

A black and white photograph of an Airbus aircraft's nose and landing gear inside a hangar. The aircraft is positioned diagonally, with its nose pointing towards the upper left. The landing gear is visible at the bottom, and the hangar's interior structure and floor are visible in the background.

Airbus

A Statistical Analysis of Commercial Aviation Accidents 1958-2015

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Since the advent of the jet age

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Scope of the Brochure

- **All western-built commercial air transport jets above 40 passengers.**
The following aircraft are included in the statistics: 328 JET, A300, A300-600, A310, A318/319/320/321, A330, A340, A350, A380, Avro RJ series, B707, B717, B720, B727, B737, B747, B757, B767, B777, B787, BAC -111, BAE 146, Bombardier CRJ series, Caravelle, Comet, Concorde, Convair 880/990, DC-8,DC-9, DC-10, Embraer E series, Embraer ERJ series, F-28, F-70, F-100, L-1011, MD-11, MD-80/90, Mercure, Trident, VC-10, VFW 614.
Note: non-western-built jets are excluded due to lack of information and business jets are not considered due to their peculiar operating environment.
- **Since 1958**, the advent of commercial jets
- **Revenue flights**
- **Operational accidents**
- **Hull loss** and **fatal** types of accidents

Definitions

- **Revenue flight:** flight involving the transport of passengers, cargo or mail for remuneration or hire. Non revenue flight 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 such time as all such persons have disembarked, excluding sabotage, military actions, terrorism, suicide and the like.
- **Hull loss:** an event in which the aircraft is destroyed or substantially damaged beyond economical repair.
- **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, except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew.

Source of Data

- The accident data was extracted from official accident reports, as well as from the ICAO, Ascend and Airbus data bases.
- Flight operations data were extracted from the Ascend data base.

Publishing a yearly brochure on commercial aviation accident statistics is a challenge that deserves some explanation. Of course, the figures for the latest year are new. But it raises some fundamental questions:

- Can we draw any safety lesson or devise any safety strategy from the latest year’s figures?
- Is there any significant change to the rest of the statistics that is worth specific action?

In both cases, the answer is NO. Therefore, why do it? This question gives rise to a number of answers, not all very convincing or satisfactory: because others do it, because people love figures, because people expect it...

Keeping in mind that our ultimate goal is to enhance safety, it is worth rewording the question and wonder: in what respect can accident statistics help to enhance safety? What can they tell us about safety? What can they not tell us about safety?

Most of the time statistics prove to be rather counter intuitive, just as probabilities. It is often even worse when it comes to rare events which are governed by “the law of small numbers” Fortunately, this is the case of aviation accidents. They are very rare events.

Publishing a yearly accident statistics brochure is an opportunity to discuss what these figures tell us or not and why.

Enhancing safety beyond statistics

2015: the safest year ever by number of fatal accidents...

In 2015, 1 fatal accident can be counted when sabotage, military action, terrorism, suicide and the like are excluded. This is it: the aeronautic industry made it down to 1 fatal accident in a whole year, thus making 2015 the safest year ever by number of fatal accidents! We need to look all the way back to 1959 (or even 1958 when no fatal accident occurred at all) to see such a noticeable figure. While this achievement may give cause for satisfaction and self-congratulation, let us not forget what it truly means, and where it comes from. Let us not forget that this is not the end of the story...

From a purely statistical point of view, it is true that this is close to the best we can expect from the global aviation safety net. The rate of accidents for 2015 is at its lowest since at least 1973 and the trend is towards flights having fewer accidents. Overall, the global safety system is effective. But safety is a little bit more complex than reaching low scores in accident statistics.

In an era of superlatives and records - the lowest rate of fatal accidents ever in aviation history, the highest number of flight cycles, the highest number of aircraft in operation, to name but a few - it is important to keep the order of magnitude of these figures in mind when interpreting statistics. More than 31 million flight cycles were flown by commercial airplanes last year. It means that, although an event may have only a 1 in a million probability of happening, it can, statistically, occur several times a year. If we then consider that the number of aircraft in operation is growing, this means that even if the rate of accidents per flight drops slightly, the actual number of accidents will increase. This casts a rather gloomy shadow over the years to come.

... but an average year by number of hull losses

And indeed... In stark contrast with the declining trend in the number of fatal accidents, the number of hull losses tends to remain relatively stable, and it even increased in 2015 compared to 2014. Thinking beyond numbers, the border between a hull loss and a fatal accident may be relatively thin sometimes. So we're making good progress, but it is stressed stability and the global safety net might well become more porous in the future. We shall not forget that the concomitance of factors leading to a fatal accident bears a random dimension. In each hull loss case, these factors could well have arranged otherwise, and thus told us a different story.

But rather than being pessimistic, we need to look and think beyond numbers. Aircraft accident statistics can prove a valuable source of information that allows for the setting of priorities and the monitoring of progress. Interpreting yearly figures however can be misleading, and we must ensure we keep an eye on trends rather than yearly variations. These trends are indicative of the evolution of the air transport system safety over the years, and they help setting the right priorities and developing the right efforts in the years to come. The accident rate has been divided by around 8 for fatal accidents, and by around 3 for hull losses in the last 20 years. Traffic increased by more than 86% over the same period. This shows that improvements bear fruit and in the past years, the air transport system has evolved in the appropriate direction in its efforts to enhance safety.

Keeping an eye on emerging hazards and threats

Today, we can see the operational environment is expanding and evolving fast with new operators, new types of operations, new players and new threats. We need to - we must - keep pace with this evolving landscape, and certainly not become complacent: safety efforts are still needed.

Despite the tremendous records and comforting numbers recorded over recent years, and in 2015 more particularly, we, as an industry, must keep dedicating our creative intelligence to the safety of passengers who fly onboard our airplanes. We now need to maintain our efforts and adapt our response to the new hazards and threats that are arising; some of which will be driving our efforts. The following can be named:

- The fleets growth rate is tremendous and the number of new aircraft being delivered every year increases exponentially, thus resulting in a higher exposure. This ramp-up in production and deliveries will in turn drive a growing need in well-trained pilots and crews to fly and operate these aircraft.
- This implies urgent and new training needs and stakes to train all these new profiles according to their background and skills.

- The latter leads us to wonder: is the safety model developed by countries with a sound aeronautical background and history suited to all new countries where aviation now strives? How can, and do the lessons we derive from our analysis of available data apply to countries with a different culture, different professional profiles and backgrounds, different operational conditions (be they environmental or economical)?
- Finally, security concerns receive more and more attention and regularly make headlines in the news. Clearly the security threat is taking its toll on commercial operations. How will the air transport system cope with this worldwide concern and increase travel security?

Knowing how the industry performed in the previous year is always a question. But it should not be the sole driver, and we need also to focus on trends and signals from today's operations. We need to keep pace with expansion and traffic increase collectively. Together, we must perpetuate our commitment to safety and continue to share the same ambition across the industry to continue to improve.



#01

Year 2015

> Fatal accidents

1 which translates
into a rate of
0.03 accident
per million flights

> Hull losses

11 which translates
into a rate of
0.35 accident
per million flights

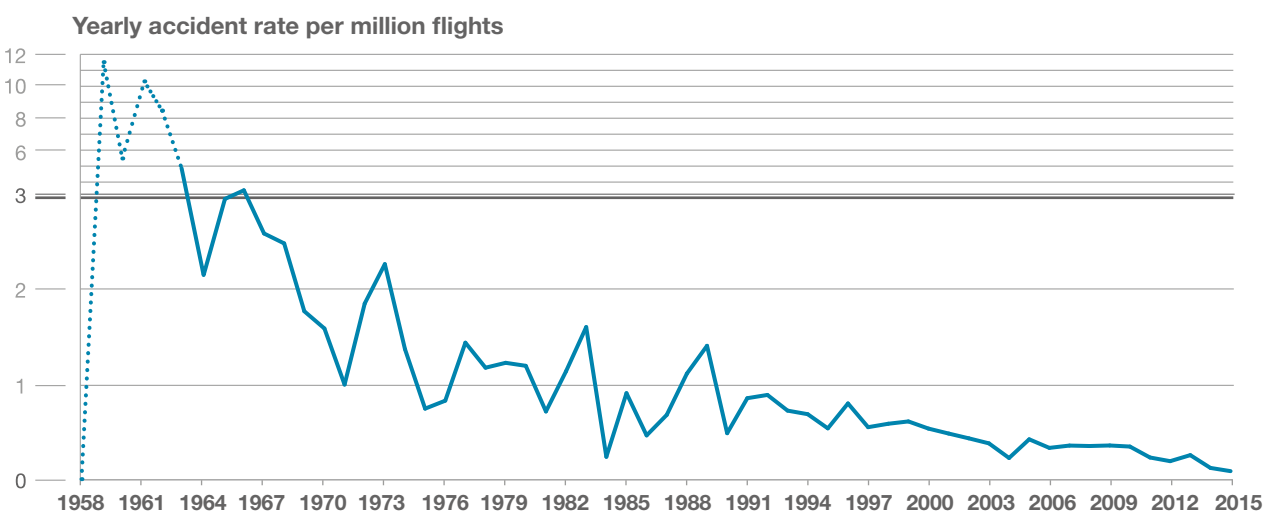
Commercial
air transport
accidents
for the year 2015

> Exposure
31 million
flights

#02

Since the advent of the jet age

Fatal



Behind the numbers

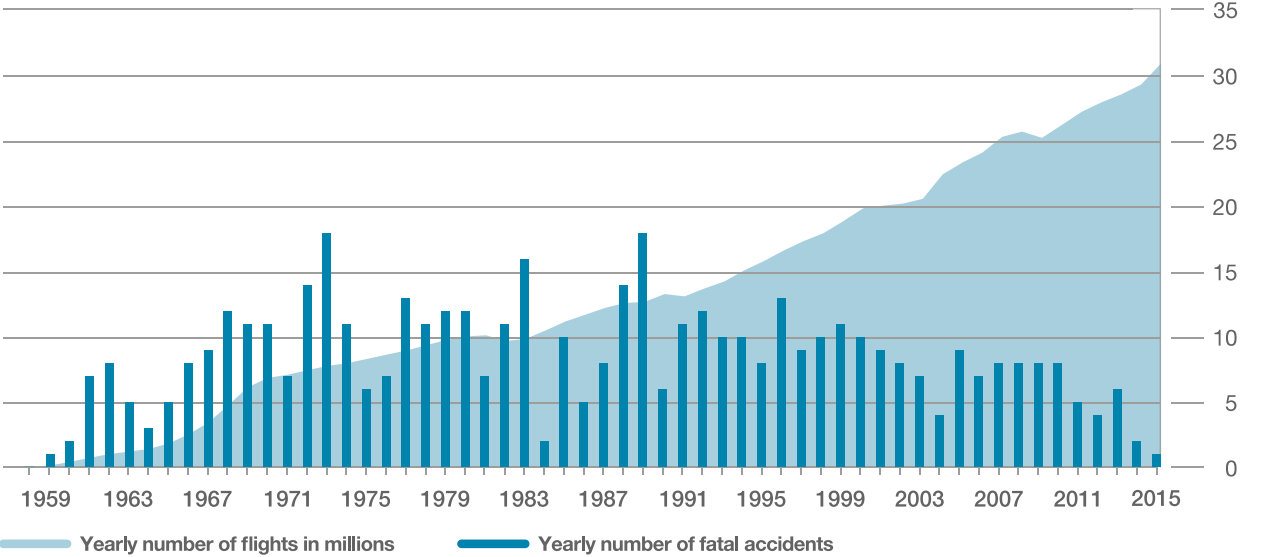
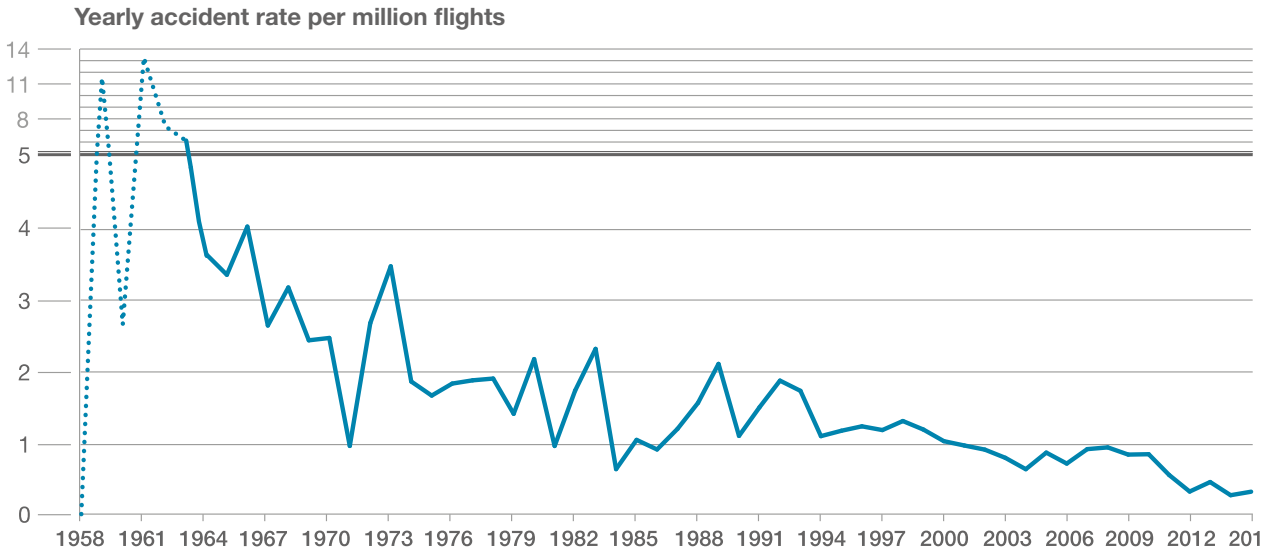
The peak values observed at the beginning of the curve illustrate the fact that accidents, being rare events, need to be considered in the light of a meaningful number of flights, reasonably at least a million flights per year.

Therefore this curve, and all those following in the brochure, will appear as dotted lines until a million flights a year are reached

Evolution of the yearly accident rate

“ A steady decrease over time ”

Hull loss



Fatal

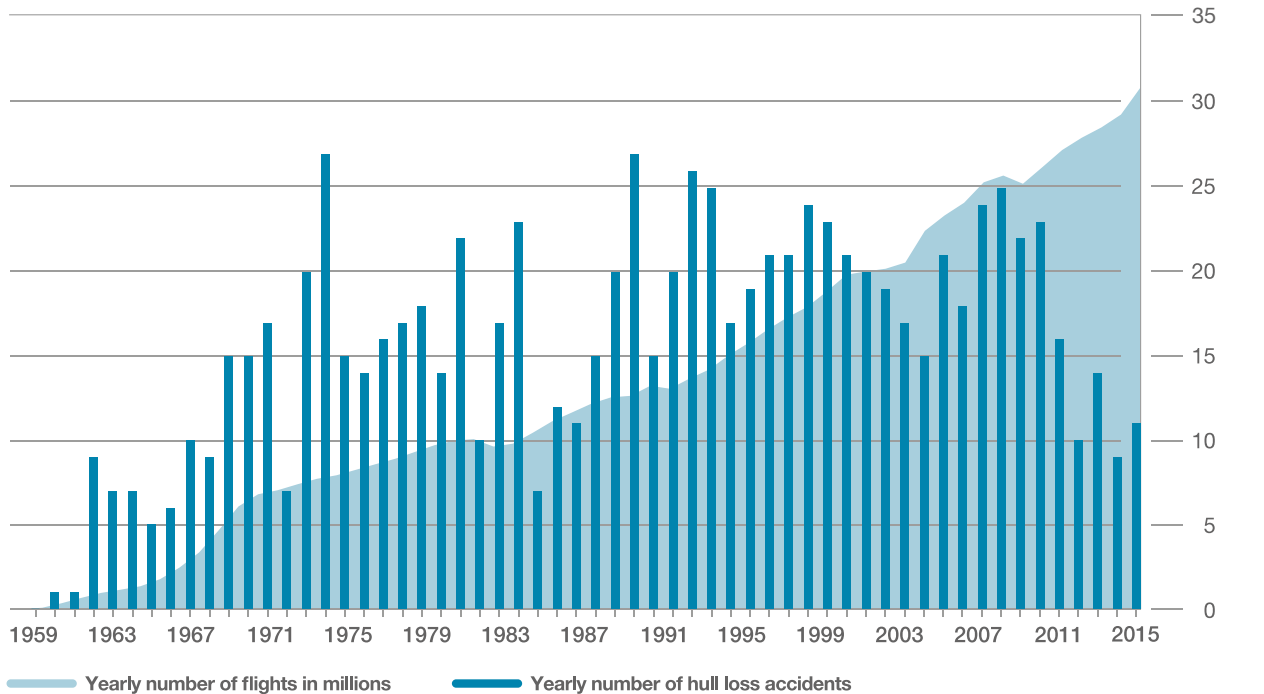
Evolution of the number of flights and accidents

“ A virtually stable absolute number of accidents despite a massive increase in exposure ”

Behind the numbers

Accidents are rare occurrences, consequently their number may vary considerably from one year to the next. Therefore, focusing too closely on a single year's figure may be misleading.

As a consequence, in the following charts, a 10 year moving average is used i.e. for any given year, the accident rate is the average of the yearly accident rates over the 10 preceding years.



Hull loss

Behind the numbers

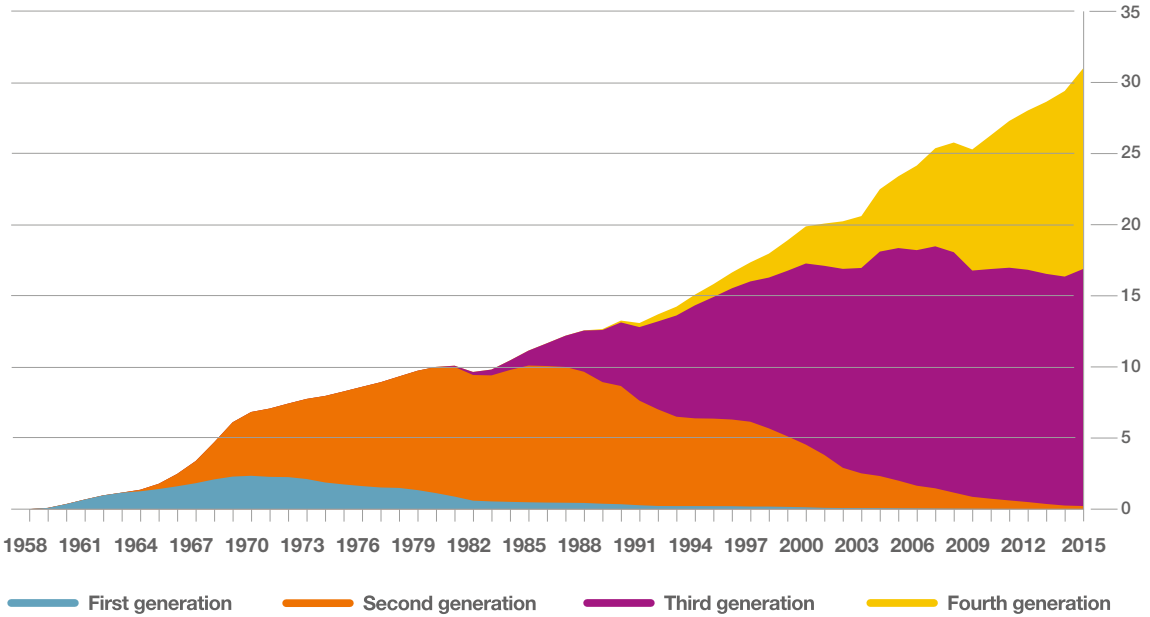
Beyond the size and nature of the fleet, a number of evolutions took place at the air transport system level impacting its safety, hence its accident rate.

Technology has evolved in different areas like aircraft, simulators, airports, air traffic control, weather forecasting etc. In parallel, qualitative progress has been achieved in the governance of airlines and authorities.

Evolution of the commercial air transport world fleet

“ Significant changes in both the number and the nature of aircraft ”

Yearly number of flights in millions



In 2015 Detail of Aircraft Generations

First Generation
Early commercial jets



671 flights
13 aircraft

Second Generation
More integrated Auto Flight System



269.722 flights
567 aircraft

Third Generation
Glass cockpit and FMS



16,6 million flights
12.782 aircraft

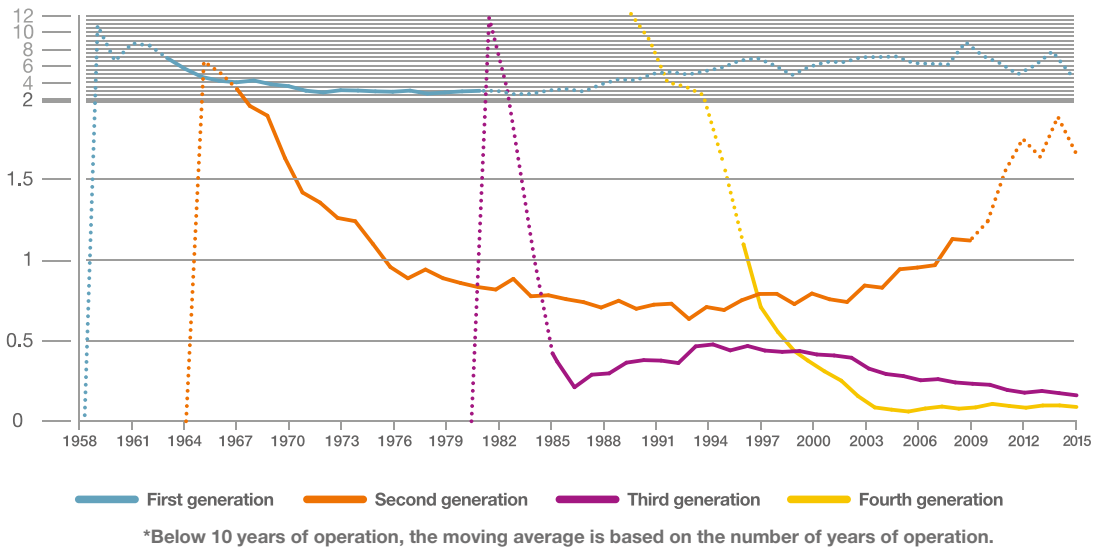
Fourth Generation
Fly-By-Wire with flight envelope protection



14,1 million flights
10.862 aircraft

- 1st year of entry into service:**
- 1952**
Caravelle, Comet, BAC 111, Trident, VC-10, B707, B720, Convair 880/990, DC-8
 - 1964**
Concorde, A300 (except A300-600), BAE 146, Mercure, B727, B737-100/200, B747-100/SP/200/300, F-28, L-1011, DC-9, DC-10, VFW 614
 - 1980**
A300-600, A310, Avro RJ series, B717, B737-300/400/500, B737 NG -600/700/800/900, B757, B767, B747-400, B747-8, Bombardier CRJ Series, Embraer ERJ Series, 328JET, F-70, F-100, MD-11, MD-80, MD-90
 - 1988**
A318/A319/A320/A321, A330, A340-200/300/500/600, A350, A380, B777-200/300, B787-8/9, Embraer E Series

10 year moving average accident rate per million flights*



Fatal

Evolution of the accident rates for each generation of aircraft

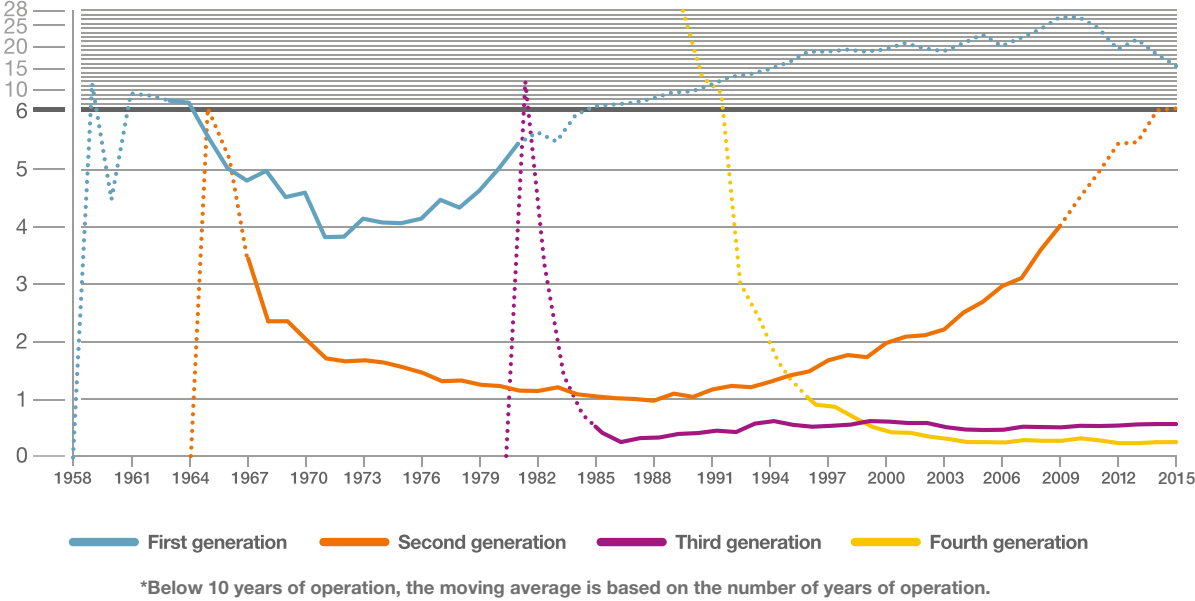
“ Advances in technology bring a decrease in accident rates ”

Behind the numbers

Commercial air transport evolves in a very dynamic environment. Today's operational conditions bear little resemblance to those at the beginning of the jet age. As a consequence, in the following charts, a 20 years frame is used.

This ensures a relatively homogeneous commercial air transport environment as well as a reasonably large statistical sample.

10 year moving average accident rate per million flights*



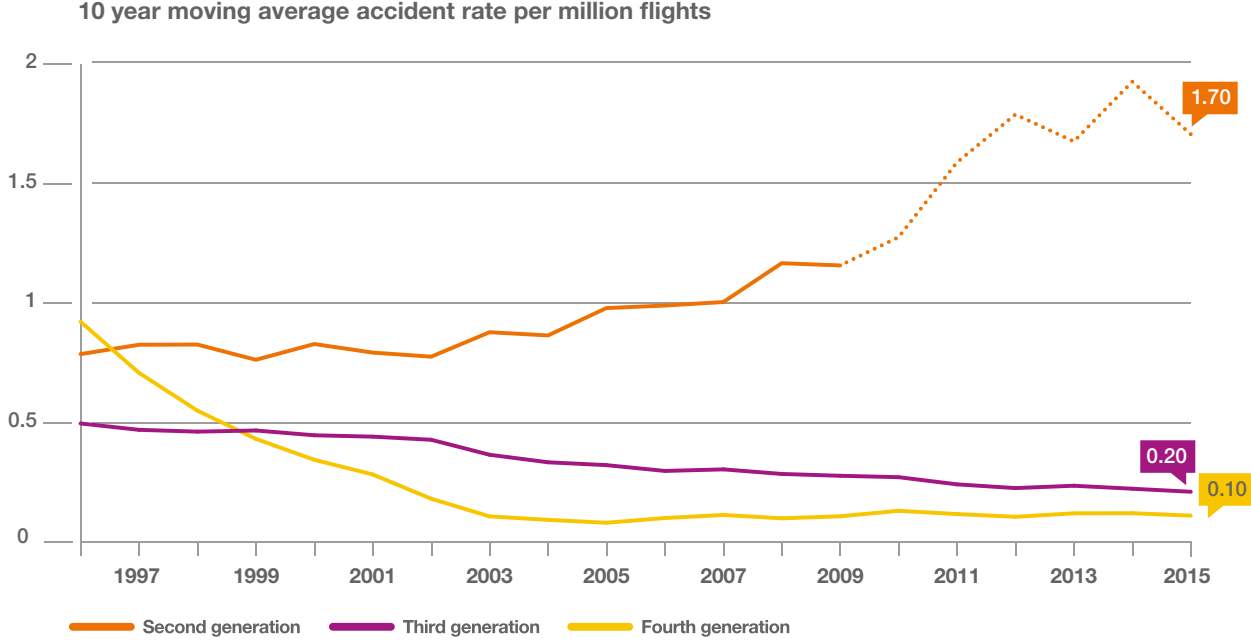
Hull loss



#03

Over the last 20 years

Fatal



Behind the numbers

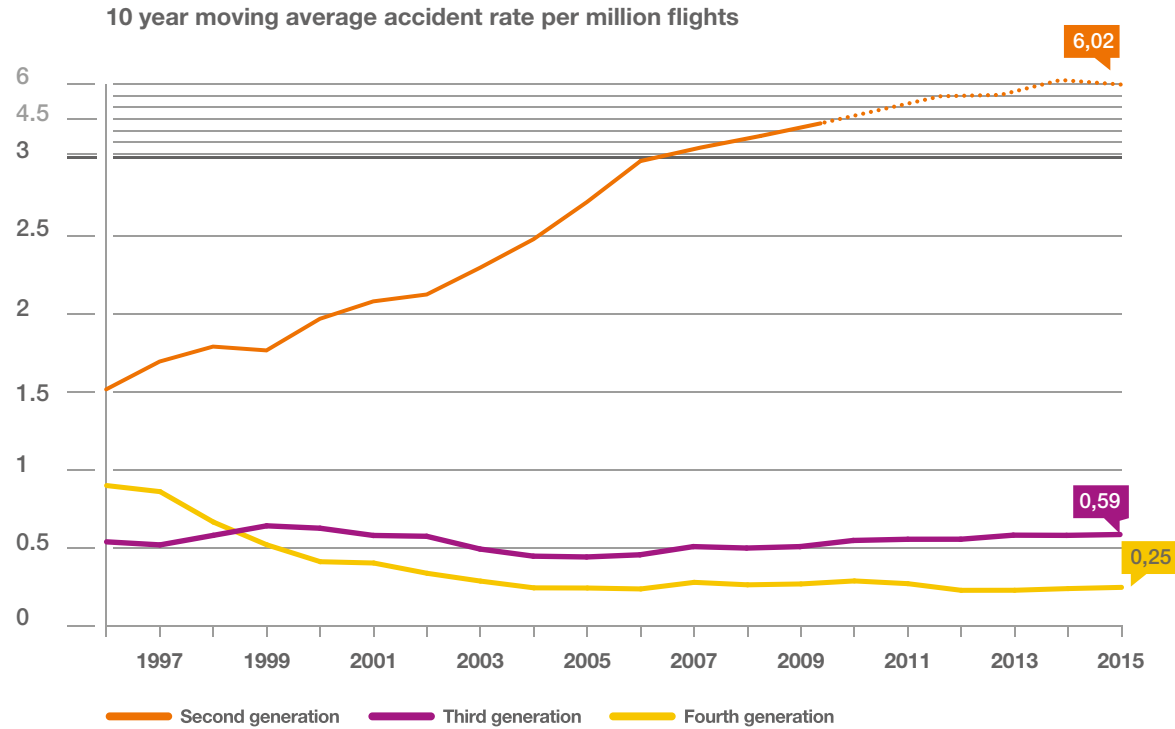
The fourth and latest generation of aircraft is characterized by Fly-By-Wire technology that allowed the introduction of flight envelope protection.

The previous generation was characterized by the introduction of Glass Cockpits that came with Navigation Displays and Flight Management Systems.

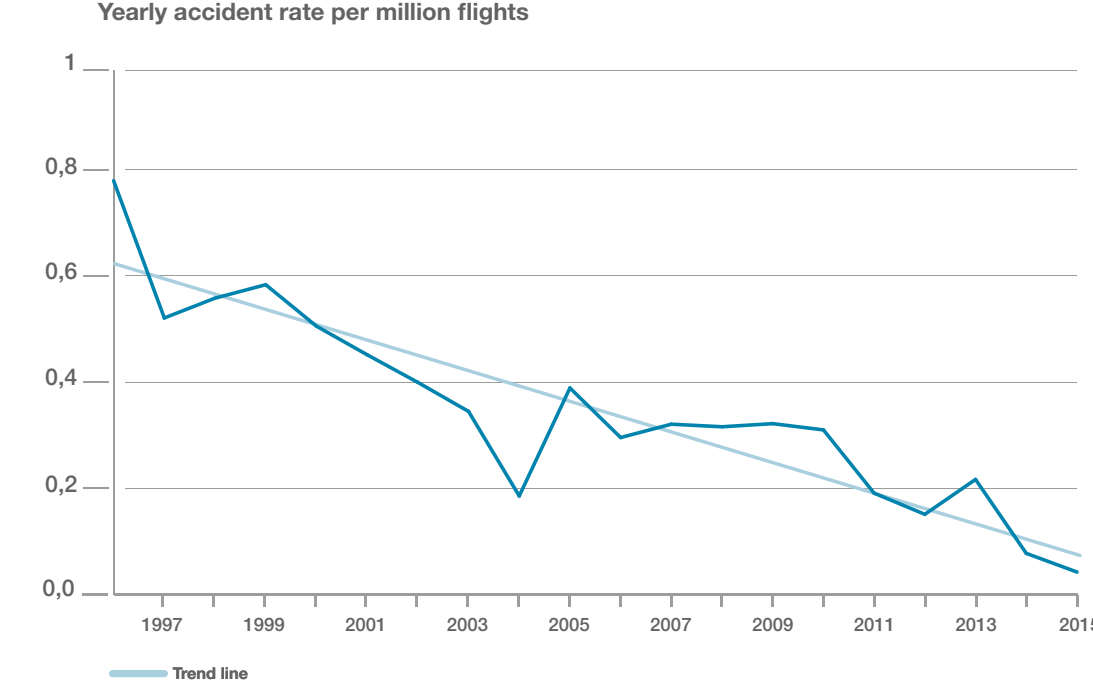
Evolution of the 10 year moving average accident rate for the last three aircraft generations

“ The introduction of the latest generation has allowed to halve the accident rate compared to the previous one ”

Hull loss



Fatal



Evolution of the yearly accident rate

“ The accident rate was divided by around 8 for fatal accidents, and by around 3 for hull losses ”

Behind the numbers

A hull loss is defined as an event in which an aircraft is destroyed or damaged beyond economical repair. The threshold of economical repair is decreasing with the residual value of the aircraft. Therefore, as an aircraft is ageing, an event leading to a damage economically repairable years before may be considered a hull loss.

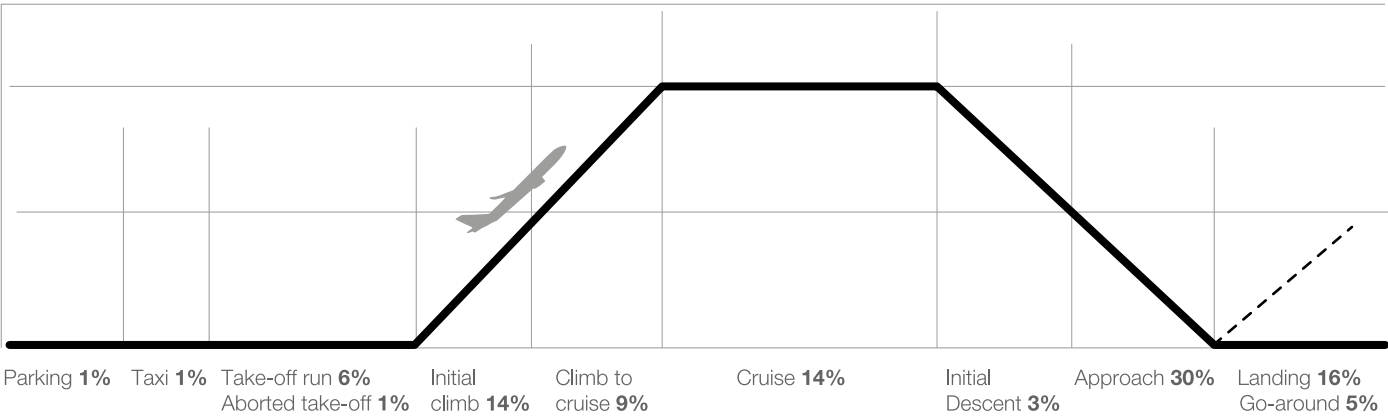
Hull loss



› Definitions of flight phases

- **Parking:** this phase ends and starts when the aircraft respectively begins or stops moving forward under its own power.
- **Taxi:** this phase includes both taxi-out and taxi-in. Taxi-out starts when the aircraft begins moving forward under its own power and ends when it reaches the takeoff position. Taxi-in normally starts after the landing roll-out, when the aircraft taxis to the parking area. It may, in some cases, follow a taxi-out.
- **Takeoff run:** this phase begins when the crew increases thrust for the purpose of lift-off. It ends when an initial climb is established or the crew aborts its takeoff.
- **Aborted takeoff:** this phase starts when the crew reduces thrust during the takeoff run to stop the aircraft. It ends when the aircraft is stopped or when it is taxied off the runway.
- **Initial climb:** this phase begins at 35 feet above the runway elevation. It normally ends with the climb to cruise. It may, in some instances, be followed by an approach.
- **Climb to cruise:** this phase begins when the crew establishes the aircraft at a defined speed and configuration enabling the aircraft to increase altitude for the cruise. It normally ends when the aircraft reaches cruise altitude. It may, in some cases end with the initiation of a descent.
- **Cruise:** this phase begins when the aircraft reaches the initial cruise altitude. It ends when the crew initiates a descent for the purpose of landing.
- **Initial descent:** this phase starts when the crew leaves the cruise altitude in order to land. It normally ends when the crew initiates changes in the aircraft’s configuration and/or speed in view of the landing. It may, in some cases end with a cruise or climb to cruise phase.
- **Approach:** this phase starts when the crew initiates changes in the aircraft’s configuration and/or speed in view of the landing. It normally ends when the aircraft is in the landing configuration and the crew is dedicated to land on a particular runway. It may, in some cases, end with the initiation of an initial climb or go-around phase.
- **Go-around:** this phase begins when the crew aborts the descent to the planned landing runway during the approach phase. It ends with the initiation of an initial climb or when speed and configuration are established at a defined altitude.
- **Landing:** this phase begins when the aircraft is in the landing configuration and the crew is dedicated to land on a particular runway. It ends when the aircraft’s speed is decreased to taxi speed.

Fatal



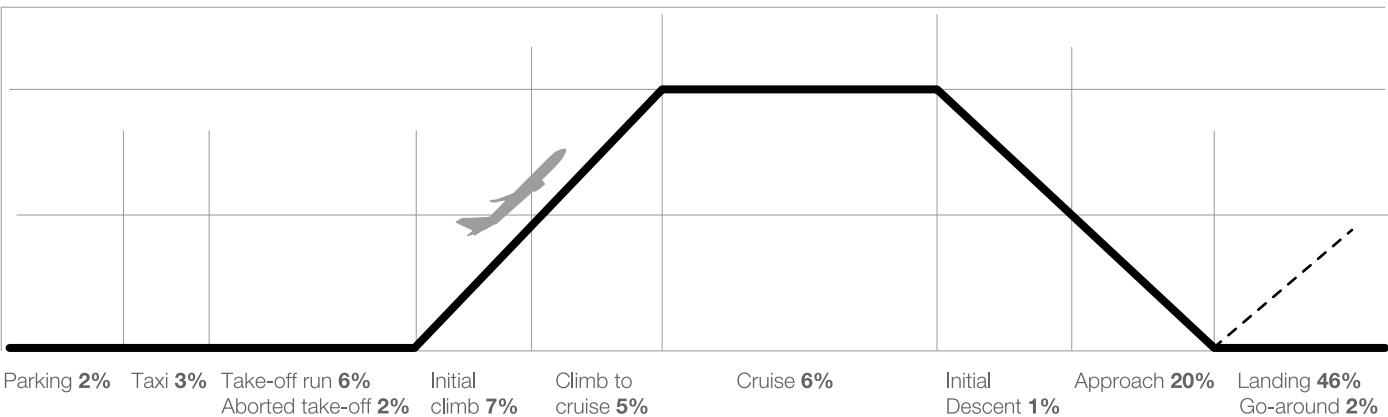
Distribution of accidents by flight phase

“ Nearly 90% of all accidents happened during the descent/approach/landing or take-off/climb phases ”

Behind the numbers

The number of flight hours is virtually neutral to the accident probability. Therefore, it makes sense to express accident rates per flights rather than per flight hours.

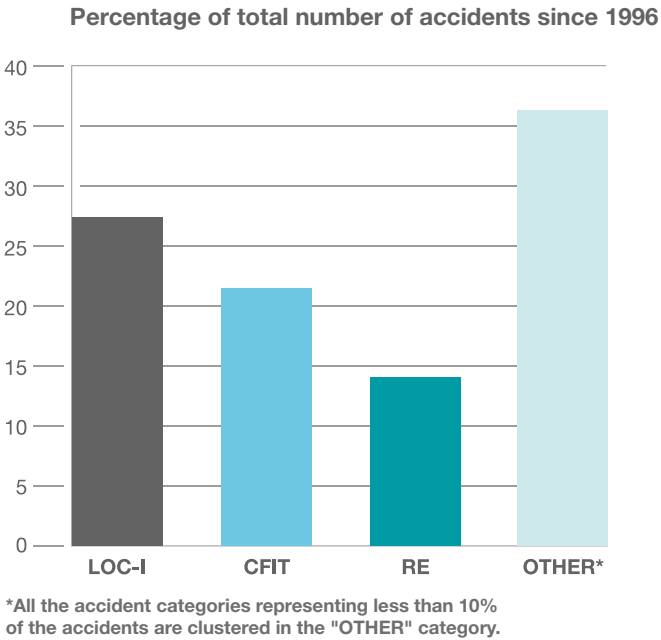
Hull loss



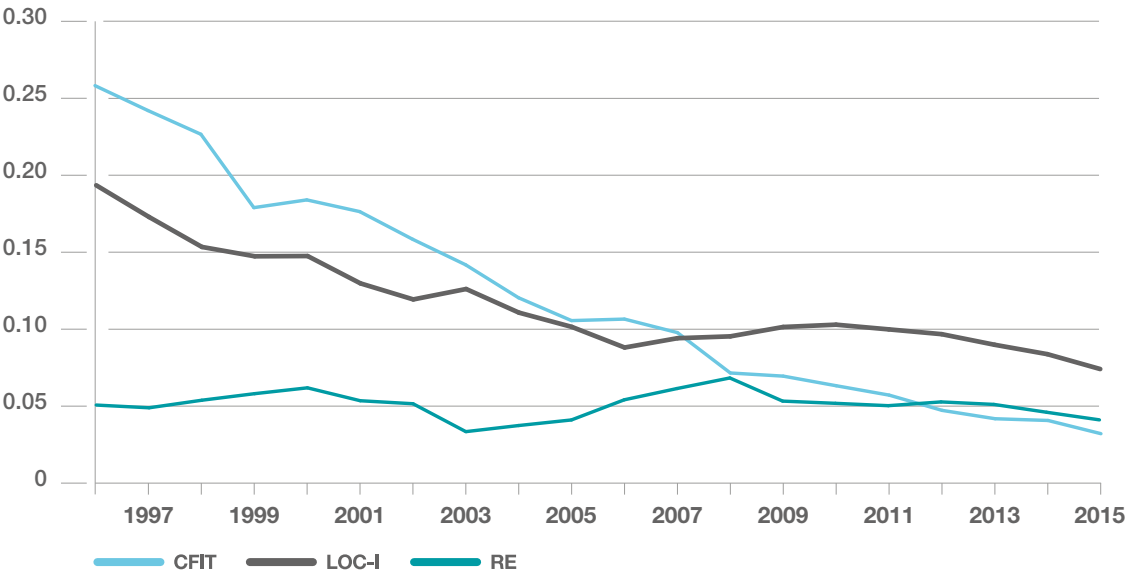
Definition of accident categories

- **System/Component Failure or Malfunction (SCF):** Failure or malfunction of an aircraft system or component, which leads to an accident, whether they are related to the design, the manufacturing process or a maintenance issue. SCF includes the powerplant, software and database systems.
- **Abnormal Runway Contact (ARC):** Hard or unusual landing, not primarily due to SCF, leading to an accident.
- **Runway Excursion (RE):** A veer off or overrun off the runway surface, not primarily due to SCF or ARC.
- **Loss of Control in Flight (LOC-I):** Loss of aircraft control while in flight not primarily due to SCF.
- **Controlled Flight Into Terrain (CFIT):** In-flight collision with terrain, water, or obstacle without indication of loss of control.
- **Undershoot:** A touchdown off the runway surface, not primarily due to SCF.
- **Fuel:** Fuel exhaustion or fuel contamination.
- **Ground collision:** Collision with another aircraft, vehicle, person or obstacle from the time the airplane leaves the gate to the aircraft's lift-off.
- **Fire:** Fire/smoke in or on the aircraft leading to an accident.
- **Icing:** Accumulation of ice on the aircraft surfaces that adversely affects aircraft control or performance.
- **Turbulence:** In-flight turbulence encounter.
- **Bird:** In-flight collision with birds.
- **Air collision:** In-flight collisions between aircraft.
- **Unknown:** Insufficient information to categorize the occurrence.

Fatal



10 year moving average accident rate per million flights



Fatal

Distribution of accidents by accident category

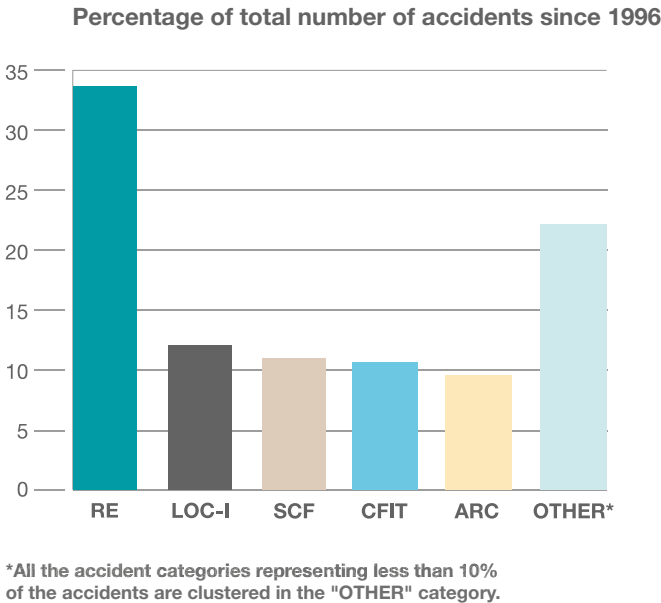
“ Three categories of accidents accounted for the majority of accidents ”

Evolution of the three main accident categories

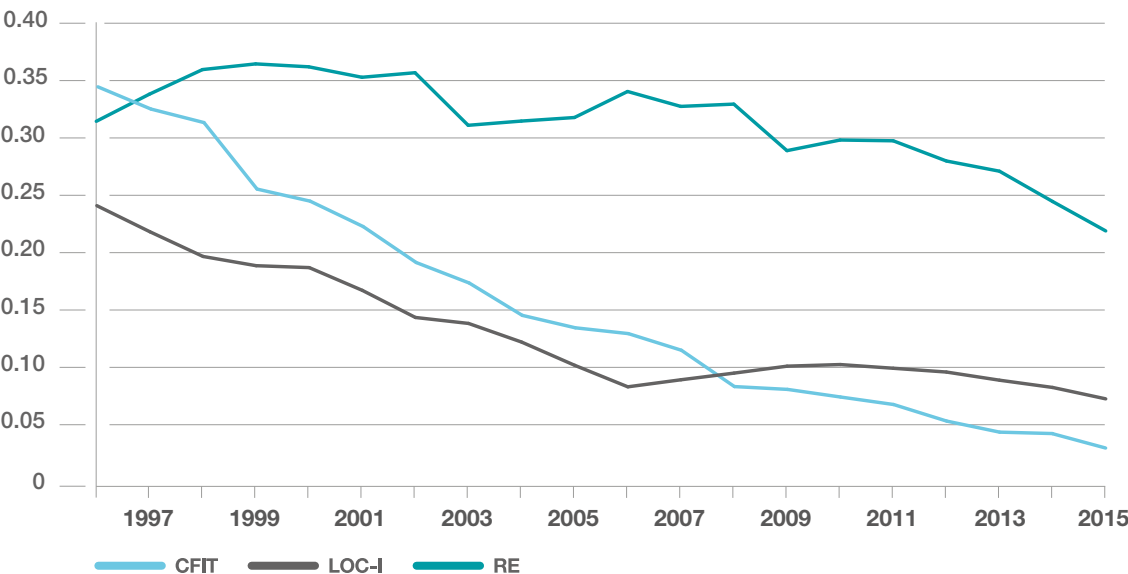
“ A very unequal success in addressing the three major accident categories: the rate of CFIT was divided by 7, LOC-I by 2, whereas RE remained stable ”

Behind the numbers

If virtually all Controlled Flight Into Terrain (CFIT) and Loss Of Control In-flight (LOC-I) accidents lead to both fatalities and hull loss, other accident categories generate mainly only material damage. As an example, 15% of Runway Excursion (RE) accidents cause fatalities, and are the third source of fatal accidents. Yet, Runway Excursions have become the main source of hull losses. As such, like CFIT and LOC-I, it represents a significant contributor to the overall accident records. Since the other accident categories have a significantly lower contribution to the overall accident records, the emphasis will be put on CFIT, LOC-I and RE in the rest of the brochure.



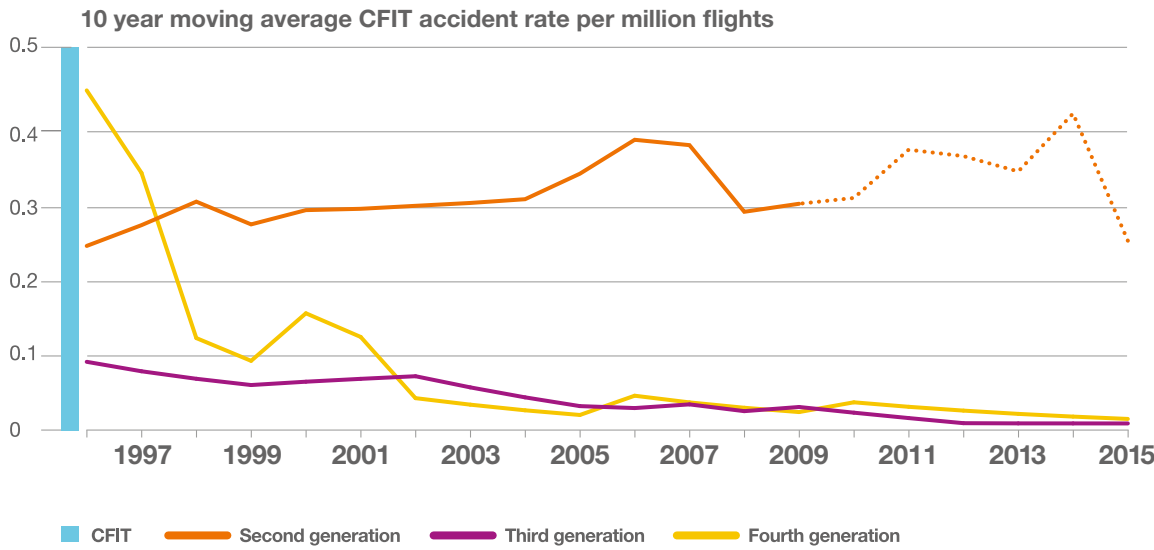
10 year moving average accident rate per million flights



Hull loss

Hull loss

Fatal



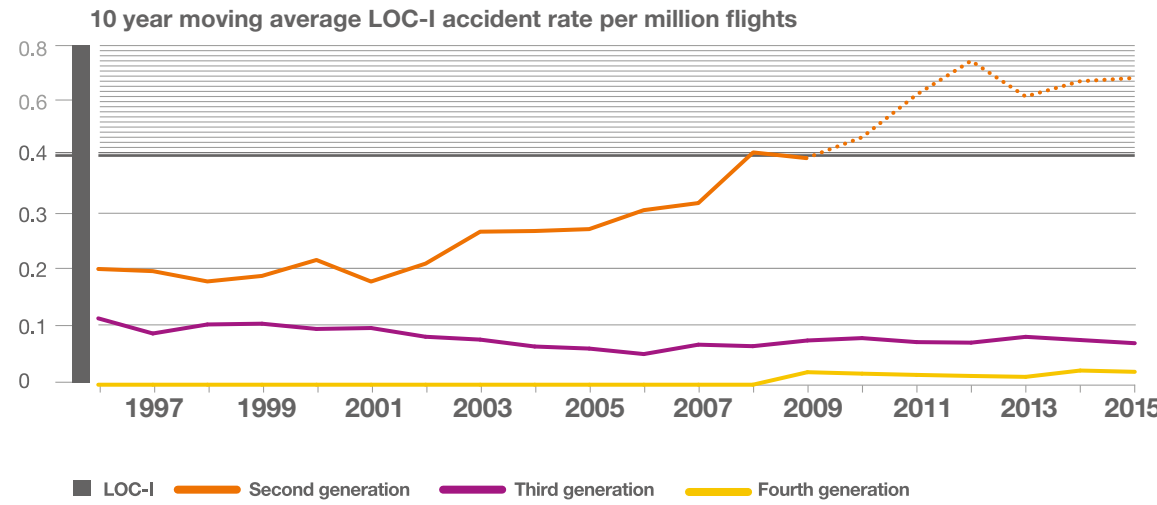
Controlled Flight Into Terrain (CFIT) accident rates

“ The introduction of Glass Cockpits, Flight Management Systems, and in the early 2000s, GPS together with Terrain Awareness and Warning Systems has brought significant gain in CFIT accident rates ”

Behind the numbers

The third generation of aircraft was introduced in 1982/83 with aircraft such as the Airbus A310/A300-600 as well as the Boeing B757 and B767.

Fatal



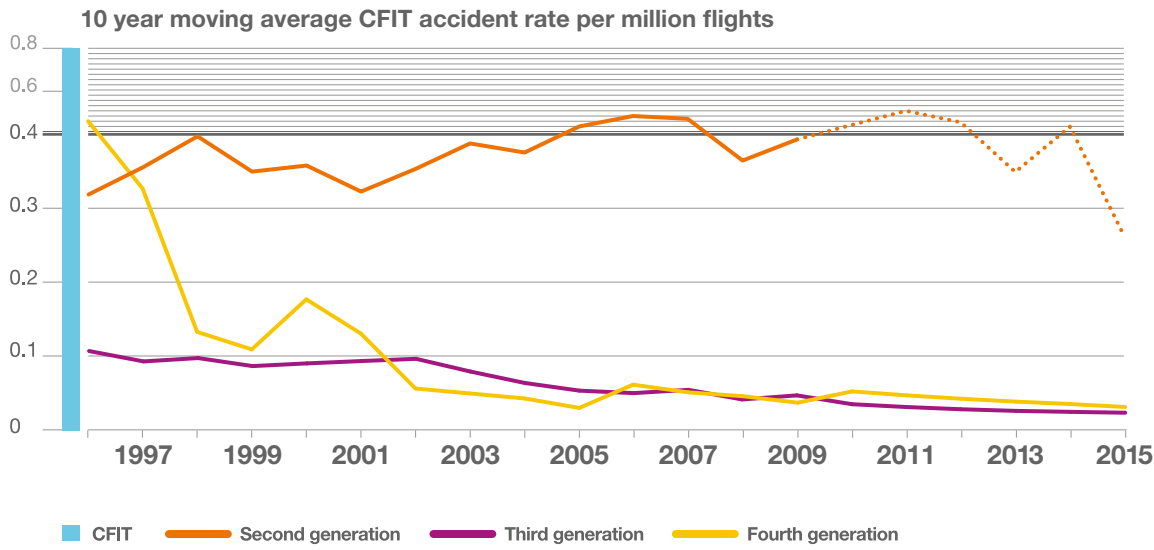
Loss Of Control In-flight (LOC-I) accident rates

“ The flight envelope protection has brought a huge reduction in LOC-I accident rates ”

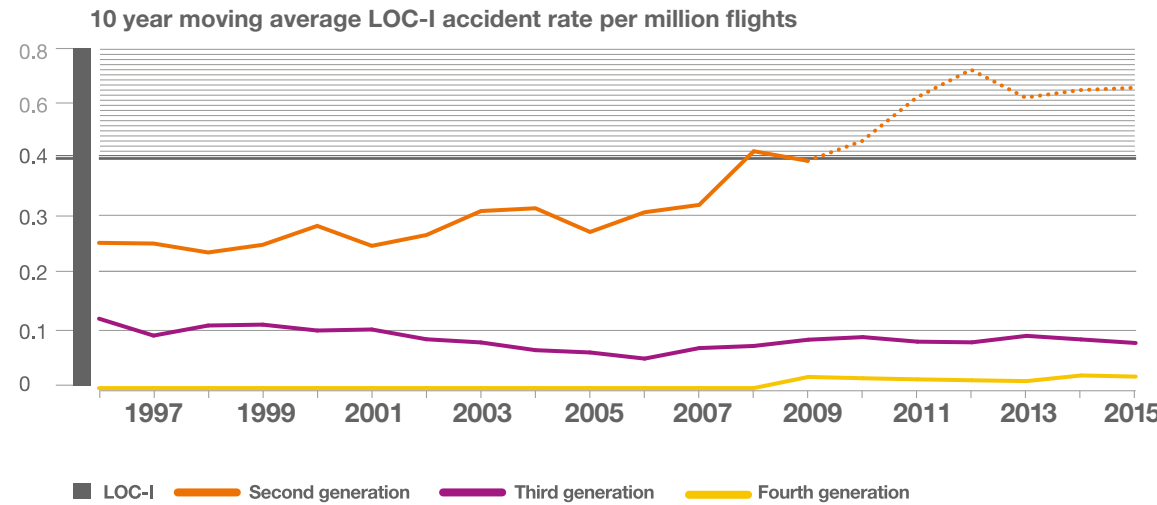
Behind the numbers

The fourth generation of aircraft was introduced in 1988 with the Airbus A320. This technology has become an industry standard and is now used on all currently produced Airbus models, on the Boeing B777, B787, Embraer E and Bombardier CS series to come.

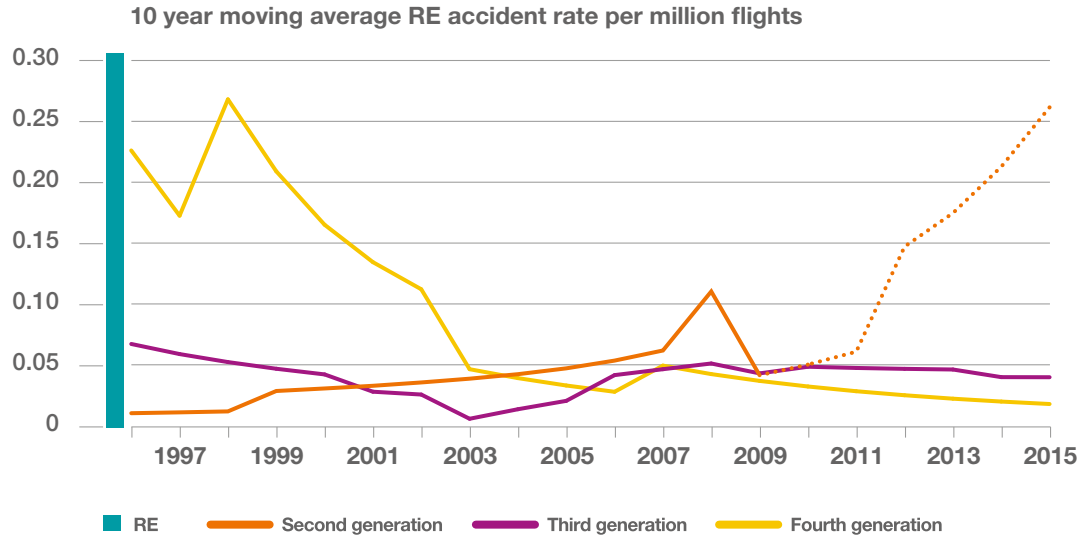
Hull loss



Hull loss



Fatal

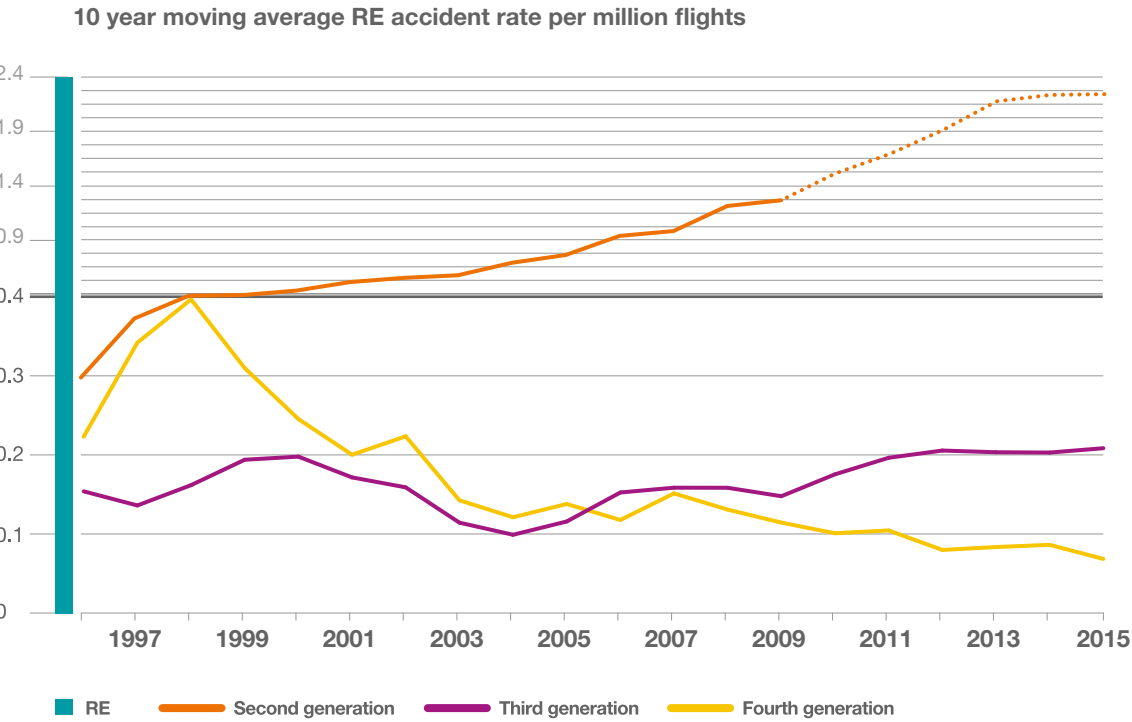


Behind the numbers

Most Runway Excursions are related to aircraft energy management. Significant improvement of RE accident rates can be expected from the introduction of an energy landing performance based warning system. Yet, as of today, the proportion of aircraft equipped with such system is too low for the overall gain to be visible.

Runway Excursion (RE) accident rates

“ The effect of recent technological breakthrough is not measurable... yet ”



Hull loss



Contact

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Also available on airbus.com





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