Commercial Aviation Accidents 1958-2013

A Statistical Analysis

AIRBUS

Contents

Scope of the Brochure

- All **western-built commercial air transport jets**
  The following aircraft are included in the statistics: 328 JET, A300, A300-600, A310, A318/319/320/321, A330, A340, 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 renumeration or hire. Non revenue flight like training, ferry, positionning, 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 passenger or crewmember is fatally injured or later dies of his/her injuries.

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.

Commercial air transport accidents for the year 2013

› Exposure

29 million flights

Fatal accidents

6

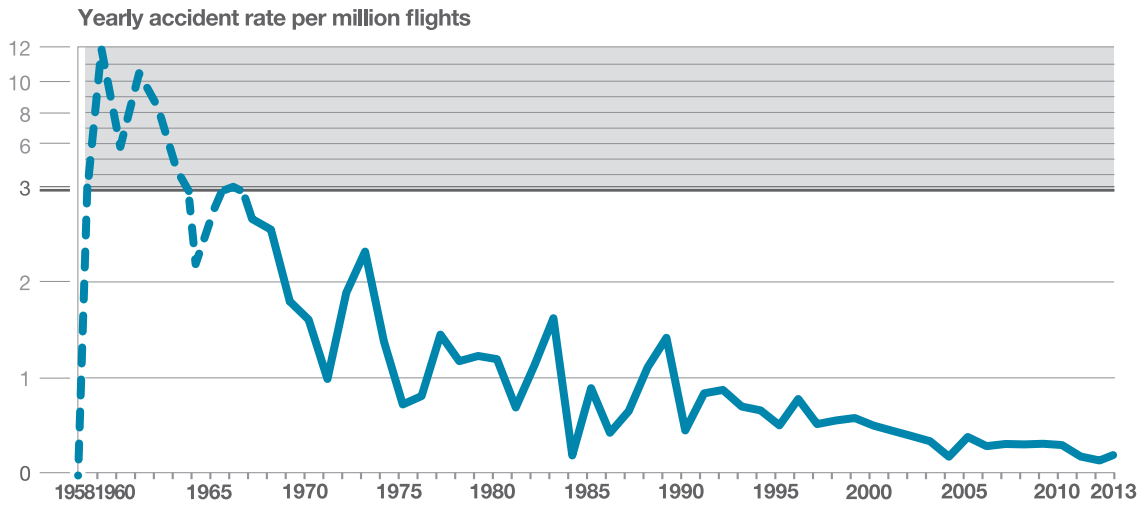
which translates into a rate of 0.21 accident per million flights

Hull losses

14

which translates into a rate of 0.48 accident per million flights

Fatal



Behind the numbers

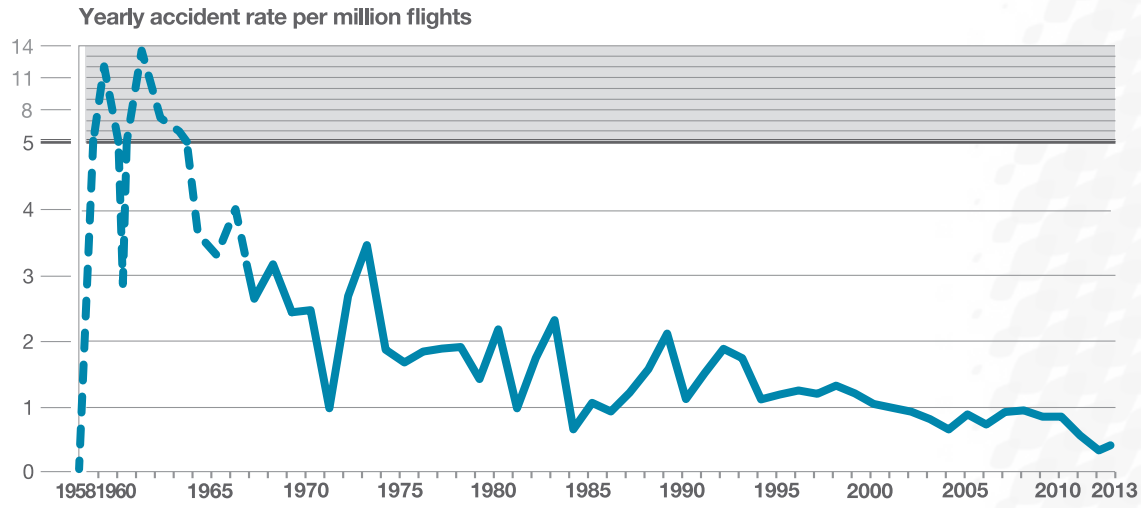
The peak values observed at the beginning of the curve illustrate the fact that accidents, being rare events, need to be considered in the light of a meaningful number of flights, reasonably at least a million flights per year.

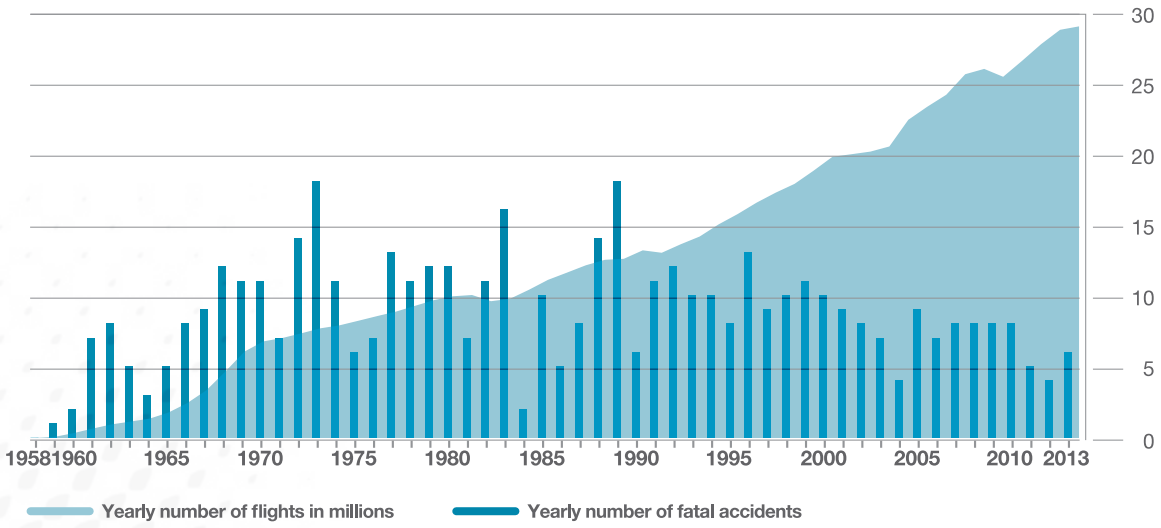
Therefore this, and all the following curves in the brochure, appear in dotted lines until a million flights a year are reached.

Evolution of the yearly accident rate

A steady decrease over time

Hull loss





Fatal

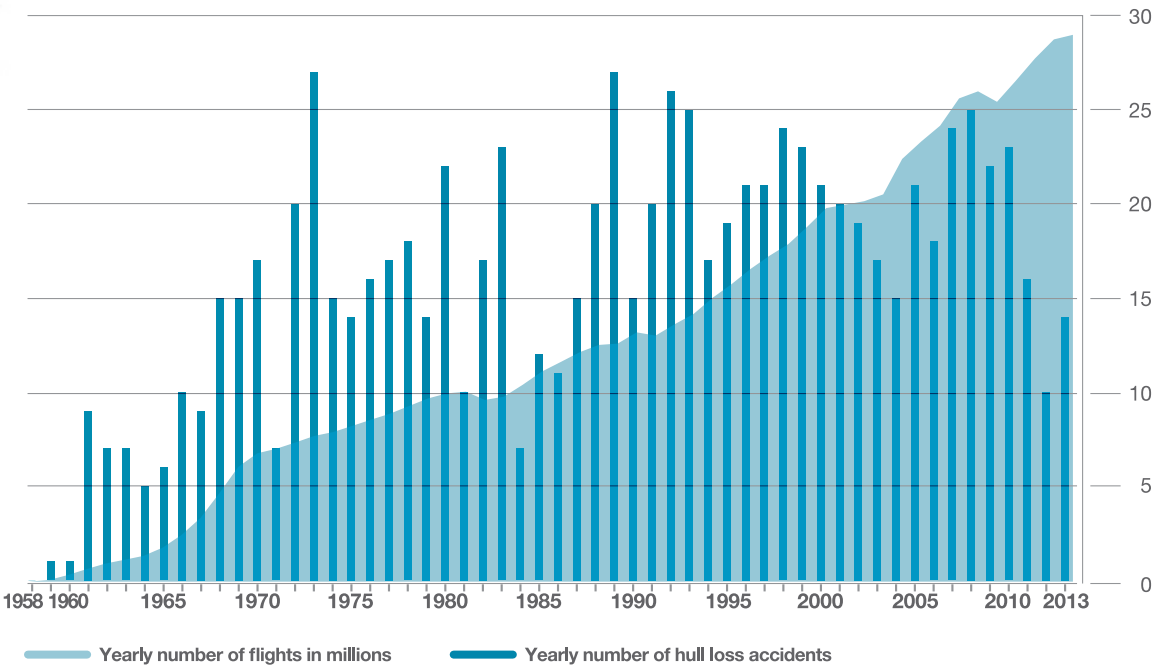
Evolution of the number of flights and accidents

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

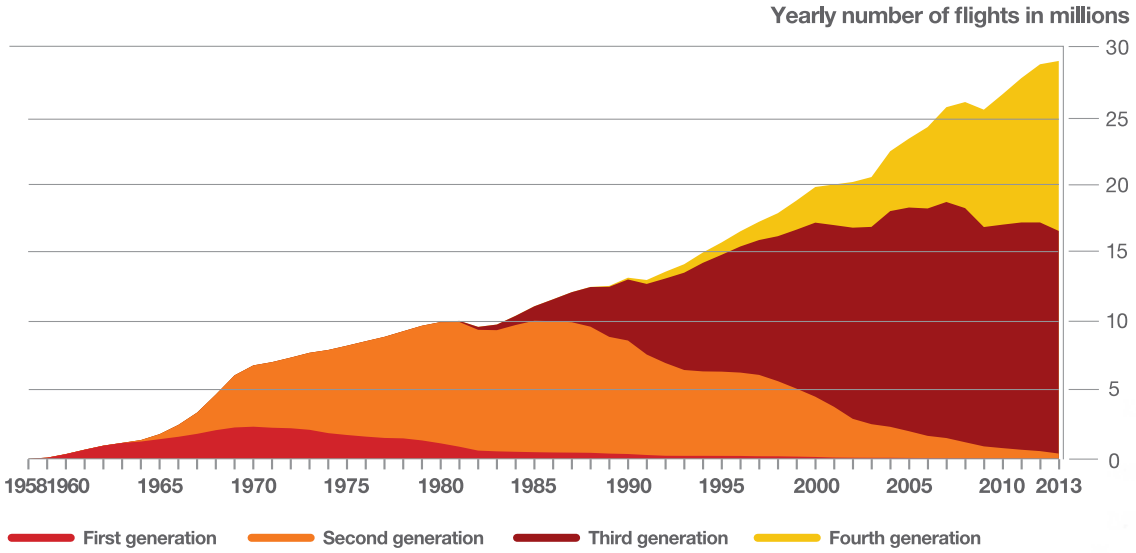
Behind the numbers

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



Detail of Aircraft Generations

First Generation
Early commercial jets

In 2013: 10,000 flights, 50 aircraft

Second Generation
More integrated Auto Flight System

In 2013: 1 million flights, 1,000 aircraft

Third Generation
Glass cockpit and FMS

In 2013: 16 million flights, 12,000 aircraft

Fourth Generation
Fly-By-Wire with flight envelope protection

In 2013: 11 million flights, 8,000 aircraft

1st year of entry into service:

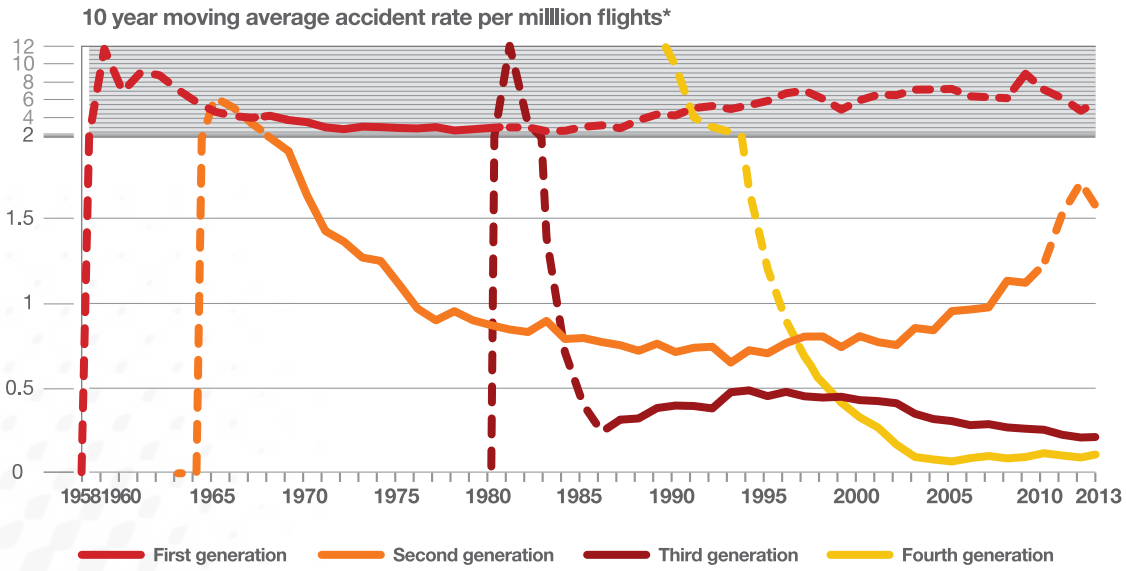
1952
Caravelle, Comet, BAC 111, Trident, VC-10, B707, B720, Convair 880/990, DC-8

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, A380, B777, B787, Embraer E Series

Fatal



*Below 10 years of operation, the moving average is based on the number of years of operation.

Evolution of the accident rates for each generation of aircraft

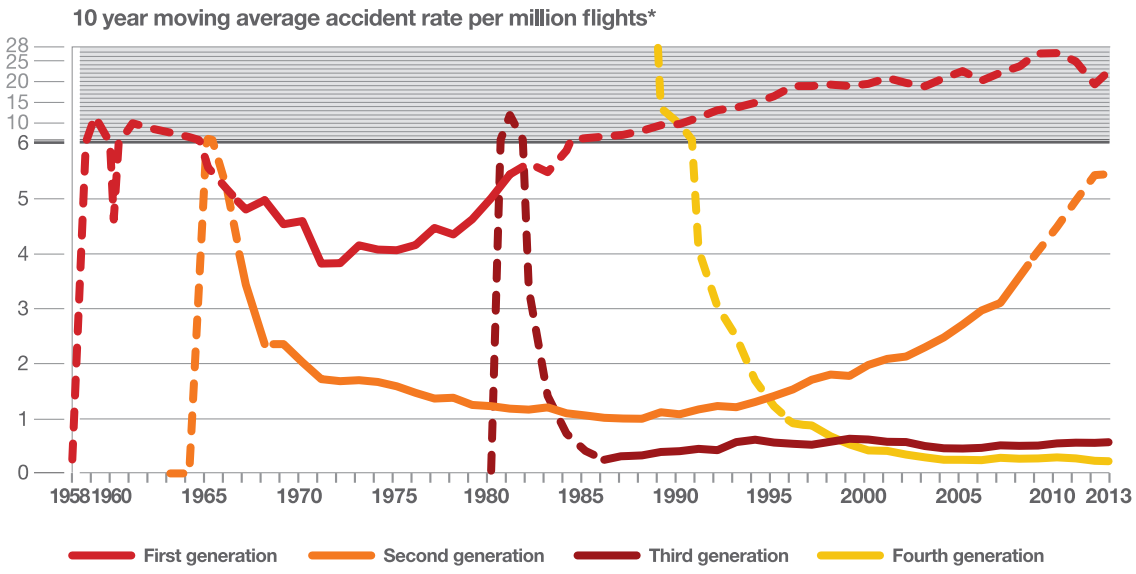
Advances in technology bring a decrease in accident rates

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.

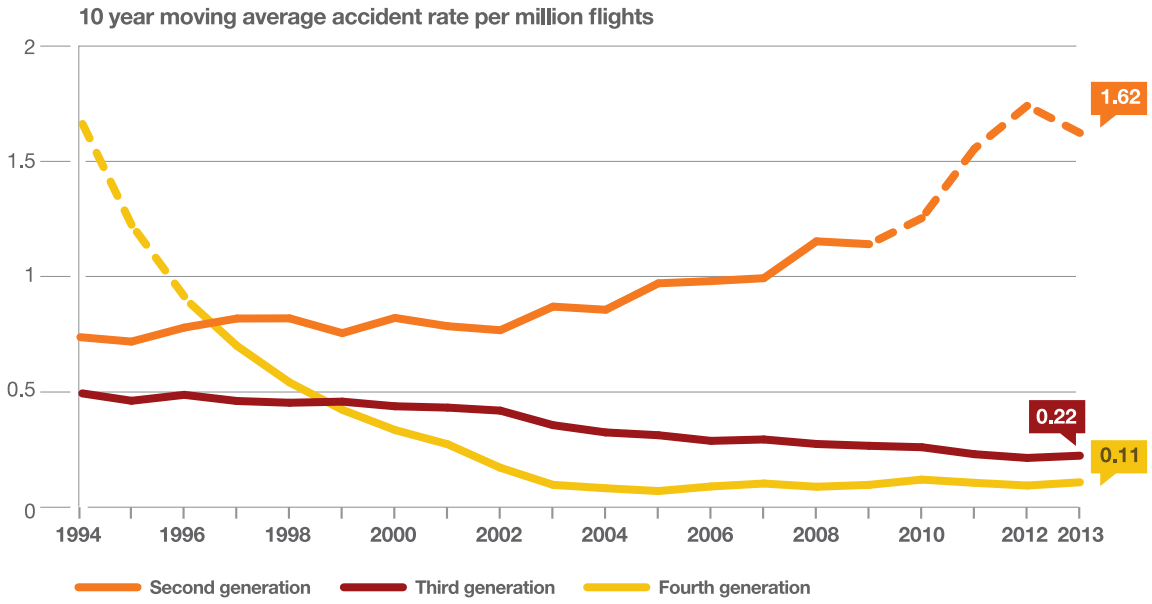
This ensures a relatively homogeneous commercial air transport environment as well as a reasonably large statistical sample.

Hull loss



*Below 10 years of operation, the moving average is based on the number of years of operation.

Fatal



Behind the numbers

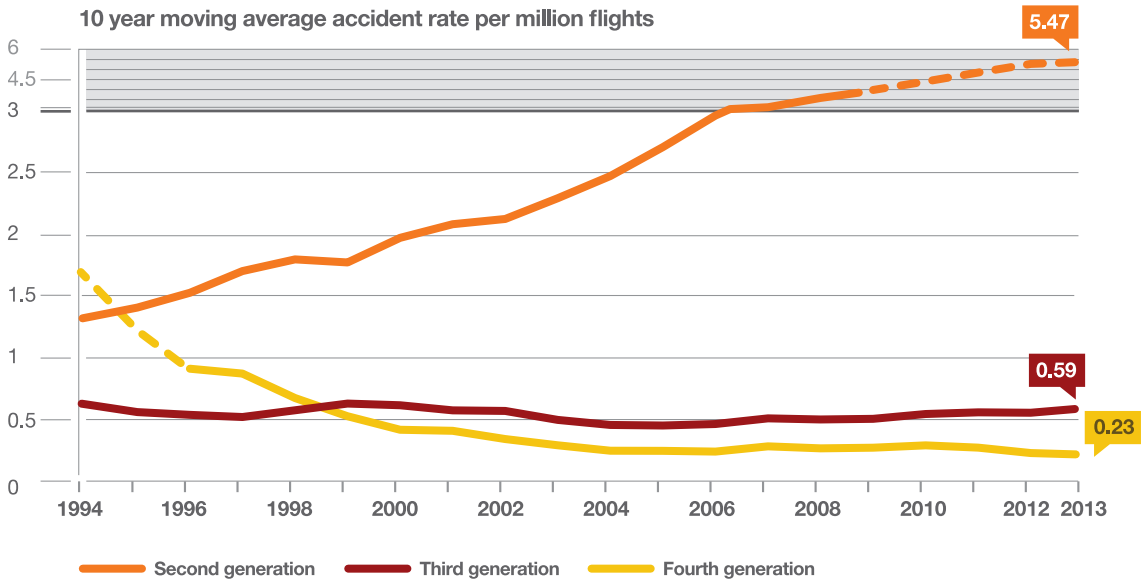
The fourth and latest generation of aircraft is characterized by Fly-By-Wire technology that allowed the introduction of flight envelope protection.

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

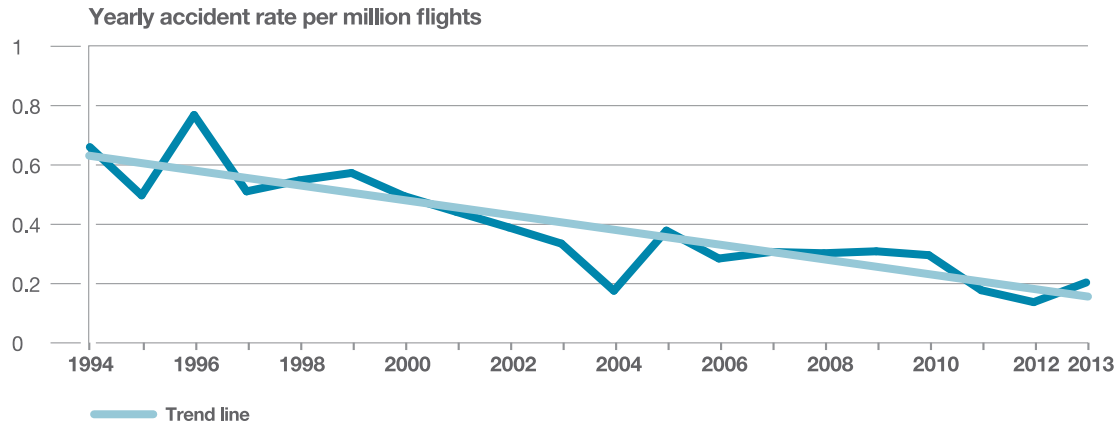
Evolution of the 10 year moving average accident rate for the last three aircraft generations

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

Hull loss



Fatal

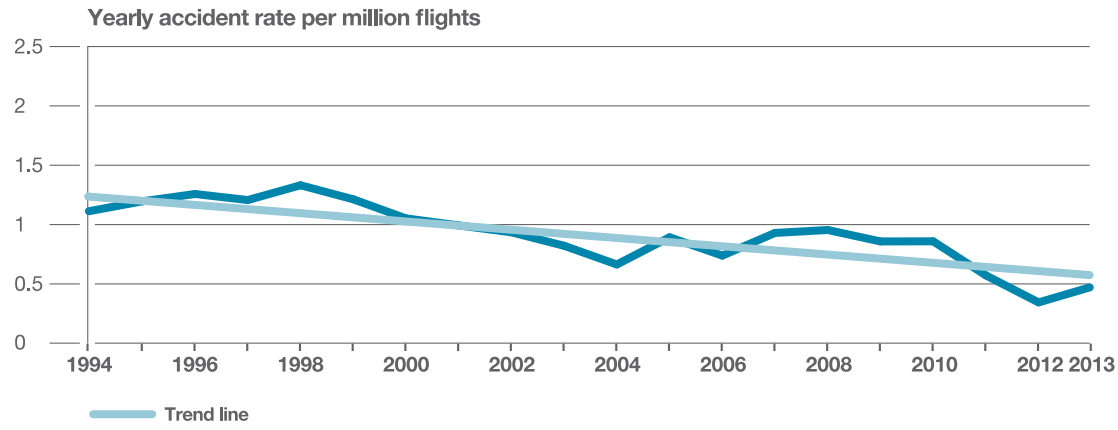


Evolution of the yearly accident rate

The accident rate was divided by more than 3 for fatal accidents, and by more than 2 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.

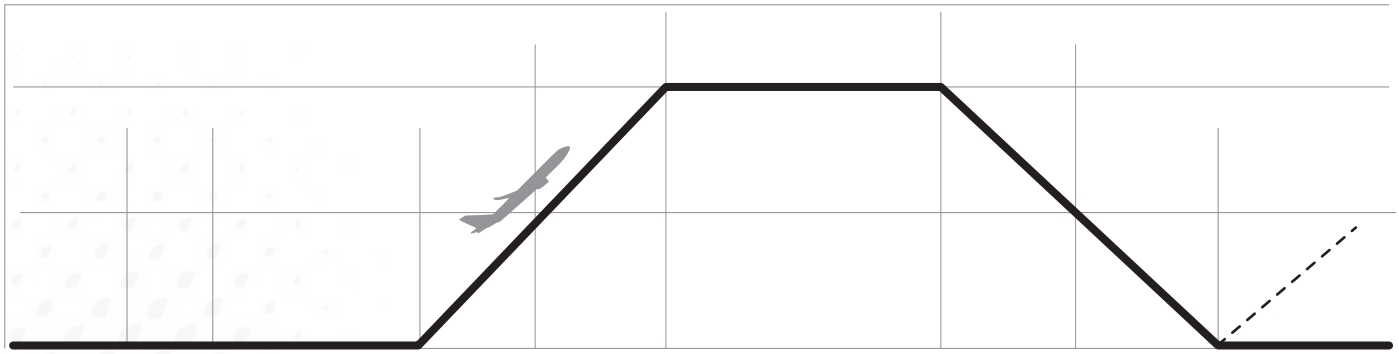


Hull loss

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



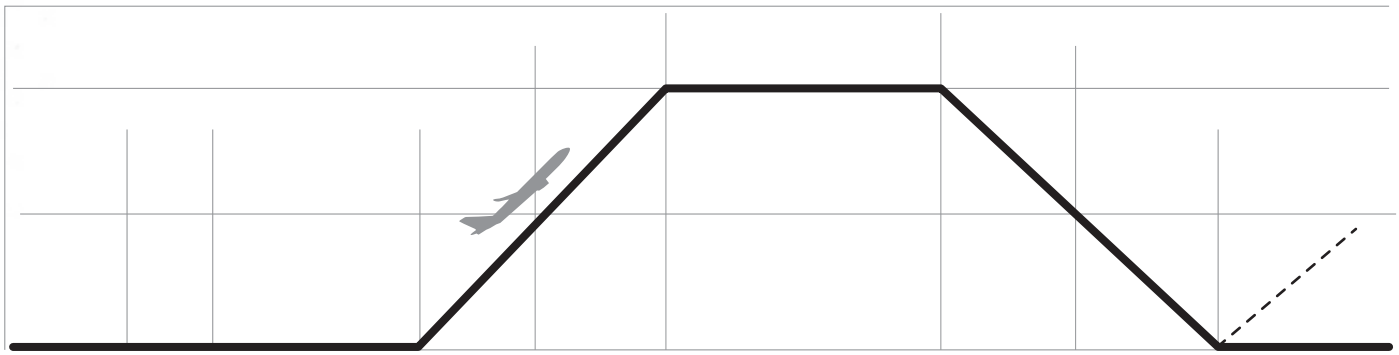
Parking **1%** Taxi **1%** Take-off run **6%** Aborted take-off **1%** Initial climb **12%** Climb to cruise **9%** Cruise **12%** Initial Descent **5%** Approach **32%** Landing **15%** Go-around **6%**

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.



Parking **2%** Taxi **3%** Take-off run **6%** Aborted take-off **2%** Initial climb **6%** Climb to cruise **7%** Cruise **5%** Initial Descent **2%** Approach **20%** Landing **44%** Go-around **3%**

Hull loss

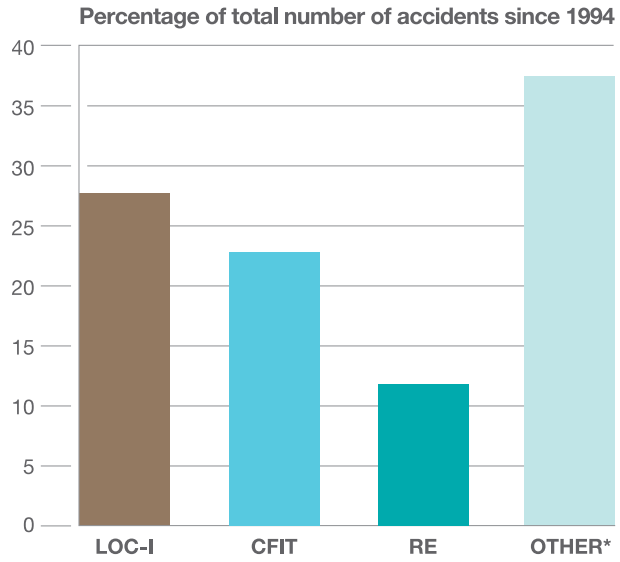
Definition of accident categories

- **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.

Distribution of accidents by accident category

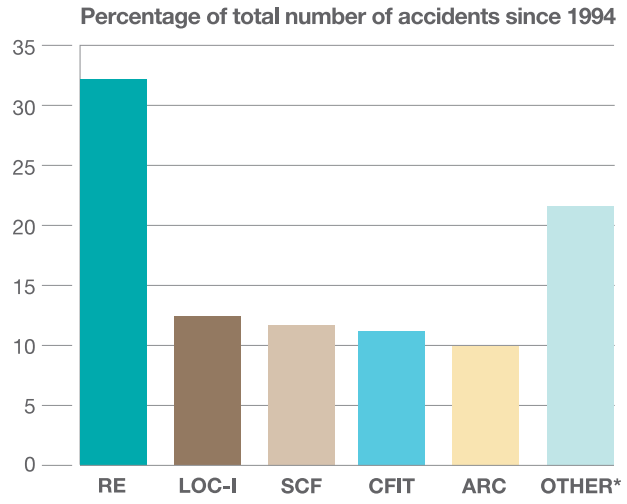
Three categories of accidents accounted for the majority of accidents

Fatal



*All the accident categories representing less than 10% of the accidents are clustered in the "OTHER" category.

Hull loss



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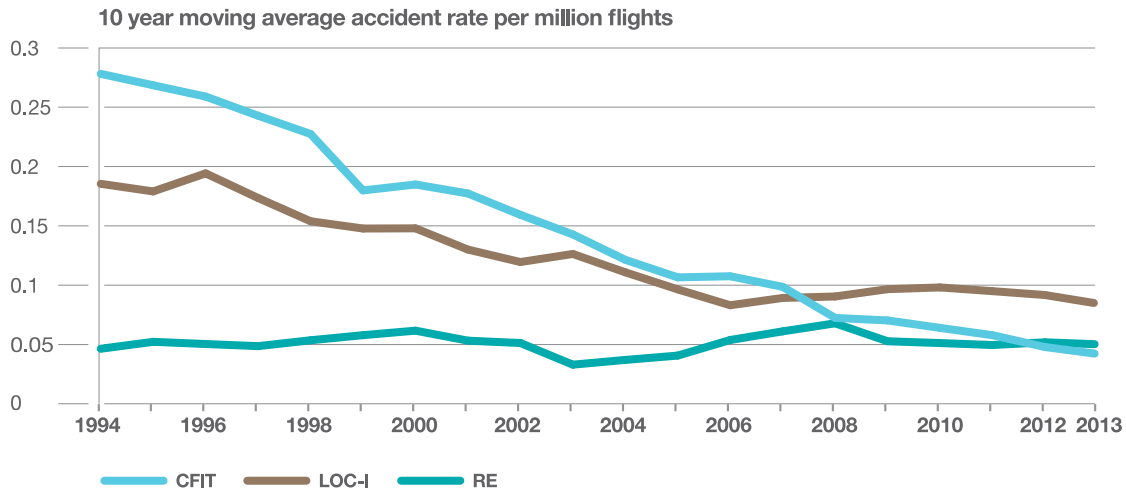
Fatal



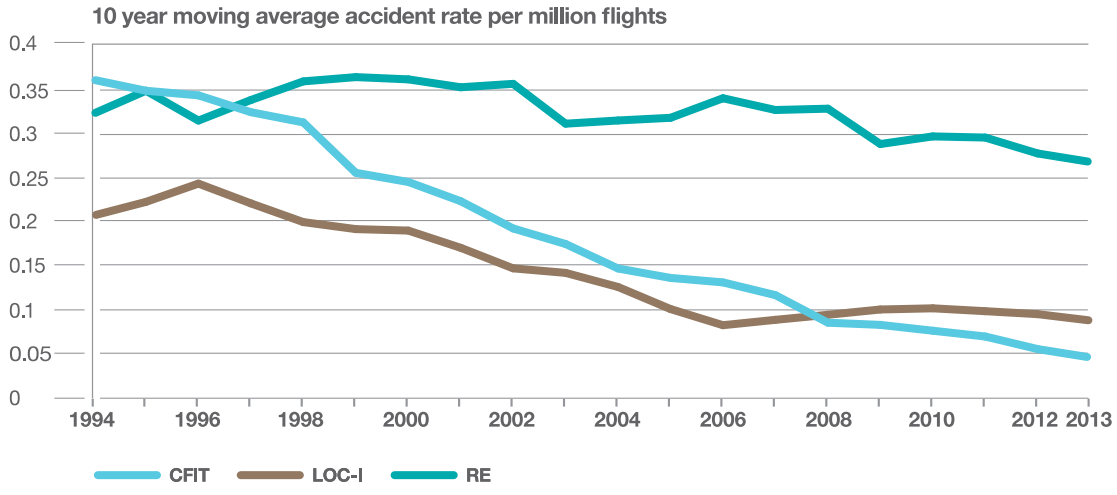
Evolution of the three main accident categories

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

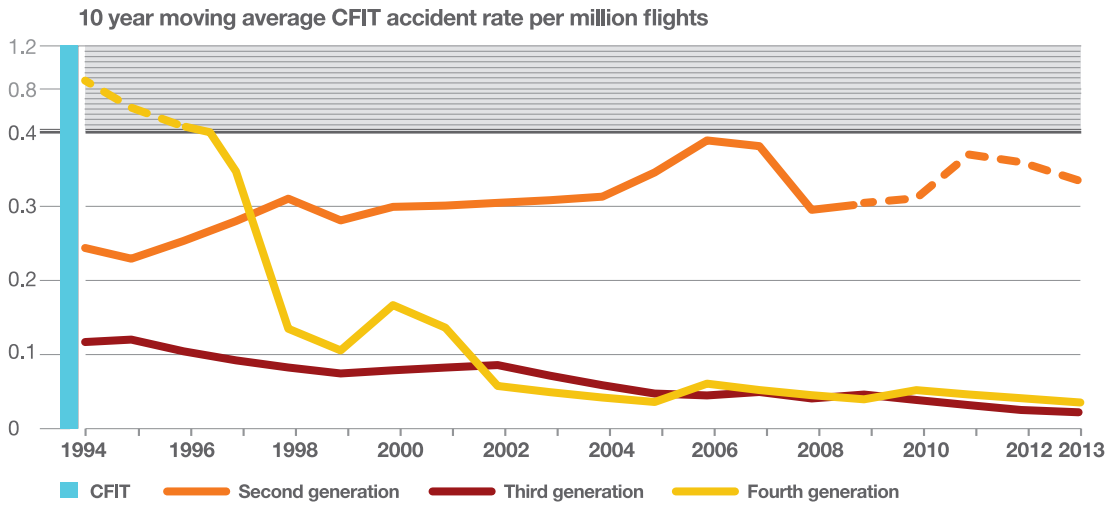
Behind the numbers

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



Fatal



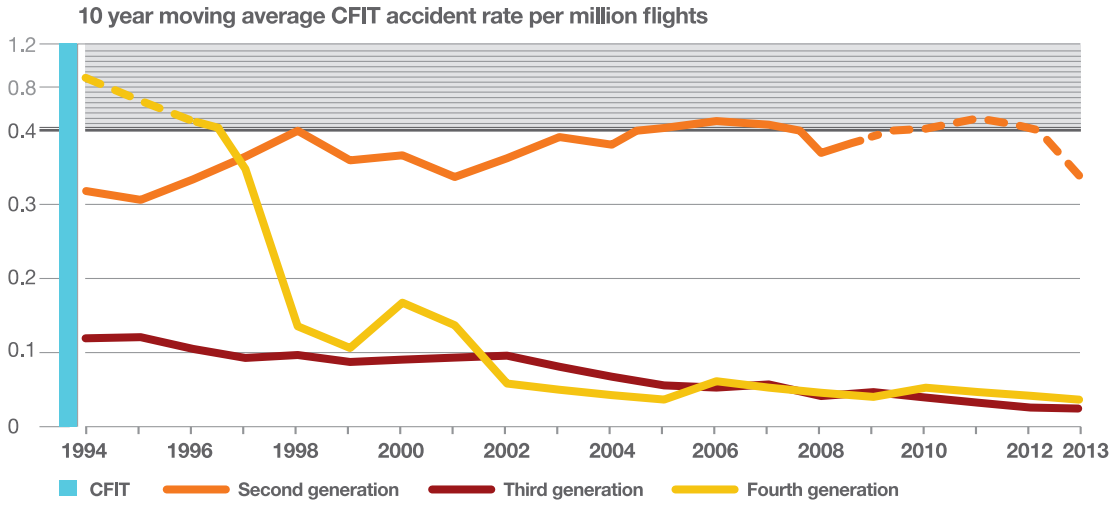
Behind the numbers

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.

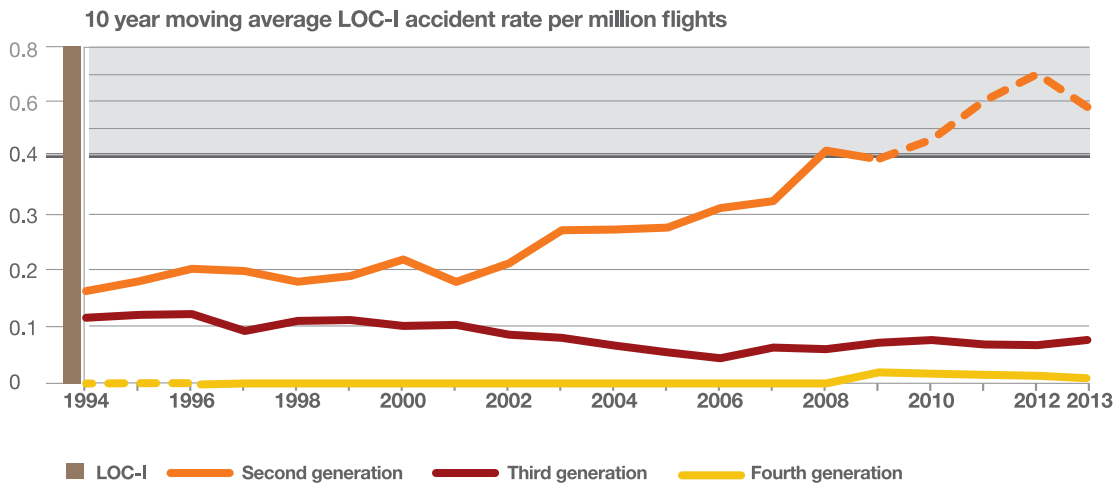
Controled Flight Into Terrain (CFIT) accident rates

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

Hull loss



Fatal

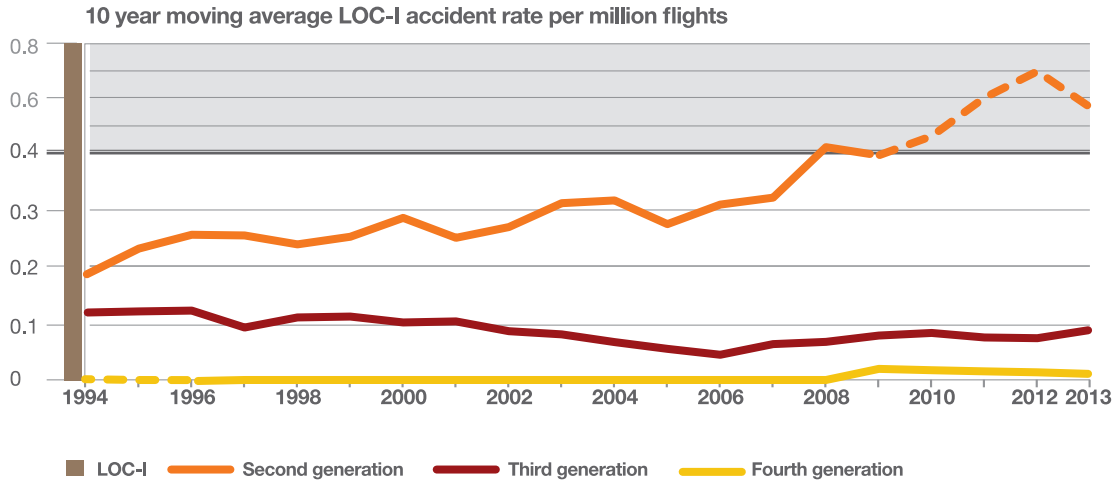


Loss Of Control In-flight (LOC-I) accident rates

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

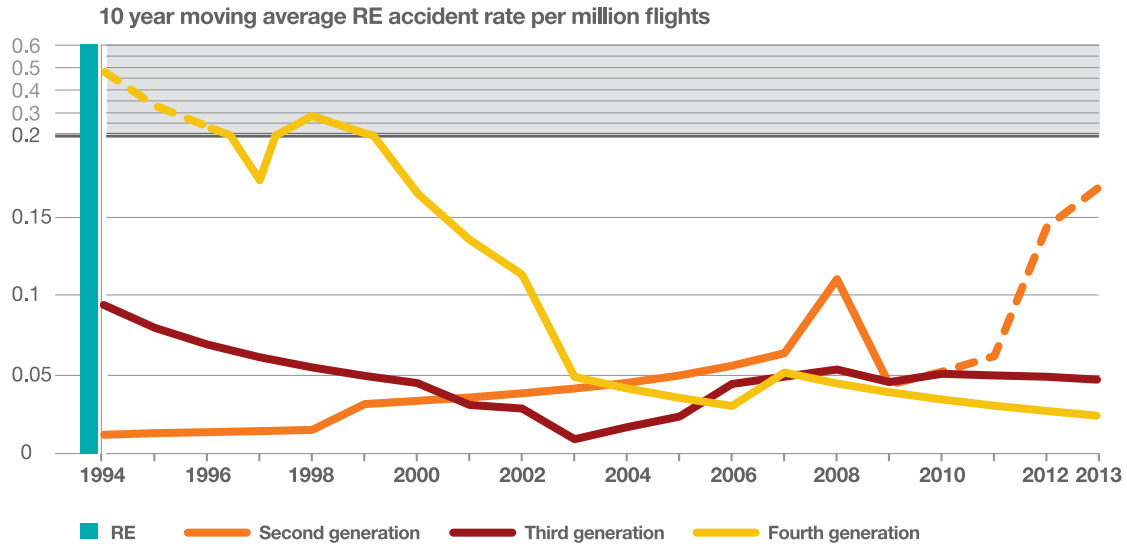
Behind the numbers

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

Fatal



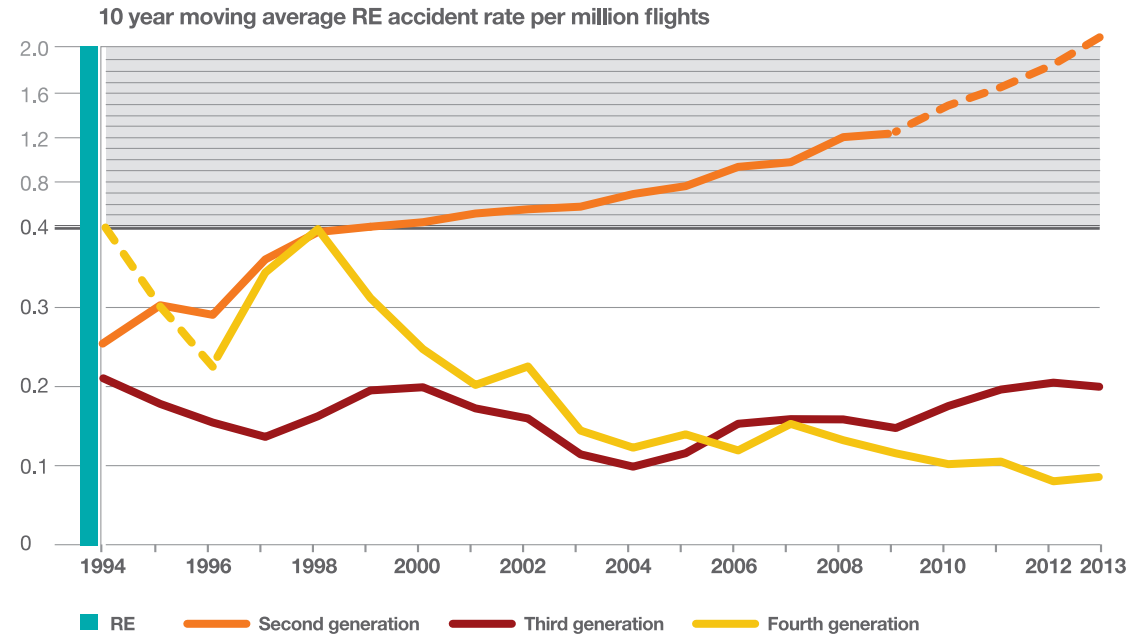
Behind the numbers

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



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