Air Safety: The Last Decade

by
Alexander Ning-Yuan Wang

Submitted to the
Department of Electrical Engineering and Computer Science
in Partial Fulfillment of the Requirements for the Degree of Master of Engineering in
Electrical Engineering and Computer Science at the Massachusetts Institute of
Technology

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Abstract

This paper presents safety data for the period of 1967-1996, with an emphasis on data from the last decade. The analysis performed is in accord with the methods and results from two earlier MIT studies on air safety. The metric utilized here, as in the other papers, is "death risk per flight".
The primary conclusions of the analysis are:

1. The airlines of the United States, are still extremely low risk with a 1 in 7 million death risk per flight on domestic non-stop scheduled flights and 1 in 1.4 million death risk per flight on international non-stop scheduled flights.
2. However, the United States can no longer clearly claim to be the world's safest airlines. For 1987-1996, that "title" belongs to the airlines from the rest of the First World.
3. As in previous decades, passenger mortality risk on Third World airlines continues to be roughly 10 times as high as on First World airlines.
4. However, when comparing First World and Third World airlines on specific routes involving First World and Third Nations (e.g. London-Cairo), the difference in mortality risk drops sharply.

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1. Introduction

Flight safety continues to be a topic of great interest to the public and thus to the news media. According to the an Associated Press survey of news editors, the number one news story in 1996 was the crash of TWA flight 800; the number five story was the crash of Valujet 592. As such, public faith in the level of flight safety has wavered. Questions such as "how safe are we really?" to "how can we tell which airline is safer?" are very much on the minds of the public.

Two prior MIT studies (Barnett, Abraham, and Schimmel 1979; Barnett and Higgins 1987) analyzed general air safety trends; these studies only considered data through 1986 and sought to address these and other questions. However, the air transportation business is still young and in flux compared to other forms of transit. Patterns in air safety may shift dramatically over the course of a decade. Thus, a new study, specifically concentrating on the results of this last decade from 1987 to 1996, is an important complement to the earlier work.

This paper uses the data from the two previously mentioned studies and, supplementing them with the most recent information on crashes and flights, completes an overall view of air safety over the last three decades spanning from 1967 to 1996. Because the greatest fear in aviation is being killed in a plane crash, this study focuses on passenger fatalities, whether they result from hostile action or from a crash. Furthermore, only scheduled non-stop jet flights and jet accidents are used for this study.

The analysis will begin with a brief discussion and justification of the risk metrics used in this study. The next section (section 3.1) considers risk comparisons between the group of US flights that were safest over 1967-1986 and the corresponding group from the rest of the world. Further analyses and discussion consider the following:

- comparison between all US domestic jet operations over 1987-1996 and all similar operations in other First World countries.
- comparisons between US international jet operations over 1987-1996 and those of the other First World countries.
- domestic and international jet safety among Third World airlines.
- a "matched comparison" of First World and Third World airline flights traversing the same routes between First and Third world nations.

After careful analysis of the air safety trends, the following results are established:

1. The United States' airlines still maintain an excellent safety record
2. However, the United States' airlines can no longer claim to be the world's safest airlines. That title seems to belong to the other First World nations grouped together.
3. Airlines belonging to Third World countries still performs poorly compared to any First World nation.
4. However, when studying flights along similar routes traversing Third World nations, the safety difference between Third World based airlines and First World based airlines is not as dramatic as previously expected. This lends credence to the view that airplanes are much safer when flying into the First World and not as safe when travelling to the Third World, regardless of airline.

2. Methods

In comparing flight risk, the First question that arises is, "how do we evaluate risk quantitatively?". A careful risk metric must be created to properly filter out unnecessary and potentially misleading indications of risk. In this study, as in the two previous studies, flight risk is defined as the probability that a typical passenger could take a random typical flight over a selected time period and flight type of interest and be killed. The risk, or passenger death risk per flight (Q), as described by Barnett and Higgins, is formulated as:

$$Q = \frac{\sum_{i=1}^{N} x_i}{N}$$

where N is the total number of flights in the relevant time period and category and x_i is the proportion of passenger killed on flight ith flight (from 1 to N). Since this evaluation of risk centers on the passenger's concerns for safety, crew deaths are not factored into the calculations. Thus, the formulation of Q follows from a $1/N$ chance of a passenger picking the ith flight and a conditional probability of x_i given the selection of that flight.[1]

While this method has already been established in the previous papers, it is still worthwhile to break down the rationale behind the creation of this formula. At First glance, basing the risk method upon fatal passenger events seems to lead to fallacious results. Fatal occurrences on aircraft, although highly publicized, are still inherently very rare, leading credence to possible statistical noise in any sort of model building based upon fatal events. It may also be interpreted that once a fatal event has occurred, it is already

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[1] Barnett, Arnold and Mary K. Higgins, "Airline Safety: The Last Decade," Management Science Vol. 35, No. 1, January 1989 p.3

too late to say something about trends which may affect future flight safety. Some other factor such as non-fatal accidents and maintenance failures may be a better "leading indication" for calculating risk.

While the above statement is certainly credible, quantifying the effect of non-fatal leading indicators becomes difficult. Non-fatal incidents may indicate unsafe practices aboard an airline but the number of non-fatal incidents may also reflect safer practices that prevented a fatal incident instead. It is no trivial task to try to model safety with non-fatal occurrences. Furthermore, the fundamental concern of an airline passenger is whether or not the passenger will die once he or she steps foot aboard the aircraft. While the use of well defined and defended non-fatal indicators for calculating that passenger's risk is certainly feasible (though difficult), historical fatal events cannot be ignored in "death risk" calculations. Thus, the basis of our risk calculation Q is passenger fatalities.

Given a basis in fatal occurrences on board aircraft, the Q value also takes advantage of the proportion of passengers killed instead of total number of aircraft occupants killed. As illustrated by Barnett and Higgins, utilizing the proportion reduces the effect of random numbers of seating aboard aircraft. Thus, an aircraft with 100 people on board and an aircraft with 50 people on board that both kill all passengers are equally significant in risk.

Lastly, Q utilizes the total number of flights over a particular flight category of interest instead of the total distance traveled. This is due to the observation that the majority of fatal events (over 90% according to Boeing studies) occur during the takeoff/initial climb or approach/landing phases.[2] There seems to be no reason to include distance as a deciding factor in risk, utilizing instead the total number of flights in the category of interest.

Having completed a device for measuring death risk, the actual data must be compiled. The majority of accident data is publicly available in *Flight International* magazine's annual articles about air safety. These articles supply fatal accident data such as date, airliner, aircraft type, death proportions of passengers, whether or not the flight was scheduled, and some flight destination and origin information. As previously stated, this study focuses primarily on jet fatal incidents, especially in the later periods. The rationale behind this change lies in the basic assumptions of a passenger's concerns and worries: what are the probabilities that a passenger steps onto a typical aircraft flying along a typical route and gets killed? Jets have become the most prevalent passenger aircraft[3] in the last two decades and represent the most current and technologically advanced aircraft. Furthermore, it can be argued that including accidents on board less technologically advanced aircraft would skew the data unfavorably. While studying commuter flights and other non-jet based flights is interesting, it would involve a whole different set of analyses which are not within the scope of this thesis. Similarly, the rationale behind choosing only scheduled flights (and accidents) is that scheduled flights fly along the most commonly used and recognized flight paths, reflecting typical routes. Non-scheduled flights themselves may have different safety levels and should thus be part

[2] Barnett, Arnold and Mary K. Higgins, "Airline Safety: The Last Decade," Management Science Vol. 35, No. 1, January 1989 p.3

[3] According to Barnett, 94% of all American flight passengers fly on jets.

of a separate analysis. Though an imperfect source of information, the *Flight International* annual safety tabulations provide enough data for preliminary estimation and calculation. When further clarification of missing data is needed, other resources such as on-line air accident databases (also publicly accessible) are used, specifically to help in the classification of the fatal events.

Total numbers of flights are derived through the use of the *Traffic ICAO Digest of Statistics* and the *Official Airline Guide* books for various years. The *Traffic* digests contain total numbers of scheduled flights on a per airline basis for several years. This resource for total numbers of scheduled and domestic flights requires a priori knowledge about the aircraft used on certain flight types among chosen airlines. For more specific knowledge of the number of flights in key categories, the *Official Airline Guide* or *OAG* provides an excellent description of actual scheduled flights on a monthly basis to all possible destinations, with certain exceptions[4]. For this study, a ten percent sample was taken of all the pages in the June editions of 1982 and 1992 to determine the number of flights falling under the categories of study previously mentioned. Specifically, the flight guide published for the exact middle of each decade, considered to be typical of the kind and amount of flying in the rest of the decade, is used to extrapolate the average number of flights in special categories for the entire decade.

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[4] The World Wide editions of the *OAG* were used for this study which include neither international flights from Canada to the United States nor Canadian domestic flights. The international flights from Canada to the US is estimated from the North American OAG to number approximately 100,000 flights per decade. Canadian domestic flights are estimated to be approximately 250,000 per decade.

Now, that the basic tools exist, flight risk may be computed and several different categories of flight risk may be evaluated. A specific explanation of calculation methodologies will ensue.

3. Discussion

3.1 A "The World Series" in Airline Safety

To assess whether US airlines are safer than their First World counterparts, we might consider an analogy of the World Series in baseball. That is, take the two best performing "teams" and compare them historically across the test period or in this case, the last thirty years. The United States would pick a team and its historical competitor, the First World nations (other than the United States), would pick a team.

Traditionally, the United States has had the safest flying records around the World. Specifically, the domestic flights of the United States' major trunkline carriers (hereafter referred to as the trunkline carriers) have had the safest records out of all of the United States' aviation history. These carriers, surviving to 1996, are:

Table 1 : Trunkline Carriers in World Series

American	**Continental**	**Delta**
Northwest	**TWA**	**United**
US Air		

Together these 7 carriers and several others that have since been consolidated into the 7 mentioned above or have ceased operations, over the course of the last thirty years, provided the vast majority of US domestic. Among the airlines absorbed in the mergers are: Southern, Hughes Airwest, North Central, Republic, PSA, Texas International, Allegheny, Frontier, Ozark, and Pan Am. The data from these absorbed airlines is also included in our calculations.

In comparison with United States major trunk lines, the scheduled international operations of First World flag carriers (hereafter referred to as the flag carriers) have had, over the period 1967-1986, the "pennant winning" safety performance outside the US. The test group established in the previous papers include the following airlines:

Table 2 : Flag Carriers in World Series

Aer Lingus (Ireland)	***Air Canada***	***Air France***	***Alitalia***	***British Airways***
Iberia	***KLM***	***Lufthansa***	***Sabena***	***SAS***
Swissair	***Austrian***	***El Al (Israel)***	***Finnair***	***JAL***
Icelandair	***Loftleidir***	***Olympic***	***Quantas***	***South African***
TAP				

Each of these airlines is the key international carrier for each of their respective First World nations. To maintain a parallel with the earlier studies, this group of airlines is used for this study as well.

Once the test groups and the flight types have been identified, risk measurements can now proceed. Since each airline performs its World Series routes exclusively on jets not counting commuter operations, *Traffic* may be used as the chief resource to calculate the total number of flights for each test group.[5] Note that for the purposes of this exercise, data is grouped into separate decades. Table 3 summarizes the findings:

[5] The number of flights over the last two years, 1995 and 1996, have yet to be supplied by *Traffic* and have been estimated for this study.

Table 3 : Total Number of Flights Performed by Two "World Series" Teams in Three Different Decades

Flight Group	**# of flights (1967-1976)**	**# of flights (1977-1986)**	**# of flights (1987-1996)**
US Major Trunkline Carriers (domestic flights)	40 million	41 million	46 million
Major 1st World Flag Carriers (international flights)	8.4 million	11 million	17 million

Next, the death proportion sums, or number of full crash equivalents, are needed to finalize *Q* calculations. The statistics of these two groups are summarized in Table 4. A line by line listing of these fatal events can be found in the Appendix.

Table 4 : # of Full Crash Equivalents in World Series Events

Flight Group	**# of Full Crash Equivalents (1967-1976)**	**# of Full Crash Equivalents (1977-1986)**	**# of Full Crash Equivalents (1987-1996)**
US Major Trunkline Carriers (domestic flights)	18.53	3.74	6.57
Major 1st World Flag Carriers (international flights)	13.63	1.65	2.02

Since the United States group flew roughly four times as many flights, one would expect that, if both groups performed equally, the number of accidents the United States experiences would be no greater than four times that of the First World Flag group. However, the above data indicates that the First World flag group is doing better than expected. This results in *Q* trends as specified below:

Table 5 : World Series *Q* values Reciprocated

Flight Group	*Q* value reciprocal (1967-1976)	*Q* value reciprocal (1977-1986)	*Q* value reciprocal (1987-1996)
US Major Trunkline Carriers (domestic flights)	1 in 2.2 million	1 in 11 million	1 in 7.0 million
Major 1st World Flag Carriers (international flights)	1 in 670,000	1 in 7.2 million	1 in 8.5 million

These results are in accord with the findings of the two earlier papers. In the period 1967-1976, the trunkline carriers (1 in 2.2 million death risk per flight) had a clear safety advantage over its nearest competitors, the flag carriers (1 in 670 thousand death risk per flight). In the second period (1977-1986), the US trunkline carrier group performed better than it did in the First period and still outperforms (barely) the flag carriers. Finally, the United States trunkline group's performance drops in the most recent period as the First World flag carriers catch up to and surpass the United States group.

3.2 Statistical Significance of Time Trend in World Series

The question that now follows is, "how seriously should we take these results"? Major fatal airline events occur at a fairly low rate (about 1 every year for the trunkline carriers and less than 1 every two years for the flag carriers). One could argue that the rarity of fatal airline events will reflect significant statistical noise which may skew any attempt at model building and that the *Q* values seen previously are not valid. The patterns observed could happen by mere chance alone and that the two groups are actually equally safe throughout the entire period.

Let us begin by taking the stance that both groups are equally safe and that any difference is merely a reflection of random statistical noise. We recognize that while the trunklines have been more or less flying the same amount throughout the period, the First World flag carriers more than double the amount of flights in thirty years. However, to a first order approximation, a rough 3.6:1 ratio between the trunklines and the flag carriers exists. Given this approximation[6], one would expect that given a fatal event, that event should have a 22 percent chance of belonging to an airline in the flag carrier group. The number of accidents belonging to the flag carrier group then would be expected to obey a binomial distribution. To test this, we count the number of fatal events. However, accidents which kill a single passenger should not have the same significance as a flight which kills everyone on board. Thus, not counting those incidents with very low fatality rates, there were in total 47 events between the two flights groups over the course of 1967-1996. The number of accidents belonging to the flag carrier group forms a binomial distribution of the form:

$$P(\text{flag carrier crashes} = n) = \frac{47!}{n!(47-n!)}(0.22)^n(1-0.22)^{47-n}; 0 \leq n \leq 47$$

Given this distribution, one would expect the number of fatal events over the thirty years to roughly come out to 10 crashes[7] for the flag carriers. As noted in the appendix, the actual number of flag carrier crashes is 18. Under the binomial distribution above, the

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[6] While the percentage of flights on the flag carriers has grown slowly over the period, this variation need not explicitly be considered in this first order analysis.

[7] E[flag carrier crashes] = 47 * (0.22)=10.34

probability of the First World flag carrier group having 18 crashes is less than 1 percent.[8] This is consistent with the view that the flag carrier flights and the trunkline carrier flights were not equally safe throughout the last three decades.

Thus far, the analysis has been based upon the distribution by number of flights throughout the thirty year period. To take a different perspective, consider the chronological distribution of the fatal events. If both groups are equally safe and no risk pattern exists, one would expect uniform and similar distributions of fatal events between the two groups.

An easy way to test for a temporal patterns is with a rank sum test. That is, rank all the accidents chronologically with the most recent fatal event being ranked number 1. The average rank for the flag carrier fatal incidents should be roughly 24. Thus, given 47 events and assuming the same pattern over time for the US trunklines and the flag carriers, the expected rank of the First World flag carriers is roughly 432. The actual rank of 500 is much lower. Similarly, the expected rank of the US major trunkline carriers is 696. The actual trunkline rank is higher at 628. Table 6 summarizes these results:

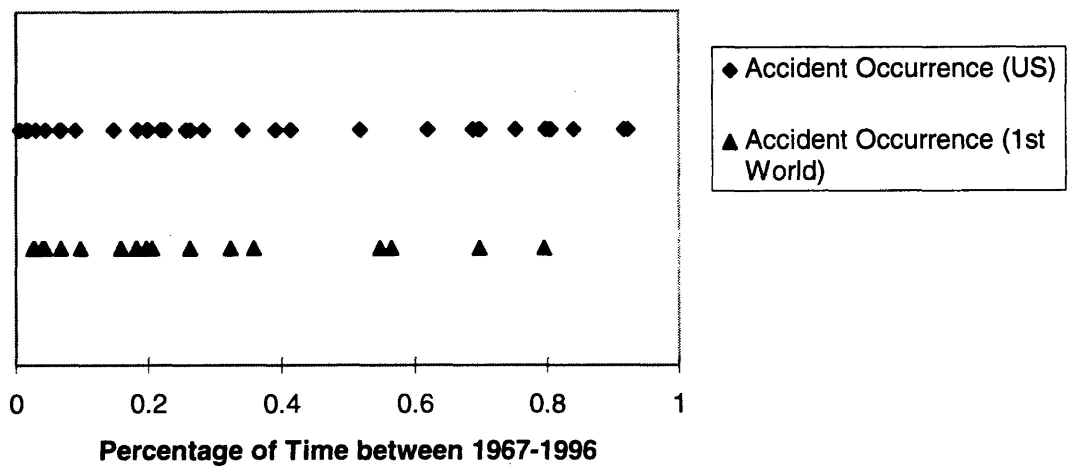
[8] P(flag carrier crashes = 18) = 0.00494

Table 6 :Rank Sum Test Results

Flight Groups	Rank Sum Expected	Actual Rank Sum	Probability of Actual Value Under Assumption of Normal Distribution
First World Flag Carriers	432	500	0.068
US Major Trunkline Carriers	696	628	0.068

As can be seen, the assumption that no pattern (or rather a uniform, normally distributed pattern) exists is unlikely. The First World flag carriers rank sum is high, indicating a higher concentration of fatal occurrences toward the beginning of the period. However, the trunkline carriers is in fact lower, indicating a slightly higher concentration of fatal occurrences toward the beginning of the period. Assuming that conditions at the beginning of the period were much more unsafe (due to poor safety technology, poor safety standards, etc.), one would expect a clustering of trunkline accidents toward the beginning of the period since the United States flew so many flights in the earlier, more dangerous periods. Then as conditions become more safe, accidents should become more scarce. These statements, however, should apply to the both the flag carrier and trunkline carrier groups assuming equal safety. As can be seen, this is in fact not the case; given that recent crashes get the lowest ranks, it is amazing that the First World flag carriers did not receive a lower rank-sum number than expected since a disproportionate number of their flights were performed recently. The actual temporal distribution of the flight accidents is shown below in Figure 1. Thus, a more unsafe flying environment at the beginning of the test period cannot fully explain the pattern observed for the trunkline carriers.

Figure 1: Chronological Fatal Air Accident Distribution (World Series Groups)



The combination of the results from the binomial testing and the rank sum testing suggest that the two group have not been equally safe for the full thirty years and that a statistically significant pattern does indeed exist. However, it is interesting to note that although the above patterns have been shown to be significant, Q is still tremendously affected by the volatility of further fatal events. For example, the earlier paper by Barnett and Higgins defined one of the test periods to be 1976-1986 where the flag carriers have a Q value of 1 in 4.4 million, about twice of what has been calculated here for 1977-1986. This is in fact due to the addition of one more fatal crash with no survivors of a British Airlines jet in 1976. In effect, one more valid fatal event in any particular category could seriously change the overall picture of air safety. This is an inescapable result of the rarity of fatal events onboard jet aircraft.

Furthermore, one could argue that these trends may be very biased and may not reflect anything useful about air safety. To make a real comparison amongst the two groups, one should arguably compare *all* domestic jet flights in the United States and *all* First World jet carrier international flights with all First World domestic jet flights and all US scheduled international flights. This causes the analysis to go into "extra innings", to complete our analogy of the World Series. Furthermore, analysis amongst "like versus like" categories should be performed and judged to see if indeed, these are the best two "teams" from their respective flying groups. Moreover, after careful considerations to the data set, only the last two decades should be chosen for analysis. Reports accounting earlier accidents and number of flights are not as reliable or as accurate as reports regarding more recent events. Thus, the focus when looking at *all* accidents should change to only the last two decades.

3.3 US Domestic and International Flights

Incorporating all domestic flights and all accidents, airlines such as Southwest, Alaska, American West, and Midwest Express are added. Furthermore, accidents not on board those airlines in our previous US flag carrier group now contribute to Q calculations. The actual accident data can be found in Appendix. The following Table summarizes these results.

Table 7 : All Scheduled US Domestic Jet Death Risk Per Flight

	1977-1986	1987-1996
Total # of Flights	46 million	56 million
Total # of Full Crash Equivalents	6.65	7.56
Reciprocal of *Q* values	1 in 6.9 million	1 in 7.3 million

Again, using *Traffic* as a reference, similar calculations are performed on the US international fatal incidents.

Table 8 : All Scheduled US International Flights Jet Death Risk Per Flight

	1977-1986	1987-1996
Total # of Flights	2.7 million	4.1 million
Total # of Full Crash Equivalents	1.92	3.00
Reciprocal of *Q* values	1 in 1.4 million	1 in 1.4 million

Keeping in mind the volatility of death risk calculations, the improvement seen on US domestic routes may not be statistically significant. Thus, no conclusion as to improved performance on US domestic flights may be made. The international flights have been more or less staying at a constant level of safety. The United States still performs far better on its domestic routes, justifying their use as a measure of the safest flights the United States has to offer.

3.4 First World Domestic and International Operations

The situation becomes slightly more complex when trying to perform similar calculations on airlines based in First World countries. The mix of jet and non jet operations on board airlines originating from the First World is in most cases unknown, thus precluding the specific use of just the *Traffic* documentation to determine the number of flights. A different methodology must be used to analyze domestic jet air travel in the First World countries.

Initially, utilizing the *OAG* June 1992 and 1982 editions, a 10 percent sample of all the pages is taken by taking every tenth page in the books and noting flights First World airline flights flying domestically. From this sample, the number of flights in total for the month of June could be calculated for the years 1992 and 1982. Extrapolating these results out for the rest of the decades each edition represents, we have an estimate for the total number of domestic First World flights conducted over the period 1977-1986 and 1987-1996. However, an unintentional bias is also introduced into the sample. Since all the destinations of the flights are listed alphabetically, it is entirely possible to miss several flights coming out of specific cities by virtue of not being every tenth page. For example, London, which is the major hub for all UK domestic flights, may happen to fall between the tenth page sample, thus eliminating a large percentage of UK domestic flying. This flaw becomes dangerous when performing country by country analysis. The UK, Japan, France, Germany, and Italy (hereafter referred to as the Big 5 countries) perform more domestic flights than any other country. Taking into account the top eight largest and most traveled cities in each country, the total number of non-stop jet domestic flights to each of these cities in the June 1982 and 1992 editions of the *OAG* are tracked. Assuming that every flight going to one of these major cities is matched by a flight going out from that city, we can approximate the amount of domestic flights in each of the Big 5 countries for the month of June. The remaining First World countries are grouped together and a 10 percent sample of all the pages in the OAG is used. The results are then extrapolated to cover each decade 1977-1986 and 1987-1996. The overall Q calculations for the First World (outside of the United States) are listed below.

Table 9 : All First World Domestic Jet Death Risk Per Flight

	1977-1986	1987-1996
Total # of Flights	16 million	19 million
Total # of Full Crash Equivalents	8.65	1.65
Reciprocal of Q values	1 in 1.8 million	1 in 11 million

A line by line listing of the calculations of the Big 5 is listed in the Appendix.

A similar type of derivation for the total number of international First World based flights is used. However, the Big 5 countries utilize jets primarily in their international flight operations. Figures from *Traffic* are valid for this subset only. The number of international flights on board airlines from the remaining countries are kept track of through use of the *OAG*.

Table 10 : All First World International Jet Death Risk Per Flight

	1977-1986	1987-1996
Total # of Flights	11 million	16 million
Total # of Full Crash Equivalents	1.62	4.05
Reciprocal of *Q* values	6.9 million	4.0 million

It seems that where previously, in the period 1967-1986, the First World domestic performance outstripped the domestic performance, the latest decade shows that the most improved and safest category is the First World domestic group.

To compare all of the results, it is clear that under any circumstances and categorizing, in the most recent decade, the First World domestic aviation performance has exceeded the "best" the United States has to offer, the US domestic flights. The First World internationals also perform better than the US domestic flights. However, the reader should keep in mind the volatile nature of death risk statistics. For example, the First World airlines had 1.65 full crash equivalents over the period 1987-1996. One more full crash equivalent would bring the total number for that period to 2.65. This would in turn drive the *Q* values down to 1 in 7 million, which is exactly the same as the death risk on board US domestic jet flights in the most recent period, 1987-1996. Thus, the trends encountered in our analysis do not indicate an overwhelming "win" for the First World airlines. However, despite the volatility of *Q* measurements, the patterns suggest that while the United States had at one point an aviation safety advantage over its nearest competitor, in the most recent decade, the First World seems to have caught up to and surpassed the US in air safety superiority.

3.5 Third World Domestic and International Flights

Flight travel in the Third World has typically been the least safe category of air travel. This is may be due to any number of reasons: political instability, lack of safety information, lack of safety regulations, etc.. In fact, the difficulty in evaluating risk for the Third World is a direct result of the lack of information regarding fatal events in the Third World. Some of the data, such as the data on Russian airlines, becomes hopelessly obscured in the political changes of the country, rendering such data useless. Other data, such as the data from Mainland Chinese airlines, is inaccurate at best and missing and fallacious at worst.

To combat these difficulties, certain decisions in gathering data are made to eliminate as much uncertainty as possible. For example, in the case of the Russian airlines, the breakup of the Soviet Union obscures the destination and flight information of the majority of the flight accidents, in effect rendering all such data as unclassifiable and therefore useless. The political breakup of such a large contributor to Third World accidents is an anomalous event which may distort perceptions of domestic flight safety and international flight safety. Thus, calculations are made without any data from Russia or any members from the former Soviet Union.

Even with removing the former Soviet Union based flight accidents, many accidents were still missing data about origin and destination, making it impossible to classify these accidents as domestic or international. 22 of these accidents occurred on

Boeing built aircraft. Referring to information provided by contacts at Boeing, it was found that 17 of these accidents occurred on domestic flight while 5 occurred on international flights. Since so many more accidents remain unclassified, thereby making a concrete determination for Q values impossible, certain assumptions have to be made regarding the unclassified accidents.

We applied three alternate rules to estimate how the remaining accidents should be divided between domestic or international flights:

1. The proportion of domestic flight accidents found on board the previously unknown Boeing flights would also apply to the remaining unknown accidents. Thus, 17/22 of all the unclassified flights accidents are classified to be domestic and the remaining accidents are classified to be international flights.
2. The proportion of known flight accidents would apply to the rest of the unknown accidents. For this case, a proportion of 48/91 was used as the proportion of domestic flight accidents.
3. All the remaining unclassified flight accidents are domestic. The rationale behind this "guess" is that international incidents usually have adequate and more widespread news coverage. Therefore, the remaining accidents could only be domestic since such little information is known about them.

The total number of domestic and international Third World airlines was calculated utilizing the *OAG* 10 percent sample as described previously. This is again due to the unknown operational mix of jets and non jets aboard Third World airlines. Furthermore, all Third World nations are grouped together. The following two tables represent the domestic findings respectively under all three aforementioned assumptions.

Table 11 : 3rd World Domestic Jet Death Risk Per Flight

Assumptions about the unclassified flights	*1977-1986 flight totals*	*1987-1996 flight totals*	*1977-1986 full crash equivalents*	*1987-1996 full crash equivalents*	*1977-1986 Q inverse*	*1987-1996 Q inverse*
Assuming Boeing proportion of flights	11 million	11 million	21.7	25.6	1 in 520 thousand	1 in 440 thousand
Assuming existing proportion of flights	11 million	11 million	19.2	24.1	1 in 580 thousand	1 in 470 thousand
Assuming all domestic flights	11 million	11 million	24.0	27.0	1 in 470 thousand	1 in 420 thousand

Similar calculations are performed when addressing the Third World international performance as shown in the next table.

Table 12 : 3rd World International Jet Death Risk Per Flight

Assumptions about the unclassified flights	*1977-1986 flight totals*	*1987-1996 flight totals*	*1977-1986 full crash equivalents*	*1987-1996 full crash equivalents*	*1977-1986 Q inverse*	*1987-1996 Q inverse*
Assuming Boeing proportion of flights	8.2 million	8.0 million	13.2	21.3	1 in 620 thousand	1 in 380 thousand
Assuming existing proportion of flights	8.2 million	8.0 million	15.7	22.8	1 in 520 thousand	1 in 350 thousand
Assuming all unknown are domestic flights	8.2 million	8.0 million	10.9	19.9	1 in 760 thousand	1 in 400 thousand

All three assumptions produce different results in Q by varying degrees. It is impossible without additional information to tell which one of these assumptions is valid. However, it is abundantly clear that the Third World performance under any assumption is much poorer than that of any First World country.

3.6 First World and Third World Airlines Along the Same Routes

While it was made apparent in the previous section that Third World airlines cannot approach any First World airline in safety performance, consider this: a jet aircraft from a prestigious airline First World airline flies into the Third World. Though safety procedures and technology are in place onboard this aircraft, the airline is flying into an area of poorer quality air traffic control than it normally receives. Is the airline still as safe as it was before? Concurrently, let us imagine a Third World airline taking the same route but from the other direction; the Third World airline flight starts in a Third World country and flies into a First World nation where it experiences superior guidance from air traffic control, better skilled emergency teams, etc.. Is this airline as safe as it was before? Whereas it is clear that the First World airlines out-perform Third World airlines in an overall view of air safety, when studying specific similar routes, it is not so clear which airline outperforms which.

To model the above mentioned events, a 10 percent sample of the pages in the OAG June 1992 and 1982 editions is taken. All international flights on board Third World airlines are noted and classified into three categories: First World to First World flights, First World to Third World flights (and vice versa), Third World to Third World flights. A similar process is conducted for First World airline based international flights, again into those same categories. These results are extrapolated to estimate the amount of flying under those categories performed throughout the decades 1977-1986 and 1987-1996.

The flight accidents are also then categorized into the aforementioned categories. While First World airline international flight incidents are easier to classify due to a higher degree of press relating to those incidents, Third World airline international flights incidents are often difficult to classify due to the lack of origin and destination information available. This is a parallel to the situation described previously in the overall study of international and domestic performance of the Third World based airlines. Again, we employ the "three guesses" used to determine the number of valid international flights. Then, the known proportion of accidents falling into the three categories is applied to those flights. The table below shows the proportions used to estimate the categorization of the international incidents.

Table 13 : Proportions Used to Estimate Third World International *Q* Values Categorized by Travel Type

	Flights Travelling Between 1st World and 1st World countries	***Flights Travelling Between 1st World and 3rd World countries***	***Flights Travelling Between 3rd World and 3rd World countries***
Total number of international flights from 1977-1982	340 thousand	2.3 million	5.6 million
Total number of international flights from 1987-1996	150 thousand	3.9 million	4.0 million
Full Crash Equivalents from 1977-1986	1	4.00	5.86
Full Crash Equivalents from 1987-1996	.007	4.63	13.6
Proportions of Flights Based Upon Travel Type (1977-1986)	.092	.368	.54
Proportions of Flights Based Upon Travel Type (1987-1996)	.0004	0.25	0.75

We continue to use our "three guesses" that we used previously to calculate total numbers of Third World international flights given so many unclassifiable accidents. Applying the proportions in Table 13 to the additional flights that the our three assumptions give us, we can estimate to total numbers of flights on board Third World carriers travelling between First World and Third World nations. We can now calculate *Q* values for Third World international fatal events occurring on originating in the First World and ending in the Third World (and vice versa).

Table 14 : Third World International Jet Death Risk Per Flight For Flights Travelling Between First World and Third World Countries Utilizing Assumptions From the Three "Guesses"

	Flights Travelling Between 1st World and 3rd World countries
Assuming Boeing proportion of flights	
Full Crash Equivalents from 1977-1986	4.51
Full Crash Equivalents from 1987-1996	4.98
Reciprocal Q value from 1977-1986	1 in 500 thousand
Reciprocal Q value from 1987-1996	1 in 780 thousand
Assuming existing proportion of flights	
Full Crash Equivalents from 1977-1986	5.06
Full Crash Equivalents from 1987-1996	5.86
Reciprocal Q value from 1977-1986	1 in 450 thousand
Reciprocal Q value from 1987-1996	1 in 660 thousand
Assuming all unknown flights are domestic flights	
Full Crash Equivalents from 1977-1986	4.00
Full Crash Equivalents from 1987-1996	4.63
Reciprocal Q value from 1977-1986	1 in 570 thousand
Reciprocal Q value from 1987-1996	1 in 830 thousand

We perform similar calculations with flights on First World airlines as seem in Table 15.

Table 15 : First World International Jet Death Risk Per Flight For Flights Travelling Between First World and Third World Countries

International Flights from the 1st World (including US)	***1st World to 3rd World***
Total number of international flights 1982 decade	2.4 million
Total number of international flights 1992 decade	2.0 million
Full Crash Equivalents from 1977-1986	1.25
Full Crash Equivalents from 1987-1996	4.02
Reciprocal Q value from 1977-1986	1 in 1.9 million
Reciprocal Q value from 1987-1996	1 in 490 thousand

Comparing the *Q* calculations for the Third World airlines with similar calculations involving First World airlines, one could see that the tremendous safety advantage experienced by First World airlines in overall international comparisons is not nearly so dramatic when comparing flights travelling between First World and Third World Countries. In the most recent decade, the First World airline safety drops on flights involving travel between the First World and Third World nations. While the Third World airlines seem to outperform the First World airlines on those flights travelling between the First World and Third World in the last decade, the reader should once again keep in mind the statistical volatility of these risk calculations. The better performance experienced by the Third World airlines in this latest decade may not, in fact be statistically significant. However, it is undeniable that the huge difference in performance in overall travel is not so apparent once specific flight paths involving travel between First World and Third World nations are studied.

4. Conclusion

The analysis performed in this paper describes, quantitatively, general air safety trends over the last thirty years from 1967 to 1996. However, the overall question remains to be addressed, "is it safe enough to fly?". For example, the United States, as shown in the calculations performed here, has roughly stayed at the same level of risk over the period 1977-1996, a 1 in 7 million death risk per flight for domestic flights and a 1 in 1.4 million death risk per flight for international flights. Compared to airlines from the Third World, the death risk for both domestic and international flights from the United States is much less by an order of magnitude or more. Compared to airlines from the other First World countries, where we find definite improvement over the last thirty years, the death risk on board flights from the United States is worse.

However, the risk calculations performed by themselves are not significant enough to determine whether or not we are "safe". An absolute measure of a "safe enough" death risk per flight level is difficult to quantify. If one subscribes to the idea that the United States flew safely in the last decade from 1977-1986, this paper shows that the United States continued to fly safely in this decade as well, although not as safely as its other First World cousins. However, for those who subscribe to the belief that the United States did not fly safely in the last decade, the results of this paper will prove to be disheartening as risk levels did not improve significantly. Ultimately, the decision on whether or not flying on board airlines from the United States or any other First World country is "safe enough" is one of personal choice and judgment which is beyond the scope of this paper.

5. Appendix

5.1 World Series Accident Listings

Table 16 : US Domestic Trunkline Fatal Events from 1967-1996

Year	Date	Carrier	# of deaths	# of total passengers	death proportion
1996	6-Jul	Delta	2	142	0.014084507
1994	8-Sep	USAir	127	127	1
1994	2-Jul	USAir	37	52	0.711538462
1992	22-Mar	USAir	24	47	0.510638298
1991	3-Mar	United	20	20	1
1991	1-Feb	USAir	20	83	0.240963855
1990	3-Dec	Northwest	8	39	0.205128205
1990	3-Oct	Eastern*	1	??	0.01
1989	19-Jul	United	111	296	0.375
1989	9-Mar	USAir	1	70	0.014285714
1989	20-Sep	USAir	2	55	0.036363636
1988	31-Aug	Delta	13	97	0.134020619
1987	7-Dec	USAir[9]	38	38	1
1987	15-Nov	Continental	25	77	0.324675325
1987	16-Aug	Northwest	146	147	0.993197279
1985	2-Aug	Delta	128	155	0.825806452
1983	9-Jan	Republic Airlines*	1	??	0.01
1982	9-Jul	Pan Am	138	138	1
1979	25-May	American Airlines	259	259	1
1979	12-Feb	Allegheny	1	22	0.045454545
1978	25-Sep	PSA	129	129	0
1978	1-Mar	Continental	2	184	0.010869565
1978	8-May	National	3	52	0.057692308
1978	28-Dec	United	10	184	0.054347826
1977	4-Apr	Southern	60	81	0.740740741

[9] Actually PSA which was subsequently merged into USAir.

* Actual number of passengers is unknown. Death proportion estimated from expected passenger complement

United States Trunkline Domestic Fatal Events 1967-1996 (cont.)

Year	Date	Carrier	# of deaths	# of total passengers	death proportion
1975	24-Jun	Eastern	109	116	0.939655172
1974	1-Dec	TWA	85	85	1
1974	11-Sep	Eastern	68	78	0.871794872
1973	27-Sep	Texas International	8	8	1
1973	31-Jul	Delta	83	83	1
1973	24-Jul	Ozark	37	42	0.880952381
1973	30-Aug	TWA	1	132	0.007575758
1973	4-Nov	National	1	116	0.00862069
1972	29-Dec	Eastern	95	163	0.582822086
1972	20-Dec	North Central	9	30	0.3
1972	8-Dec	United	40	55	0.727272727
1972	29-Jun	North Central	2	2	1
1972	20-Dec	North Central*	9	??	0.07
1971	6-Jun	Hughes Air West	44	44	1
1971	7-Jun	Allegheny	26	28	0.928571429
1969	9-Sep	Allegheny	78	78	1
1969	18-Jan	United	31	31	1
1969	6-Jan	Allegheny	9	25	0.36
1968	27-Dec	North Central	26	41	0.634146341
1968	24-Dec	Allegheny	18	44	0.409090909
1968	3-May	Braniff	79	79	1
1967	20-Nov	TWA	60	75	0.8
1967	19-Jul	Piedmont	74	74	1
1967	23-Jun	USAir	30	30	1
1967	9-Mar	TWA	21	21	1
1967	29-Mar	United*	1	??	0.01

Table 17 : First World Flag Carrier Fatal Events from 1967-1996

Year	Date	Carrier	# of deaths	# of total passengers	death proportion
1996	5-Sep	Air France	1	206	0.004854369
1993	14-Sep	Lufthansa	1	64	0.015625
1990	14-Nov	Alitalia	40	40	1
1987	28-Nov	South African Airways	141	141	1
1983	3-Jun	Air Canada	23	41	0.56097561
1983	12-Dec	Iberia	49	84	0.583333333
1979	7-Oct	Swissair	14	142	0.098591549
1977	17-Oct	Lufthansa	3	86	0.034883721
1977	3-Nov	El Al*	1	??	0.01
1977	28-Sep	Japan Air Lines	25	69	0.362318841
1976	4-Jul	Air France	2	240	0.008333333
1976	30-Aug	Air France	1	20	0.05
1976	10-Sep	British Airways	54	54	1
1974	20-Nov	Lufthansa	55	140	0.392857143
1973	5-Mar	Iberia	61	61	1
1972	18-Jun	British Airways[10]	109	109	1
1972	14-Jun	Japan Air Lines	72	76	0.947368421
1972	28-Nov	Japan Air Lines	47	62	0.758064516
1971	2-Oct	British Airways[11]	55	55	1
1971	27-Dec	Swissair	14	142	0.098591549
1969	3-Dec	Air France	51	51	1
1969	8-Sep	Sabena	28	28	1
1969	13-Jan	SAS	15	36	0.416666667
1968	24-Mar	Aer Lingus	57	57	1
1968	5-Mar	Air France	49	49	1
1968	20-Apr	South African Airways	127	132	0.962121212
1967	12-Oct	British Airways[12]	59	59	1
1967	4-Nov	Iberia	30	30	1

[10] Actually BEA

[11] Actually BEA

[12] Actually BEA

* Actual number of passengers unknown. Death proportion is estimated from the typical passenger complement.

5.2 US Air Accidents: Domestic and International

Table 18 : US Domestic Fatal Events 1977-1996 On Board Scheduled Jet Flights

Year	Date	Carrier	Aircraft	# of deaths	# of total passengers	death proportion
1996	6-Jul	Delta	MD88	2	142	0.014084507
1996	11-May	Valujet	DC9	105	105	1
1994	8-Sep	USAir	737	127	127	1
1994	2-Jul	USAir	DC9	37	52	0.711538462
1992	22-Mar	USAir	F28	24	47	0.510638298
1991	3-Mar	United	737	20	20	1
1991	1-Feb	USAir	737	20	83	0.240963855
1990	3-Oct	Eastern[13]	DC9	1	64	0.015625
1990	3-Dec	Northwest	DC9	8	39	0.205128205
1989	19-Jul	United	DC10	111	296	0.375
1989	9-Mar	USAir	737	1	70	0.014285714
1989	20-Sep	USAir	737	2	55	0.036363636
1988	31-Aug	Delta	727	13	97	0.134020619
1987	7-Dec	PSA	Bae 146	38	38	1
1987	15-Nov	Continental	DC9	25	77	0.324675325
1987	16-Aug	Northwest	MD82	146	147	0.993197279
1985	2-Aug	Delta	L1011	128	155	0.825806452
1985	6-Sep	Midwest Express	DC9	31	31	1
1982	13-Jan	Air Florida	737	70	74	0.945945946
1982	23-Jan	World Airways	DC10	2	196	0.010204082
1982	9-Jul	Pan Am	727	138	138	1
1979	25-May	American Airlines	DC10	259	259	1
1978	1-Mar	Continental	DC10	2	184	0.010869565
1978	28-Dec	United	DC8	8	184	0.054347826
1978	8-May	National	727	3	52	0.057692308
1978	25-Sep	PSA	727	129	129	1
1977	4-Apr	Southern	DC9	60	81	0.740740741

[13] Actual number of total passengers unknown. Total passengers estimated from total passengers on board other DC9 accidents.

Table 19 : US International Fatal Events 1977-1996 On Board Scheduled Jet Flights

Year	Date	Carrier	Aircraft	# of deaths	# of total passengers	death proportion	Direction[14]
1996	17-Jul	Trans World Airlines	747	212	212	1	11
1995	20-Dec	American Airlines	757	155	159	0.974842767	13
1989	24-Feb	United	747	9	336	0.026785714	11
1988	21-Dec	Pan Am	747	243	243	1	11
1986	2-Apr	TWA	727	4	114	0.035087719	11
1986	5-Sep	Pan Am	747	21	383	0.054830287	31
1985	1-Jan	Eastern	727	21	21	1	33
1985	1-Jun	TWA		1	130	0.007692308	11
1979	31-Oct	Western	DC10	63	77	0.818181818	13

[14] 11- flight going from First World country to another First World country
13- flight going from First World country to a Third World country or vice versa
33- flight going from Third World country to another Third World country

5.3 First World Accidents: Domestic and International

Table 20 : First World (Not Including US) Domestic Fatal Events 1977-1996 On Board Scheduled Jet Flights

Year	Date	Carrier	# of deaths	# of total passengers	death proportion
1992	20-Jan	Air Inter	82	90	0.911111111
1989	8-Jan	British Midland	47	118	0.398305085
1989	10-Mar	Air Ontario	21	61	0.344262295
1985	19-Feb	Iberia	141	141	1
1985	12-Aug	Japan Air Lines	505	509	0.992141454
1983	12-Dec	Aviaco	37	37	1
1982	9-Feb	Japan Air Lines	24	173	0.138728324
1981	7-Oct	NLM	17	17	1
1980	27-Jun	Itavia	77	77	1
1979	14-Sep	ATI	27	27	1
1978	11-Feb	Pacific Western	39	45	0.866666667
1978	26-Jun	Air Canada	2	102	0.019607843
1978	23-Dec	Alitalia	103	124	0.830645161
1977	30-Sep	Air Inter	1	93	0.010752688
1977	19-Nov	TAP	123	156	0.788461538

Table 21 : First World (Not Including US) International Fatal Events 1977-1996 On Board Schedules Jet Flights

Year	Date	Carrier	# of deaths	# of total passengers	death proportion	Direction[15]
1996	5-Sep	Air France	1	206	0.004854369	13
1994	24-Dec	Air France	7	280	0.025	31
1993	14-Sep	Lufthansa	1	64	0.015625	13
1991	26-May	Lauda Air	213	213	1	31
1992		British Airways[16]	1	200	0.005	11
1990	14-Nov	Alitalia	40	40	1	11
1989	19-Sep	UTA	156	156	1	31
1987	28-Nov	South African Airways	141	141	1	31
1983	3-Jun	Air Canada	23	41	0.56097561	11
1983	12-Dec	Iberia	49	84	0.583333333	11
1979	7-Oct	Swissair	14	142	0.098591549	11
1977	28-Sep	Japan Air Lines	25	69	0.362318841	13
1977	3-Nov	El Al[17]	1	??	0.01	13

[15] 11- flight going from First World country to another First World country
13- flight going from First World country to a Third World country or vice versa
33- flight going from Third World country to another Third World country

[16] Unknown date. Passenger died from food poisoning. Not listed in *Flight International.*

[17] Actual number of passengers unknown. Death proportion is estimated from the typical passenger complement.

5.3.1 Big 5 Countries: Domestic and International Calculations

Table 22 : Big 5 Domestic Jet Scheduled Flight Death Risk Per Flight 1977-1996

Country	1977-1986 Total Number of Flights	1987-1996 Total Number of Flights	1977-1986 Effective Full Crashes	1987-1996 Effective Full Crashes	Inverted Q value 1982	Inverted Q Value 1992
France	960 thousand	1.4 million	0.011	0.91	1 in 90 million	1 in 1.5 million
Germany	570 thousand	1.5 million	0	0	n/a[18]	n/a
Italy	960 thousand	1.4 million	2.8	0	338575.0102	n/a
Japan	1.8 million	2.8 million	1.1	0	1630401.188	n/a
UK	580 thousand	1.1 million	0	0.40	n/a	2702020.669

Table 23 : Big 5 International Jet Scheduled Flight Death Risk Per Flight 1977-1996

Country	1977-1986 Total Number of Flights	1987-1996 Total Number of Flights	1977-1986 Effective Full Crashes	1987-1996 Effective Full Crashes	Inverted Q value 1982	Inverted Q Value 1992
France	1.4 million	1.8 million	0	1.03	n/a	1 in 1.8 million
Germany	1.1 million	2.3 million	0	0.016	n/a	1 in 148 million
Italy	580 thousand	960 thousand	0	1	n/a	1 in 960 thousand
Japan	400 thousand	580 thousand	0.36	0	1 in 1.1 million	n/a
UK	1.8 million	2.4 million	0	0.005	n/a	1 in 490 million

[18] Not applicable due to 0 effective full crashes.

5.4 Third World Accidents: Domestic and International

Table 24 : Third World Domestic and International Fatal Accidents 1977-1996

Year	Date	Carrier	# of deaths	# of total passengers	death proportion	Flight Type	Direction[19]
1996	1-Feb	Faucett	117	117	1	Domestic	33d
1996	2-Oct	Aero Peru	81	81	1	International	33
1996	7-Nov	ADC Airlines	134	134	1	Domestic	33d
1996	13-Jun	Garuda Indonesian	3	260	0.011538462	International	13
1996	12-Nov	Saudi Arabian Airlines	289	289	1	International	33
1996	23-Nov	Ethiopian	117	163	0.717791411	International	33
1995	11-Jan	Intercontinental de Aviacion	46	47	0.978723404	Domestic	33d
1995	31-Mar	Tarom Romanian Airlines	50	50	1	International	31
1995	24-Jun	Harka Air Services	16	74	0.216216216	??	??
1995	9-Aug	Aviateca Guatemala	58	58	1	International	33
1995	13-Nov	Nigeria Airways	11	129	0.085271318	Domestic	33d
1995	3-Dec	Cameroon Airlines	67	71	0.943661972	Domestic	33d
1995	5-Dec	Azerbaijan Airways	52	76	0.684210526	Domestic	33d
1994	25-Feb	Espresso Aereo	26	26	1	Domestic	33d
1994	26-Apr	China Air Lines	249	256	0.97265625	International	31
1994	6-Jun	China Northwest Airlines	146	146	1	Domestic	33d
1994	1-Jul	Air Mauritanie	76	89	0.853932584	?Domestic?	??
1994	12-Oct	Iran Asseman Airlines	59	59	1	?Domestic?	
1994	11-Dec	Philippine Airlines	1	287	0.003484321	International	31
1994	29-Dec	THY	49	69	0.710144928	Domestic	33d
1993	5-Mar	Palair Macedonina Airlines	77	91	0.846153846	International	33
1993	26-Apr	Indian Airlines	53	112	0.473214286	Domestic	33d
1993	6-Apr	China Eastern Airlines	2	248	0.008064516	International	??
1993	19-May	SAM Colombia	125	125	1	International	33
1993	1-Jul	Merpati Nusantara Airlines	37	44	0.840909091	?Domestic?	??
1993	23-Jul	China Northwest	55	108	0.509259259	Domestic	33d
1993	26-Jul	Asiana	63	110	0.572727273	Domestic	33d
1993	28-Aug	Tadzhikstan National Airways	77	77	1	?Domestic?	??
1993	26-Oct	China Eastern	2	71	0.028169014	Domestic	33d
1993	13-Nov	China Northern	8	92	0.086956522	Domestic	33d
1992	6-Jun	Compania Panamena de Aviacion	40	40	1	International	33
1992	31-Jul	Thai International	99	99	1	International	33

[19] 11- flight going from First World country to another First World country
13- flight going from First World country to a Third World country or vice versa
33- flight going from Third World country to another Third World country
33d- flight going domestically within the Third World

Table 25 : Third World Domestic and International Fatal Accidents 1977-1996 (cont.)

Year	Date	Carrier	# of deaths	# of total passengers	death proportion	Flight Type	Direction
1992	28-Sep	PIA	155	155	1	International	33
1992	14-Nov	Vietnam Airlines	24	25	0.96	?Domestic?	??
1992	24-Nov	China Southern Airlines	133	133	1	Domestic	33d
1992	22-Dec	Libyan Arab Airlines	147	147	1	Domestic	33d
1991	5-Mar	Linea Aeropostal Venezolana	38	38	1	?Domestic?	??
1991	26-May	Lauda Air	213	213	1	International	3
1991	26-Jun	Okada Air	3	53	0.056603774	Domestic	33d
1991	16-Aug	Indian Airlines	63	63	1	Domestic	33d
1990	25-Jan	Avianca	65	65	1	International	31
1990	14-Feb	Indian Airlines	86	139	0.618705036	Domestic	33d
1990	11-May	Philippine	8	113	0.07079646	Domestic	33d
1990	2-Oct	Xiamen Airlines	99	104	0.951923077	Domestic	33d
1990	2-Oct	CAAC	75	93	0.806451613	Domestic	33d
1989	7-Jun	Surinam Airways	162	185	0.875675676	International	31
1989	17-Jun	Interflug	20	103	0.194174757	International	33
1989	27-Jul	KAL	80	181	0.44198895	International	33
1989	3-Sep	Varig	12	48	0.25	Domestic	33d
1989	21-Oct	Sahsa	131	142	0.922535211	International	33
1989	26-Oct	China Airlines	49	49	1	Domestic	33d
1989	27-Nov	Avianca	101	101	1	Domestic	33d
1988	17-Mar	Avianca	132	132	1	Domestic	33d
1988	5-Apr	Kuwait Airways	2	??[20]	0.01	International	33
1988	12-Jun	Austral Lineas Aereas	15	15	1	Domestic	33d
1988	3-Jul	Iranair	274	274	1	International	33
1988	2-Aug	Balkan Bulgarian	25	37	0.675675676	?Domestic?	??
1988	31-Aug	CAAC	1	83	0.012048193	International	33
1988	9-Sep	Hang Khong Vietnam	75	84	0.892857143	International	??
1988	15-Sep	Ethiopian	31	105	0.295238095	International	33
1988	17-Oct	Uganda Airlines	32	42	0.761904762	International	31
1988	19-Oct	Indian Airlines	124	129	0.96124031	Domestic	33d
1988	25-Oct	Aero Peru	12	69	0.173913043	?Domestic?	33
1987	3-Jan	Varig	38	39	0.974358974	International	33
1987	4-Apr	Garuda Indonesian	23	37	0.621621622	?Domestic?	??
1987	24-Jul	Air Afrique	1	148	0.006756757	International	11
1987	4-Aug	Lan Chile	1	27	0.037037037	Domestic	33d
1987	31-Aug	Thai Airways	74	74	1	Domestic	33d
1987	30-Nov	KAL	104	104	1	International	33
1986	28-Jan	VASP	1	60	0.016666667	?Domestic?	??
1986	16-Feb	China Air Lines	6	6	1	Domestic	33d
1986	3-May	Air Lanka	16	??	0.16	??	

[20] Actual number of passengers unknown. Death proportion is estimated from the typical passenger complement.

Table 26 : Third World Domestic and International Fatal Accidents 1977-1996 (cont.)

Year	Date	Carrier	# of deaths	# of total passengers	death proportion	Flight Type	Direction
1986	31-Aug	Aero Mexico	58	58	1	International	31
1986	25-Dec	Iraqui Airways	61	107	0.570093458	International	33
1985	15-Apr	Thai Airways	4	4	1	Domestic	33d
1985	23-Jun	Air India	307	307	1	International	11
1985	15-Aug	Alyemda	2	?	0.04	International	33
1984	10-Jan	Balkan Bulgarian	45	45	1	??	??
1984	30-Aug	Cameroon	2	8	0.25	??	??
1983	16-Jan	THY	47	60	0.783333333	Domestic	33d
1983	11-Mar	Avensa	1	45	0.022222222	?Domestic?	??
1983	29-Apr	Servicias Aeros Nationales	7	94	0.074468085	?Domestic?	??
1983	2-Jun	Garuda Indonesian	1	57	0.01754386	??	??
1983	11-Jul	TAME	111	111	1	Domestic	33d
1983	31-Aug	KAL	246	246	1	International	13
1983	14-Sep	CAAC	11	100	0.11	??	??
1983	23-Sep	Gulf Air	105	105	1	International	33
1983	8-Nov	TAAG	121	121	1	??	??
1983	27-Nov	Avianca	161	172	0.936046512	International	31
1983	28-Nov	Nigeria Airways	51	66	0.772727273	?Domestic?	??
1982	20-Mar	Garuda Indonesian	22	24	0.916666667	?Domestic?	??
1982	26-Apr	CAAC	104	104	1	Domestic	33d
1982	25-May	VASP	2	112	0.017857143	Domestic	33d
1982	8-Jun	VASP	128	128	1	Domestic	33d
1982	22-Jun	Air India	17	99	0.171717172	??	??
1982	16-Aug	China Airways	2	292	0.006849315	International	33
1981	7-May	Austral Lineas Aereas	25	25	1	Domestic	33d
1981	27-Jul	Aeromexico	48	60	0.8	?Domestic?	??
1981	22-Aug	Far Eastern Air Transport	104	104	1	Domestic	33d
1981	8-Nov	Aeromexico	12	12	1	?Domestic?	??
1980	21-Jan	Iran Air	120	120	1	Domestic	33d
1980	27-Feb	China Airlines	2	122	0.016393443	International	33
1980	3-Mar	LOT	77	77	1	International	13
1980	12-Apr	Transbrasil	47	50	0.94	Domestic	33d
1980	10-May	Indian Airlines	2	132	0.015151515	Domestic	33d
1980	8-Jun	Linhas Aereas de Angola	25	25	1	??	??
1980	7-Jul	Tarom	1	152	0.006578947	International	33
1980	14-Oct	THY	1	?	0.01	Domestic	33d
1980	19-Nov	KAL	8	198	0.04040404	International	13
1980	19-Aug	Saudia	287	287	1	Domestic	33d
1980	21-Dec	Aerovias del Cesar	63	63	1	Domestic	33d
1980	23-Dec	Saudia	2	268	0.007462687	??	??
1979	14-Mar	Alia	42	49	0.857142857	International	33
1979	11-Jul	Garuda Indonesian	57	57	1	??	??
1979	26-Nov	PIA	145	145	1	International	33
1979	23-Dec	THY	36	39	0.923076923	??	??
1978	1-Jan	Air India	190	190	1	International	33
1978	1-Mar	Nigeria	11	11	1	??	??

Table 27 : Third World Domestic and International Fatal Accidents 1977-1996 (cont.)

Year Date	Carrier	# of deaths	# of total passengers	death proportion	Flight Type	Direction
1978 21-Apr	KAL	2	97	0.020618557	International	13
1978 18-Aug	Philippine Airlines	1	78	0.012820513	?Domestic?	??
1977 22-Sep	Malev	25	69	0.362318841	International	33
1977 4-Dec	MAS	93	93	1	Domestic	33d

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