Proceedings of the 15th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2007
October 21-26, 2007, Miami, Florida, USA

AIRCRAFT ACCIDENT RATES

Rajesh Garg
Canadian Nuclear Safety Commission, Ottawa, Canada

Reinhard Menzel
European Aviation Safety Agency, Postfach 10 12 53, D-50452, Köln, Germany

ABSTRACT

The transport of radioactive materials occurs through various transportation modes such as air, sea, road and rail. The design and performance standards for all these transport modes have been same up until the IAEA Regulations for the Safe Transport of Radioactive Material were published in 1996. These regulations introduced a new more robust package type, named as “Type C” package, with enhanced design and performance standards required for shipments of large quantity of radioactivity material by air.

In 1998, the IAEA sponsored a coordinated research project (CRP) on *Accident Severity during Air Transport of Radioactive Material*, in order to investigate the effectiveness of the regulatory requirements for the air mode of transport. One of the tasks of this project was to collect and review the data on air accident rates for the purposes of analyzing the pertinent information on frequency and severity of air accidents related to the challenges of impact, fire and immersion posed to a package in severe air accidents. Aircraft accident data that were considered in the CRP are those involving commercial aircrafts which occurred from 1990 to 2000 with certified take-off weight more than 27,000 kg.

This paper presents the aircraft accident rates data used in the CRP and further updated to 2006, covering world wide operations for both passenger and cargo operations. The analysis presented in the paper is based on the accident data obtained from International Civil Aviation Organization (ICAO) Accident Incident Data Reporting (ADREP) system. The scope of the paper is broader than the CRP and covers aircraft with a maximum certified take-off weight greater than 2,250 kg that were either considered destroyed aircraft and/or were involved in fatal accidents that occurred until 2006. In order to factor the increase in aviation activities over the years, the data also gives the total number of departures in a particular year by regions and calculates the rate of destroyed aircraft (number of aircraft destroyed per 1 million flights), passenger fatality rate and rate of accidents with passenger fatalities for both passenger and cargo operations.

The paper shows that there has been an almost steady drop in air accidents over the years and consequently the assumptions made in the Air CRP about the rate of air accidents remain valid and conservative in respect to the updated information until the year 2006.

INTRODUCTION

The transport of radioactive materials occurs through various transportation modes such as air, sea, road and rail. The design and performance standards for all these modes of transport have been the same until the IAEA Regulations for the Safe Transport of Radioactive Material were published in 1996. These regulations introduced a new more robust package type, named as “Type C” package, with enhanced design and performance standards required for shipments of large quantities of radioactive material by air.

In 1998, the IAEA sponsored a coordinated research project (CRP) on *Accident Severity during Air Transport of Radioactive Material*, also known as Air CRP, in order to investigate the effectiveness of the regulatory requirements for the air mode of transport. One of the tasks of this project was to collect and review the data on air accident rates for the purposes of analyzing the pertinent information on frequency and severity of air accidents related to the challenges of impact, fire and immersion posed to a package in severe air accidents. Aircraft accident data that were considered in the CRP are those involving commercial aircraft which occurred primarily from 1990 to 2000 with certified take-off weight more than 27,000 kg.

This paper presents the aircraft accident rates data used in the CRP and further updated to 2006, covering world wide operations for both passenger and cargo operations. The analysis presented in the paper is based on the accident data obtained from the ICAO Accident Incident Data Reporting (ADREP) system. The scope of the paper is broader than the CRP and covers aircraft with a maximum certified take-off weight greater than 2,250 kg that were either considered destroyed aircraft and/or were involved in fatal accidents that occurred until 2006. In some cases, the accident data covers to year 2005, because complete information for Boeing manufactured aircraft for the year 2006 was not available. In order to factor the increase in aviation activities over the years, the data also gives the total number of departures in a particular year by regions and calculates the rate of destroyed aircraft (number of aircraft destroyed per 1 million flights), passenger fatality rate and rate of accidents with passenger fatalities for both passenger and cargo operations.

Although, for the purposes of the study of the Air CRP, it was more important to understand the accidents with destroyed aircraft rather than accidents with passenger fatalities, however, ICAO publishes the information on fatal accidents because it is readily available and there have been accidents in which it could not be conclusively resolved whether or not the aircraft was destroyed. The fatality data are provided in this paper to illustrate the overall improvement in aviation safety and to demonstrate that fatal accident rate is a good analogue for accidents involving aircraft destruction.

CLASSIFICATION OF AVIATION ACTIVITIES

This section describes various classifications of aviation activities used by the air industry to clarify the scope of aviation operation and types of aircraft covered by the Air CRP and in this paper.

There are two main classifications used to characterize the aviation activities: 1. Based on the type of operation carried out by the aircraft and 2. Based on the physical characteristics of the aircraft such as its size, type of propulsion and type of lift generating device.

The Chicago Convention on International Civil Aviation further classifies the aviation operations as:

1. Air transport operations, i.e., transport passengers, cargo or mail for hire or reward, state flights, such as military, police or coast guard operations; aerial work operations which include specialised application such as fire fighting, logging, aerial observations etc.; and,

2. General aviation operations which encompasses all the remaining operations such as flights conducted by flight training schools, demonstration flights and personal flights for pleasure and business.

Air transport operations can be further subdivided by the load carried into these operations as passenger operations and cargo operations. Another subdivision into scheduled, non-scheduled or other airline operations is also used.

Scheduled operations are those where the flights are carried out with regularity on specified routes. Most passenger flights fall into the category of scheduled operations.

There are primarily two types of aircraft used in air transport operations: Fixed wing aircraft and helicopters. Other categories, blimps, balloons, gyroplanes are also found in general aviation. The fixed wing aircraft may be further classified in accordance with the type of engine that they are powered with such as Turbofan, turbojet, turboprop and piston-prop.

The ICAO ADREP (the Accident Database Report) report uses the maximum certified take-off weight of aircraft for further subdivision. There are 5 weight categories as follows:

Category 1 aircraft are those that have certified take-off weight < 2,250 kg,
Category 2 aircraft are those that have certified take-off weight 2,251 kg to 5,700 kg,
Category 3 aircraft are those that have certified take-off weight 5,701 kg to 27,000 kg,
Category 4 aircraft are aircraft with a maximum certified take-off weight 27,001 kg to 272,000 kg, and;
Category 5 aircraft are those that have a maximum certified take-off weight greater than 272,000 kg.

There are many accidents in the weight category of light aircraft (0 to 2,250 kg), however, Category 1 aircraft accidents are not reportable to the ICAO ADREP system. Consequently, there is no international register of such accidents while for all others, Annex 13 to the Convention on International Civil Aviation requires the States to notify ICAO of an accident and to report accident data to the ICAO ADREP system once the investigation has been completed. As a result, ICAO has a database of large aircraft accidents worldwide. Data from this database were used to conduct the studies within the CRP and to develop this paper.

Most of the long range operations are carried out by turbo-fan powered fixed wing aircraft with a certified take off weight over 27,000 kg, i.e. aircraft in weight categories 4 and 5. Categories 2 and 3 are considered lighter aircraft while categories 4 and 5 are considered heavier aircraft. This is why the CRP's work focussed on categories 4 and 5 aircraft.

AIRCRAFT ACCIDENT DATA USED IN THE AIR CRP

The objective of the IAEA sponsored Air CRP included collection and analysis of relevant air accident data so that the accident forces to which a package of radioactive material might be subjected can be further quantified. The CRP members collected, reviewed, analysed and assessed the pertinent information on frequency and severity of air accidents against the Type C packaging requirements.

The CRP started by identifying over 5000 accidents involving all types of aircraft and aircraft operations from the preliminary review of worldwide aircraft accidents since the end of the Second World War. Given the time and resources available to this CRP, it was not possible to evaluate this large number of accidents to derive data pertinent to the objectives of the CRP, therefore, the CRP concentrated on identifying accidents that are representative of modern aircraft and involving the most severe accident environments. The data was obtained from the ICAO ADREP system for aircraft accidents.

Aircraft accidents that were considered for impact analysis were those that occurred from 1990 to 2000 and further limited to accidents that resulted in destruction of the aircraft. Aircraft accidents considered were those involving civilian commercial aircraft for two weight classes:

1) Aircraft with a maximum certified take-off weight between 27,001 kg and 272,000 kg; and,

2) Aircraft with a maximum certified take-off weight over 272,000 kg.

These weight ranges correspond to ICAO Category 4 and Category 5, respectively, as defined in the ICAO ADREP. Accidents involving large commercial aircraft were considered to result in the most severe accident environments since these types of aircraft are normally used in cargo operations, have operating envelopes in the upper velocity range, and carry large amounts of fuel. All types of fixed-wing aircraft were considered such as turbo-jet, turbo-prop and turbo-fan powered aircraft.

The number of potential high speed impact accidents was identified as 135 by applying the "coarse filter" to the approximately 350 accidents. The coarse filter was defined by using a normal impact velocity as defined in the Air CRP report of greater than 60 m/s. Accidents involving fatalities or serious injuries without related destruction of the aircraft were not considered. However, limiting the evaluation to high speed accidents also eliminates accidents involving fire and water immersion. In particular, other evaluations have shown that recorded fire duration varies inversely with impact velocity. Further, the available information for data concerning fire and water immersion was sparse and inaccurate and therefore all of the 53 aircraft

accidents that have occurred between 1990 and 2000 were considered. ADREP data further permit the categorization of aircraft accidents into accidents involving a single event, two events in sequence, three events in sequence and four or more events in sequence. The data provided the following six events associated with aircraft accidents which may have an impact on the package carried:

- Ground Impact;
- Impact in Flight / Collision;
- Post-impact Fire;
- No post-impact Fire;
- Explosion; and
- Water Immersion.

AIRCRAFT ACCIDENT RATES DATA USED IN THE AIR CRP

Although the IAEA Air CRP report used information for accident data from the ICAO ADREP, the source of information for the movement of the aircraft and aircraft accident rates in the Air CRP report is from the UK based organization Airclaims. Since the late 1980s, Airclaims has been collaborating with western aircraft manufacturers to collect data on all operational statistics and accidents involving western built turbine powered aircraft with a certified take-off weight of over 5700 kg. Accident data are also provided by Airclaims, but usually with much less detail. All accidents from Airclaims are also in ADREP, but not all accidents in ADREP are in Airclaims. Airclaims only covers occurrences with significant damage and may exclude those that had a serious injury but no aircraft damage. The only aircraft types for which comprehensive and reliable operational and accident statistics, by aircraft type, were available in this period are turbo-fan and turbo-jet powered aircraft made by western manufacturers and so the analysis was confined to these aircraft classes. The analysis reported gives accident rates for cargo and non cargo operations separately by geographical region, as well as the world wide frequencies. In the CRP report, for the purposes of accident rates:

- The data covered fatal accidents involving destroyed aircraft for all western jets in the period 1990 to 2000, inclusive.
- For each country and aircraft type, it gives the total departures for both cargo and passenger (i.e. non cargo) operations.
- The data did not make a distinction between variants of the same aircraft type.
- The aircraft types of interest were those with maximum certified take-off weight of 25,000 kg or more. Note that the accidents that were considered for impact and fire analysis by the CRP were categories 4 and 5; however, for analysis of the data for rate of accidents with destroyed aircraft, some variants of the aircraft Fokker F-28 with a certified take-off weight of 25,000 kg of which significant number exists were included.

Results of the Analysis of Accident Rates Data

The results of analysis of the accident rate data used in the Air CRP are summarized in the Table 1 below. The table provides the numbers of total loss fatal accidents per million flights for western built jet aircraft with maximum certified weight of greater than 25,000 kg for the period 1990 to 2000 inclusive. The results were presented by geographical region for passenger, cargo and for all commercial operations.

Table 1: Number of Total Loss Fatal Accidents involving western jet aircraft with certified take-off weight > 25,000 kg* for the period, 1990-2000

Airclaims Area	**Number of Accidents per million flights**		
	Passenger Operations	**Cargo Operations**	**All Commercial Operations****
Africa	2.80	9.12	3.26
Asia	1.22	7.81	1.42
Australasia	0.00	0.00	0.00
China	1.14	0.00	1.13
European JAA (Joint Aviation Authority)	0.23	0.00	0.23
Europe Non-JAA	1.99	20.88	2.28
North America & Caribbean	0.22	0.00	0.21
South & Central America	1.43	3.47	1.53
USA only	0.19	0.91	0.24
World Wide	0.57	1.93	0.64

* The data includes Fokker F-28 which falls under the category of 25,000 kg certified take-off weight. However, F-28 is no longer an aircraft used that often and is therefore not included in the updated information.

** All commercial operations include scheduled and non-scheduled revenue operations, Non-revenue operations such as ferry, training and "Others" such as air taxi, sightseeing and emergency medical services.

The accident rate analysis performed in the Air CRP indicated that the accident rates appear to vary according to:

- Geographical region,
- Type of operation, i.e., passenger and cargo; and,
- Aircraft size (with smaller aircraft appearing to suffer higher accident rates than larger aircraft).

However, aircraft accidents occur in an unpredictable manner and, as such, these accident rates could be influenced by statistical variation. In view of this, a confidence limit analysis was carried out assuming that the accident statistics conform to a Poisson probability distribution. (Poisson probability distribution is a conventional assumption for the statistical analysis of "rare" events). The results of this confidence analysis can be summarized as follows:

The world-wide accident rate for all operations for the period of 1990 to 2000 involving turbofan and turbojet powered aircraft built by western manufacturers and of a certified take-off weight exceeding 25,000 kg for total loss fatal accident is 0.64 per million flights. The accident rate for destroyed aircraft for the same period is approximately 0.8 per million flights (not shown in the table above). Total loss accident rate is higher than the total loss fatal accident rate because there is not necessarily a fatality in every accident in which the aircraft is written off.

The table also shows that the accident rates for passenger operations in Airclaims area USA and European JAA is significantly lower, at the 95% confidence level, than the world wide average for all operations. The accident rate for passenger operations for USA and JAA Operators is approximately 0.2 per million flights.

However, the following regions have significantly higher accident rates, at the 95% confidence level, than 0.2 per million flights:

South and Central America (passenger & cargo operations)
Asia (passenger & cargo operations)
Africa (passenger & cargo operations)
China (passenger operations)
Europe Non JAA (passenger & cargo operations)
USA (cargo operations)
World wide (cargo operations)

Table 2 updates the information provided in the Air CRP report and provides the information for the period 1996 to 2005. The data for 2006 are not included in Table 2 because the data for Boeing manufactured aircraft was incomplete. The new information reflects the current regulatory regime by using European Aviation Safety Agency (EASA) states instead of the European JAA states. The data uses the cut-off certified take-off weight as 27,000 kg instead of 25,000 kg used in the CRP report. Rates calculated in Table 2 are based on the number of flights reported as well as the number of fatal accidents involving destroyed aircraft but excluding acts of unlawful interference with civil aviation such as aircraft sabotaged, hijacked or shot down aircraft. In total, 78 related accidents were found for the years 1996-2005 out of which 63 accidents involved passenger operations and 15 accidents involved cargo operations.

Regions were assigned by the State of the operator. In Europe, a distinction is made grouping all States which are members of or associated with of the EASA versus all the remaining States. In addition to the rate for North America, the rate for the USA only is also calculated.

Table 2: Number of Total Loss Fatal Accidents involving Western jet aircraft with maximum capacity > 27,000 kg for the period, 1996-2005

Airclaims Area	**Number of Accidents per million flights**	
	Passenger Operations	**Cargo Operations**
Africa	2.89	7.80
Asia	0.76	3.18
Australasia	0.00	0.00
Europe-EASA (European Aviation Safety Agency)*	0.18	1.61
Europe Non-EASA	9.60	0.00
Europe Total	0.21	1.55
Latin America & Caribbean	1.15	7.51
Middle East	0.87	8.28
North America	0.08	0.47
USA only	0.08	0.49
World Wide	0.4	1.57
Combined Passenger and Cargo	0.46	

* The European Joint Aviation Authority (JAA) ceased to exist since 2003 and it has been replaced by the European Aviation Safety Agency (EASA). The number of EASA states has also changed from 27 to 31. The table uses as a base the states which are members of EASA.

Note that in the region of Middle East, there was only one accident over the ten year period in the cargo operations. However, because of the small number of movements, it had the worst accident rate of 8.3 per million departures for cargo operations over the ten year period from 1996-2005. Rates calculated on such a small number of accidents and a corresponding very small number of operations are not stable, nevertheless the numbers are presented to complete the information.

The accident rate for world-wide passenger operations is 0.4 per million flights and for world-wide cargo operations the accident rate is 1.57 per million flights. There is only a slight increase in the world-wide combined rate for passenger and for cargo operations from 0.4 to 0.46 because of the relatively small weight of cargo operations in terms of number of flights as well as the number of accidents in this calculation.

Table 2 also shows that for the category of aircraft considered, the total loss fatal accident rate world-wide has dropped from 0.64 per million flights in the period 1990 to 2000 (the number reported in the Air CRP) to 0.46 per million flights for the period 1996 to 2005.

Estimate of Accident Probabilities

The CRP report draws simplified conclusions from the databases of 336 aircraft accidents with category 4 and category 5 aircraft and shows (Figure 1) a crude and approximate event tree constructed from the accident data file and from data on aircraft accident rates. In effect, the probability of an air accident with the aircraft destroyed for scheduled flights is estimated as 8×10^{-7} per flight or 1 accident per 1.25 million flights.

By multiplying the overall aircraft accident probability with the aircraft destroyed of 8×10^{-7} per flight with the conditional probabilities given in the simplified event tree the respective probabilities of the final branches is calculated and are given in Figure 1, for example, a high speed ground impact involving no fire of any importance has a probability of 8×10^{-8} per flight.

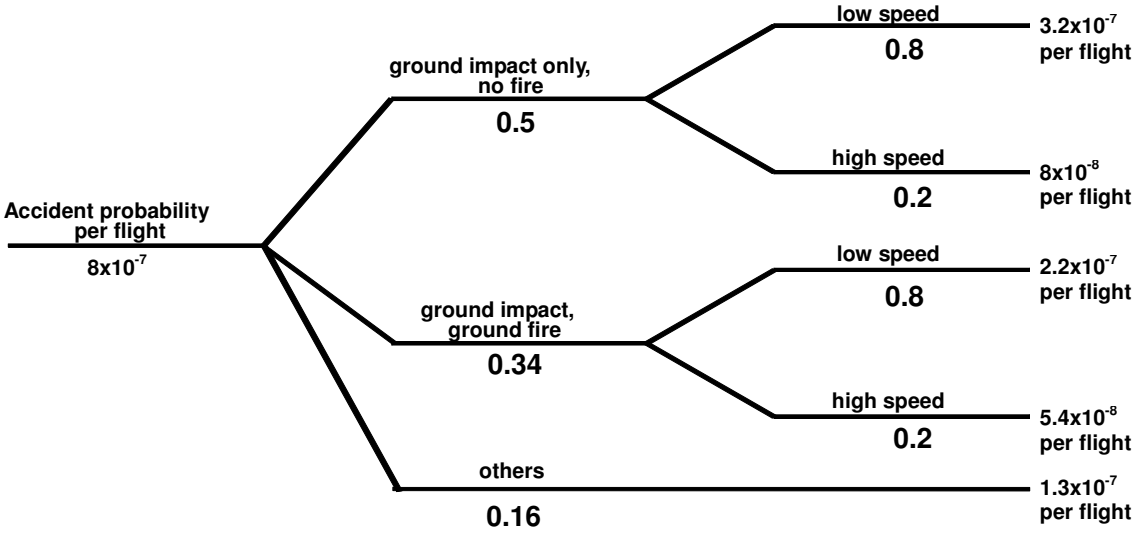

Figure 1 - Simplified event tree of aircraft accidents with destroyed aircraft – over 27, 000 kg (Ref.: Air CRP)

Probability of a package being subjected to an aircraft accident with high speed impact force

Assuming that a package carrying radioactive material is on board on all flights, the probability that the aircraft is involved in an accident where the aircraft is destroyed is 8×10^{-7} per flight (Figure 1). In most cases, the ground impact force will be of "low speed", the probability being about $3.2 \times 10^{-7} + 2.2 \times 10^{-7} = 5.4 \times 10^{-7}$ per flight. The probability of a "high speed" (defined in the Air CRP report as a velocity greater than 60 m/s normal to the ground) ground impact force is approximately $8 \times 10^{-8} + 5.4 \times 10^{-8} = 1.34 \times 10^{-7}$ per flight. The probability of a high speed ground impact force accident followed by fire is 5.4×10^{-8} per flight. In other words, the probability of a package being subjected to an aircraft accident with "high speed" impact force is about 1 per 7 million flights. Similarly, the probability of a package being subjected to an aircraft accident with "high speed" impact force followed by fire is about 1 per 18 million flights.

Probability of an aircraft accident carrying a package with large quantity of radioactive material

There are as yet no Type C packages being transported by air. Type B packages are allowed to carry up to 3000 A_1 or 100,000 A_2 whichever is lower when in special form and 3000 A_2 otherwise by air. By defining "large quantity" of radioactive material contained in a Type B package as an activity exceeding 1/10 of the above limits for Type B packages, the CRP report estimates that currently less than 1,000 such packages are transported by air annually.

The probability of an air accident with the aircraft destroyed for scheduled flights is estimated as 8×10^{-7} per flight (Figure 1). Therefore, the probability of 1000 such aircraft accidents with the aircraft destroyed can be calculated as 8×10^{-4} annually. In other words, assuming one such package with "large quantity" of radioactive material is on board per flight and 1,000 such packages are transported annually, the probability of an aircraft accident carrying such packages can be calculated as 8×10^{-4} annually or once every 1,250 years. This makes it evident that such an event is very rare for the current annual transport volume, which is not expected to increase much in the near future.

UPDATED ACCIDENT RATE INFORMATION

This section provides information on the number of accidents with aircraft destroyed and number of fatal accidents for both passenger and cargo operations. The data also gives the total number of departures in a particular year by regions and rate of destroyed aircraft (number of aircraft destroyed per 1 million flights), passenger fatality rate and rate of accidents with passenger fatalities for both passenger and cargo operations. The data covers aircraft with a maximum certified take-off weight greater than 2,250 kg and with fatal accidents and/or with destroyed aircraft that occurred until 2006. The data and the analysis presented in the following figures is based on the accident data obtained from the ICAO ADREP system and are based on information reported by States to ICAO as well as by industry sources.

Figure 2 provides the number of accidents with destroyed category 2 and category 3 aircraft during the period 1987 to 2006. ICAO does not collect any data regarding accidents to aircraft of a certified take-off weight below 2,250 kg.

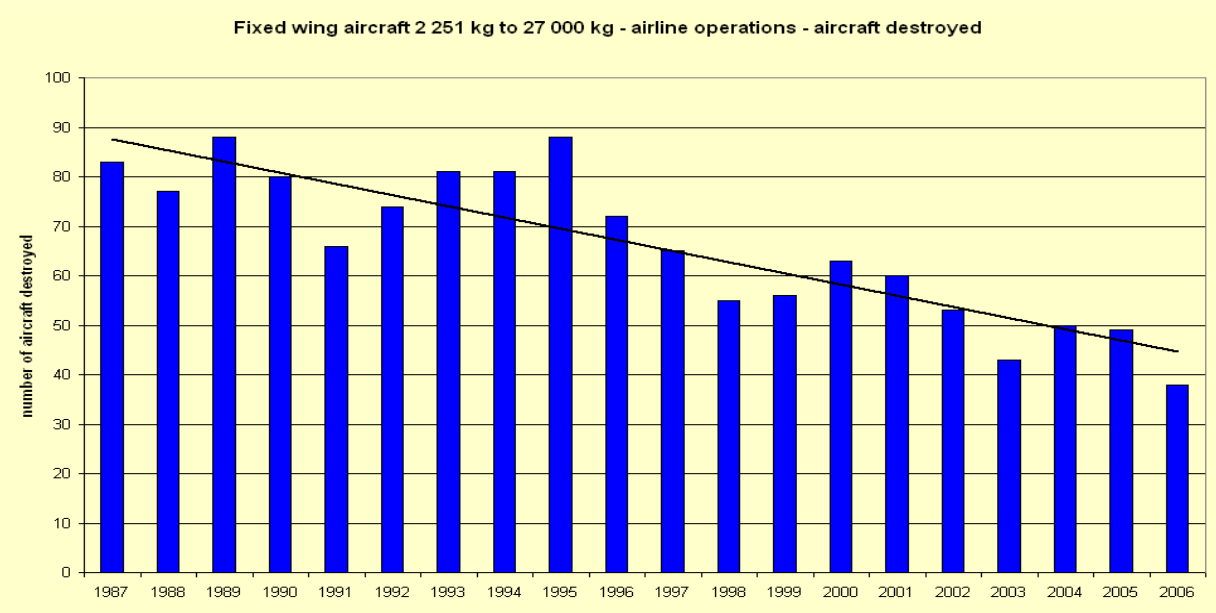

Figure 2 - Number of aircraft destroyed - 2,251 kg to 27,000 kg

Figure 3 provides the number of accidents with destroyed category 4 and category 5 aircraft during the period 1987 to 2006.

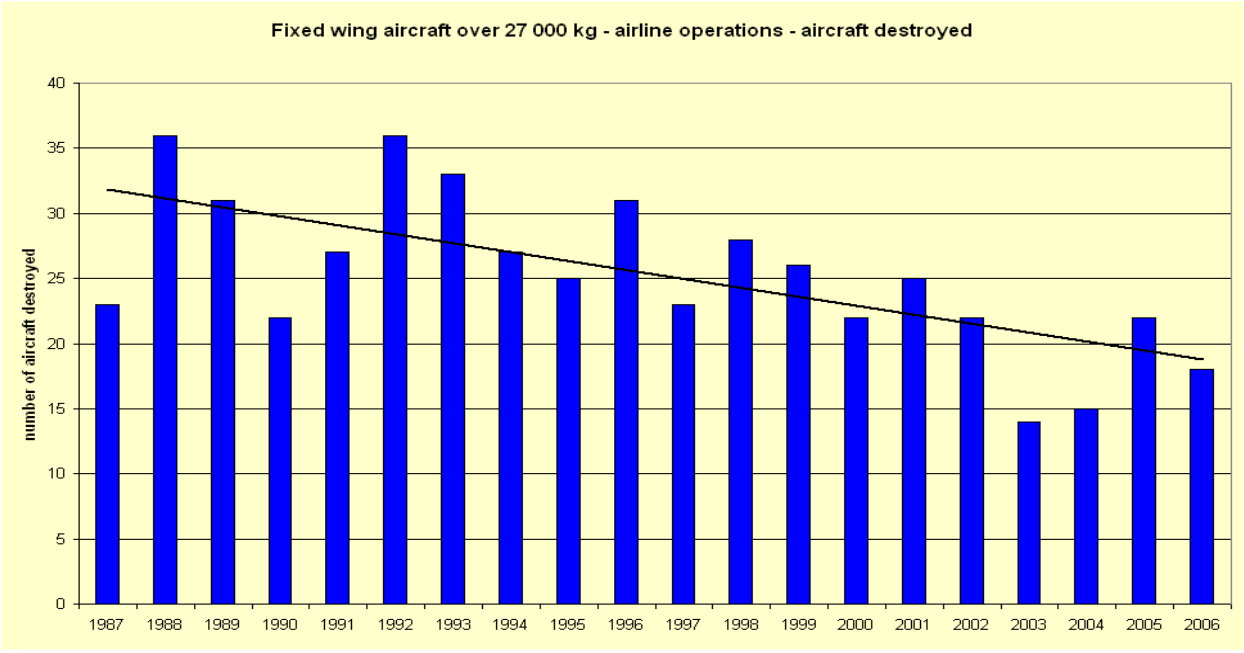

Figure 3 - Number of aircraft destroyed - over 27,000 kg

From Figures 2 and 3, it can be seen that the number of accidents involving small aircraft is larger than the accidents for larger aircraft. However, the number of accidents with aircraft destroyed has been declining. The graphs show that the number of fixed wing aircraft destroyed between 1987 and 2006 has dropped by almost 50%.

Figure 4 provides information on the total number of departures for the years 1990 to 2006 for scheduled operations. For all scheduled operations, the increase in the number of departures is about 31% for the period 1996 to 2006.

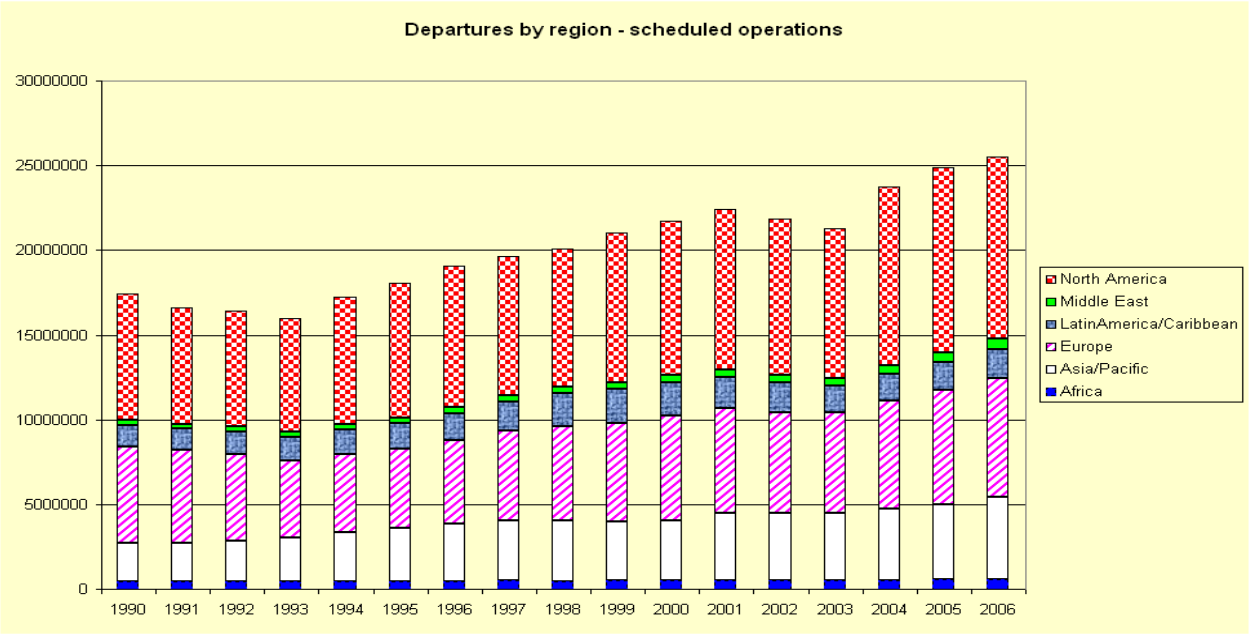

Figure 4 - Number of departures by regions - scheduled operations

Figure 5 provides the world-wide rate of aircraft destroyed per 1 million flights for fixed wing aircraft in scheduled operations during the period 1990 to 2006. Due to the reduction of the number of accidents over the ten year period (1996 to 2006) and the increase in the number of operations, the rate of accidents with aircraft destroyed dropped from about 1.9 per million departures in 1996 to about 0.75 in 2006. In fact, since 1999, the rate has stayed at or below 1.5.

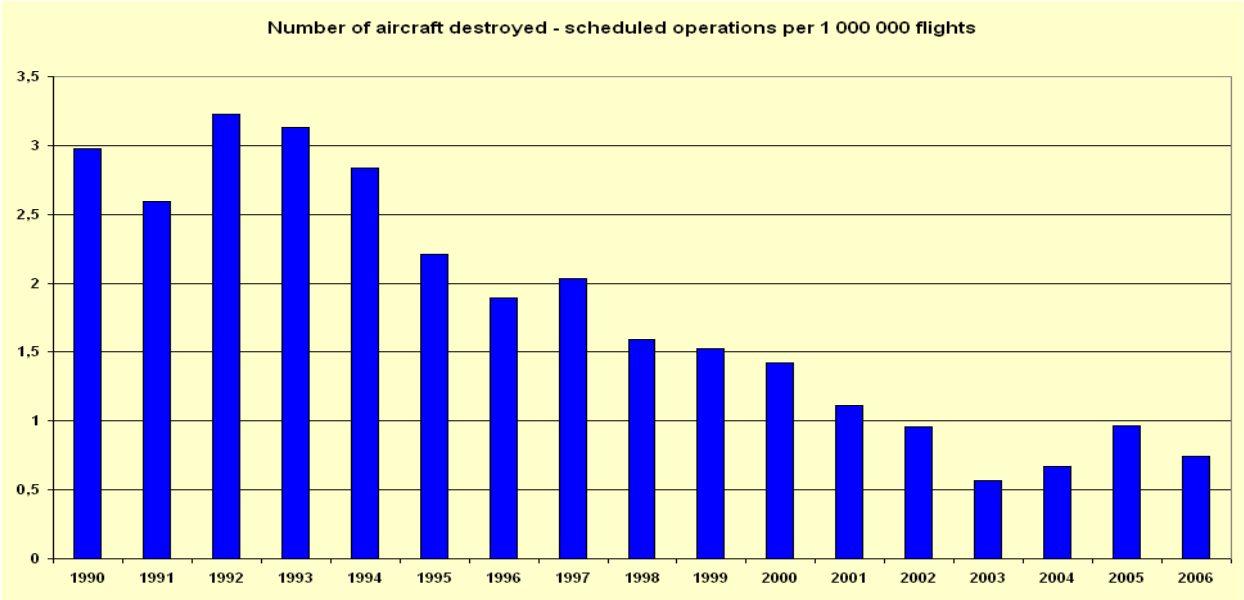

Figure 5 - Number of aircraft destroyed - scheduled operations, per 1 million flights

Figure 6 provides the rate of aircraft destroyed per 1 million flights for western jets over 27,000 kg during the period 1995 to 2005. Due to the reduction of the number of accidents over the ten year period and the increase in the number of operations, the rate of fatal accidents dropped from about 0.9 per million departures in 1995 to about 0.4 in 2004 but then increased to about 0.6 in 2005. Data for the year 2006 could not be provided as the data for Boeing manufactured aircraft for 2006 was incomplete.

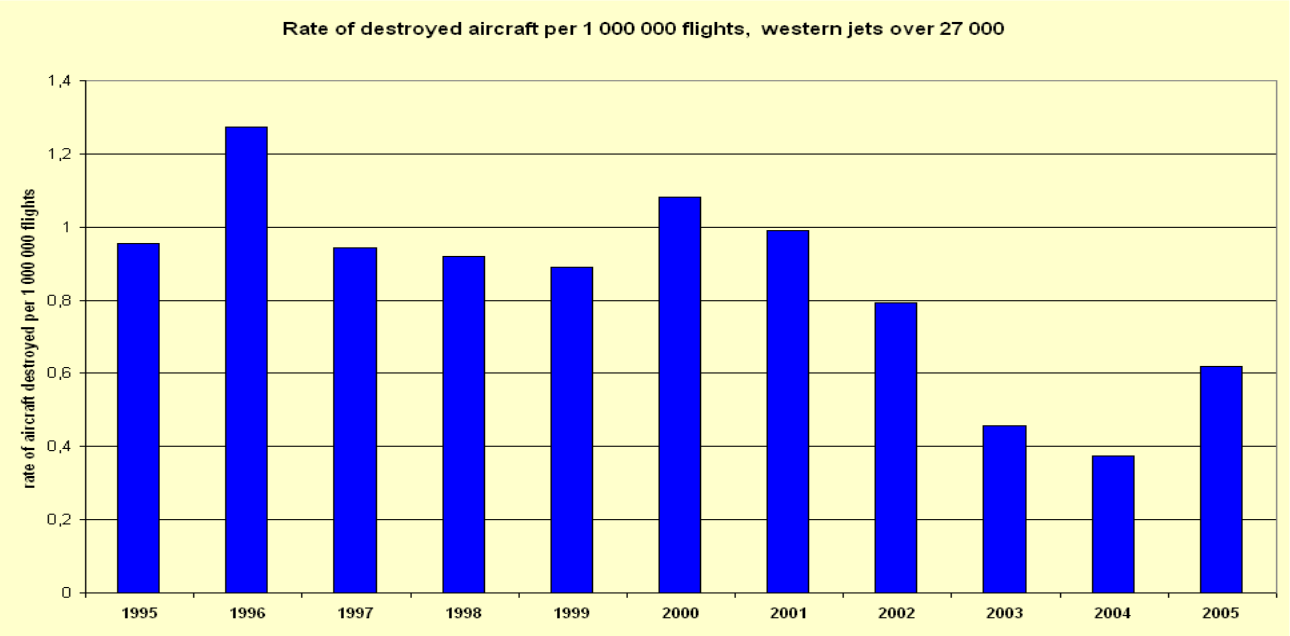

Figure 6 - Rate of aircraft destroyed – Western jets over 27,000 kg, per 1 million flights

Figure 7 shows the number of accidents with destroyed aircraft in passenger and cargo operations. It indicates that the number of aircraft destroyed in passenger operation dropped by about 50% over the ten year period of 1996 to 2006 while the number of aircraft destroyed in cargo operations remained almost the same.

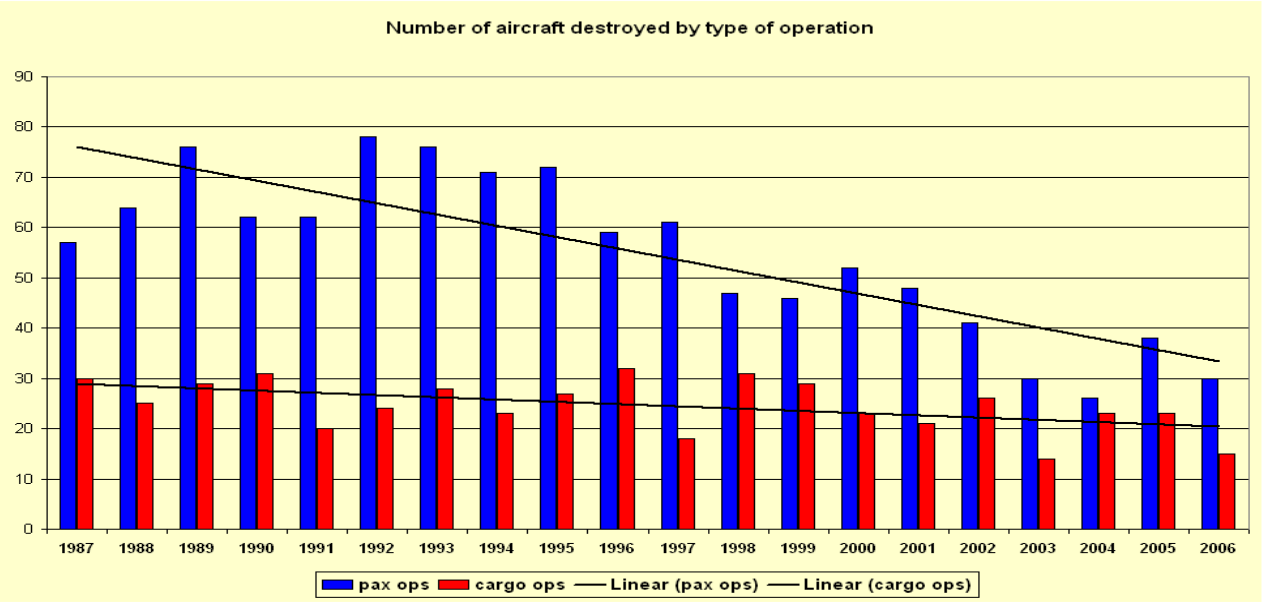

Figure 7 - Number of aircraft destroyed – Passenger and Cargo Operations

Figures 8, 9 and 10 provide information on the fatal accidents and rate of changes of the fatal accidents and the fatality rates over the years. Although, for the purposes of the study in the Air CRP, it is more important to understand the accidents with aircraft destruction instead of accidents with fatalities, ICAO publishes the information on fatal accidents because it is readily available and there have been accidents in which it could not be conclusively resolved whether or not the aircraft was destroyed. The fatality data are provided in this paper to illustrate the overall improvement in aviation safety and to demonstrate that fatal accident rate is a good analogue for accidents involving aircraft destruction.

Figure 8 provides information on the number of fatal accidents in passenger operations and the number of fatal accidents in cargo operations for the period 1997 to 2006. The figure shows that the number of accidents with fatalities in passenger operation dropped by about 50% over the period of 1997 to 2006 while the number of accidents with fatalities in cargo operations remained almost the same over the same time period which is consistent with the trend for the destroyed aircraft. The figure also shows that the number of fatal accidents in cargo operations surpassed the number of fatal accidents in passenger operations for the first time in 2004.

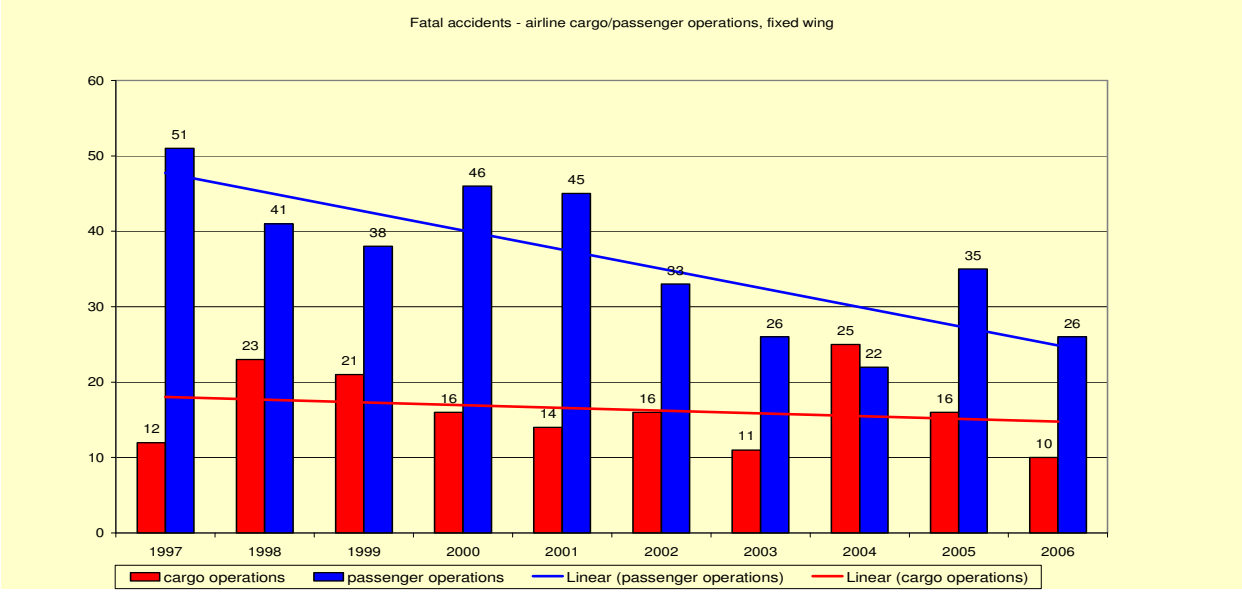

Figure 8 - Number of Fatal Accidents in Passenger and Cargo Operations, 1997 – 2006

Figure 9 provides information on the passenger fatalities rate based on passenger miles flown from 1945 to 2006 as reported in the annual report of the council of ICAO. It can be seen from the figure that the passenger fatality rate has significantly dropped over the years.

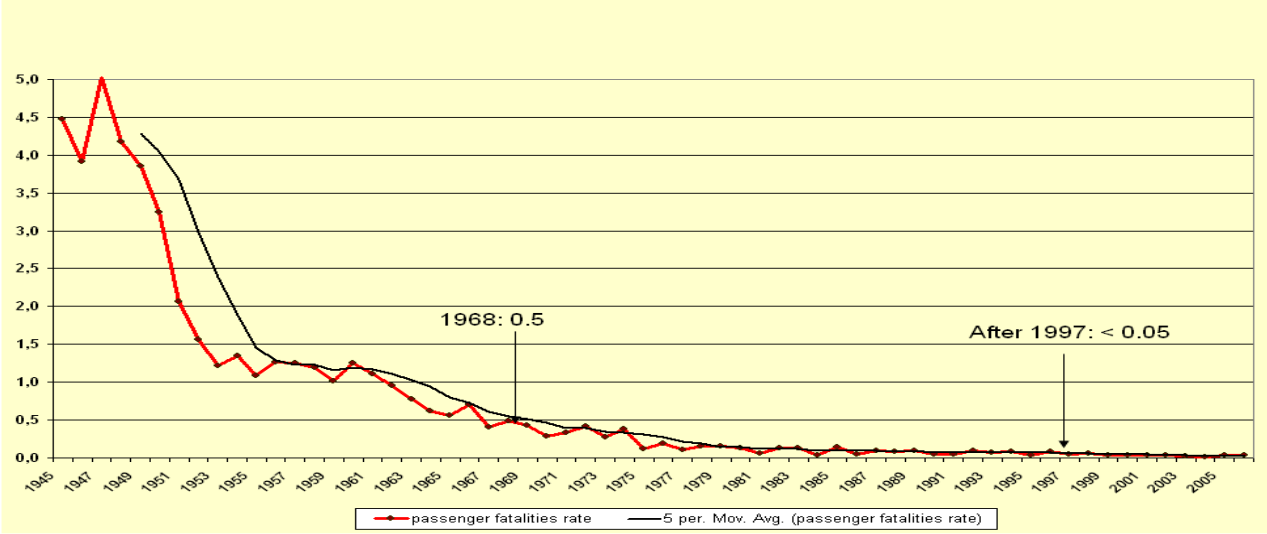

Figure 9 - Passenger Fatalities Rate from 1945 to 2006

Figure 10 provides information on the rate of accidents with passenger fatalities based on 100,000 departures (flights) in scheduled operations from 1987 to 2006. It can be seen from the figure that the rate of accidents with passenger fatalities in scheduled operations has significantly dropped over the years. However, there has been some increase in the rate of accidents with passenger fatalities since 2003.

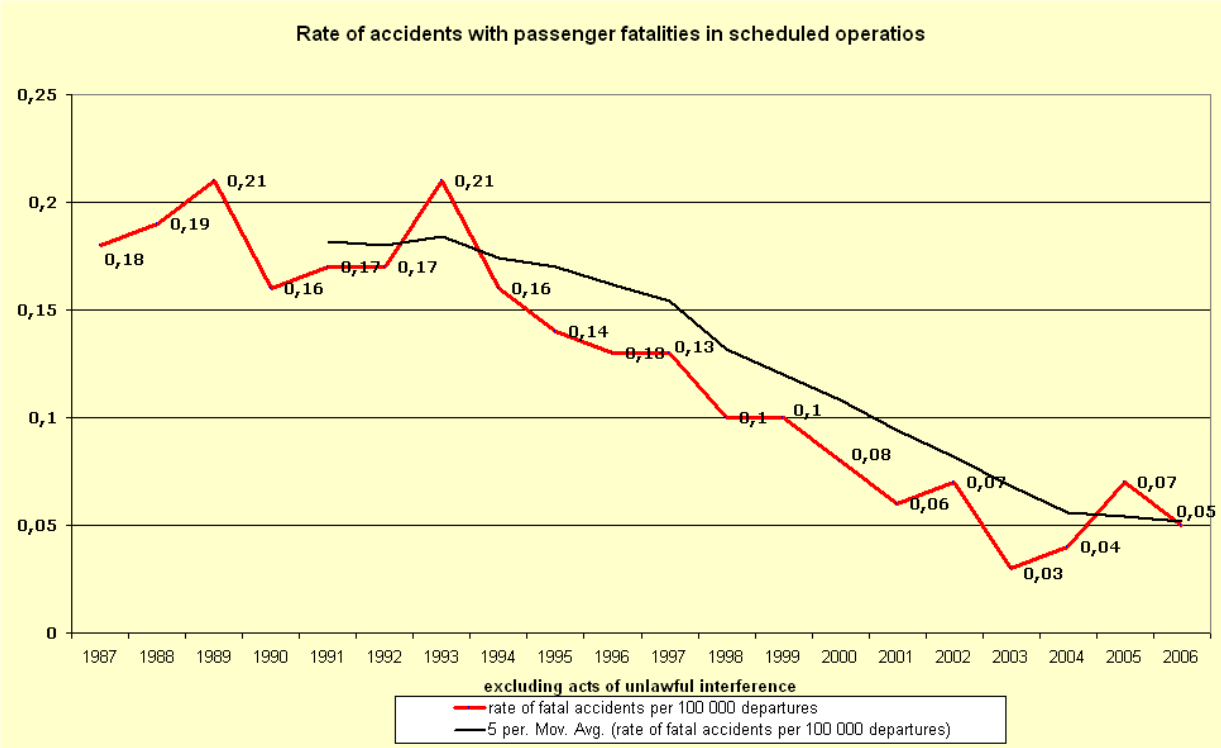

Figure 10 - Rate of Accidents with Passenger Fatalities - Scheduled Operations

CONCLUSIONS

The following can be concluded from the above figures:

1. Assuming that a package carrying radioactive material is on board on all flights, the Air CRP estimated that the probability that the aircraft is in an accident where aircraft is destroyed is 8×10^{-7} per flight or 1 per 1.25 million flights (Figure 1).

2. The probability of a package being subjected to an aircraft accident with "high speed" (>60 m/s) impact force is about 1 per 7 million flights. Similarly, the probability of a package being subjected to an aircraft accident with "high speed" impact force followed by a fire is about 1 per 18 million flights (Figure 1).

3. Assuming 1,000 packages are transported annually worldwide carrying a "large quantity" of radioactive material and that one such package is on board per flight, the probability of an aircraft accident carrying such packages is estimated as 8×10^{-4} annually or once every 1,250 years (Figure 1). Note that the "Large quantity" of radioactive material is defined in the Air CRP report as an activity exceeding 1/10 of the Type B package limits for air transport. Type B packages are allowed to carry up to 3000 A_1 or 100,000 A_2 whichever is lower when in special form and 3000 A_2 otherwise by air.

4. For the category of aircraft considered, the trend for the total loss fatal accident rate worldwide shows a decrease from 0.64 per million flights in the period 1990 to 2000 (the number reported in the Air CRP, Table 1) to 0.46 per million flights for the period 1996 to 2005 (Table 2).

5. Number of accidents with aircraft destroyed involving smaller aircraft is larger than the number of accidents for larger aircraft. However, the number of accidents with aircraft destroyed has been declining. The graphs show that the number of fixed wing aircraft destroyed from 1987 to 2006 has declined by almost 50% (Figures 2 and 3).

6. In the course of the period 1996 to 2006, the aircraft traffic (number of departures) for all scheduled operations has increased by approximately 31% (Figure 4).

7. There has been a reduction in the annual number of aircraft destroyed over the ten year period of 1996 to 2006 while there has been an increase in the number of scheduled operations. The rate of accidents with aircraft destroyed in scheduled operations dropped from about 1.9 per million departures in 1996 to about 0.75 per million departures in 2006 or a drop of more than 60% (Figure 5). The rate of accidents with aircraft destroyed dropped for western jets over 27,000 kg from about 1.2 per million departures in 1996 to about 0.6 in 2005 which is about a 50% drop (Figure 6).

8. The number of aircraft destroyed in passenger operations annually dropped by about 50% over the ten year period of 1996 to 2006 while the number of aircraft destroyed in cargo operations annually remained almost the same in the same time period (Figure 7).

9. The number of accidents with fatalities in passenger operation dropped by about 50% over the period of 1997 to 2006 while the number of accidents with fatalities in cargo operations remained almost the same in the same time period which is consistent with the trend for the destroyed aircraft (Figure 8). Based on the information, it would appear that there has been some improvement in respect to the safety of operations; however, the improvements are mostly noted in passenger operations while it appears that neither improvement, nor any deterioration in the safety of cargo operation could be demonstrated.

10. The passenger fatality rate has significantly dropped over the years from 1945 to 2006 (Figure 9).

11. The rate of accidents with passenger fatalities in scheduled operations has significantly dropped over the years from 1987 to 2006 (Figure 10).

12. The general conclusion drawn is that there has been an almost steady drop in air accidents over the years and consequently the assumptions made in the Air CRP about the rate of air accidents remain valid and conservative in respect to the updated information until the year 2006.