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Fundamentals of Aircraft Accident Prevention

Presented by H.N. Wolleswinkel
Kingdom of the Netherlands

1. Introduction

1.1 In order to stimulate the thinking on Accident Prevention this paper has been written well in advance of the 1979 AIG-meeting. The main reason for writing this paper is the fear that on this meeting the attention is so much focussed on the writing of an AccidentPrevention Manual that the important subject of Accident Prevention itself might not be dealt with in sufficient detail. If this should occur it is not only a pity that such an excellent opportunity for working on real safety matters would be missed, but also the Manual itself will lack sufficient depth if it is not based on a common understanding regarding the ways and means for accident prevention.

1.2 Quoting from page A5 and A6 of WP 5, the example Accident Prevention Manual, the basic idea is: "we must first actively search for hazards, than make sure that what we find is really a hazard and if it is, eliminate the hazard or minimize its threat". In reality however the situation is far more complex. The purpose of this paper is to highlight some of the problems encountered in a day to day practice in order to try to provide a more realistic background for discussions on the subject of accident prevention.

2. <u>To find a hazard</u>

2.1 To find a hazard is not enough; it must be reorganized by the aviation community. This point will be illustrated by some examples.

The report of the ninth meeting (16 November - 4 December 1970) of the ICAO Airworthiness Committee, Doc. 8925, AIR C-9 on page 6 - 4, item 6.2.5.1. reads:

"The attention of the Meeting was drawn to the fact that one consequence of an explosion in a pressurized aircraft was that, if part of the skin of a major compartment were to be ruptured so as to cause that section to depressurize rapidly, then the partitions (bulkheads, flooring, etc.) between the ruptured and unruptured compartments would be subjected to large and rapidly applied differential pressure loads. The problem of indirect damage being caused in this manner was especially great in the case of large capacity aircraft where relief areas vary approximately linearly with the scale factor whereas the volumes of air vary with the third power of the scale factor. Such aircraft also have long floor beams which are unsupported over their span because the freight container system prohibits such supports. It was suggested, therefore, that one means of reducing the amount of indirect damage would be to install a system of blow-out panels in the bulkheads and floors. These would have the effect of equalizing pressure throughout an aircraft that had been ruptured by an explosion, in a controlled rather than in an uncontrolled manner."

The hazard was clearly defined but it lasted until March 3, 1974 when a DC-10 crashed due to floor failure caused by a not properly locked door, popping out when the pressure increased, before any fundamental corrective action was taken.

The simple scheme, detect and eliminate, did not work in this case mainly because of the fact that the hazard was not generally recognized as such.

2.2 It is too restrictive to limit the problem to finding a hazard. Accident prevention can be promoted also by improving the system of accident and incident reporting, trend analysis and improving the means for proper accident and incident investigation.

An example of a possible improvement in this area is the use of cockpit voice recorders for incident investigation. As the CVR-information can be very useful in incident investigation, according to the operational rules in some countries, the captain can pull the circuit breaker after an incident. In the majority of cases however this in being done too late which means that valuable information is lost. This situation could be improved considerably if the playing time of a CVR could be increased to at least 3 hours.

2.3 More generally speaking one can say that there is a discrepancy between on the one side the effort devoted to accident and incident investigation and on the other side the use made of the results of these investigations.

When a specific shortcomming shows up in an investigation, usually the proper corrective action is taken. However a systematic trend analysis and an evaluation of possible fundamental shortcommings in the aviation system as such is not being done in sufficient depth.

It should be investigated whether ICAO could play a more important role in this respect. Especially when ADREP is becoming mature enough there must be good possibilities to pay more attention to this aspect.

A first step might be a systematic trend analysis of accidents. Based on that experience a further extension with collecting and analysing incidents could be considered. If this could be organised on a world wide basis in such a way that a sufficiently quick and up to date system of information could be established, it undoubtedly would contribute considerably in localising potential hazard area's.

3. To eliminate a hazard

In chapter 2 it has been argued that to find a hazard is not always the real problem. This chapter deals with some practical aspects of eliminating hazards.

3.1 One of the most fundamental problems in aviation safety is that quite often the solution to a problem is introducing a new problem elsewhere . This will be illustrated by a number of examples.

3.1.1 Fire warning systems at a certain stage did generate more false warnings than real warnings. Due to actions caused by false warnings several dangerous incidents and even accidents did occur.

3.1.2 To improve the fire resistence of cabin materials chemicals were added. However due to these chemicals the toxicity of the smoke in case of a fire increased considerably. In some cases the overall effect on the post accident behaviour of the aircraft might have been negative in stead of positive.

3.1.3 In order to protect tyres ~~for~~ from getting overinflated the wheels have been fused with a "fools plug". This device is indeed an effective protection against overinflation but it occurred already more than once that a premature failure of such a plug cansed a low pressure condition in the tyre, followed by a tyre desintegration and severe damage to the aircraft. In one case two of the three hydraulic systems were knocked out, while the aircraft still had to fly several hundred miles.

3.1.4 One of the well identified hazards is two engines out on one side. To cope with that condition pilots were trained frequently in two engine out approaches. On most aircraft this condition is so critical that during this training several fatal accidents did occur. This is a classical example of a bad solution for a hardly existing problem.

3.1.5 Vapour in fuel tanks is a well known hazard in aviation: there have been several fatal accidents due tank explosions, usually triggered by a lightning strike.
What to do about it? Gelling of the fuel? An inert gas in the tanks? Honey comb type of tank protection? Most likely all of these "solutions" will introduce more problems than they are solving.

3.1.6 The classical dilemma in establishing inspection methods and intervals is that each time an element is taken apart for inspection and reinstalling afterwards there is a small risk of not properly carrying out the work. Too much inspection can be less safe therefore, but on the other hand a too long interval can be dangerous also.
The right corrective action is quite often difficult to establish.

3.2 A second kind of fundamental problem being encountered when looking for solutions to solve safety problems, is related to the rather stringent devision between the various disciplines in aviation.

This can lead to approaches and solutions which are far from optimal from an overal point of view while some of the discrepancies might stay for ever. The following examples can be mentioned in this category.

3.2.1 There are quite detailed operational requirements about reserve fuel, fuel for alternates fuel for holding etc.
However formally speaking there is no basis in the airworthiness requirements for establishing these fuel quantities.
In other words, during the certification of a new type of aircraft the fuel consumption is not certified and all fuel consumption information is based non-approved manufacturer information. As accidents due to fuel starvation do not only occur to private aircraft, this is an unsatisfactory state of affairs.

3.2.2 The margins considered in establishing accelerate-stop distances are low. This is acceptable as long as the probability of a stop initiation at V_1 is very low and most take-offs are carried out on a non-critical runway.
Looking at this problem from an over-all safety viewpoint leads to the conclusion that an overrun can never be excluded entirely. Therefore it is very wise to make sure, whenever practical, that the conditions at the end of the runway are such that an overrun will not lead to a disaster.
Another observation in this respect is that one should be very careful in derating thrust during the take-off run. It is easy to predict that if each take-off was made critical by derating, the number of overruns would increase dramatically.

It should be realised that this is a statistical problem and not a deterministic problem.

3.2.3 There have been quite a number of accidents that could have been avoided if the basic airworthiness informaties had been bether known by the operational people. In some cases an attempt for a go-around had been made at a too late stage with the aircraft in the landing configuration and the engines at low r.p.m.

In other cases an accelerate stop was initiated without using the proper braking techniques, causing the aircraft overrunning at the end of the runway, while using the right procedures ample margin would have been available.

3.3 As indicated already in chapter 2,it is very seldom possible to work on its ower when eliminating a safety hazard. In most cases one has to rely on quite a considerable part of the aviation community.

Notwithstanding the excellent achievements in aviation safety the system can be rather sluggish and sometimes it is even impossible to accomplish certain things. Especially this is the case when quite different branches of the aviation community have to work together. This can be illustrated by the following examples.

3.3.1 One of the most urgent problems in aviation safety is that of the ageing aircraft, especially second or third hand aircraft in remote parts of the world. It is well known that in quite a number of cases the communication between operator and manufacturer is insufficient but it seems quite hard to improve this situation.

As continuous airworthiness is becoming more and more dependent on an intensive cooperation between manufacturer and operator this is an urgent and important problem. If service experience is not repated back to the manufacturer in a reliable way for all aircraft he produced, the overall safety is seriously compromised.

3.3.2 Another well known example in this category is the fundamental weakness in radio communication (R.T.). The number of incidents and accident due to misunderstandings in the R.T. is much too high. Since the Tenerife accident, where more than 580 people lost their lifes, nearly everybody is aware that R.T. is a weak link in the total aviation activity.
It is fair to say that the present high safety standard in civil aviation for a greater part is the result of consequent carrying through of the fail safe principle. Aircraft designs such as the modern jets, which are based in fail safe do have a much better safety record than for instance helicopters, where fail safe principles could not be applied so consequently. The same is true on the operational side; nowadays crew composition is such that each crew member can monitor and, if necessary, take over completely the task of his colleague and therefore both technically and operationally it is hardly possible any more that one single failure can lead to an accident. The only exception is the R.T. Here indeed one simple misunderstanding can be fatal.
Although this problem has been recognised already for a long time there has been no fundamental action so far to eliminate this hazard. The main reason is that it is both technically and operationally a very hard problem to solve. This is even more so as any solution has to be agreed upon in international

cooperation.

3.3.3 It is a well known fact that the safety level in aviation varies widely in different parts of the world. Several factors are involved here such as weather, the quality of training and maintenance, route frequencies etc.
A very important aspect however is the quality of the ground facilities such as beacons, landing aids, weather information, radio coverage etc.
In this case again the hazards are well known and technically speaking the solutions are in hand but in practice it is entremely difficult to organize things on a world wide basis in a satisfactory way.

4. <u>To review safety measures</u>

4.1 Sometimes manufactures and airlines are complaining that aviation authorities are always adding new requirements and increasing the severity of existing requirements.
It is therefore fair and logical to consider also the opposite question; which safety measures taken in the past can be eliminated now as due to changing circumstances or based on an overwhelming amount of experience they can be considered as out of date, or at least exaggerated. To illustrate this point a few examples are given.

4.1.1 In older days the reliability of engines was far less than it is now. A requirement for life rafts on board of an aircraft that had to fly over water for an extensive period of time was meaningful under these circumstances.

At present the reliability of engines is such that one might question ~~that~~ whether it is still logical to have rafts on board on a flight from Amsterdam to New York with a three or four engine aircraft and not on a flight from Amsterdam to London with a two engine aircraft.
Based on accident statistics there are good reasons for dropping the life raft requirent for fixed wing jet aircraft entirely. The same approach could be considered for the special equipment on board of aircraft flying over the North Pole.

4.1.2 More debatable is the necessity of oxigen equipment for passengers. Oxygen all over the place in an aircraft in itself is a potential hazard which caused already several dangerous incidents. On the other side decompression cases where the lack of oxygen would have been fatal or dangerous do not seem to occur. It could at least be considered whether up to a certain maximum altitude, for instance 40.000 ft, oxygen for passengers could be omitted, provided that the aircraft can descend very rapidly in emergency cases.

5. Final Remarks

5.1 In itself it is an excellent idea to devote so much time and effort to accident prevention during the next AIG meeting. ICAO could be a good focus point for this kind of activity. It is doubted however whether the material is muture enough to finalize the work on an Accident Prevention Manual at this very meeting. It is absolutely necessary to have a thorough discussion and a common understanding of the subject before a Manual can be drafted.

5.2 Both the detection and elimination of hazards quite often is a very complex process involving a lot of international cooperation. In the majority of cases where hazards have been identified outside the existing attention area's of the various disciplines, an organised coordination between disciplines has to be established.
To accomplish this on an international level usually is a very slow and time consuming process. It is worthwhile to investigate how ICAO could play a role in this process.
To deal with this, in itself very important, aspect in a Manual, does not seem very meaningful.

5.3 In civil aviation excellent frameworks have been developed for dealing with all kind of safety matters such as licencing, airworthiness, operations etc. The most efficient way to deal with hazards is to deal with them within these frame works.
Only in very exceptional cases where existing frame works are not adequate, separate procedures should be developed.
The main emphasis should by on supporting, improving and coordinating these existing framworks and not so much on entirely separate activities.