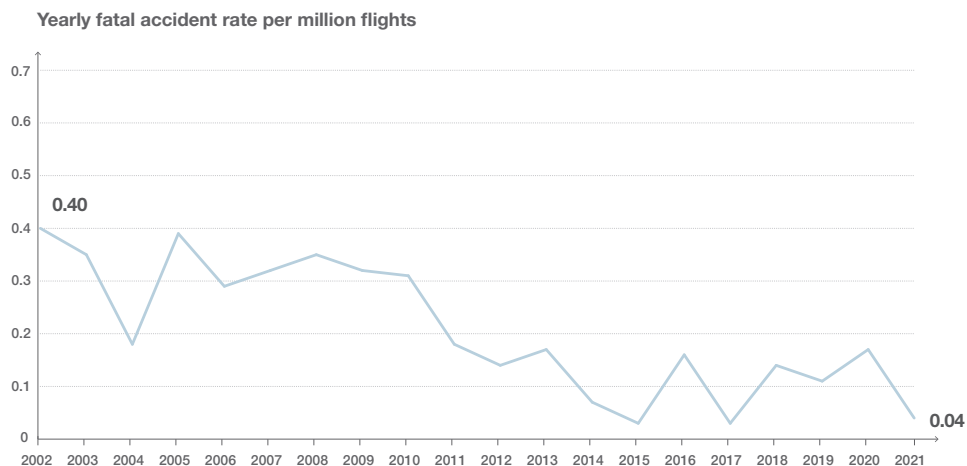
Evolution of the Yearly Accident Rate

A significant reduction in fatal and hull loss accidents was achieved across the commercial aviation industry since 2002.

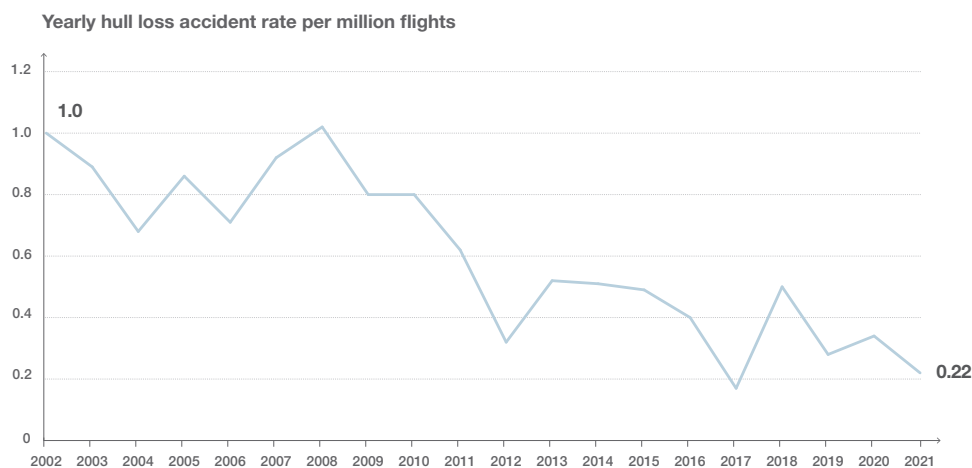
2021 recorded the lowest number of accidents since 2017, but there was still a significantly lower number of flights due to the global Covid-19 crisis. It shows that the accident rate for a single year is not indicative of the overall safety trend.

Despite the reduction of the yearly accident rate since 2001, the rates recorded over recent years have remained above the lowest rate ever recorded in 2017. It is a call to action for all actors in the commercial air transport system to be safety vigilant and to strive to reach zero accidents, especially in an anticipated period of rapid recovery to pre-pandemic levels of operation.

Fatal



Hull loss



Evolution of Accident Rates by Aircraft Generation

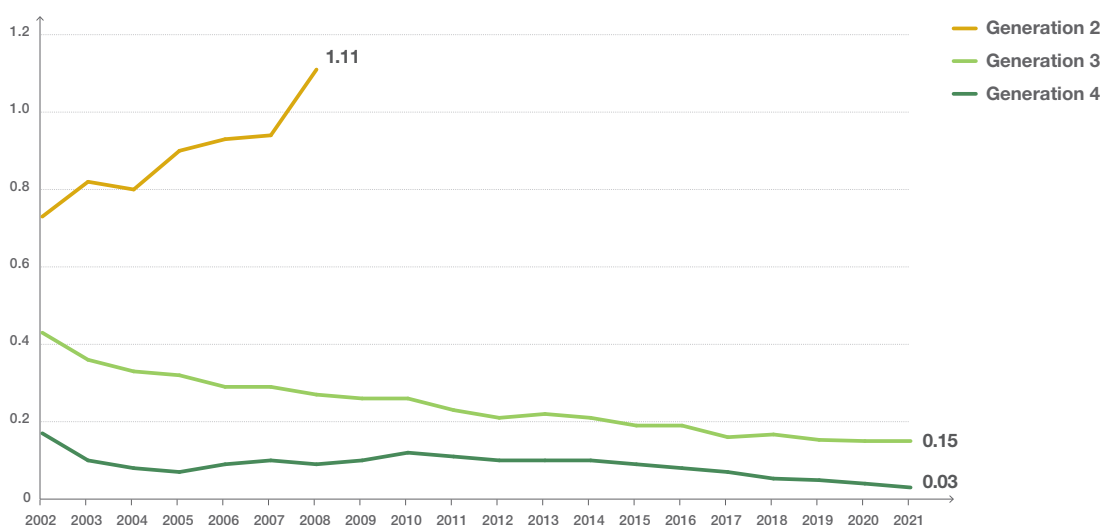
Fourth-generation aircraft accident rates are more than 3 times lower than the third-generation rates.

Third-generation aircraft reduced accident rates by introducing glass cockpits with navigation displays and flight management systems. Fourth-generation aircraft further reduced accident rates by introducing fly-by-wire technology, which made flight envelope protection possible. The accident rates for the third and fourth generation continued to decrease in 2021. This is indicative of the overall safety trend observed over recent decades.

Fourth-generation commercial jet aircraft flew 54% of flights in 2021. As this percentage increases over the next decade, the overall accident rate for commercial air transport should further decrease due to the noticeably lower rate of this generation when compared to the previous third-generation aircraft.

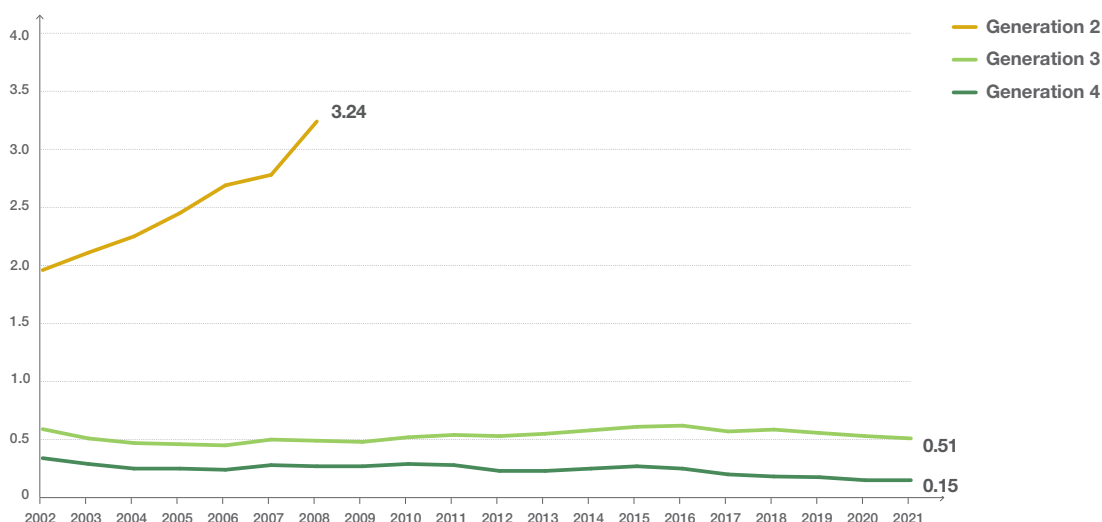
Fatal

10 year moving average fatal accident rate (per million flights) per aircraft generation



Hull loss

10 year moving average hull loss accident rate (per million flights) per aircraft generation



Accidents by Flight Phase

Definitions of Flight Phases

The flight phases described below are based on standard ICAO definitions:

- **Standing:** The phase of flight prior to pushback or taxi, or after arrival, at the gate, ramp, or parking area, while the aircraft is stationary.
- **Taxi:** The aircraft is moving under its own power prior to takeoff or after landing. This phase includes the taxi to runway, the taxi to takeoff position and the taxi from runway until the aircraft stops moving under its own power.
- **Takeoff:** From the application of takeoff power, through rotation and to an altitude of 35 feet above runway elevation or until gear-up selection, whichever comes first. This phase includes rejected takeoff.
- **Initial climb:** From the end of the takeoff phase to the first prescribed power reduction, or until reaching 1000 feet above runway elevation, whichever comes first.
- **Enroute:** From completion of initial climb through cruise altitude and completion of controlled descent to the Initial Approach Fix (IAF).
- **Approach:** From the IAF to the point of transition from nose-low to nose-high attitude immediately prior to the flare above the runway.
- **Landing:** The phase of flight from the point of transition from nose-low to nose-up attitude, immediately before landing (flare), through touchdown and until the aircraft exits the landing runway or when power is applied for takeoff in the case of a touch-and-go landing, whichever occurs first.

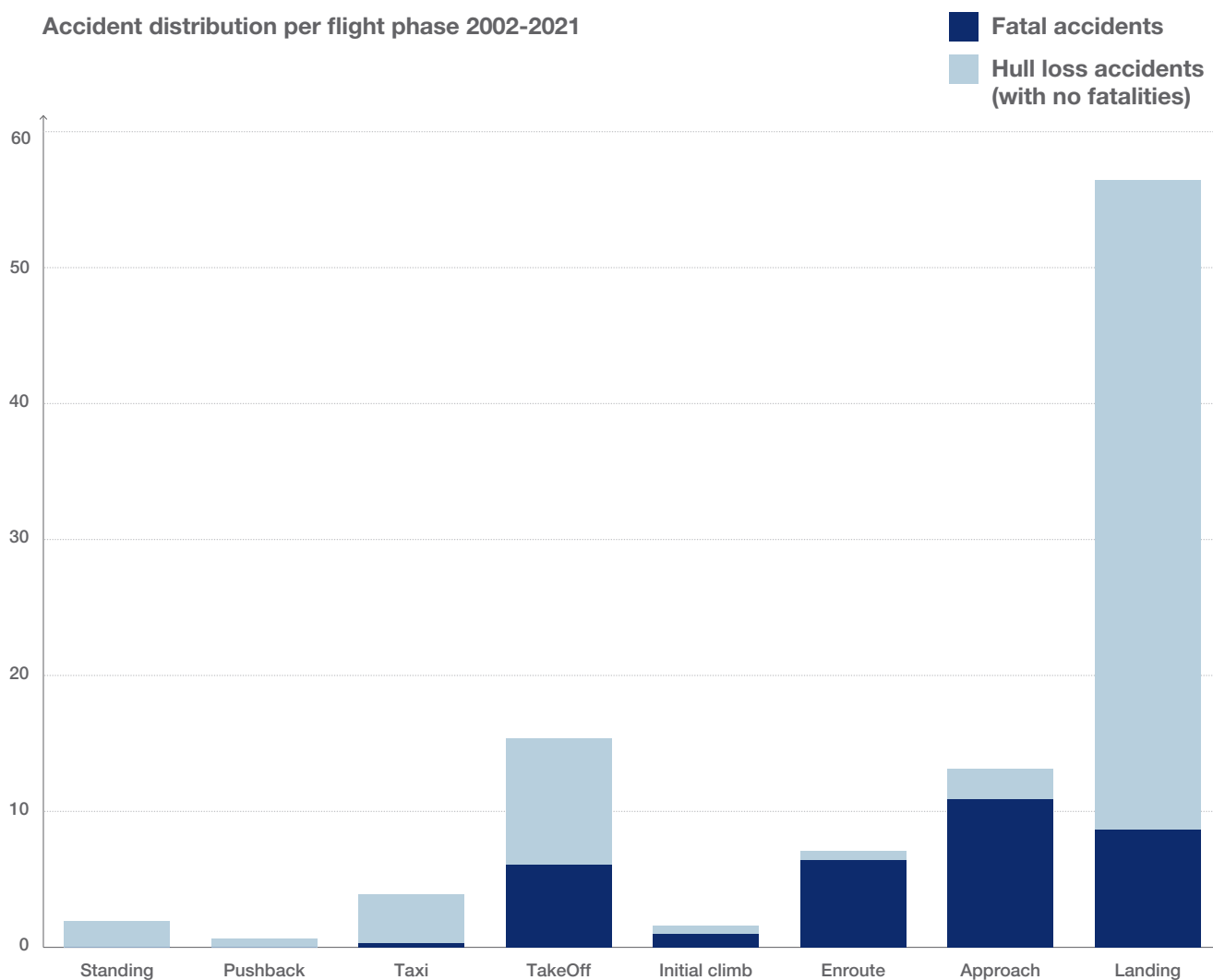
Most of the accidents over the last 20 years occurred during approach and landing phases.

Approach and landing are highly complex flight phases, which place significant demands on the crew in terms of navigation, aircraft configuration changes, communication with Air Traffic Control, congested airspace, and degraded weather conditions.

This combination of high workload and the increased potential for unanticipated events can create a complex interplay of contributing factors, which may lead to an accident.

Of the 5 hull loss accidents recorded in 2021, 3 occurred in the approach and landing phases. One hull loss was due to a component failure on taxi and the fatal hull loss accident was classified as an enroute LOC-I.

Accident distribution per flight phase 2002-2021



Accidents by Accident Category

The leading cause of fatal accidents over the last 20 years was LOC-I.

LOC-I accidents have significantly reduced for fourth-generation aircraft enabled by fly-by-wire technologies.

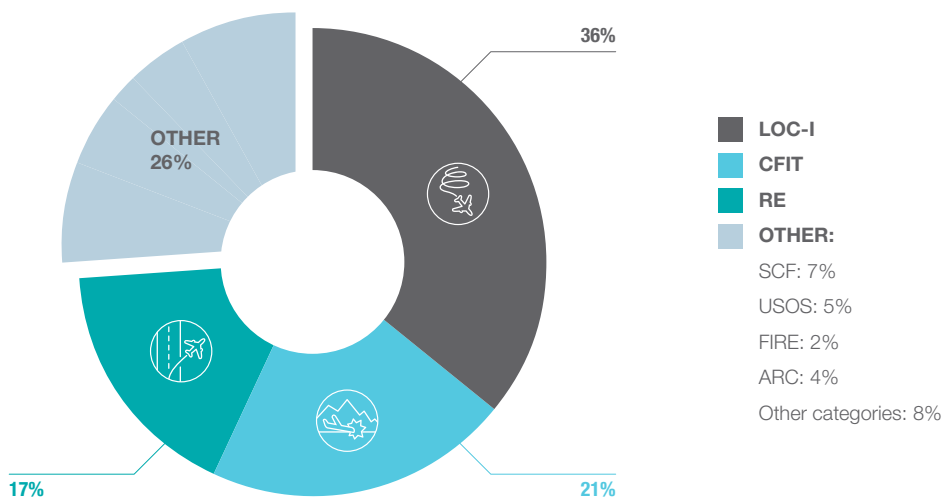
CFIT accidents are the second largest category of accidents. The number of these accidents is decreasing with the continued development of navigation and Terrain Awareness and Warning System (TAWS) technologies, which are available on both third and fourth-generation aircraft.

Runway Excursions (RE), including lateral and longitudinal types, are the third major cause of fatal accidents and the primary cause of hull losses.

Emerging technologies, both energy-based and performance-based, show promising trends for preventing longitudinal RE accidents.

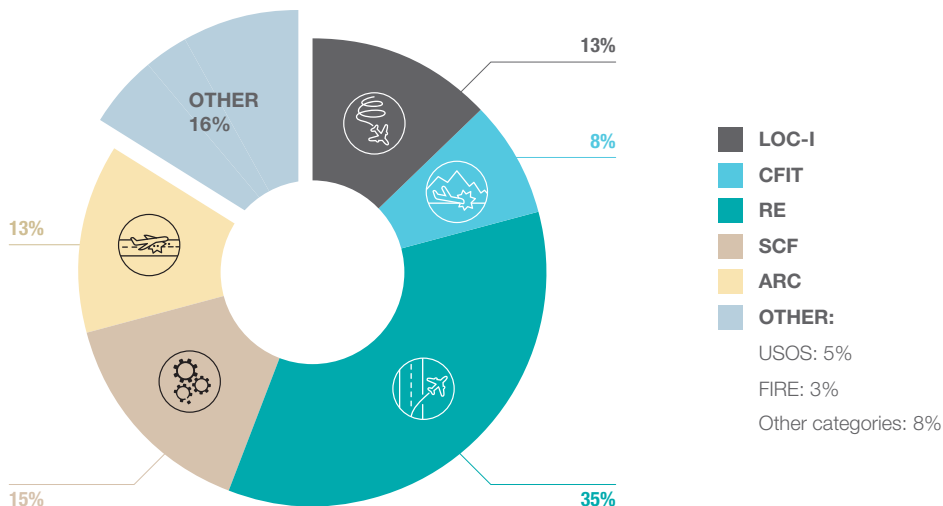
Fatal

Fatal accident distribution per accident category 2002-2021



Hull loss

Hull loss accident distribution per accident category 2002-2021



Evolution of the Main Accident Categories

Over the last 20 years, the fatal accident rate for CFIT accidents reduced by 89%, and LOC-I by 65%.

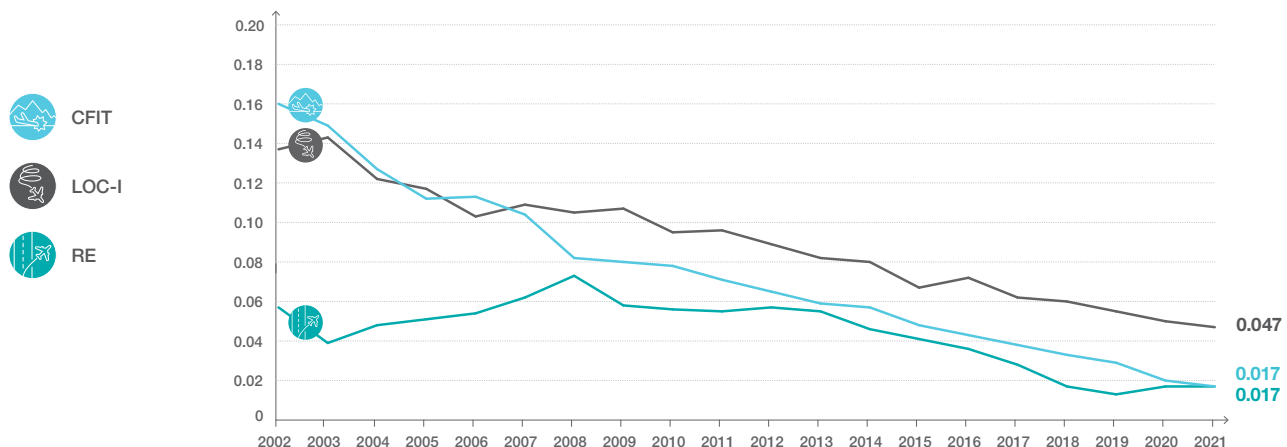
The proportion of flights flown by aircraft equipped with Flight Management System (FMS) and Terrain Awareness and Warning System (TAWS) technologies, which help to prevent CFIT accidents, has grown from 68% to 99% over the last 20 years.

More than half of all flights in 2021 were made using fourth-generation commercial jet aircraft equipped with fly-by-wire enabled technologies. The rate of LOC-I accidents is 89% lower for fourth-generation aircraft when compared with third-generation aircraft. As the proportion of flights made using fourth-generation aircraft continues to grow, the rate of LOC-I accidents is expected to decrease further.

New technologies to address the causes of RE accidents were first deployed over 10 years ago. The number of aircraft equipped with RE prevention technologies today represents approximately 9% of the in-service fleet. There is an overall decreasing trend for hull losses due to RE accidents. Aircraft fitted with RE prevention technologies have not recorded any RE related fatal or hull loss accidents over the last decade.

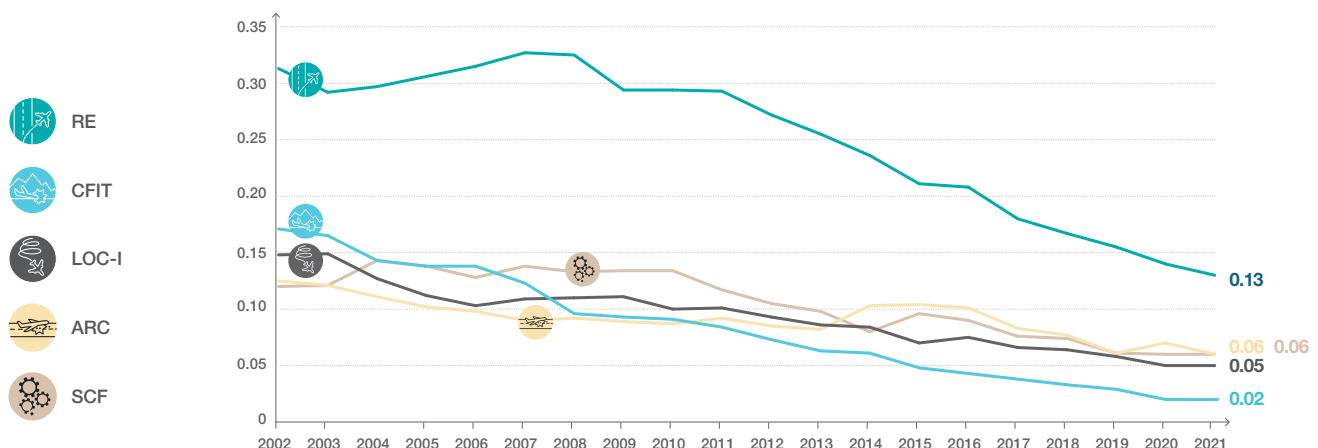
Fatal

10 year moving average fatal accident rate (per million flights) per accident category



Hull loss

10 year moving average hull loss accident rate (per million flights) per accident category



Controlled Flight Into Terrain (CFIT) Accident Rates

The introduction of glass cockpits, FMS and TAWS has helped to reduce the CFIT fatal accident rate by 86%.

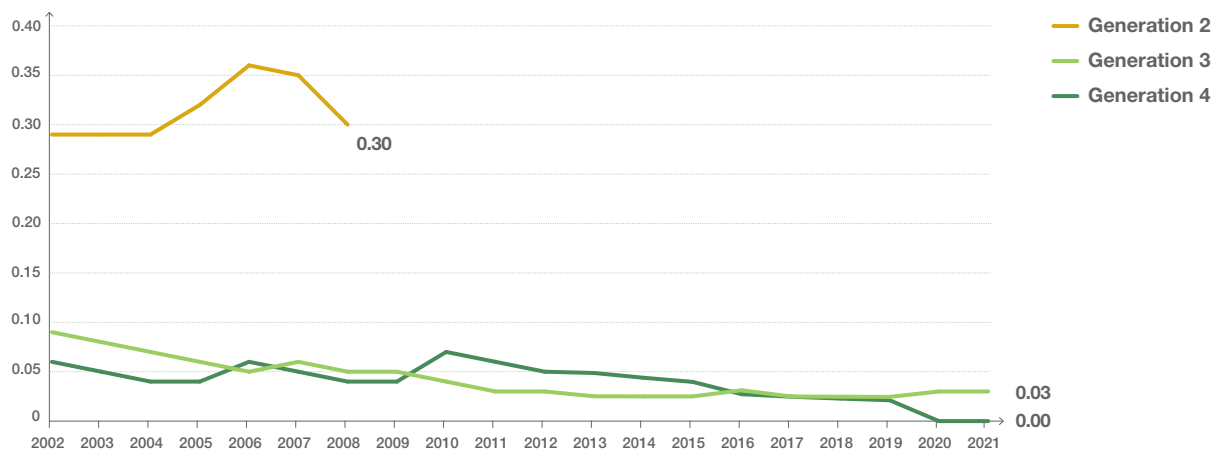
Technologies to reduce CFIT were introduced progressively with Terrain Awareness and Warning System (TAWS).

Glass cockpits installed on the third generation of aircraft improved navigation performance due to the introduction of a Flight Management System (FMS) and navigation displays that helped to further reduce the CFIT accident rates.

There were no fatal or hull loss CFIT accidents recorded for fourth-generation aircraft in the last decade. Therefore, the 10-year moving average rate is zero for this generation in 2021.

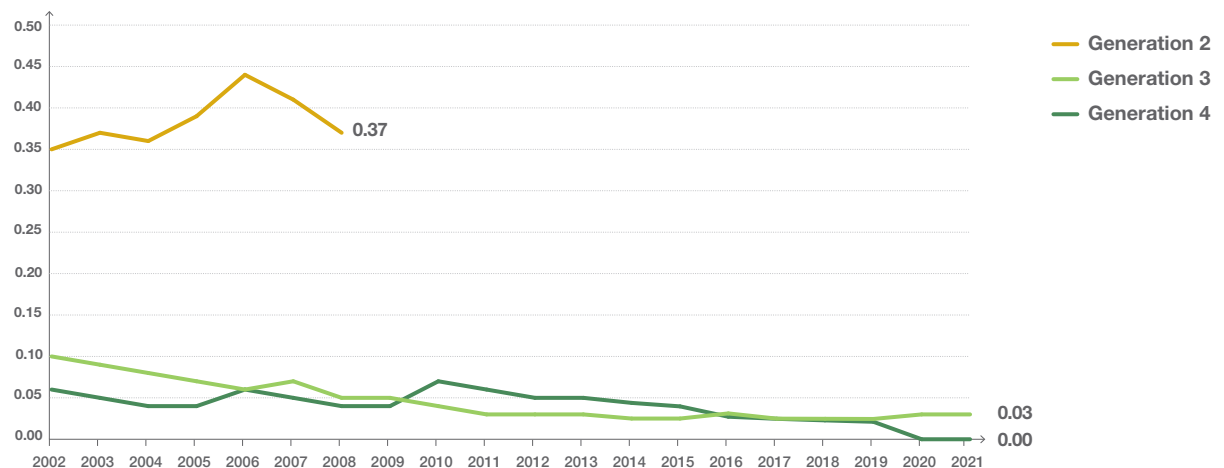
Fatal

10 year moving average CFIT fatal accident rate (per million flights) per aircraft generation



Hull loss

10 year moving average CFIT hull loss accident rate (per million flights) per aircraft generation



Loss Of Control In-flight (LOC-I) Accident Rates

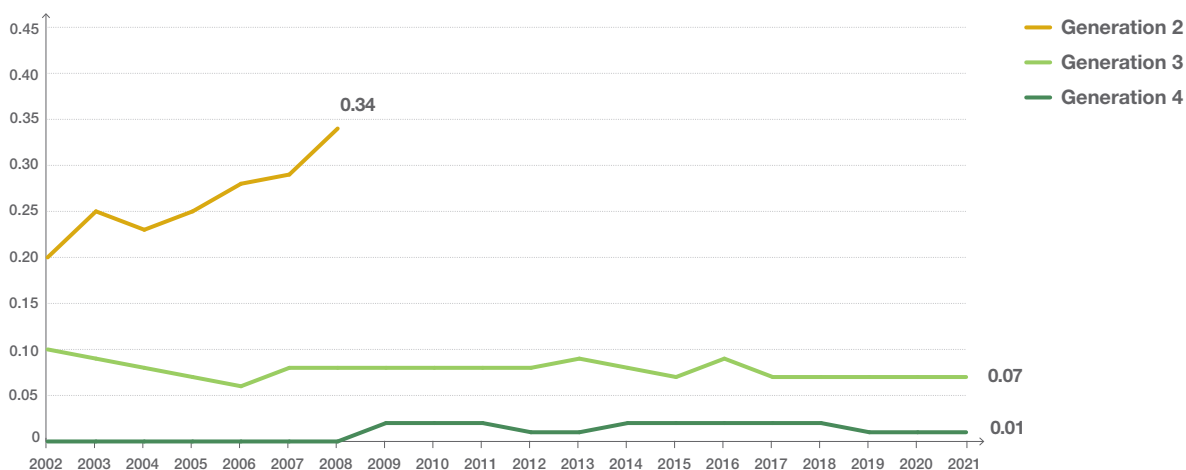
Flight envelope protection has helped reduce LOC-I fatal accident rates by 89%.

The fourth-generation aircraft have accumulated over 30 years of in-service experience since the A320 aircraft first entered into service in 1988.

This represents more than 223 million accumulated flights by the end of 2021, which is a strong statistical basis illustrating the significant safety benefit of fly-by-wire enabled and flight-envelope-protected aircraft to address LOC-I accidents.

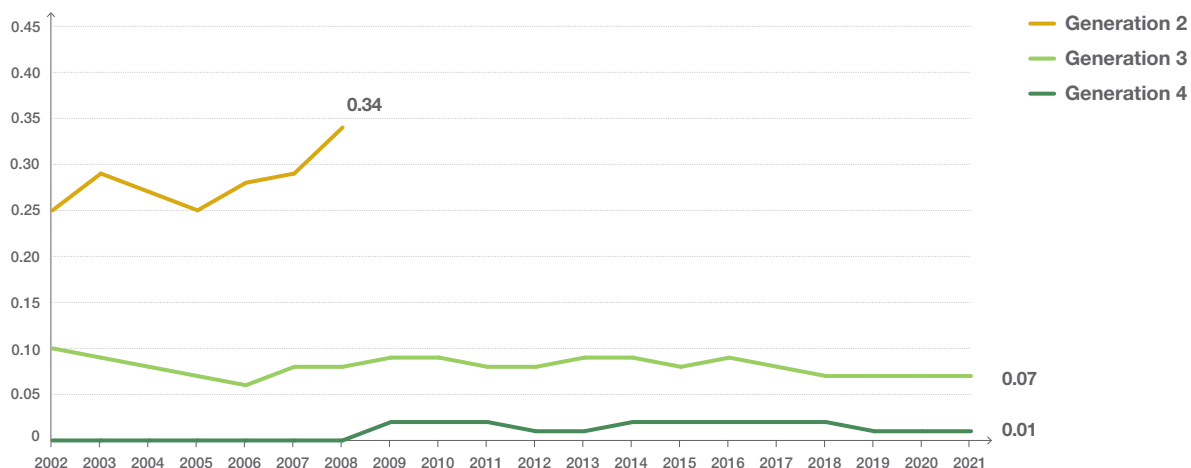
Fatal

10 year moving average LOC-I fatal accident rate (per million flights) per aircraft generation



Hull loss

10 year moving average LOC-I hull loss accident rate (per million flights) per aircraft generation



Runway Excursion (RE) Accident Rates

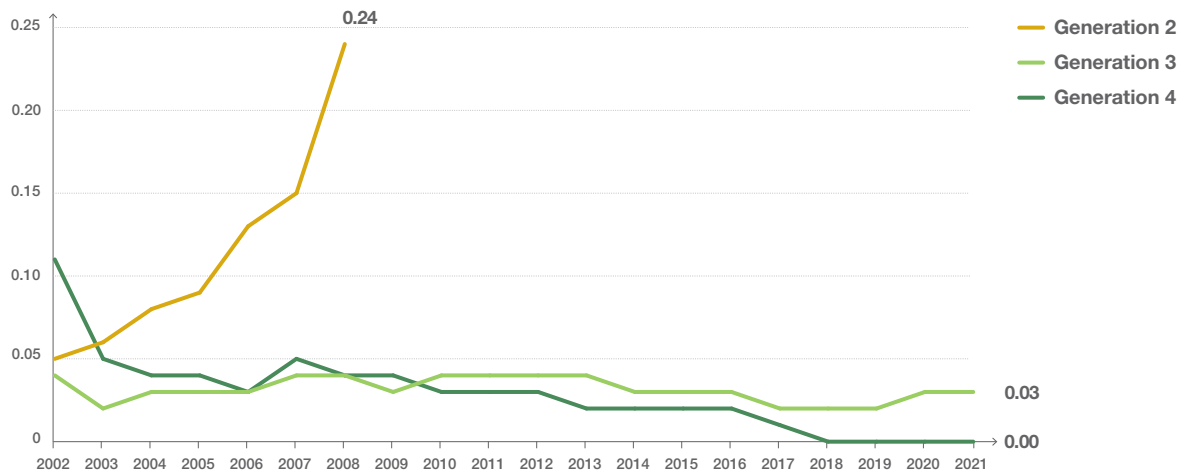
Technologies to reduce RE accidents have been available for over 10 years.

Most longitudinal RE accidents are related to aircraft energy management. An improvement of RE accident rates should be expected with the introduction of real-time energy and landing performance-based warning systems, such as the Runway Overrun Protection System (ROPS) available for Airbus aircraft.

In 2021, the number of aircraft equipped with ROPS has increased to 9% of the worldwide fleet.

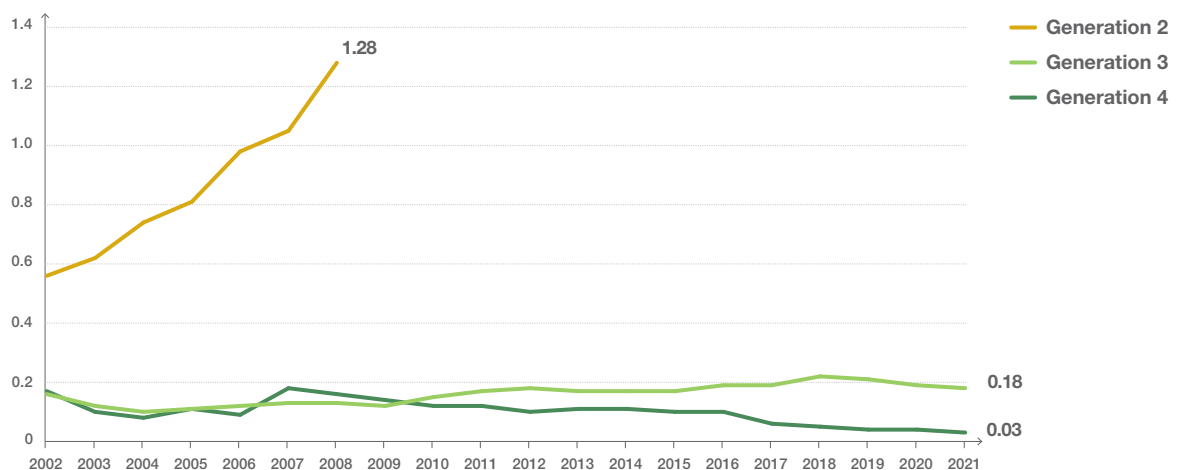
Fatal

10 year moving average RE fatal accident rate (per million flights) per aircraft generation



Hull loss

10 year moving average RE hull loss accident rate (per million flights) per aircraft generation





AIRBUS

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