



Treatment of risk within commercial air transport

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TREATMENT OF RISK WITHIN COMMERCIAL AIR TRANSPORT

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TREATMENT OF RISK WITHIN COMMERCIAL AIR TRANSPORT

1. INTRODUCTION

Risk as a subject of study is not restricted to commercial air transport or the performance of aircraft, but is treated as such within this Data Item solely to give the points raised a practical framework to aid understanding. The basic principles outlined are capable of being used in unrelated studies.

Worked examples on risk analysis that illustrate the principles outlined in this Data Item are introduced and briefly described in Section 6.

2. CONCEPT OF RISK

The operation of an aircraft either for commercial air transport or, for that matter, to military-transport standards, is subject to ethical and social pressures to operate “safely”. Operators and the official bodies responsible for regulating air transport would be failing in their obligations if aircraft were permitted to operate in an unsafe manner and passengers would not be prepared to fly.

But what does operating safely mean and what influences public perceptions of safety in the context of air transport? Total safety is an un-attainable ideal and the implication of this statement is that people live their lives at some level of risk and are, therefore, conditioned to expect, and to accept, this risk – whatever it might be. There are also strong indications that most people are prepared to accept a small, short-term increase in risk in order to gain some benefit perceived to be sufficiently desirable. However, there are no accurate and agreed values for the levels of risks generally considered to be acceptable. ‘Acceptable risk’ varies from person to person within any community, from community to community and from time to time. Consequently, the best that can be hoped for is to deduce a risk level that will be acceptable to a sufficiently large proportion of the population for any period of time, and a general trend with time.

The definition of acceptable risk is complicated also by the dual compound nature of risk itself, containing, as it does, elements both of the severity of the consequences of an event and the probability of that event occurring. For example, people are very happy to gamble at very bad odds, but not to accept high risk at good odds.

A further point upon which one must be clear is the difference between the probability of an occurrence and the probability of exposure. This is best illustrated by referring to Extended Range Operations (ETOPS or EROPS) where, assuming the rate of engine failure is constant during the en-route phase of flight, the consequence of a failure occurring is significantly increased for an engine failure in the phase of flight most remote from a diversionary airfield. Hence in a 10 hour flight the level of risk will vary and may only be exceptionally high for one hour of that flight. So for that particular operation risk per flight, risk per hour flown and risk per hour flown in the critical phase will all give different interpretations of the understanding of risk for that operation. Hence as well as using the term ‘risk’ in a general sense a ‘unit of risk’ can be used to quantify the general risk at any time. It is also possible to consider the concept of a critical flight time. This is a flight duration, for example, following an engine failure, where the probability of failure of a second engine is equal to the specified incident probability.

Given the difficulty in defining a specific level for acceptable risk, it is possible to draw a number of general conclusions, as follows.

- (1) People live their lives at a level of risk which they are generally prepared to accept, but this level varies from person to person, place to place and time to time.
- (2) In order to gain some tangible benefit, for example to earn money, travel abroad for a holiday or travel on business, people are prepared to accept a small, short-term, increase in *perceived* risk above their generally accepted level, for example that experienced whilst crossing a busy road or driving their car.
- (3) People will accept higher occurrence probabilities of events perceived to have less severe consequences than of events perceived to have more severe consequences.
- (4) People's perceptions of air-transport-related risks are heavily influenced by the media which, in turn, tend to be sensitive to the frequency of catastrophic events within a period of time, for example the number of fatal airline accidents per year, regardless of the exposure to risks during that period.

Consequently, in using the concept of acceptable risk to set target unit risk levels for commercial air transport, it is important to ensure the following.

- That they are set at levels that are capable of being achieved and are perceived to be acceptable by the majority of air-travellers.
- That they are in line with the expected inverse relationship between severity of effect and probability of occurrence.
- That they are set at levels, considering annual utilisation, which can be seen as the exposure to risk, such that the media will not be triggered into an adverse reaction by an apparent annual fatal accident rate. In periods where utilisation is increasing from year to year, this implies that the safety rate per hour of utilisation must be increased year by year or the unit risk rate reduced to avoid an unacceptable and steady increase in the total number of fatalities each year.

3. INTERNATIONAL RISK MANAGEMENT

All regulations governing the design, construction and use of aircraft for public transport have been subject to an evolutionary process which, expressed in its crudest form, has been the result of aircraft accidents. In other words standards have been found wanting and, to prevent further occurrences, improvements and refinements have been introduced. Not every small requirement has been written as the result of an accident, but the evolutionary process has allowed changes to be constructively developed that reflect an overall philosophy that meets the perceived safety need. As discussed in Section 2 public perception has been a strong driver for improving standards with time.

In evolutionary terms the early public transport standards of 1919 permitted the use of large single-engined aircraft, something that became unacceptable to the public due to too many forced landings. Then the poor-performing twin-engined aircraft of the 1930s were superseded after the Second World War by aircraft that had a level of performance following engine-failure that was considered acceptable. This is merely one example of a process that spread into every corner of aircraft development, and it continues today.

To quantify these principles of risk, design standards can be reduced to examples of hazard and the acceptable probability of occurrence *per* unit of risk, as shown by one example in Table 3.1.

TABLE 3.1 Unit of Risk
An example of a scale of airworthiness hazards and probabilities per hour of flight[†]

<i>Probability description</i>	<i>Numerical probability</i>	<i>Acceptable event classification</i>	<i>Example</i>
Frequent: Likely to occur often in the life of an aircraft	10^{-3}	Increased crew workload	Minor systems failures, nuisances
Reasonably probable: Unlikely to occur often but may occur several times during the life of each aircraft		Minor effect	Engine failure
Remote: Unlikely to occur to each aircraft during its life but may occur several times during the life of a number of aircraft of the type	10^{-5}	Major effect	Minor damage, possible passenger injuries, low-speed over-run, falling below take-off net flight path
Extremely Remote: Possible, but unlikely to occur in the total life of a number of aircraft of the same type	10^{-7}	Hazardous effect possible	Extensive damage, possible fatalities, high-speed over-run, ditching, double engine failure on twin-engined aircraft, hitting obstacle after take-off
Extremely improbable: Very unlikely to occur in the life of the World fleet of a particular aircraft type	10^{-9}	Catastrophic effect certain	Aircraft destroyed, multiple fatalities

[†] Table 3.1 is one example of how risk can be managed and circumstances may dictate other more severe or more lenient standards, given the underlying principles. For any specific question of what aircraft performance standards should be used on any occasion, a more careful examination of the detail is necessary.

The term 'Unit of Risk' requires an accurate definition in any analysis, but can be represented in any manner that is acceptable to the analyst, given the overriding obligation not to corrupt the findings by use of manipulative classifications, either intentional or inadvertent. It is usually expressed as a summation of events within a time period, for example engine failures per flying hour. Some further examples that expand on this are as follows.

Events-based Units of Risk

- **Engine failure**
Engine inoperative, fuel off. Turboprop with propeller windmilling or feathered. Does the definition include precautionary engine shut-downs due to warnings or other reasons? Does it include engine failures at any power level, or only failures at high power?
- **Loss of thrust/power**
Where an engine is running at idle or low power, but not performing correctly. Does this only include prolonged loss of thrust/power or any short-term loss?
- **Aircraft diversion**
Is this a diversion because of engine failure, or for reasons such as other operational necessities, passenger sickness or fuel problems? Does it include returns to the departure airfield? Does it include diversions from all phases of the flight or only from a particular phase?
- **Accident**
What level of injury or aircraft damage defines an accident?
- **Fatal accident**
If an injured passenger succumbs later to their injuries, should this be included in the definition of 'fatal accident'.
- **Incident**
This can be almost anything from a minor departure from the normal, through a systems failure, to a major upset manoeuvre that causes no injury or damage.

Time-based Units of Risk

- **Per hour**
Is time counted from when the aircraft is pushed-back, first moves under its own power, or when the brakes are released on take-off or only when the aircraft is airborne? Does it include all flying, such as air-test flight-time, training and positioning, or only revenue flights? Is it limited to time beyond a threshold, for example the ETOPS phase of flight?
- **Per month, year, etc**
- **Per flight**
All flights or only revenue flights? Per flight for a commuter aircraft will not mean the same thing as per flight for a long-range jet transport.
- **Per phase of flight**
- **Per take-off/landing**

In quoting a risk or event statistic it goes without saying that the quality of the finding depends entirely on the definition of unit of risk. Whenever possible the definition used should be a standardised one that is in use in other analyses and has international acceptance. Also due recognition must be taken of the risk exposure where, for example, the risk on a long-range flight will vary with the proximity of diversionary airfields.