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The Practice of Aircraft Accident Investigation

The author offers readers a look at how one country handles accident investigations. More important, he presents his ideas on how accident investigation needs to be approached, from narrowing the accident cause or causes to writing the report and handling follow-ups.

by

Aage Roed
Chief Technical Investigator
Swedish Board of Accident Investigation

Transport Aircraft Safety Improves

Since the introduction of the jet transports in the 1950s transport aviation safety has increased dramatically. This is remarkable considering the enormous complexity of the air transport system. In aluminium tubes equipped with wings, we are transporting passengers at altitudes where temperatures and pressures are so low that no one can survive more than a few seconds and at speeds that exceed the speed of sound. These fantastic vehicles are powered by engines heating air to incinerating temperatures. In this hell-hot engine environment, metal survives thousands of hours of extremely high stresses. The airplanes are controlled by complex electro-hydraulic systems and can be flown automatically with high precision between departure and arrival points separated by oceans and continents.

To manage these complex machines we need groups of highly trained specialists who must learn to work together and understand each others problems. Since safety is so good we must have been remarkably successful in creating teams with an outstanding ability to cooperate.

In spite of our high standards, we loose approximately 20 large transport aircraft every year. In addition to the human tragedies, the accidents cost the airlines, and thus the passengers, large sums of insurance money. If two jumbo-jets with full passenger loads collide and fall down on a large city, aviation insurance companies would be hard-pressed to cover the costs generated by that catastrophe.

Need Continues for Accident Investigation

Accidents should be prevented through risk or incident analysis. Unfortunately we are not clever enough to detect all risks or to see how combinations of small risks sometimes lead to very large accidents. Still worse, quite often we do not react to serious incidents before they materialize into accidents.

Prevention through analysis will become increasingly more difficult the safer we become, not only because the detection of the risks become more difficult, but because it becomes more

and more difficult to convince people about the risks and to do something about them. For this reason accidents will happen and there will be a continuous need for accident investigations.

Who Should Investigate Accidents?

It is difficult to investigate aircraft accidents. The job only can be properly done if certain requirements are met. These are:

- The investigators must not be affiliated with the organizations they are investigating.
- The investigators must be prepared to travel to the accident site at extremely short notice and must try to reach it in shortest possible time.
- The team travelling to the accident site must consist of specialists in selected fields.
- The investigation team must have complete control of the accident site and of the continuing investigation.
- The investigators must be very well-trained for their jobs.

These requirements preclude the use of adhoc scrambled investigation teams. A permanent board is required.

The Swedish Accident Investigation Organization

In Sweden we have a very small board. It consists of four members: two lawyers (former judges) and two investigators (one operational and one technical). Four persons can make two teams. This is sufficient to take care of two accidents occurring roughly at the same time. A smaller board is not recommended.

The question may now be asked: "Is it possible for a small board to investigate everything from gliders to jumbo jets?" Obviously not! To solve this problem we have specialists loosely connected to the board from all areas of aviation. These are dedicated persons who join the board when needed.

However, a good national team is not sufficient to do the job. When working in a low risk field like transport aviation (or rather, in a high risk field where few accidents happen) one would not get the necessary feeling for the problems if one did not seek and maintain international contacts. For this reason we translate all of our important reports into English and trade information with a number of accident investigation authorities in the world.

We also ask for help from other nations and have received excellent assistance from England's Accident Investigation Board (AIB), the United State's National Transportation Safety Board (NTSB), Canada's Aviation Safety Board and, of course, International Civil Aviation Organization (ICAO). We have formed an informal "club" with the Nordic safety boards. We meet at least once a year, trading information and discussing problems. We also have signed an agreement to help each other in special difficult cases, such as in cases of major accidents where the small national boards could not possibly handle the investigations alone. If a large airliner crashes anywhere in Scandinavia, the Scandinavian boards would join together to solve the case. This is a type of insurance that makes it possible for us to be prepared for major cases without the need to maintain large organizations. It saves money and keeps "dead weight" out of the boards.

I believe that the correct way of attacking the difficult work of accident investigation for small nations is to maintain small, well trained boards that can be reinforced by specialists from home or abroad when necessary. A good idea might be to have an European pool of trained specialists. It would solve the nearly impossible and economically unwise problem of maintaining highly trained specialists in all fields of accident investigations in all countries.

What Should Be Investigated?

According to Swedish law, all accidents with serious injury or extensive damage to the aircraft should be investigated by the board. "Aircraft" is defined as anything flown by man from hanggliders and balloons to jumbo jets. The consequence of this has been negative. We have spent too much (wasted) time on unimportant accidents and too little on important ones.

Our goal should not be to investigate everything that happens. One gets more preventive action by selecting the most important cases from the accident flora and treating these carefully. Lesser accidents should be reported in short notes that may be based on pilot reports or police reports. Selection gives time for thorough investigation of serious accidents and incidents. If one writes long reports on all types of accidents, many reports might become dull and uninteresting. As a result the recipients quit reading, the credibility of the board decreases and the preventive effects of the accident investigation work goes down.

Someone has said that "aviation safety management (including accident investigation) is like eating an elephant. You can't have it all at once; you have to take a piece at the time."

Accident Prevention is Goal of Investigation

Accident investigations have only one purpose: Accident Prevention.

The investigators shall:

- Find facts.
- Analyse facts.
- Find causes.
- Make recommendations for preventive actions.

The investigation shall not serve as a basis for punitive actions. Punishment effectively stops the flow of safety information and the open discussion of safety problems.

Several factors often combine to create accidents. This combination of factors may be difficult to detect. The following examples illustrate the problems.

Viscount Encounters Severe Icing

On January 15, 1977, a day with severe icing conditions, a Viscount on approach to Bromma Airport suddenly dived into the ground. It was fairly easy to exclude everything but tail stall due to ice as an accident cause. The stabilizer nearly stalled when the flaps were extended to 30 degrees and the aircraft started to oscillate in pitch. When the flaps were fully extended to 45 degrees the stabilizer flow separated completely and the aircraft dived into the ground. It was found that the anti-icing system had been switched off and the accident could easily have been classified as "pilot error." However, further investigation showed that:

- The anti-ice system had been switched off just before the accident, when the outer marker was passed (company procedure). Switching sounds could be heard on the cockpit voice recorder.
- The anti-ice system gave insufficient heating of stabilizer leading edge under severe icing conditions (shown by flight tests).
- There had been several similar accidents.
- No information about previous accidents was available to the pilots.
- The flight manual stated that the system gave sufficient ice protection in severe icing conditions.
- The captain mistook the pitch-oscillations as "rough flying" by the inexperienced co-pilot.

Flap angle limitation in icing conditions would have prevented the accident.

ADF Switched Off During Approach

The evening of January 3, 1983, a light twin-engine aircraft crashed on approach to Gothenburg-Save Airport. The aircraft was very low on fuel; no refuelling stop had been made during the flight. When the pilot made an uncoordinated right turn at low altitude the fuel in the right tank sloshed away from the sump and the right engine stopped. The pilot did not control the resulting yaw/roll-motion and the aircraft rolled to the right, lost altitude and struck a hill. This appeared to be a typical "pilot error" case. Further investigation revealed that:

- The airplane departure had been delayed due to poor weather at Geneva.
- The people on board were on their way to a traditional New Year's dinner at the home of the pilot's mother.
- The pilot made the long northbound NDB-approach in darkness well left of track and was informed about this by Gotenburg Control.
- A weak easterly wind was blowing.
- The pilot had made a large number of night approaches to the airport and was familiar with the area; his own factory was located below the approach path.
- The pilot sounded very surprised when informed that he was left of track.
- A factory to the left of the approach path

had been closed down at night for the first time in seven years and no factory lights were lit.

- The pilot descended to low altitude above the unlit factory and then suddenly turned right.

- The ADF had the volume control and on/off control in the same knob.

- The ADF had been switched off. This made the ADF point exactly in the direction of the correct approach path.

Evidently the pilot switched off the instrument when he tried to reduce the volume to eliminate the disturbance of the station signal. This again led to a low altitude right turn and an engine stoppage due to fuel starvation.

The accident probably would not have happened if the ADF had been equipped with separate on/off and volume knobs, in spite of the pilot's failure to make a refuelling stop, since no right turn would have been required.

Pilot Not Warned About Turbulence

On January 31, 1980, a light twin with three people onboard enroute from Warsaw to Roskilde, Denmark, crashed near Malmoe-Sturup Airport in southern Sweden. The outboard one meter section of the left wing was found 520 meters from the main wreckage. It was a clear case of an in-flight wing failure. The airplane had been flown along a warm-front with embedded thunderstorms. Was this a pilot error case? Detailed investigation showed that:

- The wing had been modified. Tip-tanks had been added without additional wing strengthening. Due to the outboard shift of the lift force and increased wing bending with empty tip tanks. The wing would fail at 4.85 gs instead of 5.7 gs.

- Information about thunderstorms along the airway was not available to the pilot.

- Malmoe control did not understand the pilot when he asked about cumulus information although the pilot said that he was "running into some heavy turbulence."

- Radar tracking data showed that the pilot slowed down to the correct turbulence penetration speed.

- The pilot was not informed about the severe turbulence reported by airline crews.

- The flight manual poorly presented information about the risks of flying in thunderstorms.

- The wing failed when the aircraft was flying at recommended turbulence penetration speed.

- The airplane had short, rigid wings that quickly bend to their limits when loaded.

- Dynamic maximum lift effects due to sharp gusts can overload wings even at speeds where a wing would stall at limit load at static maximum lift. This is generally not known.

The accident could have been avoided if the pilots, the meteorologists and the controllers had been better informed about the risks of flying through thunderstorms. The accident would have been avoided if the pilot had been told to fly slightly north or south of the frontal zone.

These accidents illustrate the necessity to carefully analyse all factors in order to determine the sequence of accident events.

Poor Reports Reduce Effectiveness

A poorly written report can destroy the effectiveness of an investigation. Negative reactions to uninteresting, bureaucratic and poorly formulated reports may do more damage to aviation safety than no reports at all.

It takes time to learn how to write reports and it takes time to write them. Basic report writing requirements are:

- List all facts in the factual section. Avoid analysis in this section.

- Analyse the listed facts in the analysis section. Do not add new facts here.

- Summarize important findings and list the sequence of events that caused the accident in a concluding section.

- Make recommendations based on the findings only.

However, it may be very difficult to determine if one event or a sequence of events caused the accident. One may be struck with several possibilities of varying degrees of probability. If so, it may be wise to exclude the most remote probabilities. Too many "ifs" and "buts" may make a report unreadable. The major problem may be drowned in less important ones.

Quite often the accident investigation reveals safety problems that did not cause the accident. It would be a waste of money not to report these problems but it may be wise to do that in a separate report in order not to confuse the analysis of the accident cause.

Recommendations Must Be Sold

The accident investigator must "sell" his recommendations to the aviation authorities (civil or military). Love does not always exist between the two. One side criticizes and the other must accept or reject the criticism. If the accident investigator does not handle his selling correctly he will do little more than create enemies and very few of his recommendations will be accepted. Certain basic rules must be followed.

- Write short, clearly defined, objective and well-supported recommendations that you are convinced will help prevent the recurrence of the accident in question.

- Limit the number of recommendations to a few important ones that can be handled by the authorities.

- Avoid taking snooty attitudes towards your "customers" either as a group or an individual. The misses they have made may have been yours had you been in their situation.

- When you are convinced that your recommendations are very important, follow-up how they are handled. If they are rejected, request time for continued argument.

Open Mind Is Essential

A board of accident investigation must have a very open mind. Investigators must be prepared to listen to ideas contradicting their own beliefs. The board must encourage people who read their reports to express disagreement if they find something that they believe is wrong. Mistakes must be publicly corrected.

The attitude towards dependents of accident victims must be very generous. A few hours spent listening to their grieving may help them through a very difficult time.

Finally, avoid "kicking" dead or living accident victims. When it is necessary to point out human failures, do it with consideration of both the positive and the negative effects it may have.

The question of why men make mistakes must always be considered. ♦

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