

provisional issue

NLR-TP-2000-210



An analysis of the safety performance of air cargo operators

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This investigation has been carried out under a contract awarded by the Netherlands Directorate-General of Civil Aviation (RLD), contract number LI/99.121/2. The RLD has granted NLR permission to publish this report.

Parts of this report are based on a presentation held at the 12th Annual European Aviation Safety Seminar, March 6 - 8, 2000.

Division: Air Transport

Issued: March 2000

Classification of title: unclassified



Summary

Previous research has suggested that cargo operators suffer a disproportionately high number of accidents. The degree of unsafety could however not properly be quantified due to lack of data. The objective of the underlying study was to quantify the safety record of different categories of cargo operators by calculating the accident rate, i.e. the number of accidents per million flights. Flight cycle data of Western-built jet- and turboprop aircraft was combined with aircraft ownership data to calculate the number of flights for different operator/aircraft combinations. This was subsequently combined with accident data to calculate accident rates.

There are a number of differences between passenger and cargo operations. The average age of cargo aircraft typically is twice as high as the age of a passenger aircraft. Most cargo operations take place at night, while for passenger operations the number of night-time operations is only around 20% of the total number of movements. The analysis shows that especially the group of cargo operators that conduct flights on a non-scheduled base (so called ad-hoc cargo operators) have a particularly high risk profile. The accident rate of these ad-hoc cargo operators is almost seven times higher compared with scheduled passenger traffic of major operators. Asia, South America and especially Africa are the problem areas with respect to safety of air cargo operations. African cargo operations are dramatically unsafe with almost 17 accidents per million flights. The difference in the level of safety between cargo and passenger operations is most noteworthy in Africa, North America and South America. In North America, the accident rate of ad-hoc cargo operators is 2 times higher compared with major cargo operators.

The very sparse information that is available on Russian built jet aircraft indicates an accident rate for cargo flights that is twice as high as that for passenger flights. The level of safety of Russian built cargo aircraft is expected to deteriorate further because the disintegration of Aeroflot resulted in the breakdown of the existing way in which training, maintenance and logistics was organised. While Russian built aircraft are well-designed, continuous airworthiness has always been a problem due to the lack of a proper maintenance concept. These problems are now aggravated because of the lack of spare parts.

Results of this study indicate that, in Africa, cargo-operations by state-owned operations are two times less safe than cargo operations by private airlines. No hard evidence of the causal factors of this difference could be found, but there are indications that corruption, favouritism, and lack of motivation play a role.



When a comparison is made between types of accidents of cargo and passenger operators, there are no significant differences in the relative distribution. This suggests that the higher accident rate of cargo operators can not be attributed to a single cause. The study shows that cargo accidents do occur more frequently in the take-off and climb phases of flight than passenger accidents.

There is a decreasing accident rate for aircraft of a newer generation for both passenger and cargo aircraft.

The Aviation Authorities in Europe have agreed to perform inspections (ramp checks) on foreign aircraft under the Safety Assessment of Foreign Aircraft (SAFA) program. During the SAFA ramp checks compliance with specific International Civil Aviation Organization (ICAO) requirements are checked. Results of SAFA inspections show that ad-hoc cargo operators are more often non-compliant with ICAO regulations than other operators. The majority of these findings were observed on aircraft of Russian design.

The study concludes that the main cause for the lower safety level of cargo operators from the developing countries is lack of financial resources. The best solution for continuous and long lasting improvements in aviation safety is achieved through a proper functioning of the National Aviation Authority (NAA). Efforts should be aimed at strengthening the NAAs.



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Abbreviations and acronyms

ACAS	Aircraft Analytical System
ADREP	Accident /incident Data Reporting system
ATM	Air Traffic Management
CAA	Civil Aviation Authority
CG	Centre of Gravity
CIS	Commonwealth of Independent States
ECAC	European Civil Aviation Conference
GDP	Gross Domestic Product
ICAO	International Civil Aviation Organization
JAA	Joint Aviation Authorities
MTOW	Maximum Take-Off Weight
NAA	National Aviation Authority
NASA	National Aeronautics and Space Administration
NLR	Nationaal Lucht- en Ruimtevaart Laboratorium
NTSB	National Transportation Safety Board
RLD	RijksLuchtvaartDienst
SAFA	Safety Assessment of Foreign Aircraft



1 Introduction

A previous joint NLR/RLD/CAA study identified that air cargo operators suffer a disproportional number of fatal accidents [Ref. 1]. Because of the limited scope of this previous study, it was not possible to quantify the degree of unsafety of different categories of cargo operations. This would require the calculation of an accident rate, i.e. the accident probability per flight or the accident probability per flight hour. Calculation of the accident rate requires reliable information on the total number of flights conducted. However, many flights conducted by cargo operators are non-scheduled, and it is very difficult to obtain reliable information on the number of non-scheduled flights that take place around the globe. An innovative approach, based on using flight cycle information of individual aircraft, was necessary to accurately determine the number of unscheduled flights that are being conducted.

While the cargo operators represent only a small portion of the global aviation industry, the impact on the safety record is believed to be significant. There is a need to quantify the accident rate of cargo operators. The factors that govern this accident rate need to be determined. Cargo operators should be given recommendations on how to improve the safety of their operations, while national and international aviation authorities need guidelines for possible regulatory activities (inspections, regulation, etc) that should be employed.

The present study therefore focussed on the quantification of the accident rate of different categories of cargo operations and the factors that influence safety of air cargo operations.

This study was initiated as a joint effort by the National Aerospace Laboratory NLR in the Netherlands and the Directorate General of Civil Aviation (RLD) of the Netherlands.

The central research question of this study was to calculate the accident rate for different categories of cargo operators, and to identify the factors that govern the safety of cargo operators. A second objective was to investigate whether results of inspections on foreign aircraft (ramp checks), conducted according to the Safety Assessment of Foreign Aircraft (SAFA) program of the Joint Aviation Authorities (JAA), can provide additional insight in the causes of the relatively high accident rate of air cargo operations.



2 Characteristics of cargo operations

2.1 Definitions

Cargo operations, for the purpose of this study, are those where no fare-paying passengers are carried and the flight is essentially for the purpose of carrying cargo (including mail). Passenger operations, for the purpose of this study, are those where the flight is conducted with an aircraft that is primarily fitted for the transportation of fare-paying passengers, i.e. the upper half of the aircraft fuselage does not contain any significant cargo area. Generally, some cargo will be carried in the lower half of the aircraft fuselage. Combi-flights are defined as those flights that are conducted with an aircraft of which the passenger cabin is partially fitted for the purpose of carrying cargo, and partially fitted for the purpose of carrying fare-paying passengers.

In this study, combi-flights are excluded from the analyses. The primary reason for exclusion is the relatively small number of combi-flights (less than 1% of all scheduled flights) when compared with cargo and passenger flights. This small sample size could potentially introduce problems with reliability of numbers.

2.2 Safety related characteristics of cargo operations

The comments below have been obtained from persons experienced in the field of freight/cargo operations. They are views built up over many years.

These comments are unlikely to apply to the major global scheduled cargo operators. They are more likely to apply to the smaller ad-hoc type non-scheduled cargo operator flying old converted cargo aircraft.

- Many world-wide cargo operations are at night and there is no doubt that all ground and flight crew and controllers are, in general, less alert in the early hours than during day-light hours. The high percentage of night-time operations is one of the reasons why turnover in personnel is relatively high. Young pilots often use the cargo business and the commuter passenger business to log the flight hours that are necessary for entry into the world of the big flag carriers. Older pilots, who have retired from the big operators (e.g. for reasons of age) sometimes find employment at cargo operators, where they spend an additional five years in service. This can lead to flight crews with very large differences in age between captain and co-pilot, which could be a problem as far as Crew Resource Management (CRM) is concerned (e.g. dominant behaviour).
- A noticeable problem for these cargo operators is their use of older aircraft - aircraft that have been withdrawn from use for the carriage of passengers for some time. Few, if any, of



the ad-hoc type operators use modern dedicated cargo aircraft with glass cockpits, modern performance and systems capability.

- When aircraft become freighters, some safety equipment may be removed. For example, on some old turboprop freighters, the autopilots may have been removed. Older aircraft are more likely to have exemptions from new, costly safety systems, such as Traffic Alert and Collision Avoidance Systems, high spec Flight Data Recorders and Cockpit Voice Recorders. Other new design features will not be incorporated because of 'grandfather rights', which allows certification according to older standards. In many cases this may be perfectly reasonable, but in some cases it is not.
- Old aircraft can also mean poorer internal lighting, cabin heating and crew facilities as well as old safety equipment and poor evacuation facilities. Access to the full length of the cabin may also be very limited owing to the size, shape and location of the cargo. Fire detection and suppression systems may be limited in their capability.
- Operations may be made into aerodromes where there are limited aerodrome fire fighting services, because this may be determined by the number of passengers being handled by the aerodrome, or the aerodrome may be military or used out of normal hours.
- Cargo facilities at airports are typically remote from the passenger facilities. Access to and from the aircraft are not generally as good for aircraft occupants and rest and refreshment facilities for them may not be as good as at a passenger terminal. This can have an impact on the comfort of flight crews during lengthy turnarounds. Facilities for crews may be primitive, cold, poorly illuminated and not conducive to adequate pre-flight crew briefings.
- Commercial pressures can be evident. Cargo can arrive hours late but crews are still expected to deliver on time and they may therefore infringe their legal duty hours. This may also lead to rushed procedures, e.g. to depart before night take-off curfews.
- Training standards are probably comparable with those for passenger operations. However, cargo operators have a much higher turnover of flight crews. This may be because cargo operations are often to diverse, unfamiliar and unattractive destinations which may be less appealing to pilots in the longer term than passenger operations.

Hazards that are specific for cargo operations are centre of gravity (CG) location out of limits and shifting cargo. Several accidents have occurred in the past where failures made during cargo loading resulted in either a CG that was not within limits, or cargo that was not properly



restrained, which caused a dangerous CG shift while manoeuvring in flight. The entire sequence of cargo loading operations, from preparation of the pallets/containers through the information provided to flight crews, has a direct effect on safety. In many cases, the flight crew, while being ultimately responsible, has no practical way to verify the aircraft's weight and balance before take-off. Cargo handler positions are typically entry-level positions characterised by relatively high rates of turnover. Because of a high turnover rate it can be difficult to control the quality of the cargo loading process. As it is critical to the safety of flight to ensure that cargo has been loaded according to plan and properly restrained, the NTSB has recommended that all individuals associated with the loading process must be provided with consistent and comprehensive training in aircraft loading [Ref. 7]. In addition, the NTSB recommends installation of a system that displays aircraft weight and balance and gross weight in the cockpit. However, current systems are known to have problems regarding their operational use, especially regarding calibration and maintenance.

Note that the existence of hazards that are specific for cargo operations does not necessarily imply increased overall risk, as there are also hazards that are specific to passenger operations. Violent passengers, hijacking or sabotage are problems that are almost exclusively related to passenger operations.

2.3 Night operations

In CAA's Global Fatal Accident Review [Ref. 5], it is suggested that the fatal accident rate at night is more than twice that for day. However, this result is based on the estimation that 20 % of all landings are made at night. No distinction was made between cargo and passenger operations in estimating this amount.

For the purpose of this study, a comparison was made between the number of day- and night movements of passenger and cargo aircraft. A night movement was defined as a departure or arrival, taking place between 20:00 hrs and 06:00 hrs. The comparison was limited to scheduled flights, while only movement data for 1995 were analysed. It was assumed that 1995 movement data is sufficiently representative of current operations. Figure 1 presents the differences in the number of night movements for cargo and passenger operations. More than half of all cargo movements took place at night, while only a fifth of all passenger operations took place at night.

A NASA study on the effects of overnight operations concludes that flying at night imposes a number of physiological challenges that are not present in comparable daytime operations [Ref. 8]. The physiological disruption can cause lower performance. Another factor identified in the NASA study is that the quality of daytime sleep obtained by overnight cargo crew is inferior to that obtained by crewmembers sleeping at night. In addition, factors such as restricted visibility,



loss of depth perception and contrast could further increase the probability of an accident at night.



Figure 1: Distribution of day and night movements

In order to assess whether there is indeed increased risk during night-time operations, the relative risk was calculated. The results indicate an association between night operations and increased probability of an accident for cargo operations. The probability appears to be more than four times higher than for daytime operations with cargo aircraft. For passenger operations this association could not be established at the 0.05 significance level.

2.4 Fleet characteristics

Figures 2 and 3 present the average fleet age history of the last 18 years for cargo and passenger aircraft. Figures are presented for Western-built and CIS-built aircraft, including turboprops. The average age of Western-built cargo aircraft has been steadily increasing from 14 to 22 years, whereas the average age of Western-built passenger aircraft has stayed relatively constant at approximately 10 years. For CIS-built aircraft, the average age of both passenger and cargo aircraft has increased from approximately 10 to 20 years. The results illustrate that the Western-built passenger aircraft fleet is continually being renewed. These new generation aircraft are generally designed according to newer standards and with a different design philosophy regarding safety. The cargo fleet, however, continues to grow older, as it seems the older aircraft continue to remain profitable. For CIS-built aircraft the average age of the passenger fleet shows the same trend as the cargo fleet which can be explained by the CIS civil aircraft industry having virtually collapsed. Many countries that used to rely on CIS-built aircraft have converted to Western types.

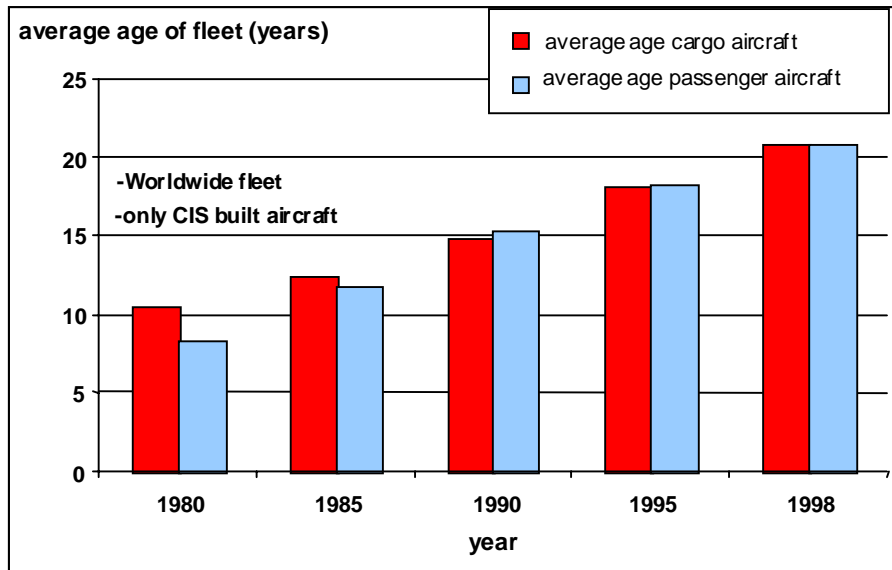


Figure 2: Average age of fleet, CIS-built aircraft

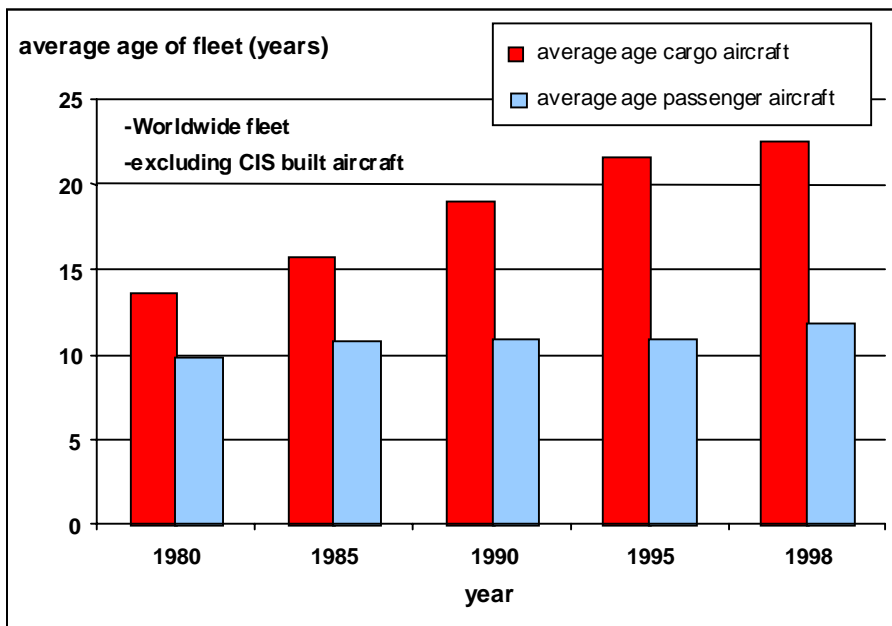


Figure 3: Average age of fleet, Western-built aircraft

Flight cycles for the present day fleet of Western-built jets were compared with the original design life. Design life information was obtained from [Ref. 9]. Results indicate that, on average, cargo jet aircraft have utilised 50 % of the original design life in cycles, while passenger jet aircraft have on average utilised 33 % of the original design life in cycles. It is important to note that for many aircraft the original design life cycles have been adjusted to increase their service life.



While many operators that use older aircraft have an impressive safety record, it can not be denied that the operation of older aircraft will require extra maintenance attention. If this is not fully recognised by the operators, it could, in combination with other factors, lead to a reduced safety margin.

3 Calculating accident rates

3.1 Approach

One way to quantify the level of safety of aviation is calculating the accident rate, i.e. the number of accidents per flight or per flight hour. To calculate an accident rate, not only the number of accidents must be known, but also the total number of flights that were conducted during the same period of time (accident and non-accident flights)¹. While for scheduled flights it is relatively easy to calculate the number of flights using time-table information, for non-scheduled flights² this is not possible. There are no databases available that directly contain non-scheduled flight information.

A solution to this problem was found by analysing flight cycle information for individual aircraft, identified by their serial numbers. By combining this information with the ownership history of the individual aircraft, the total number of flights conducted by each operator can be estimated.

3.2 Calculating the total number of flights

Aircraft utilisation data is registered in the Aircraft Analytical System (ACAS). ACAS is a computer software system detailing the history and the current operational and maintenance status of over 30,000 individual transport aircraft seating more than 15 passengers plus business jets. It is marketed and maintained by AvSoft of the UK. ACAS is sourced from operators, manufacturers and regulatory authorities. Utilisation data for Airbus, Boeing, Douglas, ATR, BAe, Embraer and Saab aircraft is updated monthly directly from the manufacturer. Other aircraft are updated less frequently directly from the operator. The ACAS version that was used in this investigation did not include Russian-built aircraft data.

The ACAS database contains ownership and flight cycle information for Western-built turboprop and jet aircraft from 1948 onwards. For the current study, information from 1970 up to 30 June 1999 was used. It must be noted that for the 1948-1975 timeframe the information in

¹ Accident rates are calculated in relation to the number of flights, as flights are considered to provide the most useful and valid criterion to indicate safety standards [Ref. 4].

² By definition a large proportion of flights conducted by ad-hoc operators are non-scheduled



the database is far from complete. While the ownership information is in most cases available, the corresponding number of flights is often not known. For these cases, the number of flights is indicated as '0' in the ACAS database. Section 3.3 explains how an estimate of the number of flights was established by the study team.

Several criteria were used to establish the final aircraft sample analysed in this investigation:

- All business jet aircraft were excluded from the data sample
- All turboprop aircraft with a MTOW < 5700 kg were excluded from the data sample
- All aircraft were excluded for which the "role" was classified as either one of the following:
 - Ambulance
 - Corporate/government
 - Military freighter
 - Military tanker
 - Military
 - Utility
 - AEW/SAR/patrol
- All records which indicated a total number of landings for one specific aircraft/owner combination of 10 or less were excluded from the data sample.

The latter was required for two reasons:

1. To eliminate those cases (mainly from the 1948-1975 time frame) where the corresponding number of flights is not known, and therefore a "0" was entered in the database. These cases are further discussed in section 3.3.
2. In many cases aircraft are being bought and subsequently resold by broker organisations. In these cases, the aircraft is owned by the broker organisations, and during this ownership period sometimes a limited number of flights are being made (e.g. ferry). These activities fall beyond the scope of the current study and were therefore excluded.

The resulting list of aircraft types is presented in appendix A.

The resulting database contains approximately 49,000 records, where each record contains the number of flights for one particular aircraft (identified by its serial number) for one particular operator. For each aircraft it is indicated whether it is configured for the transportation of passengers or has a full cargo configuration. Within an aircraft's lifecycle, its role may change. Many passenger aircraft are at a given moment converted into freighters to expand their economic life. Within the ACAS database the conversion dates can be retrieved, hence even for



converted aircraft a distinction can be made between flights conducted as a passenger aircraft and flights conducted as a full freighter.

Approximately 2000 different operators are represented in this selection. Included are passenger operators, cargo operators and operators that transport both passengers and cargo. For each of these operators, it was determined whether it was a

- Major operator
- Integrator
- Supplemental air carrier, or
- Ad-hoc operator.

The following definitions were used:

Major operators are the big companies that have a large fleet of jet aircraft. They typically operate both passenger as well as cargo aircraft on scheduled and non-scheduled flights. Within the operator the flight crew are interchangeable between cargo and passenger operations. Cargo aircraft and passenger aircraft make use of the same maintenance and training facilities. Examples of these types of operators are KLM, Lufthansa and Air France.

Integrators are the large parcel delivery operators. Parcel delivery operations are characterised by a high need for on-time performance, whereas utilisation of the fleet is relatively low. Because of the importance of on-time performance, the investments made in maintenance, both in terms of time and money, are high. Some integrators even have spare aircraft that can be used should a technical problem occur to one of the aircraft. Examples of integrators are UPS, FedEx and DHL.

Supplemental air carriers are commuter airlines and their counterparts in the cargo world. They deliver passengers and cargo to the majors for further transportation. In general, the supplemental air carriers make use of smaller aircraft, and a relatively large part of their fleet are turboprop aircraft.

Ad-hoc operators are characterised by a very high percentage of unscheduled flights. Flights are conducted on those routes that are not being served by the majors. Typically the number of aircraft in the fleet is low (one or two aircraft), and especially for ad-hoc cargo operators the aircraft that are being used are older generation aircraft (B-707, DC-8). Many ad-hoc passenger operators are aimed at the holiday charter market.



In order to classify each of the 2000 operators into one of these 4 categories, information from the following sources was used:

- Flight International World Airline Directory (several issues)
- JP airline-fleets international (several editions)
- Additional sources such as brochures, web-sites, etc.

In addition, it was determined whether the operator was either a passenger operator, a cargo operator, or an operator that transports both passengers and cargo.

Because the accident sample was restricted to the 1970-1999 time frame (see section 3.5), only the corresponding number of flights that took place within this time frame had to be considered. The ACAS database only gives the total number of flights for the period of time that a certain operator owned the aircraft. Consequently, for those cases where the ownership started before 1970 and ended after 1970, the actual number of flights after 1970 had to be estimated. For this estimation it was assumed that the aircraft utilisation (number of flights per day) was constant for a given aircraft/ownership combination.

3.3 Aircraft without utilisation information

For a fairly large number of aircraft the utilisation is not known to the ACAS database. This is particularly the case for older aircraft (for instance Caravelle, Boeing 707) that are being operated by small companies. For this group, which contains 9000 aircraft/operator combinations for 758 different operators, the number of flights in the ACAS database is listed as '0'. The smaller companies operating older aircraft are typically the ad-hoc operators that are the subject of this study. Deleting this group from the sample would potentially result in the calculation of incorrect accident rates. Therefore it was decided to estimate the number of flights for these aircraft based on the average utilisation of the aircraft in the ACAS database.

For the different categories different average utilisation numbers were established. The results are presented in Table 1.



Table 1: Average utilisation per operator category

Category	Role	Flights per day
Ad-hoc	Cargo	3.22
Ad-hoc	Passenger	3.68
Integrator	Cargo	2.29
Integrator	Passenger	2.70
Major	Cargo	2.80
Major	Passenger	4.79
Supplemental	Cargo	6.77
Supplemental	Passenger	6.27

Subsequently, aircraft utilisation was calculated by multiplying the number of days in service with the average utilisation per day.

3.4 Total number of flights

Combining the information from the previous sections leads to the total number of flights for each category in the time frame considered. The result is presented in Table 2.

Table 2: Total number of flights per operator category, 1970-1999

Category	Role	Flights
Ad-hoc	Cargo	6,707,868
Integrator	Cargo	5,899,989
Major	Cargo	13,098,005
Supplemental	Cargo	4,861,079
Ad-hoc	Passenger	17,149,140
Integrator	Passenger	198,852
Major	Passenger	329,754,290
Supplemental	Passenger	89,245,965

Note: Integrators are by definition pure cargo operators. The fact that there are a small number of flights in the 'integrator passenger' category is due to the fact that some integrators operate one or two passenger aircraft, for instance for the transport of personnel.

3.5 Accident sample

The primary source of accident information used in this study is the ADREP database of the International Civil Aviation Organisation (ICAO). This database contains worldwide incident and accident information from 1970 onwards for jet and turboprop aircraft with greater than



12,500 pounds / 5,700 kilograms maximum take off weight. Only hull losses and fatal accidents were considered for this study.

The accident sample needed to match the flight cycle information resulting from the ACAS database. Therefore the following additional restrictions were made:

- Only “Western-built” aircraft were considered (see appendix A)
- Business jets (according to the definition used in ACAS) were excluded from the accident sample
- Accidents to an aircraft (identified by its serial number) that is not represented in ACAS were excluded from the accident sample.

In cases where the accident aircraft’s serial number was not listed in ADREP, other sources of information were used to identify the accident aircraft’s serial number.

In addition, the following accidents were excluded from the study sample:

Accidents with fatalities but no or only minor damage to the aircraft. Examples are fatalities due to in-flight turbulence encounters, jet blast fatalities, fatalities due to persons falling off aircraft stairs during boarding etc. Accidents due to terrorism were only included in the sample if the act of terrorism resulted in a hull loss.

Hull losses that occurred while the aircraft was on the ground with no payload on-board were excluded from the study sample. An example of such a case would be a hull loss resulting from a collision while the aircraft is being taxied for maintenance purposes.

The resulting accident sample contains 606 accidents. For all accidents it was verified whether the accident aircraft was configured for the carriage of passengers or cargo, and if the flight was a revenue or non-revenue (training, ferry, positioning or test) flight. In addition, it was determined whether the flight was scheduled or non-scheduled.

The distribution of accidents from the sample among type of operator is presented in Table 3.

Table 3: Distribution of accidents among types of operator.

	Passenger	Cargo
Major	355	46
Integrator	0	6
Supplemental	98	9
Ad-hoc	46	46

3.6 Accident rate

The accident rate for each of the different types of operators can be calculated by dividing the number of accidents (Table 3) by the total number of flights (Table 2). The results of this exercise are presented in Figure 4.

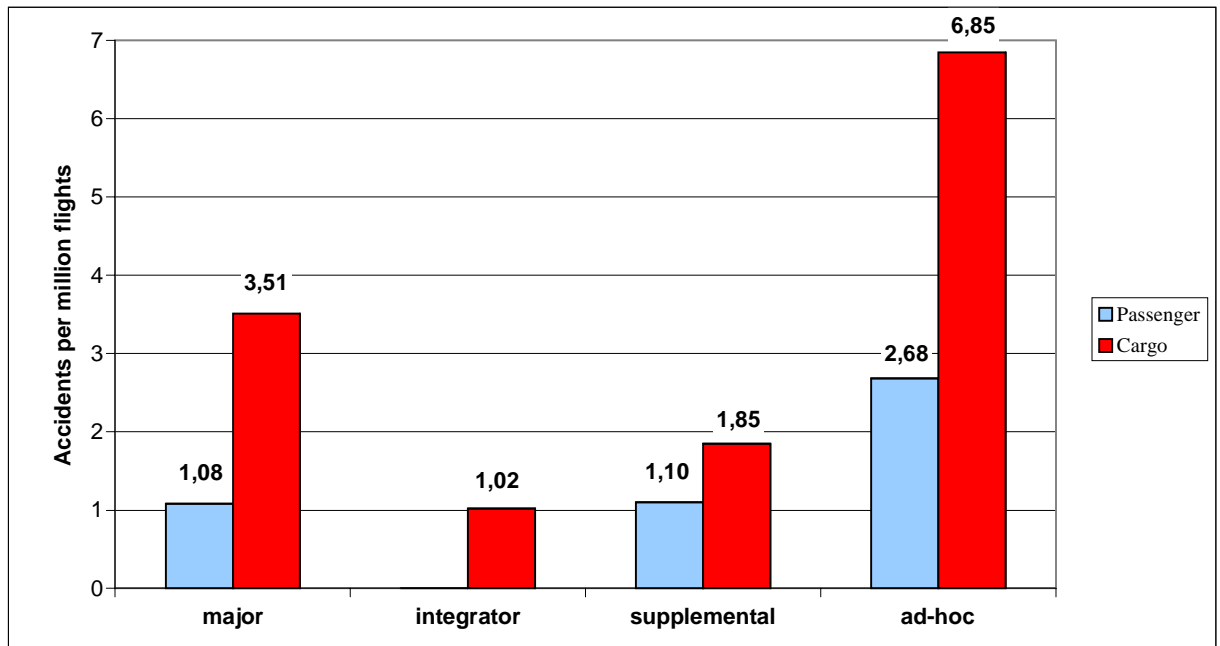


Figure 4: Accident rate for different types of operator

4 Analysis of the results

4.1 Accident rate of different types of operator

Figure 4 clearly shows the disproportional high accident rate of ad-hoc cargo operators. The accident rate for the ad-hoc cargo operators is almost seven times higher compared with scheduled passenger traffic by major operators. Figure 4 also shows that non-scheduled (ad-hoc) passenger traffic is almost three times more accident prone than scheduled passenger traffic. Perhaps surprising is the fact that the accident rate for major cargo operations is more than three



times higher than scheduled passenger operations by major airlines. This is remarkable because many of the major operators conduct both passenger and cargo operations, whereby flight-crews are interchangeable and the aircraft make use of the same maintenance facilities. For all types of operators passenger operations have a lower accident rate than cargo operations

In some aspects cargo operations are more complex than passenger operations. The diverse composition of air cargo requires different ways of packaging and handling, depending on the nature, the volume and the weight of the shipment. Contrary to passenger traffic, where it can be expected that the passenger will eventually return to his departure point, this is not the case for cargo. Significant imbalance in the flows of cargo is the result. On some routes more than 4 to 5 times more cargo is offered than on the return flights.

This study examined the safety of cargo operations with dedicated cargo aircraft in comparison with passenger operations. A significant portion of the world's air cargo is transported as belly-load in passenger aircraft. For shippers, freight forwarders and ground handlers it is not relevant whether the cargo will be transported in full freighter aircraft or as belly-load in passenger aircraft. Freight forwarders seek opportunities that best fit the shipper, which airline will be selected is in most cases a matter of urgency and costs. There are no differences in the way cargo is treated. This suggests that any differences in the safety record between passenger and cargo operations can not be attributed to the activities of the shipper and the freight forwarder. Other factors must be of influence.

A factor that could indirectly contribute to the higher accident rate for cargo aircraft may simply be the fact that cargo does not complain. While for passenger aircraft the fact that an aircraft does not look safe or feel safe can be a reason not to choose that particular airline, for cargo aircraft this is not the case. In addition, the flight crews of passenger aircraft feel a responsibility for the safety of the passengers. The lack of this responsibility in cargo operations may lead to a shift in priorities from safety to (on-time) performance. The need for on-time delivery is often very high. In many cases flights are conducted on a contract basis, and renewal of the contract depends on the performance of the company, where a prime performance indicator will be the number of delays.

The integrators show a very low accident rate. When interpreting this figure it must be kept in mind that these are global accident rates. The integrator business however is almost exclusively limited to US operators. The overall accident rate for US operators is significantly lower than the world average. For a better understanding of the data we must look at accident rates for the different regions of the world. This is done in the following section.



4.2 Accident rate per region of the world

First we look at overall data, without making a distinction between types of operator. We only differentiate between passenger and cargo operations. This information is presented in Figure 5.

The world is divided into seven regions:

- Africa
- Asia
- Australasia
- Europe
- Former USSR
- North America
- Central – and South America.

This subdivision is the same as is used by the UK Civil Aviation Authority in the Global Fatal Accident Review [Ref. 5]. A list of countries included in each of these regions is presented in Ref. 5.

For the purpose of this study, the criterion for classifying an aircraft to a region is the state of registry of the aircraft.

For the former USSR the total number of flights with Western-built aircraft is too low to be able to calculate rates that are statistically robust, therefore this information is not presented in Figure 5.

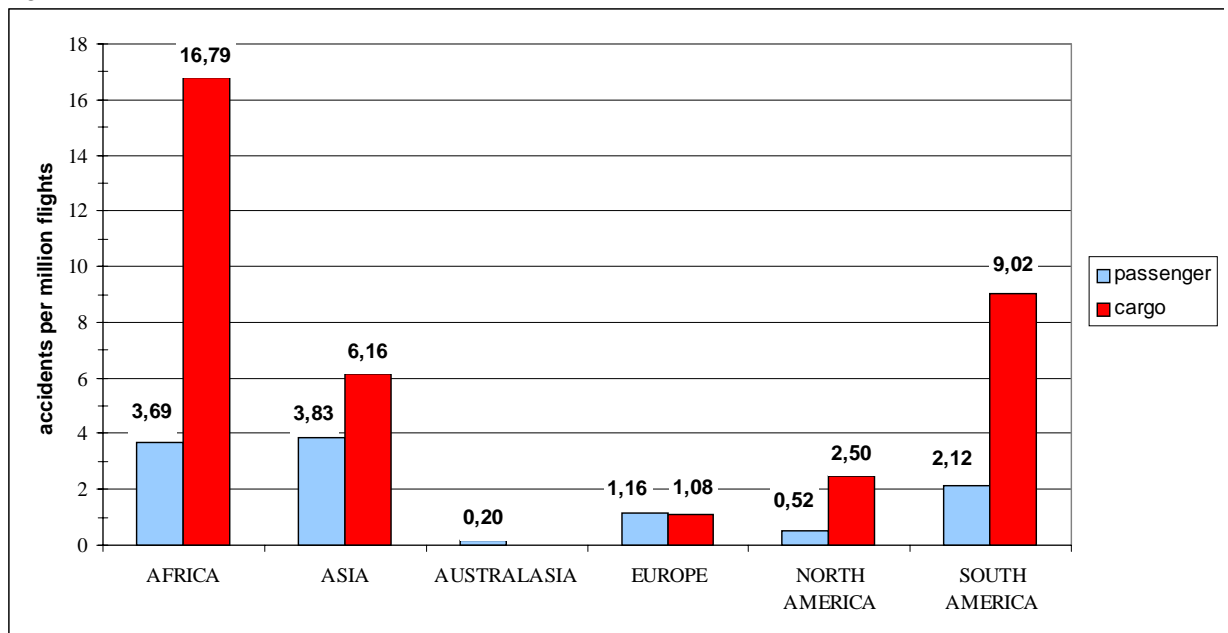


Figure 5: Overall accident rates per operator region



From Figure 5 it becomes obvious that Asia, South America and especially Africa are the problem areas with respect to safety of air cargo operations. The variation in the accident rate between different regions is much greater for cargo operations than for passenger operations. Remarkable is that Europe's cargo accident rate is low and does not differ significantly with the rate for European passenger operators.

To get a feeling of the accident rate of Eastern-Built aircraft in the (former) USSR, the limited utilisation data from Aeroflot [Ref. 3] can be used. Utilisation data from 1980 to 1992 inclusive is provided for the aircraft types listed in Table 4:

Table 4: Aeroflot aircraft

Passenger operations	Cargo operations
Ilyushin IL-62	Ilyushin IL-76
Ilyushin IL-86	Antonov AN-12
Tupolev TU-134	Antonov AN-26
Tupolev TU-154	
Yakovlev Yak 40	
Yakovlev Yak 42	

Note: The list of passenger aircraft is limited in the sense that it only includes jet aircraft. Passenger turboprops such as An-24, An-26 and L-410 are not included. The list of cargo aircraft is limited in the sense that some cargo aircraft types (such as the Antonov An-124) are not included.

A corresponding accident rate can be calculated after determining the number of Aeroflot accidents with these types of aircraft in the 1980-1992 time frame. The resulting accident rates are presented in Figure 6.

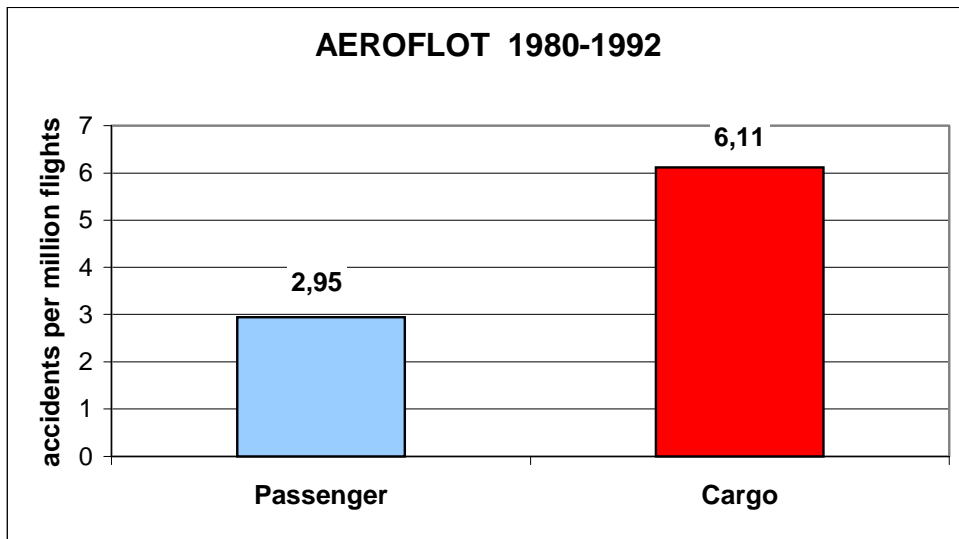


Figure 6: Accident rate for the Aeroflot fleet

Caution is necessary when comparing the “Aeroflot” accident rates with the other accident rates, as both the time period and the aircraft inclusion criteria are different compared to the previously calculated rates. It is noteworthy however that Aeroflot’s accident rate is almost as high as the accident rate in Asia, and given the breakdown of Aeroflot that has occurred after the time period on which this rate is based, it is highly questionable whether this situation has improved in more recent years in the Commonwealth of Independent States.

The breakdown of Aeroflot not only resulted in the emerging of many small airlines but also in the breakdown of the existing way in which training, maintenance and logistics had been organised. While Russian built aircraft are well-designed, continuous airworthiness has always been a problem due to the lack of a proper maintenance concept. These problems are now aggravated due to the lack of spare parts. For some aircraft types spare parts are already very difficult to get, for other types this will become a major issue in the next 5 years or so. Bogus parts (parts without a valid certificate of airworthiness) are a serious safety threat.

A possible explanation for the differences in safety performance throughout the world could be the difference in economic strength. In Figure 7, an overview is presented of the distribution of economic strength among the countries of the world, expressed as Gross Domestic Product (GDP) per Capita.

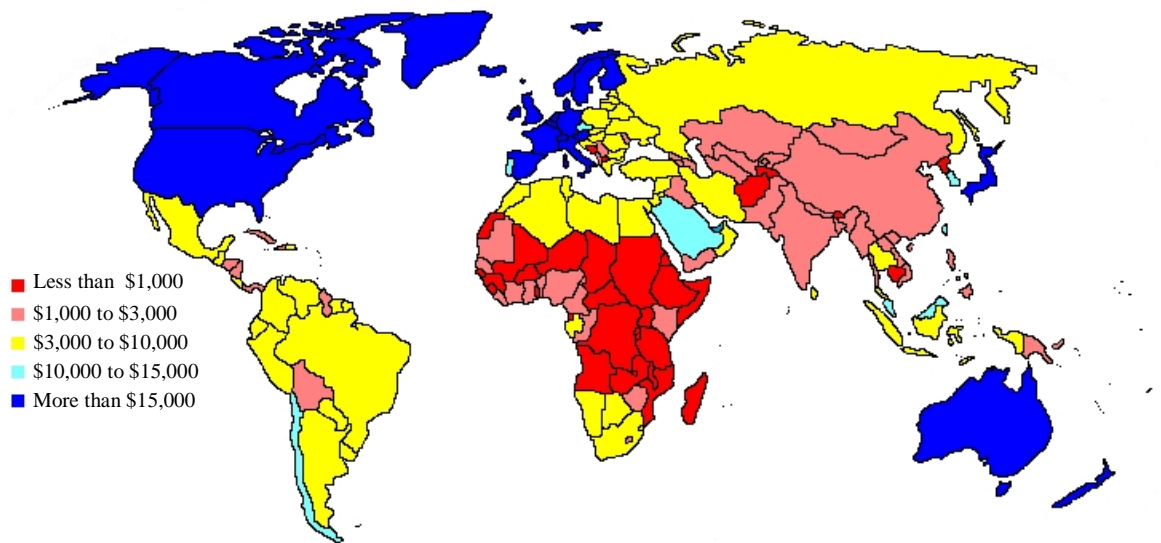


Figure 7: Gross Domestic Product Per Capita, 1996, in 1996 US \$

In this figure, the GDP per capita are calculated using Purchasing Power Parities to convert the level of GDP expressed in national currencies into a common currency. The comparison between figures 5 and 7 shows that the poorest world regions (lowest GDP per Capita) have the worst safety record, an observation that is not new. The relation between accident rate and gross domestic product was also demonstrated in [11].

The poor economic situation in some countries is very often mentioned by persons experienced in the field of cargo operations as causal to the high accident rate. Inspectors in the Safety Assessment of Foreign Aircraft (SAFA) programme believe that the main cause for the lower safety level of cargo operators from the developing countries is lack of financial resources (see section 5.6). The aviation environment is very competitive and when economic survival is an issue and safety measures cost money, safety tends to get less priority. Economic constraints impede the build-up of an adequate operational infrastructure. This suggests that the less developed nations should be supported to build up a mature operational aviation infrastructure addressing both national governments (air traffic control and airport facilities and equipment, general education facilities), and operators (operational and maintenance training, facilities and equipment). In this respect it is important to note that income disparity between the richest one billion and the poorest one billion people has doubled over the last decades and has reached a staggering level of 150 times. There appears no end in sight for these widening gaps since the gaps are not only in current levels of income, but also in future market opportunities and in higher levels of human development. While the bottom 20% of the world's population receives



only 1.4% of the GDP, it has also a share of only 1.0% in global trade, 0.2% in global commercial lending and 1.3% in global investment [12].

If the accident rates of the regions of the world (Figure 5) are further subdivided into type of operators (Figure 8) we get a better understanding of what is happening. First of all if we look at European operators, we observe a good safety record which is nearly equal for all types of operators. In contrast with Europe, North America shows significant differences in safety between passenger and cargo operators, with cargo operators being less safe than passenger operators. The safety record of the integrators is best of all types of cargo operations within the US. The good safety record of the integrators can partly be explained by the fact that these operators often fly well-known routes to the larger, better equipped, airports. What is disturbing is the high accident rate of ad-hoc cargo operators in the US. This rate is even higher than the rate for non-scheduled passenger traffic in Africa and South America. These African and South American accident rates are unsatisfactory high at two to four per million flights, but the cargo operators in these regions are dramatically unsafe. Surprisingly, in both these regions the safety of major cargo operators is just as bad as that of ad-hoc cargo operators. The ad-hoc passenger accident rate in Asia, which stands at 10 accidents per million flights, is also reason for great concern.

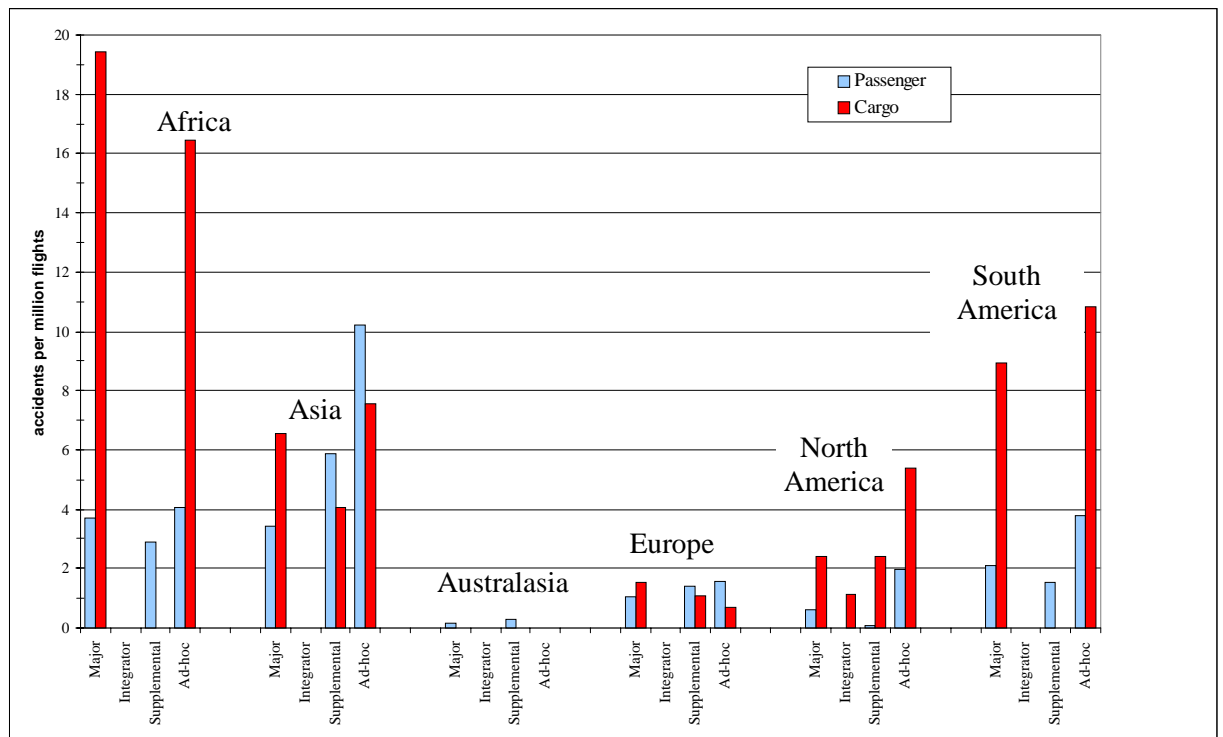


Figure 8: Accident rate per region for different types of operators



4.3 State-owned airlines

Additional insight into the situation in Africa is provided by comparing the safety of state-owned airlines with private airlines. An airline was classified as “state-owned” if more than 50% of the shares are held by the state, according to the information provided in Flight International (several issues) and JP airline-fleets international (several issues). The result of this comparison is presented in Figure 9.

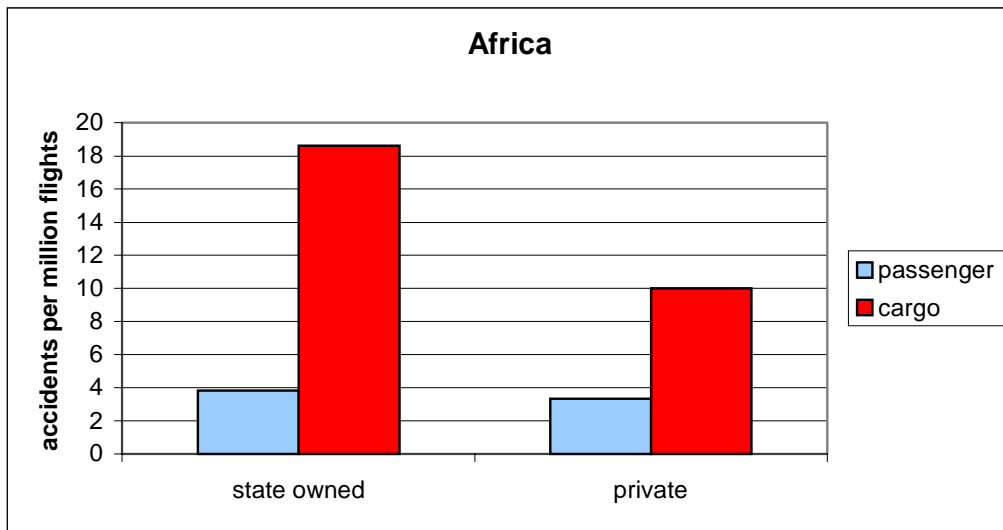


Figure 9: Comparison of state-owned and private airlines

Whereas there is no difference between the accident rate of passenger operations of state-owned and private airlines, cargo-operations by state-owned airlines are two times less safe than cargo operations by private airlines³. No hard evidence of the causal factors of this difference could be found, but there are indications that corruption, favouritism, and lack of motivation play a role.

The difference in accident rate between state-owned and private airlines was also calculated for the other regions in the world. Although differences are observed, these are not as significant as in Africa.

4.4 Types of accidents

In the previous sections it was demonstrated that the accident rate of cargo operations is unproportionally high compared with passenger operations. In order to further investigate the reason behind this high accident rate, the different types of accidents that occurred were

³ The χ^2 test shows that the difference is statistical significant at the 80% level, which means that there is a 20% probability that this is a chance result.



compared for both passenger and cargo operations. The same accident sample of 606 accidents as used earlier in the study (section 3.5) was used for this analysis.

The comparison was based on the *primary event* associated with the accident, as defined in the ICAO ADREP database. Events are used in the ADREP database to describe what has happened. They do not provide information on why an accident has happened and should therefore not be interpreted as accident causes.

Related events were grouped in order to make the data statistically more reliable, and for ease of survey. For example, the events “collision with embankment”, “collision with ditch”, “collision with snowbank”, “collision with chimney/mast/pole”, “collision with powerline/cable/wire”, “collision with approach lights” and “collision with flood lighting pole/mast” were all classified as “collision with object”.

The results of this comparison are presented in Figure 10. In this figure the *relative* occurrences are compared, in stead of absolute numbers. For example, 130 of the total number of accidents for passenger operations (26%) were classified as “collision with ground”. For cargo operations, 28 of the total number of 106 accidents (26%) were collision with ground accidents. So although the absolute numbers are very much different, in both cases a quarter of all accidents are “collision with ground” accidents. It are these percentages that are compared in Figure 10.

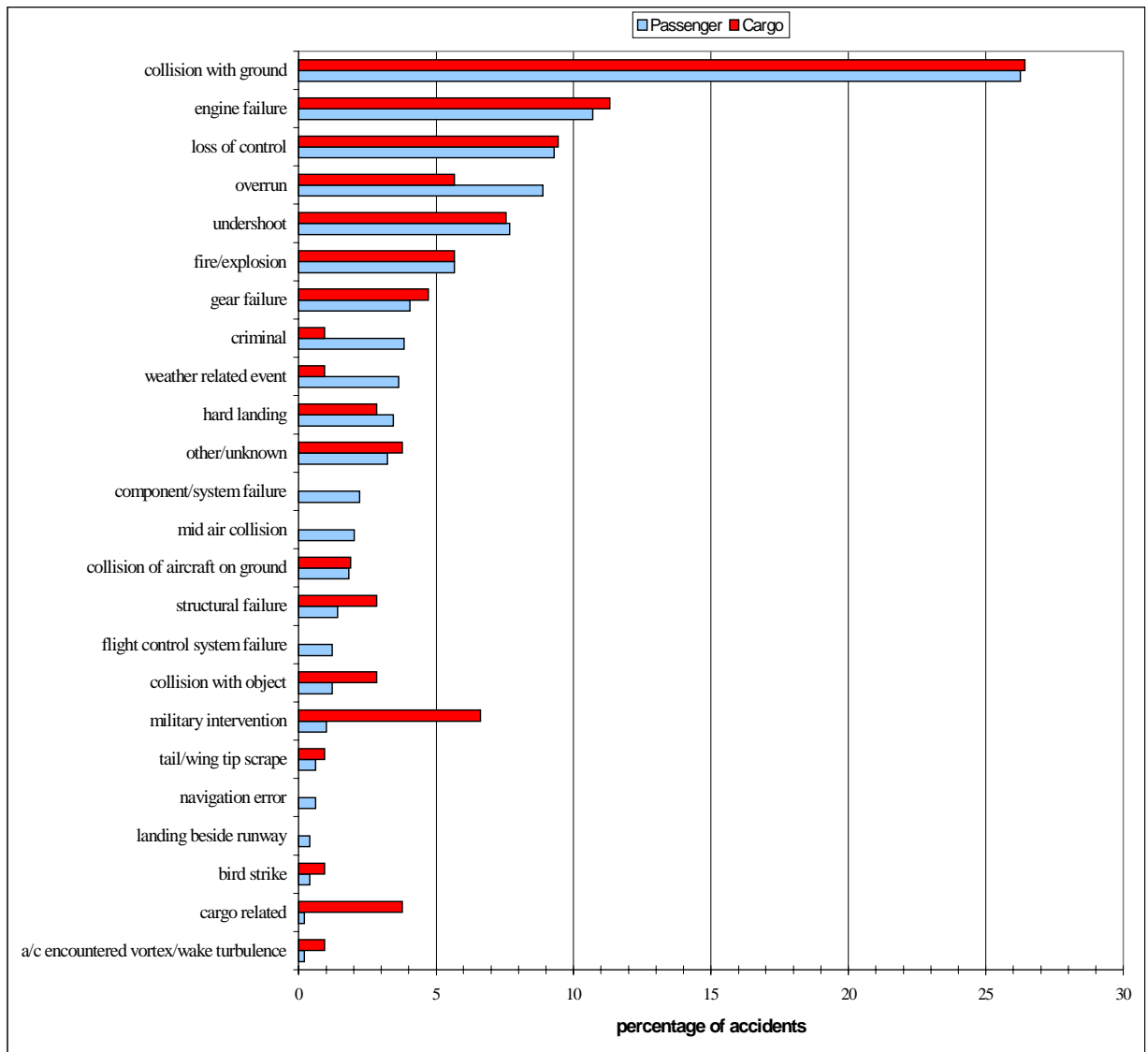


Figure 10: Comparison of type of accident

Figure 10 shows in general a very similar distribution of types of accidents. The distribution of the most frequent occurring accidents (collision with ground, engine failure, loss of control, undershoot and fire explosion) is the same for passenger and cargo operations. Apparently, all accident types occur more frequently in cargo operations. Minor differences are present in cargo related events, criminal acts, weather related events, military interventions and overrun type of accidents. The fact that criminal acts are more often aimed against passenger operations can easily be explained by the fact that these events are planned to have an as high as possible impact on society. Military intervention accidents occur more frequently during cargo operations. Cargo operations continue in regions with high military activity (e.g. for weapons delivery or humanity relief flights) whereas most passenger airlines cease passenger operations



to those regions. Cargo related accidents are often weight and balance problems, either created by shifting cargo or by wrong loading. Education and training of ground crew must be emphasised. Although it is the flight crew that is ultimately responsible, the importance of the ground crew should be acknowledged. Ground handling organisations must adopt a safety culture. Cargo restraining in small aircraft deserves special attention. The lack of standardised containers for these aircraft is an important aspect.

No explanation other than coincidence could be found for the differences for weather-related events and overrun accidents. In these cases the absolute number of accidents is small, and as a result the statistical reliability of the percentages is not as high as for the most frequent accident types.

Comparison of the distribution of accident types between the world's regions did not show any significant differences.

The fact that there are no major differences in the distribution of accident types between passenger and cargo operations suggests that the higher accident rate of cargo operators can not be attributed to a single cause. This observation is concurrent with a finding of a previous study [Ref. 1], which concluded that the five most frequent causal factors of fatal accidents are the same for cargo and passenger flights. These causal factors were all from the "crew" causal group, and included:

- Flight handling,
- Inappropriate action,
- Lack of positional awareness,
- Poor professional judgement,
- Slow/low on approach.

Because of the higher accident rate of cargo operations, the fact that the relative distribution of accident types is nearly the same for passenger and cargo operations leads to the conclusion that *all* types of accidents occur more frequently in cargo operations. Improvements in safety must come from the whole range of possible safety enhancing measures: crew training, aircraft maintenance, operational procedures, airport and ATM infrastructure, aircraft equipment and especially crew training. Operators should develop a good training program with the corresponding training facilities. The crew should be a team where all team members are competent, current and proficient. This needs to be an extra point of attention if the flight crew comprises different nationalities. Promotions should not be based on favouritism or military experience but on good airmanship.



4.5 Accident flight phase

A comparison was made of the flight phases in which the accidents occurred. The flight phase classification of the ADREP database was used for this purpose. ADREP differentiates between 22 flight phases. Because of the relatively small number of accidents (606) the number of flight phases is too large to perform a meaningful analysis. Reordering into six main groups was necessary. Table 5 shows the correlation between ADREP flight phases and the main groups that were used in this analysis.

Table 5: Flight phases

This study	ADREP flight phase
Take off	Aborted take-of Take off Take off run
Climb	Initial climb Climb to cruise
Cruise	Change of cruise level Cruise En-route
Approach	Approach Approach/holding Base leg Uncontrolled descent Final approach Intermediate approach Missed approach/go around Normal descent
Landing	Landing Touchdown Landing roll Level off/touchdown
Taxi	Taxiing - pushback -tow Taxi to- from runway

In Figure 11 the flight phases in which the accident did occur are compared between passenger and cargo flights. The accident sample for this analysis was the same as described in section 3.5 in this report. The comparison shows that regardless of the type of operation, most accidents occur during the approach phase. This fact is well known from earlier studies. Notice however



that the percentage of approach accidents for cargo operations is somewhat smaller than for passenger operations. Cargo operations have suffered relatively more accidents during the take-off and climb phases of flight than passenger operations.

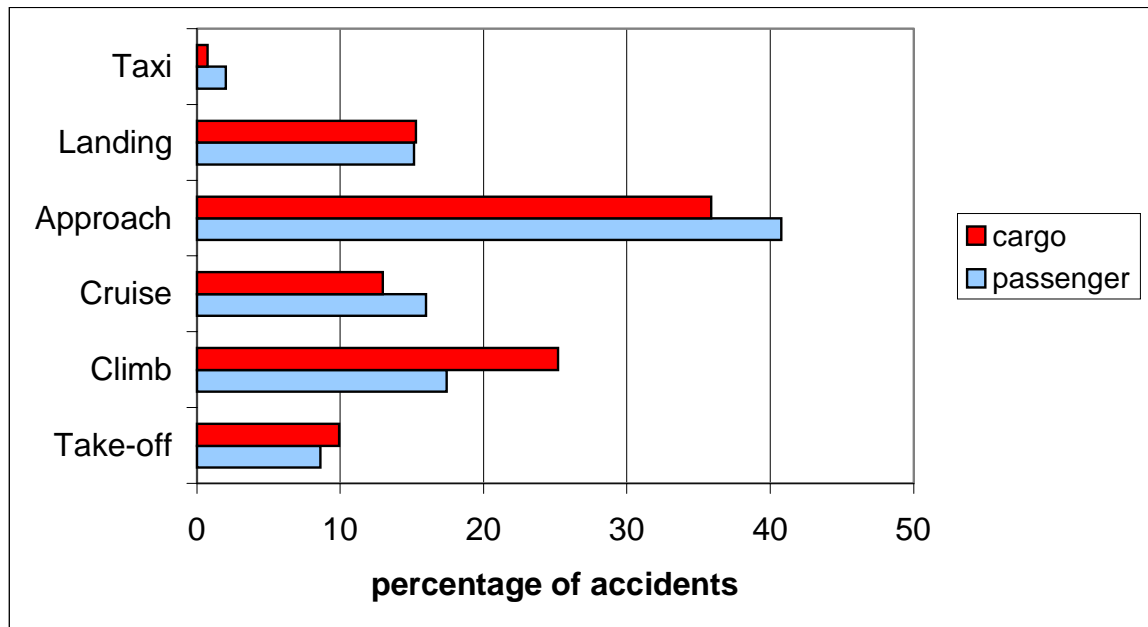


Figure 11: Comparison of accident flight phases

It was shown in Figure 10 that the causes of cargo accidents almost precisely followed the causal distribution for passenger operations. This fact does not make it very easy to find an explanation for the fact that cargo accidents occur more frequently during the take-off and climb phase than passenger accidents.

Take-off and climb are characterised by high aircraft weights and high engine thrust settings. If there are any deficiencies to aircraft systems or instruments, they will probably become apparent during take-off and climb. Loading errors, such as wrong centre of gravity, overweight, or cargo that is not properly restrained, will have their effect during take-off, or more specifically, at or immediately after aircraft rotation. This is confirmed by the accident data.

4.6 Aircraft generation

Aircraft and system manufacturers are constantly trying to improve the efficiency, reliability and safety of their products. Technological advances and the introduction of the human factors discipline into systems engineering have led to a significant reduction in in-flight shutdown rates of engines, the introduction of glass cockpits, two-person flight crew, fly-by-wire systems,



etcetera. One way to rate the effect of these technological improvements on aviation safety is comparing accident rates for different generations of aircraft.

Data from aircraft manufacturers indicate a significant reduction in accident rates with each successive generation (Ref. 6). To investigate whether this trend is similar for cargo and passenger aircraft we compared accident rates for each aircraft generation. The results of this comparison are presented in Figure 12.

For the purpose of this study, aircraft were classified into three different generations.

First generation

First generation aircraft are typically designed in the 1950s. Most of the aircraft were certified before 1965 according to British Civil Airworthiness Requirements (BCAR's) or other certification bases. Jet engines were still very new, and the aircraft had very limited cockpit automation, simple navigational aids and limited approach equipment. Examples are Fokker F-27 and Boeing 707.

Second generation

Designed in the 1960s and 1970s, second generation aircraft have more reliable engines. The aircraft were certified between 1965 and 1980, not yet based on common JAR-25/FAR-25 rules. Cockpit equipment is more advanced, with better auto pilots, auto throttles, flight directors and better navigational aids. Examples of second generation aircraft are Fokker F-28, Boeing 737-200 and Airbus A-300.

Third generation

Third generation aircraft, designed in the 1980s and 1990s, typically show considerations for human factor aspects in the cockpit. Electronic Flight Instrument Systems (EFIS) and improved auto pilots are being used. Furthermore, the aircraft are equipped with ACMS data systems and high-bypass engines designed according to higher certification standards. Fly-by-wire systems are introduced on several types. Examples of third generation aircraft are Fokker 50, Boeing 737-700 and Airbus A-320.

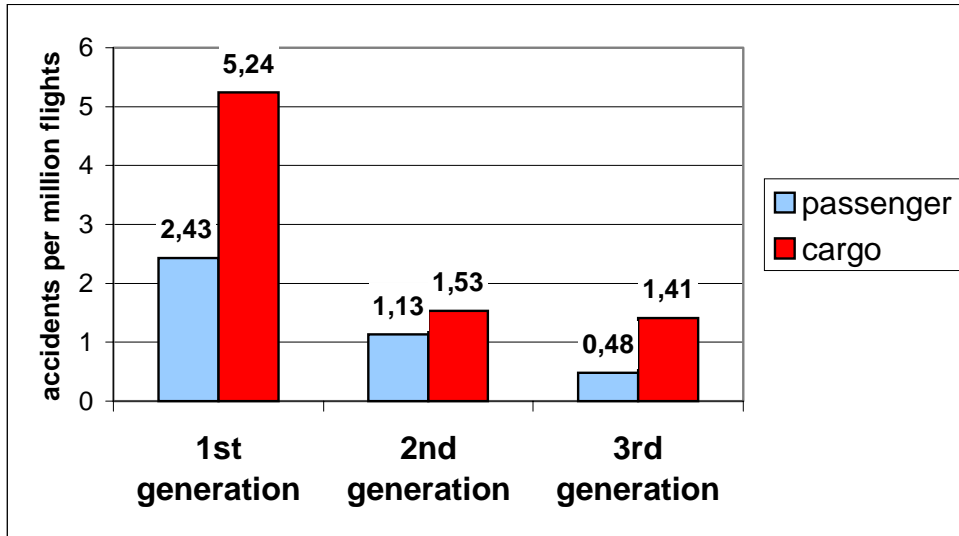


Figure 12: Comparison of accident rates for different aircraft generations

In Figure 12 we see a decreasing accident rate for aircraft of a newer generation for both passenger and cargo aircraft. For first generation aircraft, the accident rate for cargo aircraft is more than twice as high as the passenger aircraft accident rate. For second generation aircraft, the accident rate for cargo aircraft is significantly lower, and much closer to the 2nd generation passenger aircraft accident rate. While third generation passenger aircraft show a continuing improvement in safety, the third generation's cargo aircraft accident rate seems to be levelling off. This 3rd generation cargo accident rate is based on a very small number of accidents however and is therefore statistically not reliable.

As was demonstrated in Figure 3, the average age of cargo aircraft is higher than the age of passenger aircraft. This suggests that a larger section of the cargo fleet is composed of older generation aircraft. To validate this assumption we calculated the relative number of flights for each aircraft generation within the reference period. The results are presented in Figure 13. While more than half of all passenger flights were conducted with 2nd generation aircraft, and almost a third with 3rd generation aircraft, the majority of cargo flights was performed with 1st generation aircraft, while the contribution of 3rd generation cargo aircraft is almost negligible.

The fact that for cargo operations relatively more flights are carried out with older generation aircraft that have a higher accident rate could be causal to the higher overall accident rate for cargo operations.

The lower accident rate of newer generation aircraft is probably not caused by technological improvements to the aircraft alone. Improvements in operating procedures, ATM infrastructure,



increased knowledge on phenomena such as wind shear and wake vortex could also contribute to the better safety figures for newer generation aircraft. First generation aircraft operated in today's environment are probably safer than exactly the same aircraft operated three decades ago. The quality of the operator will have a significant effect on the safety figures. In this respect, the marked difference in the accident rate of 3rd generation passenger aircraft and 1st generation cargo aircraft could reflect a difference in the quality of the operator as well as the quality of the aircraft.

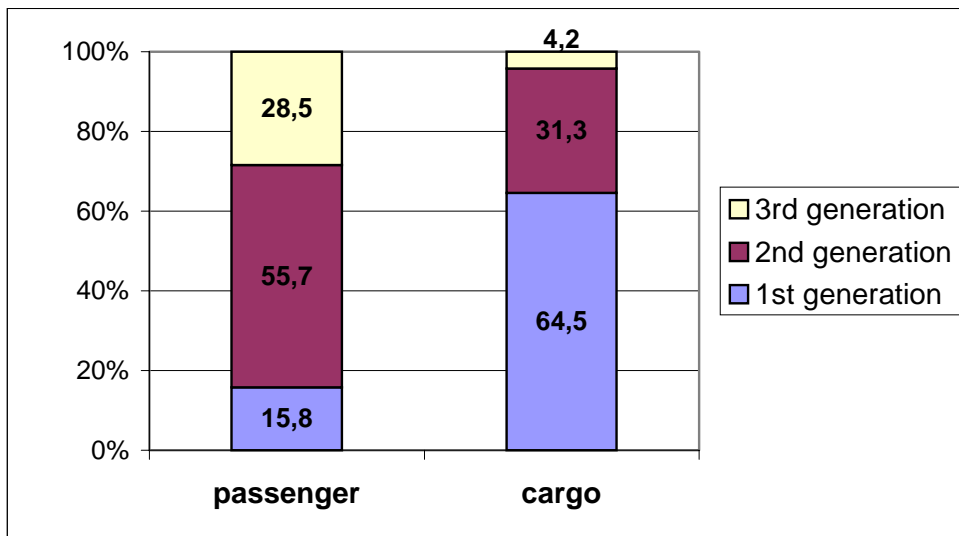


Figure 13: Comparison of the relative contribution of different aircraft generations to the total number of flights during the reference period (1970-1999)

5 SAFA inspections

5.1 Introduction

In theory it should make no difference in which state an aircraft is registered because almost all nations have signed the Chicago convention and thus are committed to abide by ICAO standards. It is obvious however that the level of safety varies considerably throughout the world. This is one of the reasons why European Nations have launched the SAFA (Safety Assessment of Foreign Aircraft) programme. The National Aviation Authorities of the European Civil Aviation Conference (ECAC) have agreed to perform inspections (ramp checks) on foreign aircraft. This SAFA program is co-ordinated by the Joint Aviation Authorities (JAA). The objective of the SAFA programs is to collect information about the safety level of foreign operators. Based on this information, actions can be taken aiming at an increase of the level of aviation safety.



5.2 Inspections

The SAFA program started in the Netherlands at the end of 1997. At the start of the program it was considered desirable to obtain an impression of all foreign operators flying to the Netherlands. In 1997 and the following year a total of 273 inspections were performed. As a result, 83 of the 85 foreign operators that perform scheduled services have been inspected at least once, and 26 of a total of 98 of the foreign operators that perform charter services were inspected.

Based on these first impressions it was decided to focus in 1999 on those airlines that have shown to have significant deviations from the ICAO Standards [Ref. 10]. Based on the '97/'98 experiences, it was decided to focus on ad-hoc/charter cargo operators. It was planned to execute 150 inspections. In reality 162 inspections have taken place on a total of 98 foreign operators.

If a distinction is made between passenger versus cargo operations and scheduled versus unscheduled operations (ad-hoc, charter), the SAFA inspections that have been executed in 1999 were divided as presented in Figure 14.

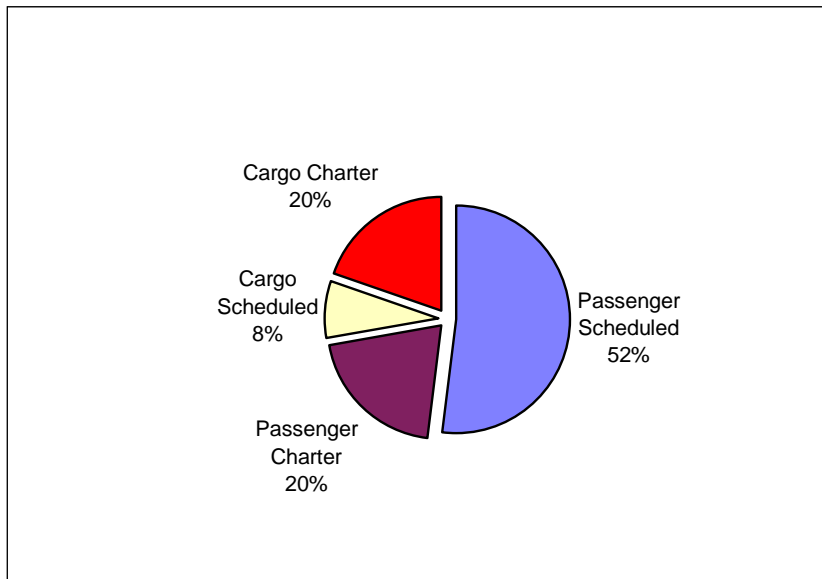


Figure 14: Distribution of inspected operators per type of operation.

5.3 Inspection findings

During the SAFA Ramp checks compliance with specific requirements from ICAO Standard 1 (Personnel Licensing), Annex 6 (Operations of Aircraft) and Annex 8 (Airworthiness of Aircraft) are checked. The items to be inspected are listed on the JAA SAFA inspection list and

are grouped into operational items (pilot licenses, operational procedures, operations manual, checklists etc.) and technical items (general external condition of aircraft, safety equipment in the cabin, technical documentation, Minimum Equipment List, Tech Log etc.).

The outcome of the inspections, which effectively are non-compliances with the ICAO Standards, are categorised. The different categories are based on the anticipated influence on the safety of the aircraft that has been inspected.

The five categories are summarised in Table 6 below.

Table 6: Categories of SAFA inspection findings

Category	Inspection finding(s)
0	No deviations from the ICAO Standard established.
1	Deviations from the ICAO Standard established, no immediate safety concern.
2	Major deviations from the ICAO Standard, corrective action required, no direct safety concern.
3a	Major deviations from the ICAO Standard, corrective action required before flight because of safety concern.
3b	Major deviations from the ICAO Standard, corrective action required before flight, action not accepted by Flight Crew therefore enforced by SAFA Team.

The categorisation of the findings of the 162 inspections performed in 1999 is presented in Figure 15. It must be emphasised that because of the focus on those operators that had serious findings in previous inspections, the number of category 3a findings (18,5 % of all inspections) is relatively high.

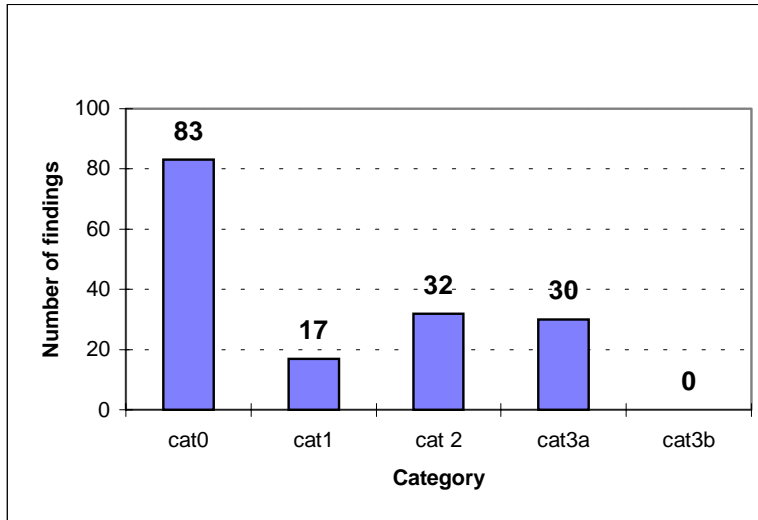


Figure 15: SAFA inspection findings per category

If we look in more detail to the most serious findings (cat. 3a) we see that 50 % of all category 3a findings were established during an inspection of an ad-hoc cargo operator (Figure 16).

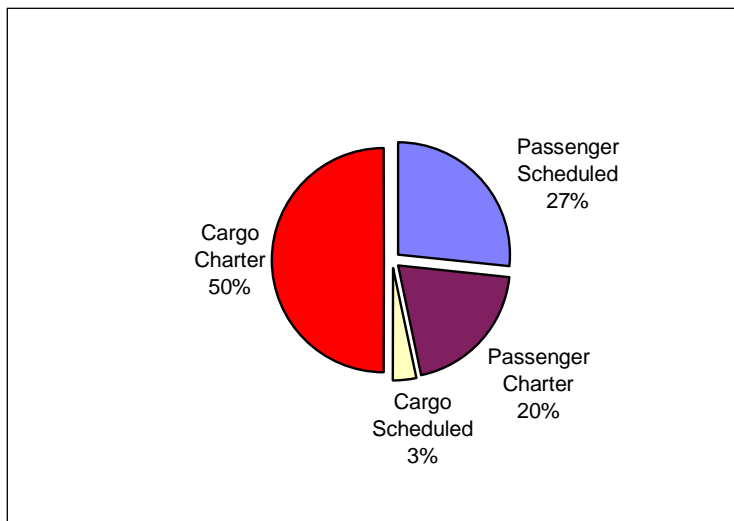


Figure 16: Distribution of category 3a inspection findings per type of operation

5.4 Relevance of inspection results

Because the inspection findings point to the ad-hoc cargo operators, the relative importance of this type of operation is investigated for the Netherlands. As shown in Figure 17, of all the flights by foreign operators to the Netherlands 93% are considered scheduled passenger services. Only 1% of the flights are executed by ad-hoc cargo operators. Although the safety influence of the ad-hoc cargo operations on the total aviation activities in the Netherlands is relatively limited, it is still considered important.

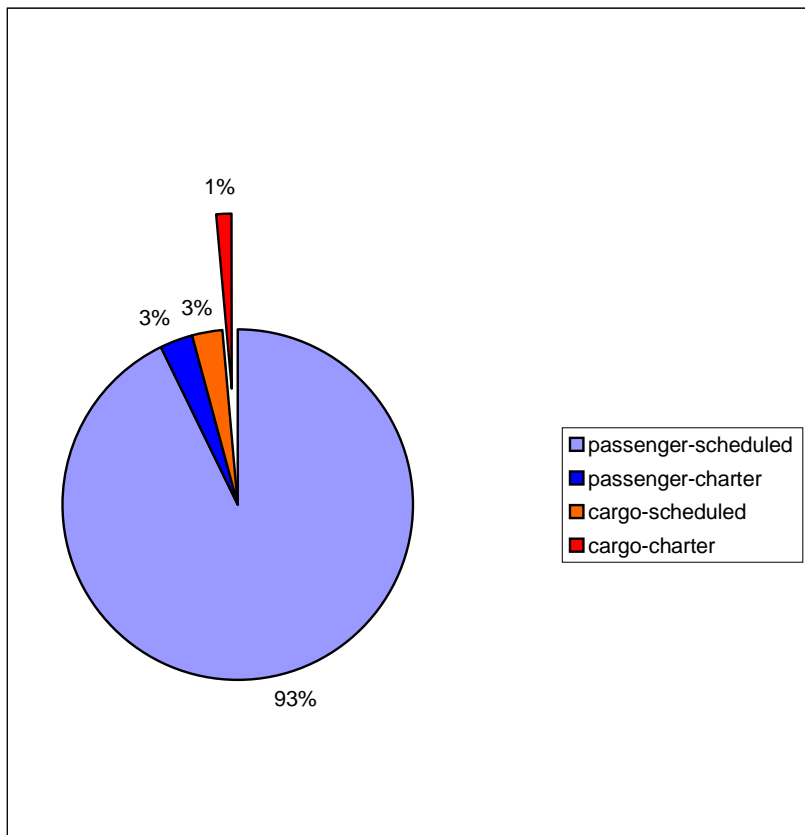


Figure 17: Distribution of commercial flights by foreign operators to the Netherlands per type of operation.

5.5 Content of findings

In general terms the deviations that are observed when inspecting the ad-hoc cargo operators are the following:

- Flight Deck
 - improper execution of flight preparation such as establishing of weight & balance and fuel calculations;
 - no proper safety equipment in cockpit (such as shoulder harnesses);
 - pilot license not available or expired;
 - navigation maps out-of-date or not available.

- Cabin
 - insufficient oxygen for number of passengers onboard, no adaptation of Flight Level flown;
 - baggage not properly stowed;



- dangerous goods in cabin;
 - insufficient numbers of seats for passengers onboard;
 - no (spare) seat belts or no seat belt extensions;
 - seats block free access to emergency exits.
- Airframe
 - structural damage of aircraft;
 - no proper repair of dents/scratches in aircraft fuselage.

The majority of these findings were observed on aircraft of Russian design and operated by East European states and Former Soviet Union States.

5.6 Possible causes of the findings

What could be the causes for the fact that ad-hoc cargo operators have relatively more SAFA Ramp Check findings than other operators? Based on the considerable number of SAFA inspections that have been executed by the RLD-SAFA-Team, the following observations are considered important:

1. The majority of the ad-hoc cargo operators with SAFA inspection findings originate from the former Soviet-Union and East European States and operate aircraft of Russian design.
2. The main cause is the fact that the majority of above mentioned operators have difficulty to survive economically in the very competitive aviation environment. When survival is an issue and safety measures cost money, safety tends to get less priority.
3. Certain operators do not learn from faults made and do not have a system established that assures a proceeding/progressive insight. The RLD-SAFA-Team inspectors are sometimes asked by the foreign Flight Crews to raise safety issues with the management of the operator. Apparently the Flight Crews are not able to report themselves to their management. Fear of job loss may be the reason. In certain airline organisations the management does not appreciate initiatives by their own personnel.
4. In certain aircraft types, requirements such as passenger oxygen were not taken into account in the basic design. A retrofit modification is either not available or too costly for the operator.
5. For certain operators the distribution of responsibilities regarding operation, maintenance and oversight have become very complex. As an example there are those operators with an



Air Operator Certificate (AOC) from State A (or sometimes more than one State), the head office in State B, aircraft maintenance performed by an organisation in State C, flight crew licensed by State D and aircraft registered in State E. This may result in a very scattered oversight of the responsible National Aviation Authorities.

6. There is the impression that a lower level of safety is accepted by the flight or maintenance crew of the aircraft involved, because of the fact that no fare-paying passengers are transported but cargo.

6 Conclusions

- More than half of all cargo movements take place at night, while only a fifth of all passenger operations take place at night.
- There is an increased risk associated with cargo flights conducted at night compared with daytime operations. This association could not be found for passenger operations.
- Over the past 18 years, the average age of Western-built cargo aircraft has been steadily increasing from 14 to 22 years, whereas the average age of Western-built passenger aircraft has remained constant at approximately 10 years.
- The accident rate of ad-hoc cargo operators is almost seven times higher compared with scheduled passenger traffic of major operators.
- The accident rate of cargo flights of major operators is more than 3 times higher than passenger traffic of major operators.
- The accident rate for non-scheduled passenger operations is almost 3 times higher than that for scheduled passenger operations.
- Asia, South America and especially Africa are the problem areas with respect to safety of air cargo operations.
- The difference in the level of safety between cargo and passenger operations is most noteworthy in Africa, North America and South America.



- African cargo operations are dramatically unsafe with almost 17 accidents per million flights.
- In Africa, Asia and South America there is no significant difference in the accident rate for major and ad-hoc operators. In North America however, the accident rate of ad-hoc cargo operators is more than 2 times higher compared with major cargo operators.
- The accident rate of cargo operations by state owned airlines in Africa is two times higher than that of cargo operations by private airlines. There is no difference between the accident rate of passenger operations of state-owned and private airlines in Africa.
- When a comparison is made between types of accidents of cargo and passenger operators, there are no significant differences in the relative distribution. This suggests that the higher accident rate of cargo operators can not be attributed to a single cause.
- Compared with passenger operations, accidents to cargo operations occur more frequently in the take-off and climb phases.
- Both passenger and cargo aircraft, have a lower accident rate for aircraft of a newer generation.
- While a majority of passenger flights in the past three decades was conducted with 2nd generation aircraft, the majority of cargo flights were conducted with first generation aircraft.
- Results of SAFA inspections show that ad-hoc cargo operators are more often non-compliant with ICAO regulations than other operators.
- The main cause for the lower safety level of cargo operators from the developing countries is lack of financial resources.



7 Recommendations

- Following the example set by passenger operators, airlines are encouraged to adopt a “safety first” attitude towards cargo operations.
- It is recommended that cargo operators are made aware of the potential problems associated with night flying, and are provided with advice on the best ways to minimise the negative effects of night flying.
- While it is recognised that the operation of older aircraft in itself does not compromise safety, this can only be the case if the necessary maintenance and inspection items are carried out in a correct manner. The identification of the correct maintenance and inspection items is the combined responsibility of regulators, operators and manufacturers. Continuous co-operation and analysis by these groups on the subject of ageing aircraft is strongly recommended.
- The National Aviation Authorities of developing countries should be supported in their efforts to become strong and effective.
- Although grounding of aircraft by the authorities if there is an immediate safety concern is necessary it does not solve problems. The prime instrument for safety improvement should be support.
- The best solution for continuous and long lasting improvements in aviation safety is achieved through a proper functioning of the National Aviation Authority (NAA). Efforts should be aimed at strengthening of the functioning of the NAAs. A proper functioning NAA will assure an effective oversight of the operators under the NAA’s responsibility and appropriate corrective and preventive actions in case of non-compliances.
- Actions resulting from SAFA inspections should be co-ordinated throughout ECAC countries.



8 References

- [1] A.L.C. Roelen, G.W.H. van Es, H. Goei, A.G. Sayce, S. Doherty, *Safety aspects of air cargo operations*, paper presented at the 11th European Aviation Safety Seminar, Amsterdam, March 1999.
- [2] R. Khatwa, A.L.C. Roelen, *An analysis of Controlled Flight Into Terrain (CFIT) accidents of commercial operators, 1988 through 1994*, NLR TP 94558 U, NLR Amsterdam, 1996.
- [3] Airclaims, Special Bulletin SB 230, Airclaims Ltd, London, March 1994.
- [4] R. Ashford, *Global Airline Safety – The problem and possible solutions*, Report RA/9703, November 1997.
- [5] Civil Aviation Authority, *Global Fatal Accident Review 1980-1996*, CAP 681, CAA, London, March 1998.
- [6] E. Tarnowski, J.J. Speyer, Integrating human factors and automation with progress in aircraft design and flight management, *Proceedings of the IASC-97 International Aviation Safety Conference*, held in Rotterdam, the Netherlands, August 1997.
- [7] National Transportation Safety Board, Aircraft Accident Report, *Uncontrolled impact with terrain, Fine Airlines Flight 101, Douglas DC-8-61, N27UA, Miami, Florida, August 7, 1997*, PB98-910402, NTSB/AAR-98/02, June 1998.
- [8] P.H. Gander, K.B. Gregory, L.J. Connell, D.L. Miller, R.C. Graeber, M.R. Rosekind, *Crew Factors in Flight Operations VII: Psychophysiological Responses to Overnight Cargo Operations*, NASA Technical Memorandum 110380, NASA Ames Research Centre, February 1998.
- [9] M. Kingsley-Jones, I. Sheppard, “Ageing airliner census 1997”, *Flight International*, Number 4582, Volume 152, 9 – 15 July 1997.
- [10] Ministry of Transport, Public Works and Water Management, Directorate-General of Civil Aviation, Aviation Inspection Department, RLD-SAFA Team Jaarrapport, April 2000.



- [11] H.C. Visser, If I were a rich man ... my accident record wouldn't be so bad!, *Proceedings of the IASC-97 International Aviation Safety Conference*, held in Rotterdam, the Netherlands, August 1997
- [12] Mahbub ul Haq, "Human development in a changing world", *1992 Human Development Report*, United Nations Development Program, New York, 1992.

Acknowledgements

This study was conducted under a contract awarded by the Netherlands Department of Civil Aviation (RLD). The authors thank the following persons for their valuable input to this study: Albertine Verweij, Hans Knuvers (Air Transport Association Netherlands), Robert Baltus (Schreiner Airways), Jos van der Woensel (Zygene European Freight Consult), Adrian Sayce (UK Civil Aviation Authority).



Appendix A Aircraft types included in the analysis

Airbus:	A300, A300-600, A310, A319, A320, A321, A330, A340
ATR:	ATR42, ATR72
Aerospatiale:	Caravelle, Corvette, Nord 262
Aerospatiale/BAe:	Concorde
BAe:	146, ATP, J31, J41, 1-11, 748, Vanguard, Viscount, VC10
Beech:	1900
Boeing:	707, 720, 727, 737, 747, 757, 767, 777
Bombardier:	DHC-7, DHC-8
CASA:	212, CN235
Convair:	CV580, CV600, CV640
Dassault:	Mercure
Douglas:	DC8, DC9, DC10, MD80, MD90, MD11
Dornier:	228, 328
Embraer:	Brasilia
Fairchild:	Metro, F27
Fokker:	F27, F28, F50, F100
Grumman:	Gulfstream 1
Handley Page:	Herald
IPTN:	CN212, CN235
Lockheed:	L1011, L188, C-130
NAMC:	YS11
Saab:	340, 2000
Shorts:	330, 360