

Airbus

Commercial Aviation Accidents 1958-2014

A Statistical Analysis



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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 like 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...

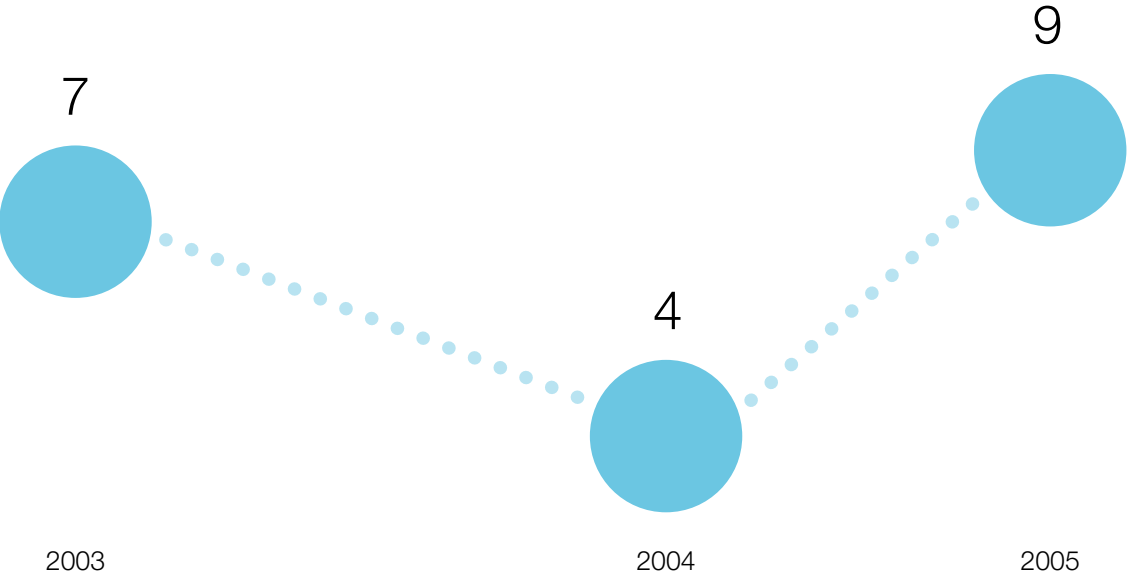
Keeping in mind that our ultimate goal is to enhance safety, it is worth rewording the question and wonder: in what respect can accident statistics help to enhance safety? What can they tell us about safety? What can they not tell us about safety?

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.

What can yearly figures tell us or not about safety?

With tens of millions of flights each year, commercial aviation suffers between 2 and 13 fatal accidents depending on the year. Sometimes, variations from one year to the next can be huge. It was the case in 2003, 2004 and 2005 with respectively 7, 4 and 9 fatal accidents, corresponding to fatal accident rates of respectively 3.4, 1.8 and 3.8 per 10 million flights. Do these figures tell us something about safety? Can we say it was improved by a factor of two in 2004?



If we consider a given year, for example last year, 2014, a lot of unknowns remained about one of the accidents, namely that of the MH 370 flight. With the information available as of today, we cannot determine whether this accident fits into the scope considered for our accident statistics. Indeed, sabotage, military actions, terrorism, suicide and the like are excluded from the accidents we consider in order to remain focused on Safety risks.

Due to lack of information, the accident mentioned is not considered, for the time being, in the statistics presented hereafter. Just focusing on plain numbers, what difference would it have made?

Without this accident, the yearly rate of fatal accident in 2014 was 0.7 per 10 million flights. Should this accident turn out to be within the scope considered, this number changes to 1.1 per 10 million flights, that is 50% higher than without it.

What do these two examples tell us?

Was the air transport system much safer (about twice as much) in 2004 than in 2003 or 2005? Likewise, the fatal accident rate of 2013 being 2.1 per 10 million flights, can we say 2014 was either 3 times safer or just twice as safe (we'll be able to conclude on the magnitude once more information is available on the circumstances of the accident)? Or do these examples simply illustrate that we cannot say such a thing, at least based on accident statistics only? Indeed, the definition of safety is more subtle than a count of real accidents over a year. Similarly, a very cold winter in parts of the world wouldn't tell us anything sound about global warming.

If we get back to the ICAO definition of safety, "the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management", safety refers to the possibility to harm. In other words, it refers to likelihood more than to real events.

Deriving likelihood or probabilities from statistics is not as simple as changing names and calling statistics "probabilities".



It is even more difficult when it comes to rare events. Fortunately enough, accidents belong to this rare events category despite the growing number of flights. They result from a combination of elements of varied natures

- technical, environmental, individual, organizational...
- each of which not being sufficient to lead to the accident. Some of these elements result from strong trends (e.g. increasing number of flights in some regions of the world with specific weather conditions, or to airports surrounded by high terrain), some others are more singular facts (e.g. performing an action at a very precise moment in time although doing it slightly earlier or later would have changed the whole scenario). How many times a year a fatal concomitance of elements occurs is not directly correlated to the safety level of the air transport system. It carries a random dimension, the very one that makes yearly accident numbers or rates insufficient to say something sound on safety. What is more interesting safety wise is to understand how fatal concomitance of elements can occur.

Yet, over the years, numbers allow for building trends. These trends are less sensitive to yearly random variations. Thus, they contribute to providing insights on the evolution of the air transport system safety.

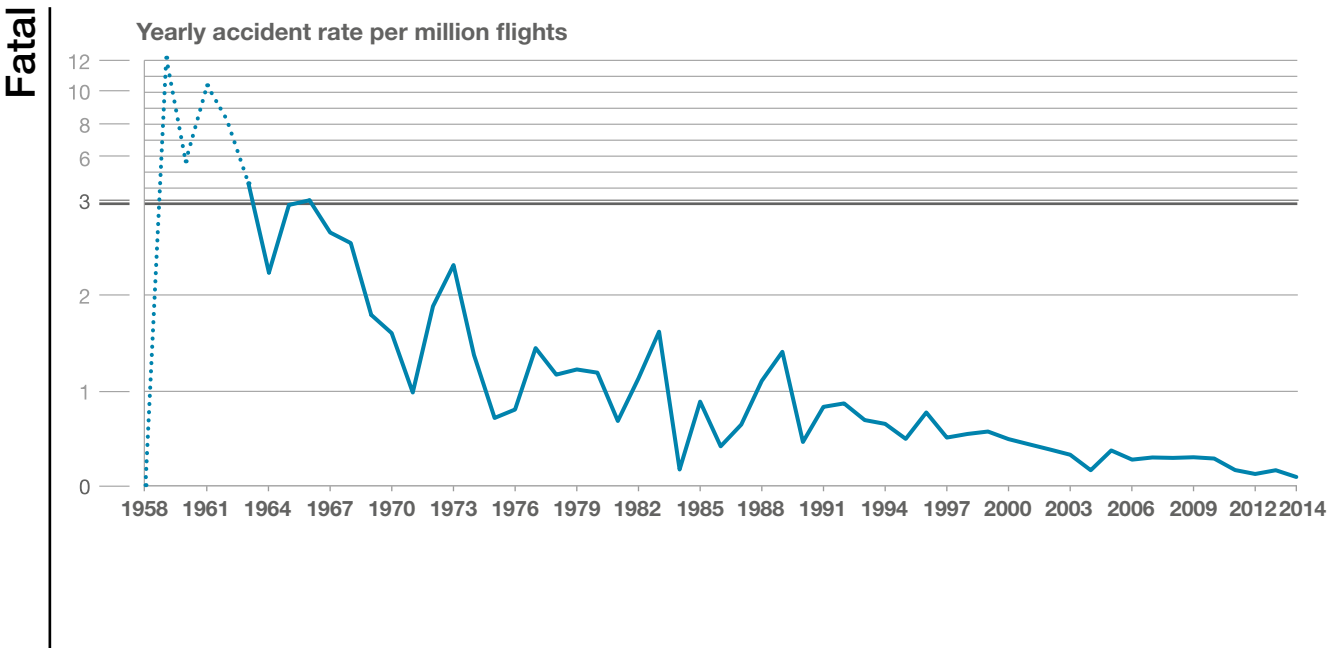


> Fatal accidents
2 which translates
into a rate of
0.07 accident
per million flights

> Hull losses
9 which translates
into a rate of
0.32 accident
per million flights

Commercial
air transport
accidents
for the year 2014

> Exposure
28.4 million
flights



Behind the numbers

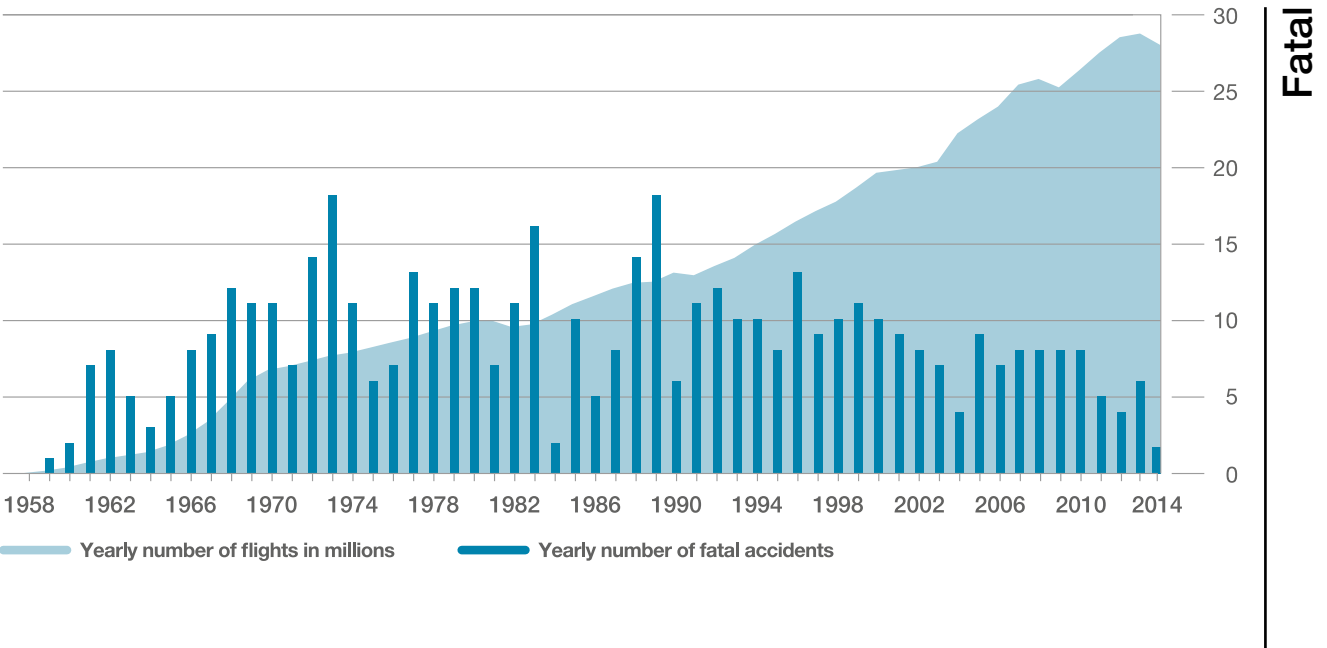
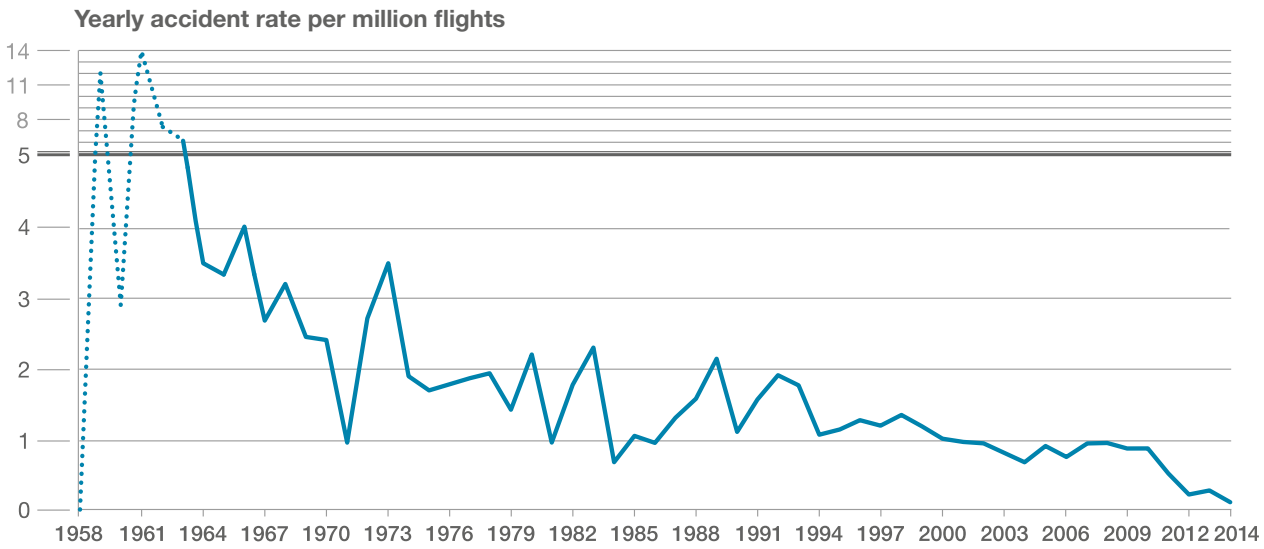
The peak values observed at the beginning of the curve illustrate the fact that accidents, being rare events, need to be considered in the light of a meaningful number of flights, reasonably at least a million flights per year.

Therefore this, and all the following curves in the brochure, appear in dotted lines until a million flights a year are reached.

Evolution of the yearly accident rate

“ A steady decrease over time ”

Hull loss



Evolution of the number of flights and accidents

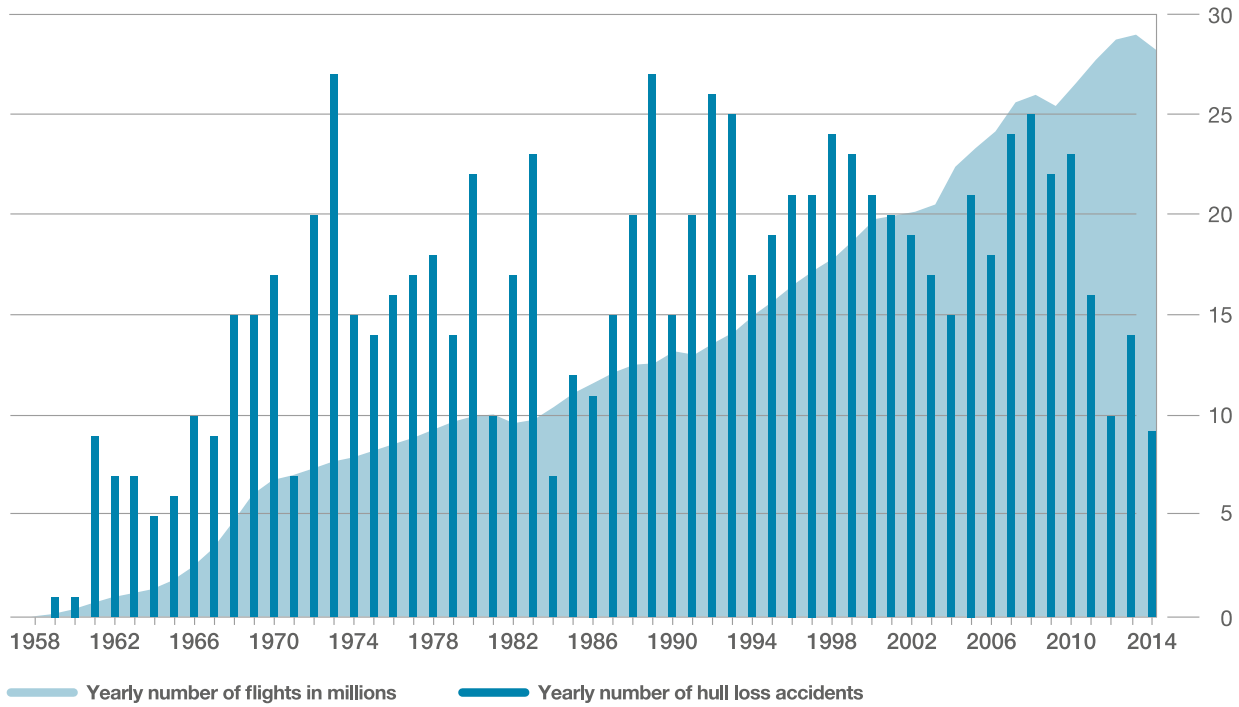
“ A virtually stable absolute number of accidents despite a massive increase in exposure ”

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

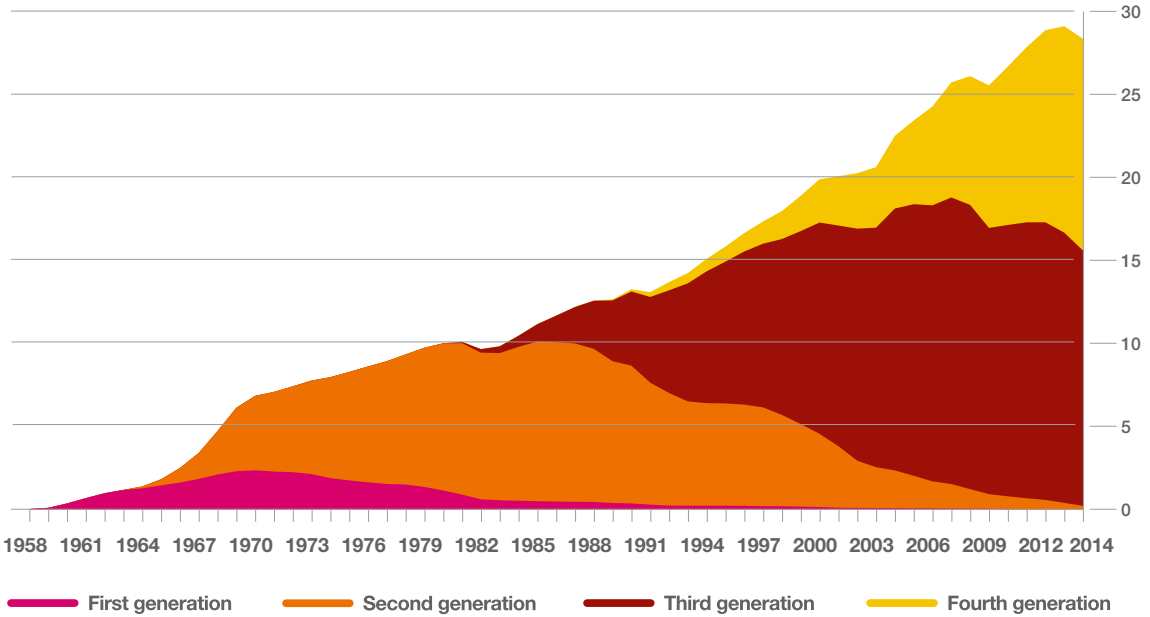
Beyond the size and nature of the fleet, a number of evolutions took place at the air transport system level impacting its safety, hence its accident rate.

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



First Generation
Early commercial jets

200 flights
23 aircraft

Second Generation
More integrated Auto Flight System

231,800 flights
687 aircraft

Third Generation
Glass cockpit and FMS

15,4 million flights
12,600 aircraft

Fourth Generation
Fly-By-Wire with flight envelope protection

12,8 million flights
10,074 aircraft

1st year of entry into service:

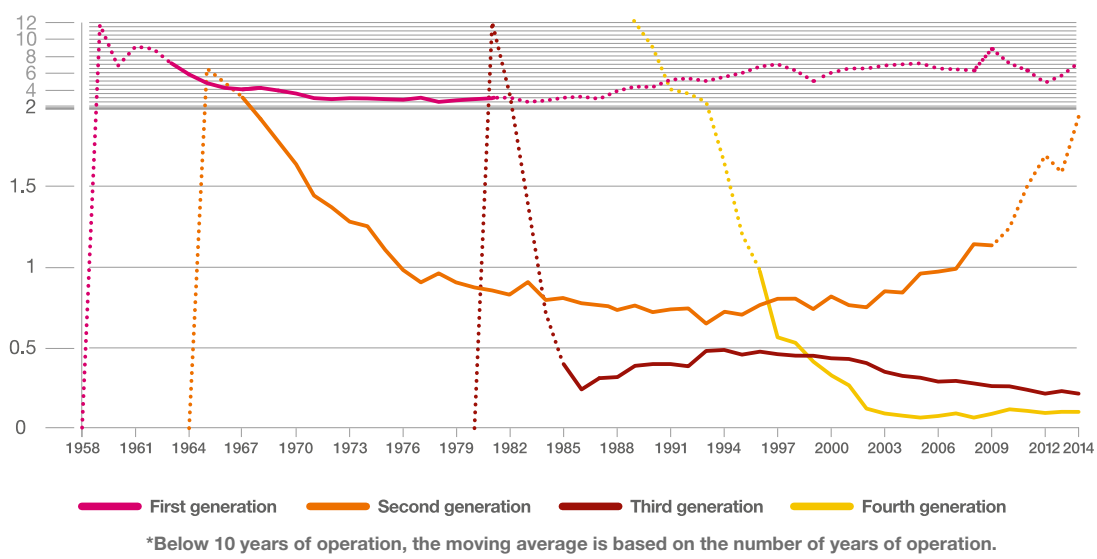
1952
Caravelle, Comet, BAC 111, Trident, VC-10, B707, B720, Convair 880/990, DC-8

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, B787, Embraer E Series, A350-900

10 year moving average accident rate per million flights*



Fatal

Evolution of the accident rates for each generation of aircraft

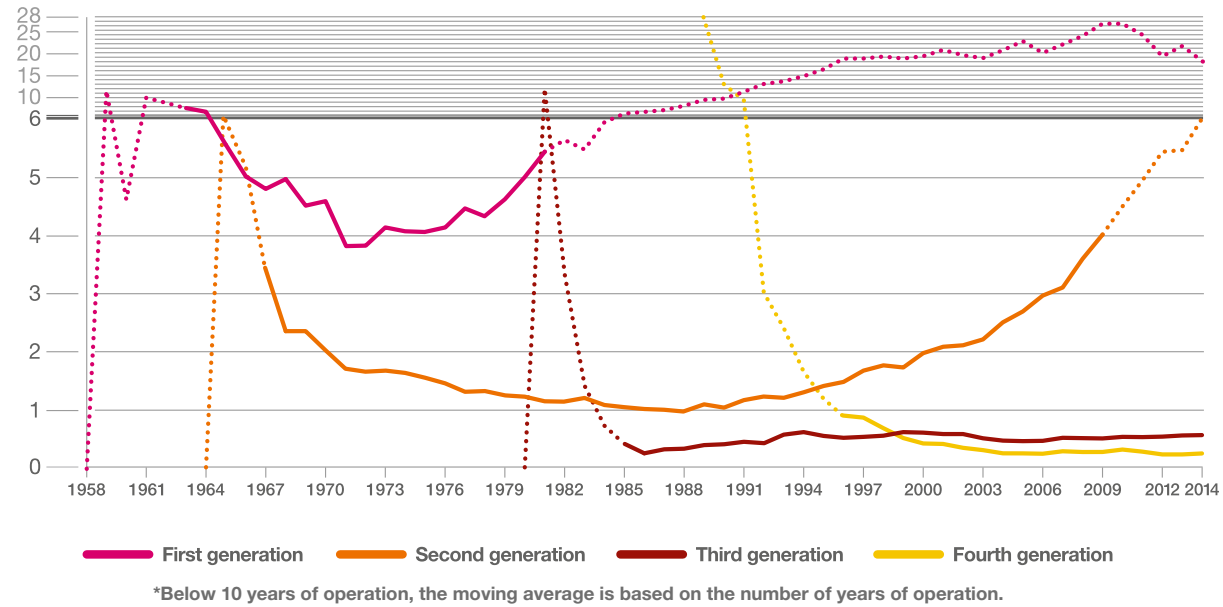
“ Advances in technology bring a decrease in accident rates ”

Behind the numbers

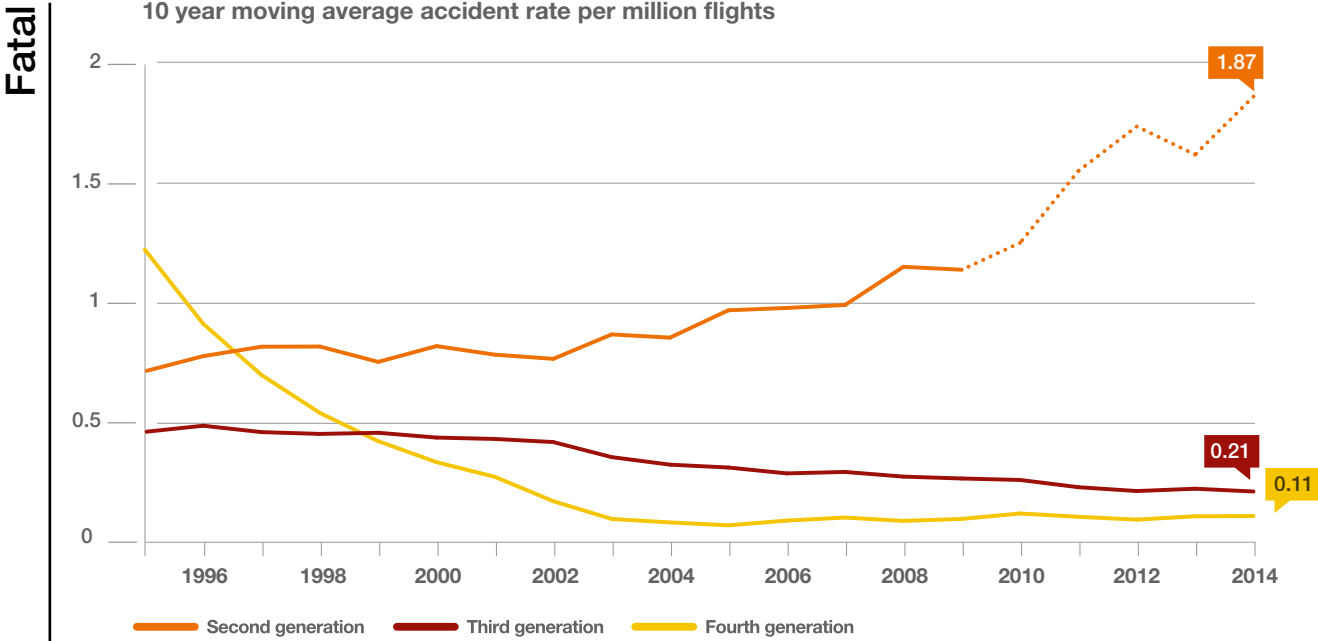
Commercial air transport evolves in a very dynamic environment. Today's operational conditions bear little resemblance to those at the beginning of the jet age. As a consequence, in the following charts, a 20 years frame is used.

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



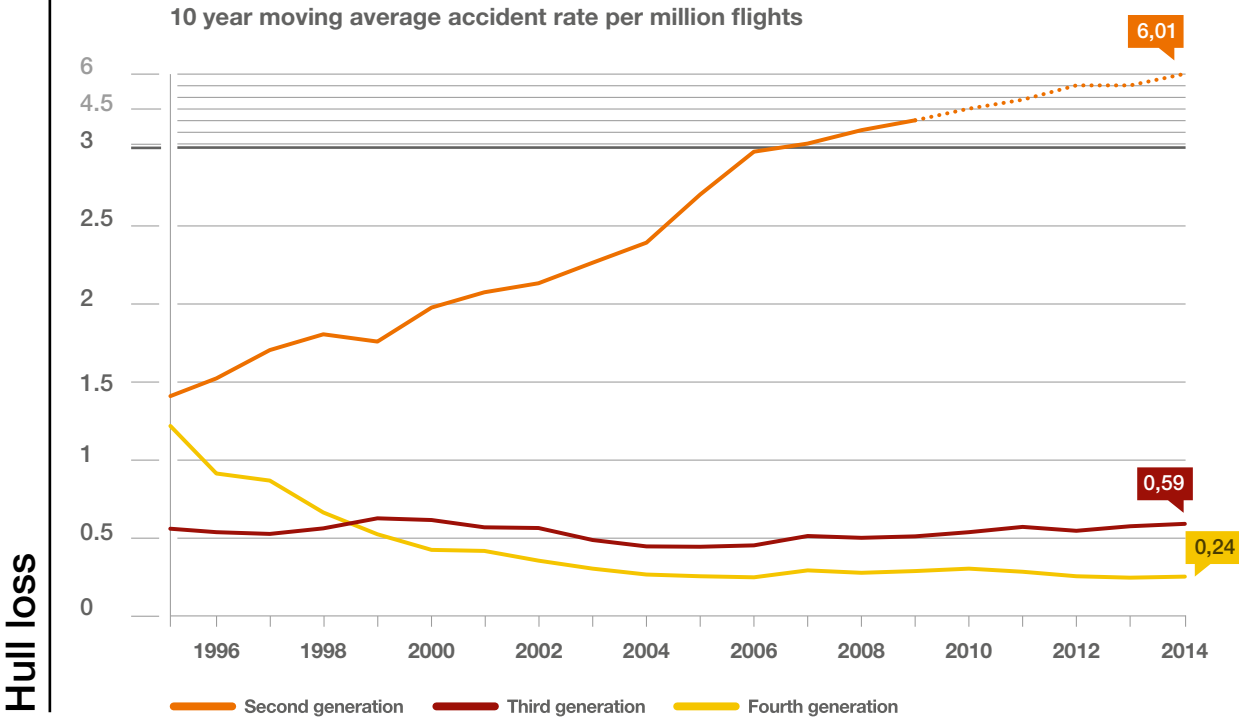
Behind the numbers

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

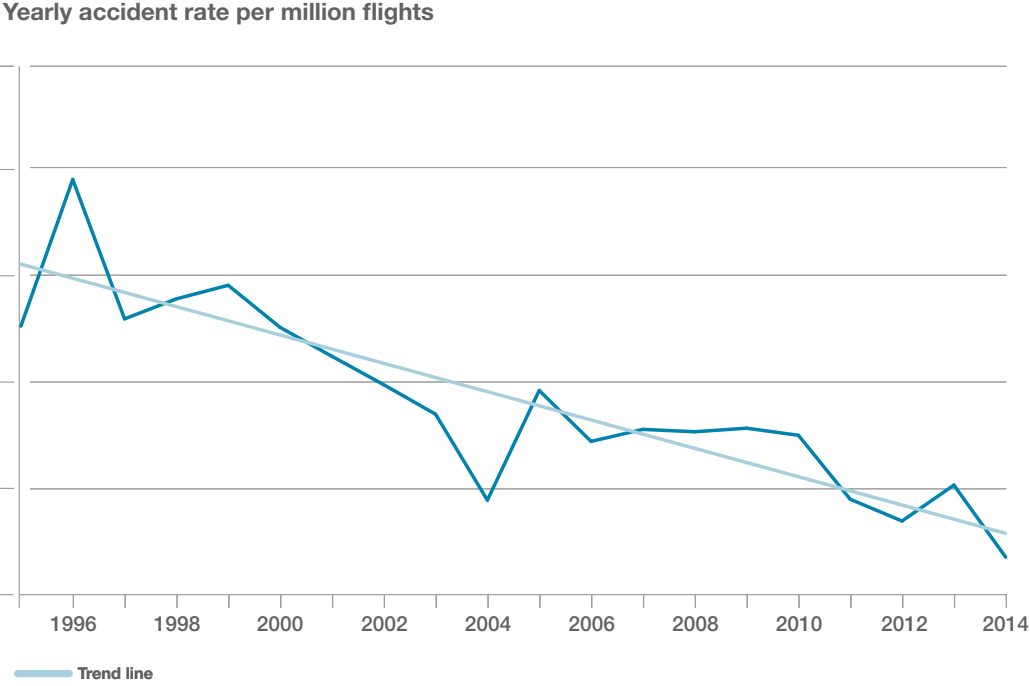
The previous generation was characterized by the introduction of Glass Cockpits that came with Navigation Displays and Flight Management Systems.

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



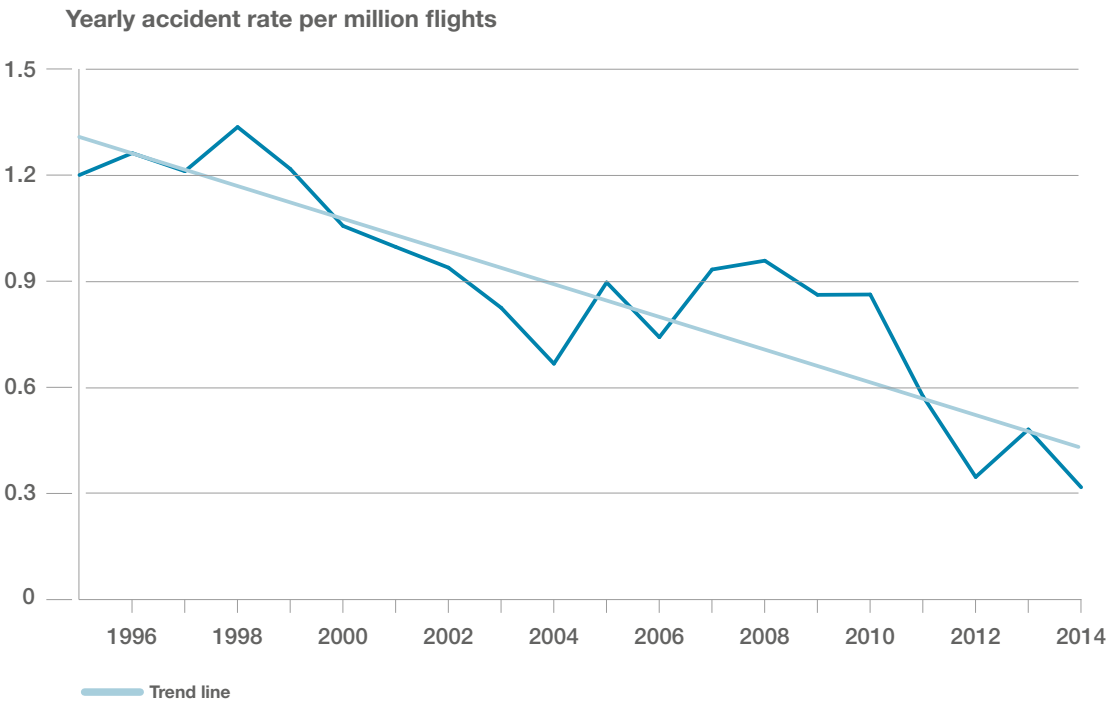
Fatal

Evolution of the yearly accident rate

“ The accident rate was divided by around 5 for fatal accidents, and by around 3 for hull losses ”

Behind the numbers

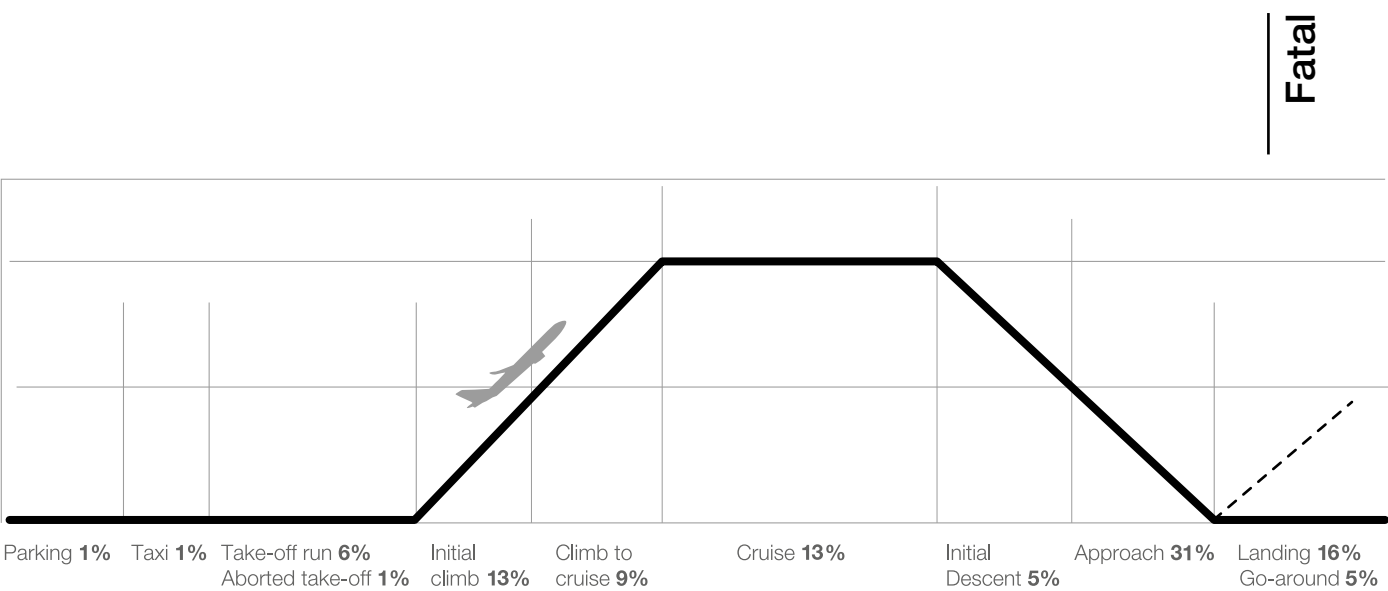
A hull loss is defined as an event in which an aircraft is destroyed or damaged beyond economical repair. The threshold of economical repair is decreasing with the residual value of the aircraft. Therefore, as an aircraft is ageing, an event leading to a damage economically repairable years before may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



Hull loss

› Definitions of flight phases

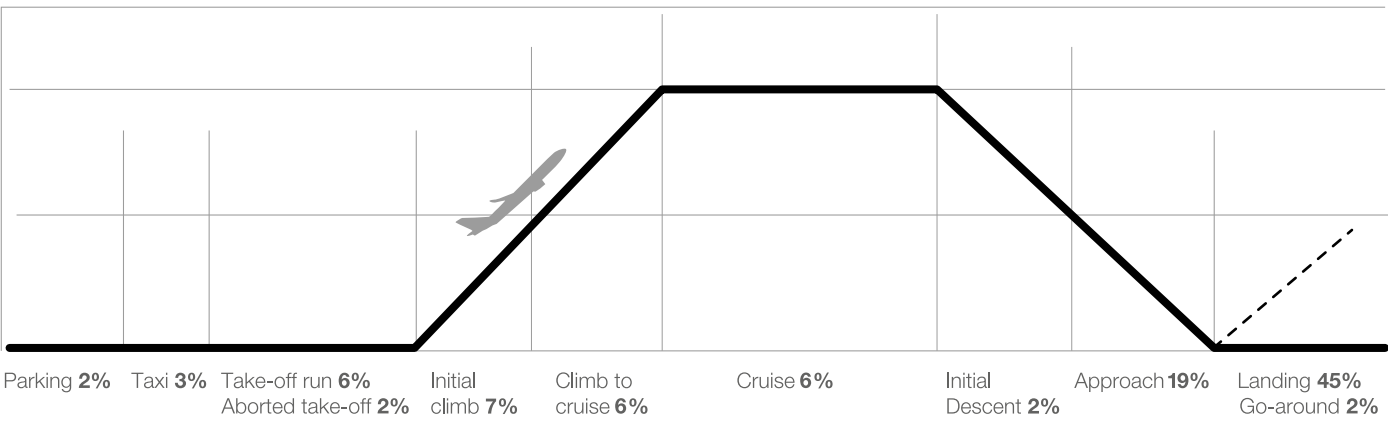
- **Parking:** this phase ends and starts when the aircraft respectively begins or stops moving forward under its own power.
- **Taxi:** this phase includes both taxi-out and taxi-in. Taxi-out starts when the aircraft begins moving forward under its own power and ends when it reaches the takeoff position. 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.



Distribution of accidents by flight phase

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

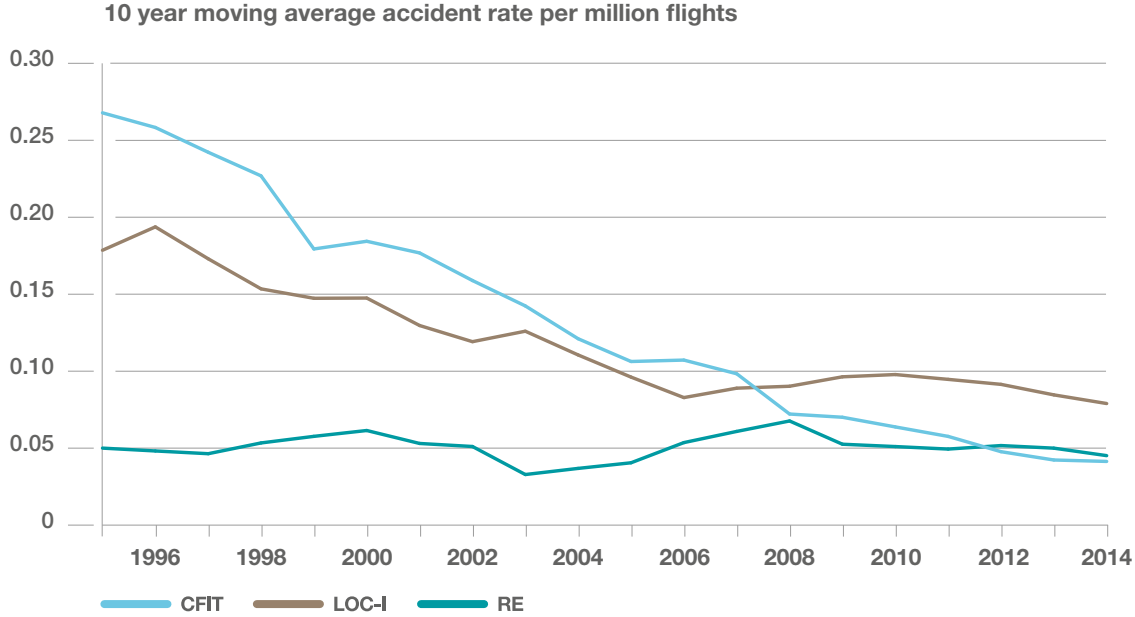
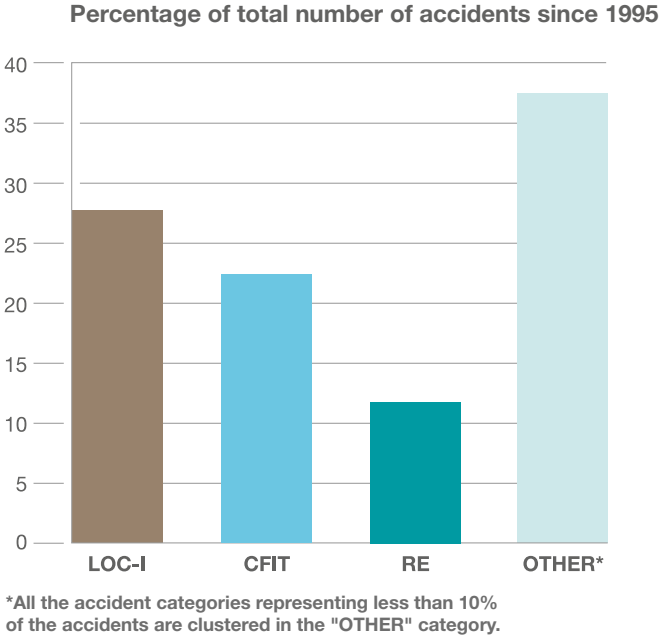
Behind the numbers
The number of flight hours is virtually neutral to the accident probability. Therefore, it makes sense to express accident rates per flights rather than per flight hours.



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



Fatal

Distribution of accidents by accident category

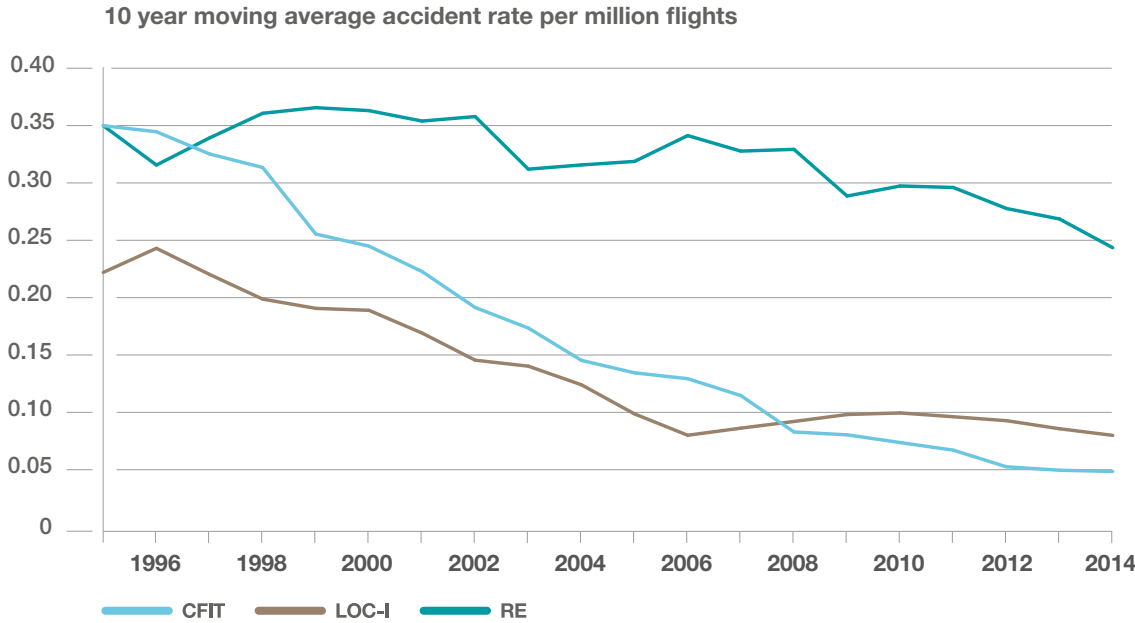
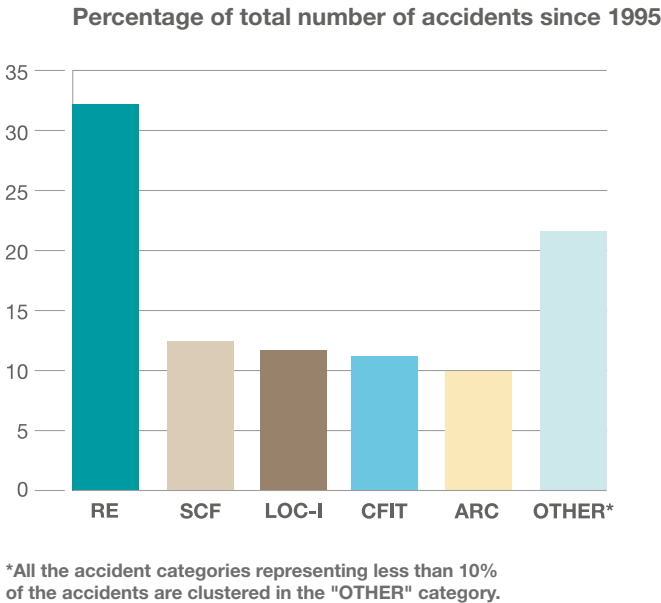
“ Three categories of accidents accounted for the majority of accidents ”

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 ”

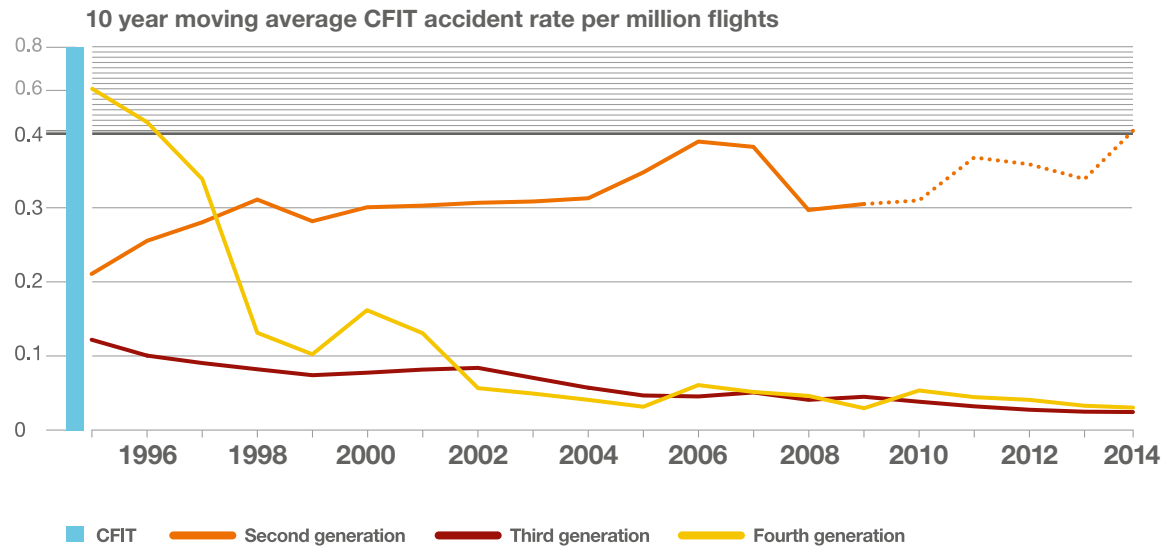
Behind the numbers
If virtually all Controlled Flight Into Terrain (CFIT) and Loss Of Control In-flight (LOC-I) accidents lead to both fatalities and hull loss, other accident categories generate mainly only material damage. As an example, 15% of Runway Excursion (RE) accidents cause fatalities, and 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.

Hull loss



Hull loss

Fatal

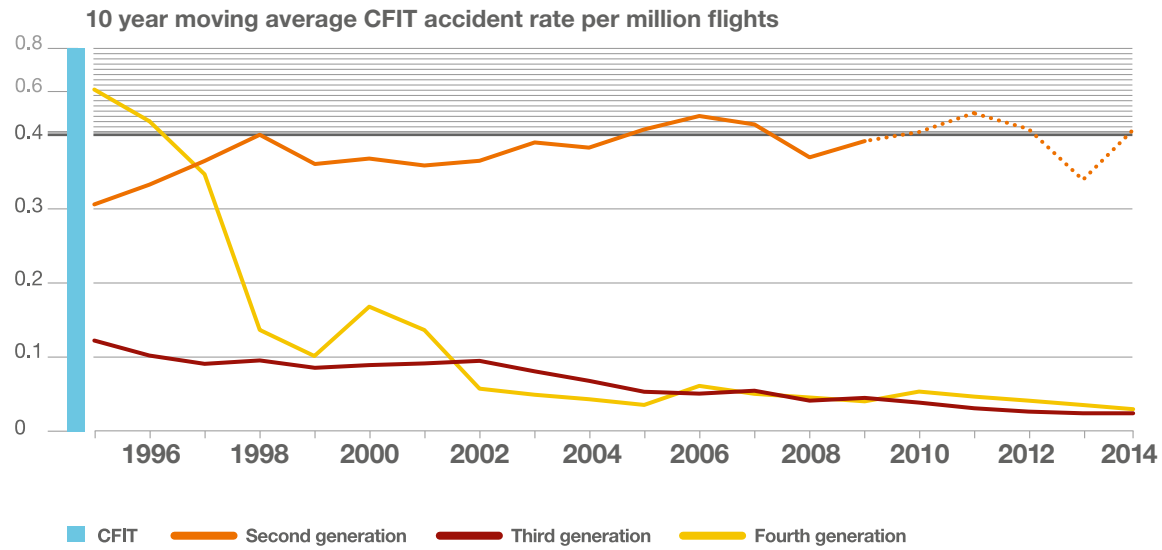


Controlled Flight Into Terrain (CFIT) accident rates

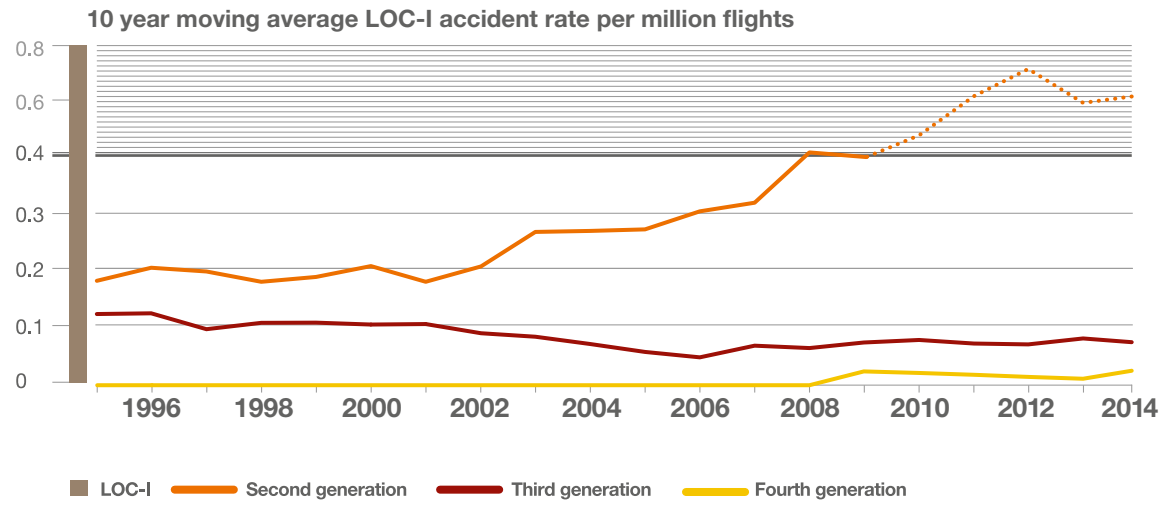
“ The introduction of Glass Cockpits, Flight Management Systems, and in the early 2000s, GPS together with Terrain Awareness and Warning Systems has brought significant gain in CFIT accident rates ”

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.

Hull loss



Fatal

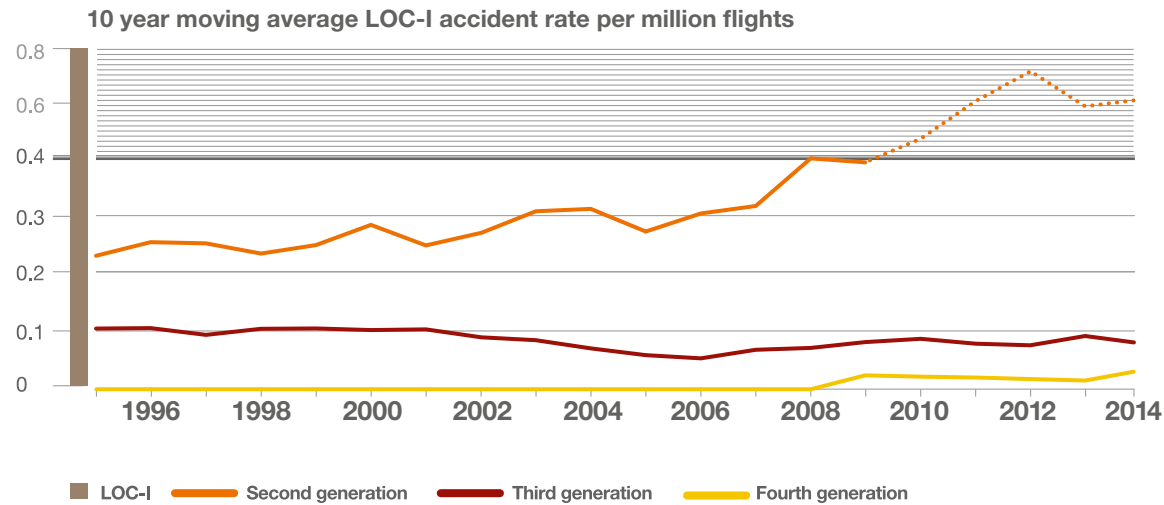


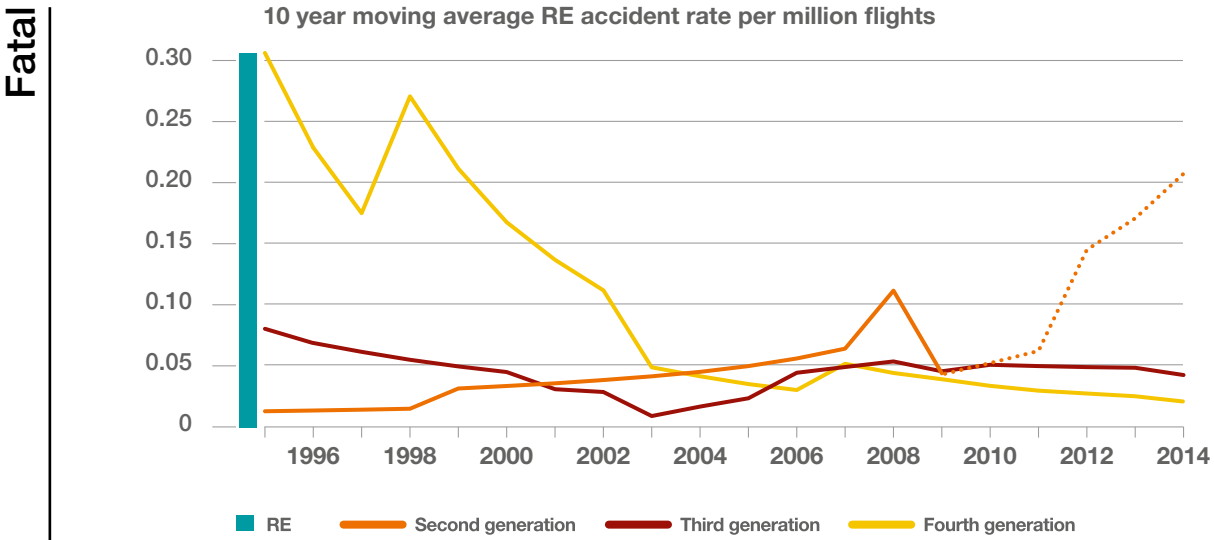
Loss Of Control In-flight (LOC-I) accident rates

“ 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



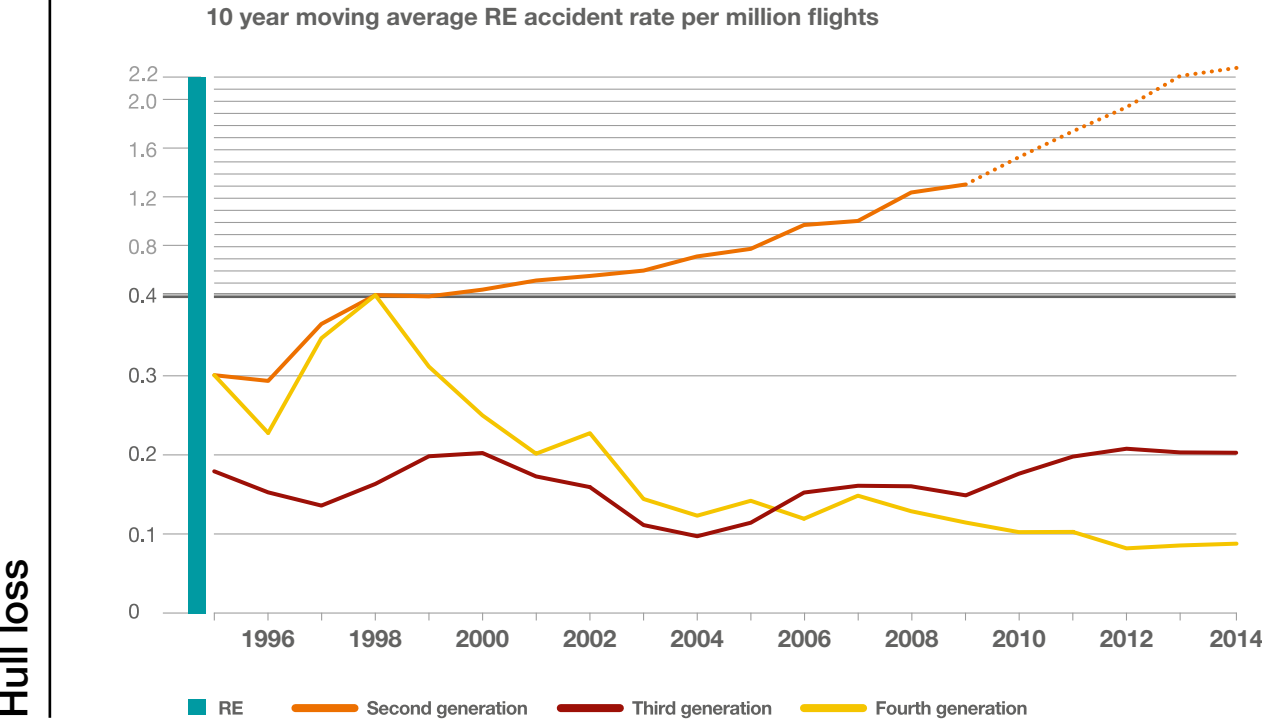


Behind the numbers

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 ”



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