EFFECTIVE SAFETY MANAGEMENT SYSTEMS FOR ACCIDENT PREVENTION

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Abstract

This paper looks at the developments in aviation safety and the role that Safety Management Systems have played in accident prevention. Examples of aviation accidents are discussed which have influenced the development of SMS. The paper considers the importance of prompt recovery of recorded data and how that can have a significant impact on effective safety management systems. The role of risk management as a fundamental element of safety management is illustrated.

1 Introduction

Last year was one of the safest ever for commercial aviation, with roughly one passenger death for every 7.1 million air travellers worldwide, although improving accident statistics do not guarantee increasing safety and there are many high risk events which could quickly change these trends.

The 1970-1980 era was the advent of technological advances which improved aircraft reliability and introduced many safety devices which reduced aircraft accidents. The technological advances continued through the 1980-1990 period which was also characterised by Professor James Reason's work on accident causation. The development of the Reason model is well known and has become a basic tool for investigations. Through this approach further improvements in aviation safety were achieved.

However analysis of serious accidents indicates that many established aircraft operators have exhausted the advances offered by the earlier safety management strategies developed in the 1980/2000s and that new ideas are needed. A step change for the better in airline safety performance took place around the year 2000, but those advances have become entrenched. And while safety today is at an all-time high, improvements in the safety rate stopped in the mid-2000s. The plateau marked a departure from a century of aviation safety that had shown a steady improvement since the Wright Brothers.

2 Current Safety Statistics

The year 2011 was a very safe year for civil aviation. It was the second safest year by number of fatalities and the third safest year by number of accidents. The rate of passenger fatalities in the year 2011 was similar to the post-war record low rate of passenger fatalities, set in 2004 at one per 6.4 million passengers. The year also had one of the lowest total number of passenger deaths, despite a sharp rise in the number of flights and passengers worldwide. In 2004, 344 passengers died in commercial aviation accidents, but the industry carried 30% fewer passengers on many fewer flights. The figures exclude acts of terrorism.

Locals gather at the site of a turbo-prop aircraft accident near Madang in Papua New Guinea that killed 28 passengers. The aircraft went down as a violent storm approached.

The record is best for carriers flying Western-built planes. Last year, they experienced one major crash per three million flights worldwide, roughly 49% better than in 2010 and roughly three times better than 2001, according to the International Air Transport Association (IATA), a global trade group. The figure represents the industry's best performance since IATA began collecting crash records in the 1940s. Including Russian-built and other types of airliners, the global accident rate fell slightly to about two crashes per million flights, or seven times higher than the rate for Western-built planes such as those made by Airbus-a unit of European Aeronautics Defence and Space Co.-Boeing Co., Bombardier Inc. and Embraer SA.

While the year's records are noteworthy, they don't guarantee future safety and could even undermine it by breeding complacency.

3 Safety Management Systems

A Safety Management System (SMS) is a systematic approach to managing safety, including the necessary organisational structures, accountabilities, policies and procedures. From an airline perspective, it is a constituent part of the overall management system of the airline organisation. It is recognised that many organisations are at different levels of the implementation of an effective Safety Management System. Properly administered a safety management system will deliver a company the ability to identify and track potential hazards. Consequently it will permit the hazards to be removed or at least mitigated before any significant damage or injury might be done. That is the theory; in practice the evidence is not so positive.

The key elements of a Safety Management System are shown in the following diagram. They can be divided into four main components:

- Safety Policy and Objectives
- Safety Risk management
- Safety Assurance
- Safety Promotion

It seems we are bombarded with information about “safety management systems” these days in everything we read in the safety press and publications. The classic SMS includes elements of safety occurrence and hazard reporting and safety investigations. It could be argued that without a good reporting culture, the management of “safety” is almost impossible. If we do not know what is happening on the flightline or in the hangar, then we cannot make the necessary improvements to reduce risk and improve safety levels. Managers and supervisors will be in blissful ignorance of the real situation until a serious event occurs that cannot be ignored. The ideal situation is that any safety hazard or safety concern is reported and action is taken to address these before they become an incident or accident. This is the utopia of preventive or proactive safety. In practice, this is very hard to achieve as operational staff members usually have very little time for non-operational tasks and do not perceive the benefit from reporting something “that might happen.” Changing the mindset is

essential if SMS is to be successful. It is also greatly assisted if the reporting process is simple and readily accessible such as being able to submit a safety report during the cruise phase, for example. Electronic reporting is ideal, but the use of paper forms is still widespread and effective. They can be completed after the finish of a flight at home or in the hotel.

Safety assurance is accomplished through flight data monitoring, line operations safety audits, and safety actions from system improvement recommendations. An operator's SMS is an easy target for the investigators after an accident. Determining why the SMS failed is not so easy. However, it has been reported that many smaller operators have met the letter of the legislation by constructing a SMS manual, in some cases supplied by external consultants. But the elements of SMS have not been rolled out to day-to-day operations. Some of the reasons include cost, and a reluctance to be open with the staff about safety issues. This must change if the promise of SMS in reducing accidents is to occur.

Although all the elements are essential for an effective SMS it can be argued that the Safety Risk Management is the key to an effective SMS. These are the processes that identify hazards and attempt to address the hazards and reduce the risks to the lowest practical level (ALARP). Without knowing what is happening at the frontline management cannot implement an effective SMS to address the operational hazards. Without the key elements of safety occurrence reporting, safety investigations and auditing the Operational Risks will not be managed and the Safety Management System will not be effective.

To be effective all staff must be engaged and understand the Safety Management System. The basic questions which a SMS should answer are: what are the operational risks and what would be the most likely causes, what mitigation strategies have been introduced to reduce the risks and how effective are they?

4 The Australasian Experience

The 28th November 1979 was a very auspicious date for air safety particularly in the Australasian region. It was the date of the greatest loss of life in an air transport accident in this region and also one of the worst accidents worldwide. An Air New Zealand McDonnell Douglas DC10 with 257 people on board impacted the slopes of Mount Erebus in Antarctica with the loss of all on board. The accident touched the lives of thousands of people and had significant impact on the way aviation accidents are investigated. The investigation by the New Zealand Transport Accident Investigation Commission [1] followed the usual format although under difficult circumstances due to the remote location. The Cockpit Voice Recorder and Flight Data Recorder were recovered relatively undamaged so they provided valuable evidence regarding the aircraft operation. It was ascertained that the aircraft had been fully serviceable and had flown at a low altitude towards Mount Erebus until the Ground Proximity Warning System (GPWS) alerted the crew to their position. However the GPWS warning was too late for the crew to respond sufficiently and out climb the rising terrain.

As New Zealand did not have the facilities to play back and analyse the recorders, they were taken to the National Transportation Safety Board (NTSB) laboratories in Washington. There the initial playback and analysis proceeded without difficulty. The obvious conclusion was that the aircraft had been fully serviceable and that this was a classic “controlled flight into terrain” (CFIT) accident. The term CFIT has been used now for many years as a “class” of accident. I personally find this term inadequate as it tends to dehumanise what are usually complex human performance accidents. CFIT accidents involving commercial turbojet aircraft still occur.

From the information available a phenomenon known as “whiteout” had obscured the terrain and the crew did not visually detect the approaching terrain. The government investigation report covered the findings and concluded that the crew had flown at a low altitude and did not detect the high terrain on their flight path. As was common in those days the accident was referred to as “Pilot Error”.

One of the advances since 1979 is the development of improved ground proximity warning systems, enhanced GPWS. So the GPWS of 1979 that only gave an inadequate 6-second warning to impact in the Erebus case has been replaced by the Enhanced GPWS of today with its advanced terrain awareness features. All the CFIT accidents over the last 5 years have involved aircraft without an EGPWS fitted.

So the investigation of *what* happened was relatively straightforward based on the evidence from the Digital Flight Data Recorder (DFDR). A serviceable aircraft had flown into rising terrain. The question or questions were why, why, why? These are often the most difficult questions to answer because they involve human beings and human performance. The cockpit voice recorder (CVR), or more aptly called the cockpit audio recorder, is often the key to answering these questions, even if the crew survives the accident.

In the Erebus case, although the background noise was low, there were five people on the flight deck, four flight crew and one flight commentator who relayed information to the passengers on the progress of the flight and the sights to be seen. Hence the determination of what was said by which individual was not entirely without doubt.

Although this occurred long before the concept of an integrated safety management system, there were elements of SMS already in place. One of these was an internal reporting system. The captain of the previous sightseeing flight to the Antarctic on November 14, fourteen days before the accident flight, compared the coordinates of the navigation beacon at McMurdo and the waypoints that the flight crew had been given by the Navigation Department. He discovered that there was a significant distance between the two tracks, almost 30 nautical miles. He advised the navigation section, which during the night prior to the accident flight "corrected" the waypoints. Unfortunately the captain of the accident flight was not advised of this change and was expecting the track to take them into the area of the McMurdo Sound rather than directly toward Mount Erebus. Contemporary Safety Management Systems have information dissemination as a key element to ensure effectiveness of change management.

5 Role of Flight Recorders in SMS

As was demonstrated at Erebus in 1979 and many subsequent accident investigations, the prompt recovery and analysis of the recorders are essential for the successful outcomes of complex investigations. But many accidents occur over water, and the recovery of the recorders from the seabed becomes a major exercise. The location of the recorders, and in many cases also the location of aircraft wreckage, depends upon the underwater locator device, which emits a sonar signal for 30 days when activated by water. Since the mid-1970s missing or damaged recorders have only prevented a full analysis of the accident in a small number of major accidents. Out of more than 3,000 accidents involving Western-built commercial aircraft, fewer than a dozen CVRs and FDRs have not been found according to the International Air Transport Association. And in most cases enough wreckage was retrieved to piece together a probable scenario, although this could have taken many months and probably did not result in a definitive conclusion of why the accident happened.

Underwater searches [3] were required for 26 aviation accidents over the last 30 years. The searches lasted anywhere from 3 days in the case of Alaska Airlines Flight 261, which crashed in the Pacific in January 2000, to 77 days to find the recorders in the Pacific in April 2008.

Alaska Airlines Flight 261 CVR underwater recovery by remote vehicle.

Prompt recovery and analysis of flight recorders are also key elements of Safety Management Systems. Without the information regulatory agencies are not able to take action and any safety improvements may not be effective. The loss of the Air France 447 Airbus A330 over the Atlantic is the most recent major accident involving the design of a modern technology aircraft. This accident has far reaching consequences for contemporary aviation safety and therefore it was imperative that the flight recorders were recovered. Despite an estimated $40 million spent on the initial two searches a third search had to be conducted to eventually recover the recorders nearly 24 months after the accident.

The investigation of AF447 has taken three years, involving immensely costly mid-Atlantic searches covering 17,000 square kilometres of often uncharted sea bed to depths of 4,700 metres. It was five days before debris and the first bodies were recovered because of the remoteness of the accident site in equatorial waters between Brazil and Africa.

Prior to the recovery of the recorders, the cause of the accident could only be inferred from a few salvaged pieces of wreckage and technical data sent automatically from the aircraft to the airline's maintenance center in France. It appeared to be a failure of the plane's pitot tubes. These had apparently frozen over, giving erroneous airspeed indications and causing the autopilot to disengage. From then on the crew failed to maintain sufficient airspeed, resulting in a stall which lasted for over almost four minutes before the aircraft impacted the sea.

6 Organisational Accidents and Pilot Error

Let's return now to November 1979 and the implications for safety management systems and air safety investigation. The investigation was conducted in the established manner, collecting all available factual information, utilising the resources of the U.S. NTSB, the British Air Accidents Investigation Branch (AAIB), the equipment and aircraft manufacturers, the Civil Aviation Authority (CAA), and the various organisations representing the company and the staff. This resulted in a standard International Civil Aviation Organisation (ICAO) Annex 13 report and included a probable cause of the accident. For that time there was nothing unusual in this approach. However a royal commission [2] was appointed to enquire into the Erebus accident. This commission had the advantage of not only the evidence from the investigation report but also the mandate to call witnesses from all areas associated with the aircraft, the aircraft operation, and the public. With the assistance of counsel: "By the time the hearings of the commission had concluded every aspect of the disaster and its surrounding circumstances had been explored by counsel in considerable detail." However the circumstances of the final stages of the approach without the advantage of the CVR and DFDR would never have been known at all.

The airline witnesses who appeared were intent on establishing pilot error as the effective cause of the accident. This was not unusual even in 1979 and later in the 1980s. The classic safety management system however takes a very different approach through open reporting and management commitment to safety in a "Just Culture" environment.

A review of reports from that time, for example, will show that "pilot error" was still a common conclusion. However, the Erebus Commission went much further looking into the company decisions, policies, and procedures as well as the actions of the board and the middle-manager levels. This was perhaps one of the first applications of the "Reason model," which did not come into practice for another 10 years or more. But it certainly began the advances in air safety investigation where we looked back into the sequence of decisions, the training, and the basic human factors and human performance. Later this became the standard for safety investigation through the work of James Reason and Patrick Hudson, amongst others. And safety education and training, human factors and crew resource management are key elements in a safety management system.

On 27 November 2008, an Airbus A320 registered D-AXLA operated by XL Airways Germany crashed into the Mediterranean during approach to Perpignan airport in the south of France. There were no survivors among the seven aviation professionals on board. Apart from a few pieces of wreckage, most of the airplane sank within minutes. The flight crew had lost control of the aircraft while demonstrating - rather than checking - the functioning of the aircraft high angle of attack protections.

What was significant about the accident was that the airplane was owned by Air New Zealand (ANZ) and crashed exactly twenty-nine years after the ANZ DC10 hit Mount Erebus, in Antarctica. The Perpignan accident, which caused the death of five New Zealanders, was a tragic accident which could have been prevented if an effective Safety Management System had been in use. The risks associated with checking the stall system at low level could have been assessed and mitigated.

7 Australian Regulatory Requirements

If James Reason was the innovation of the 1980s and 1990s, "safety management systems" could be considered the next stage in the development of improved safety of operations. For many of us safety management systems have been a way of life. It was not until ICAO defined safety management systems in 2005 that we realised what had become relatively common place for many of us. The regulations, eventually introduced by the Australian Civil Aviation Safety Authority as Civil Aviation Order 82.5 [5] in 2009, defined the various elements and the need for a documented SMS.

8 Airbus Design

In July 2011 the French air crash investigation organisation, the Bureau d'Enquêtes et d'Analyses (BEA), published its third interim report into the investigation of the Airbus A330 AF447. The conclusion was that the crew had acted incorrectly to repeated stall alerts and kept trying to climb, instead of leveling off or descending to pick up speed. All indications suggested the aircraft had functioned as it had been commanded. The data recordings showed that the plane was responsive to the point of impact. The transcript of the voice recorder confirmed that one of the pilots had pulled the sidestick back and kept it there for almost the entirety of the emergency. But even if one pilot got things badly wrong, why did the other two pilots fail to correct this error. As the aircraft entered the worst of the weather, the pilot flying told the cabin crew to prepare for turbulence. A few moments later the outside air temperature dropped, the pitot tubes iced up and an alarm sounded briefly to warn that the autopilot had disengaged. The flight recorder indicates that, without saying anything, the pilot flying pulled back on the stick and, kept the nose up input causing the aural warning, "Stall! Stall" as the airspeed began to reduce. He left it there despite the stall warning that was recorded 75 times. Instead of moving the stick forward to pick up speed, the aircraft continued to climb at almost the maximum rate. If he had simply set the control to neutral or re-engaged the autopilot, all would have been well.

Like all the other aircraft in the modern Airbus range the A330 is controlled by side sticks beside pilots' seats. These side sticks are not connected to the aircraft control surfaces by levers and pulleys, as in older aircraft. Instead commands are fed to computers, which in turn send signals to the engines and hydraulics. This so-called fly-by-wire technology has huge advantages. Doing away with mechanical connections saves weight, and therefore fuel. There are fewer moving components to go wrong, the slender electronic wiring and computers all have multiple back-ups, and the onboard processors take much of the workload off pilots. Better still, they are programmed to compensate for human error.

But the fact that the second pilot's stick stays in neutral whatever the input to the other is now questioned as a design deficiency. It is not immediately apparent to one pilot what the other may be doing with the sidestick.

There have been numerous cases where the independence of the sidesticks, and their summing action, has led to unusual attitudes or added some confusion to the flightcrew understanding of the situation. Airbus has designed the system which for the vast majority of the time is very effective. Most of the time the flightcrew fly in full automation and do not move the sidesticks so that Flightcrew hand-fly the aeroplane ever less now because automation is reliable and efficient. This accident has reopened the debate regarding sidesticks and the flightcrew training in manual flying and recovery from unusual situations.

The important consideration is for the certifying authorities and their safety management systems. If they have records of incidents and events associated with the independent sidesticks should their safety systems have identified the potential risks and the potential catastrophic outcome?

An area of research resulting from the Air France accident is on satellite technology to transmit critical safety information from the aircraft. The idea of sending real-time safety data to a ground station has been around for several years. Certain maintenance data are transmitted now, as it was in the Air France case. However, technology does not currently allow large quantities of data to be transmitted due to bandwidth and cost. When considering that flight recorders have hundreds of parameters recorded each second, to transmit that data to a ground station becomes very problematic. One suggestion is to send basic flight information such as the heading, altitude, speed, and geographical location to a ground station on a regular basis. This is an interesting suggestion as it mirrors the original flight data recording requirements introduced in the 1960s, which stipulated basic five or six parameters. These proved to be too limited for useful accident analysis.

The easier development would be to lengthen the duration of the underwater locator signals on the flight recorders or improve the signal strength so that the recorders can be located quickly and easily in extreme situations. It has been suggested that the specification for the duration of the signal transmission should be increased to 3 months. Other options for satellite tracking such as EPIRBs could be considered.

Despite ongoing studies for the potential for streaming data to a ground station during flight, the traditional onboard flight data recorder will still be the essential tool for air safety investigation. The reasons are the high costs of data streaming and the massive amounts of data currently recorded and often needed to understand the complexity of aircraft systems. A recent study found that even with a 50% reduction in current satellite transmission costs, the price tag for streaming data could be millions of dollars. Obviously in today's financial environment this is not the most economical solution to the problem. However the technology is available, and there are some military and commercial applications already in operation. So like many of the advances in aviation safety this may well become an accepted practice in the future.

9 Reporting Requirements for Safety Management Systems

If we return to the Air France accident, it has been reported that pitot failures were well known on the Airbus long-range fleet. Air France had reported problems to Airbus and Thales, the manufacturer of the pitot probes. The interim BEA investigation report documents the history of the probe issues, yet the possible high risk of these failures does not appear to have been recognised and certainly did not generate prompt corrective action. The risk assessment that is part of an effective Safety Management System did not identify the level of risk or the SMS was not implemented effectively.

There may have been several reasons for this. These reports were only a small part of the total reports received regarding Airbus aircraft operations. The critical step is to determine the severity and risk level associated with one or more reports and assess the potential for a catastrophic outcome. This is a fundamental step in a safety management system.

In general everyday operations there is no shortage of occurrence reports and safety hazards identified by staff. Although we encourage open reporting of any safety concern, it is not always successful. From my experience, for example, an operator of 40 jet aircraft could expect 1,000 operational safety reports per year. Of these less than 5% would be considered other than minor, low risk. The most difficult task is how to ensure that the reports that could be indicative of a critical failure, in the right circumstances, are treated with the appropriate level of response. Risk ratings are used as the main tool, but these are open to interpretation. Experience and corporate knowledge can be essential in this process. Some types of occurrences have obvious risks and are rated reasonably consistently. However, other proactive (pre-emptive) safety concerns can be much harder to risk rate. The concern of a line pilot may be an isolated instance and then it becomes a difficult judgement issue. Very often these safety concerns are related to changes in procedures, processes, or documentation. The investigation often finds that change management procedures were not followed or were incomplete. Communications are the key, as they were lacking in November 1979.

In Australia, the Australian Transport Safety Bureau [6] (ATSB) is the government safety investigation agency that has a mandatory reporting requirement. Any accidents or serious incidents, as defined by ICAO Annex 13, are immediately reportable including a death or serious injury, serious damage, or missing aircraft. However, the ATSB also has a list of further immediately reportable events that include such things as "airprox" (aircraft breakdown in separation), violation of controlled airspace, takeoff or landing on closed or occupied runways, uncontained engine failures, fuel exhaustion, undershooting, over running or running of the side of a runway amongst several other event types. The ATSB also has a class of reportable events called routine reportable, which have to be reported. These include injuries, other than serious, other than serious damage, a ground proximity warning system alert, runway incursion, and several other broad definitions related to aircraft performance, weather, loading, and air traffic system events. The result is the ATSB receives around 15,000 notifications per year on average, 8,000 of which are accidents, serious incidents or incidents, many of which do not get recorded. However the ATSB only carries out approximately 30 investigations per year. So less than 0.2% of reports are investigated. Another 0.2% [4] are published as Level 5 factual reports where the operators' internal investigation reports are edited and published.

With so many reports, there will be issues that warrant investigation but are not always obvious from one or two reports. A robust effective analysis system is essential to filter out the reports that can be indicative of a significant risk. The Australian Civil Aviation Safety Authority is taking a greater role in the process of safety investigation as it can no longer rely on the ATSB to investigate all serious or significant events. It is also concentrating on auditing the operator's safety management systems to ensure that the operator carries out a full and unbiased investigation so that safety lessons can be learned. For an effective Safety Management System there must be a full and robust safety investigation capability

10 Aviation Safety Challenges

A review of recent serious accidents shows that most were preventable. If accidents are analysed by broad category, then runway excursions and incursions, and loss of control, are the main types of accidents in recent years [8]. If an effective Safety Management System is in operation by the regulatory authority, aerodrome operator or aircraft operator the numbers of these accidents should be minimised.

10.1 Runway Excursions

If we look at runway excursions, the majority can be linked to poor decision-making, breakdown in Standard Operating Procedures, and poor Crew Resource Management (CRM). Most occur off an unstabilised approach, which results in landing long and fast. If we look back 10, 20, or 30 years, we see the same symptoms and the same results. Why didn't the crew execute a missed approach rather than persevering with a bad approach?

There are several sources of data as part of the SMS which would give good information about potential runway excursions: Flight Data Analysis Programs, Line Operations Safety Audits and check and training for example. To be effective the investigations involving these data sources have to produce effective Findings which lead to the optimal outcome of safety improvements to prevent reoccurrences. Commitment by management and staff is essential so the safety management systems can be effective in preventing this type of accident.

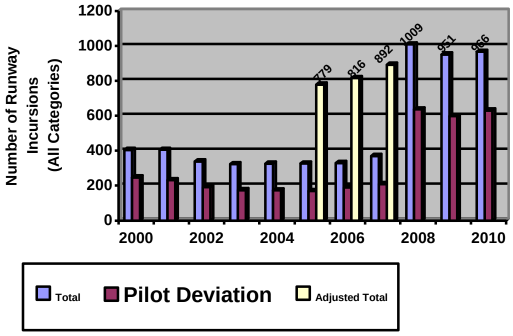
Dr. Tony Kern [7] believes there is a need for check and training organisations to reinforce basic flying skills so that pilots fly accurately and do not accept deviations from target speeds, localiser and glide slopes, and the required stabilised approach criteria—basic flying skills we were all taught during our training. There is a train of thought that we are not as diligent in our aircraft operations in an automated flight deck as we were in the previous technology flight decks.

There are also technological advances which could prevent this type of accident through take-off and landing performance monitoring. With electronic monitoring of the aircraft retardation or acceleration the aircraft position on the runway can be monitored and the remaining length of runway could be analysed to determine if the operation will result in a safe outcome.

10.2 Automation

What is beginning to evolve is the complexity of flying highly automated aircraft when the automation starts to fail or gives erroneous indications. As we have seen from the Air France example what is apparent from some situations is that the failure modes and degraded status of some automated flight decks can be very confusing. It would appear that the designs do not provide as much help or guidance to the flight crew as they should. With multiple failures or erroneous data inputs generating various confusing, opposing signals, the automated systems should ideally review and advise the flight crew on the most optimum response. Also although modern flight decks make a positive contribution to safety performance, pilots are not as practised at manual flying as they used to be so that flying aircraft that have reverted to raw flight and navigational conditions becomes too demanding in difficult situations. Since the year 2000 serious accidents have frequently involved pilot failure to manage situations that they should really have been able to handle successfully. The year 2009 was no exception. Recent examples include the Turkish Airline Boeing 737-800 at Amsterdam, the Colgan Air Bombardier Q400 at Buffalo, New York, the FedEx Boeing MD-11F landing accident at Narita, Tokyo. Notice that we are not using the term "pilot error" but rather looking at the human performance issues, the system designs, the training, and lack of understanding of the degraded states of the automation. Hence the lessons from Erebus in 1979 are still very much part of safety investigation today.

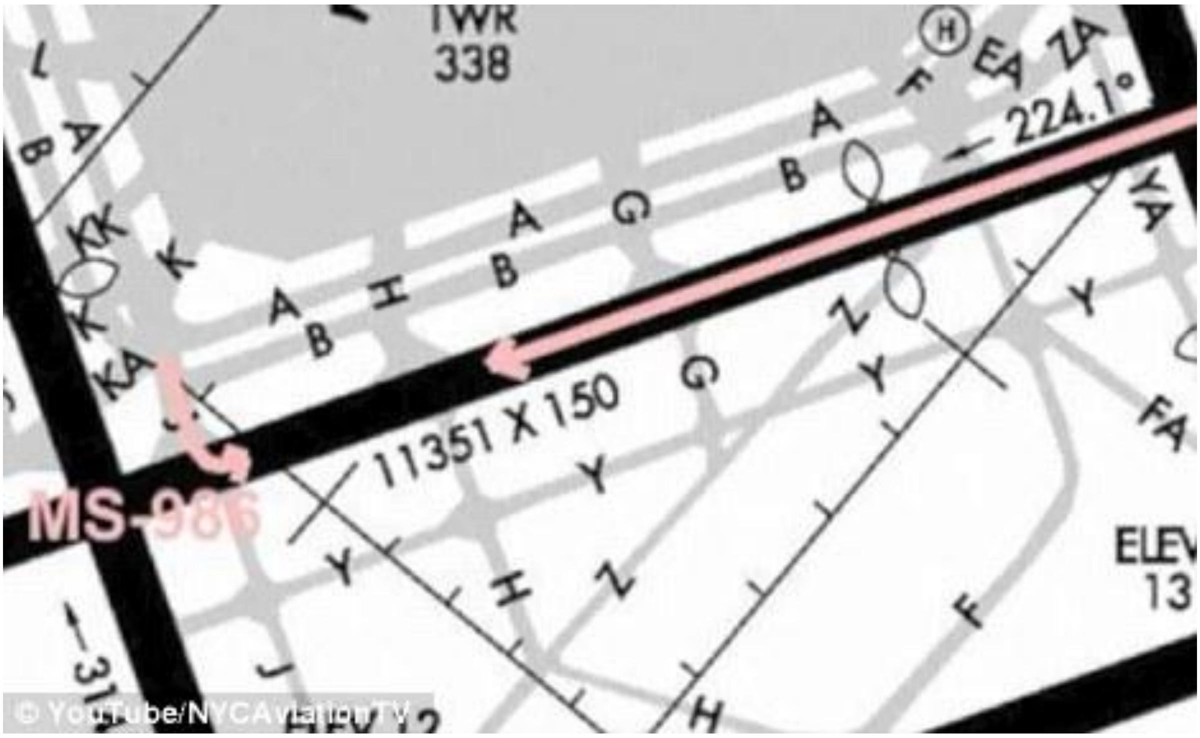
10.3 Runway Incursions



Runway Incursions FY 2000-FY 2010 adapted from http://www.faa.gov/ airports/runway safety/ statistics. FY 2005-2007 data adjusted with new ICAO definition.

An Egyptian Boeing 777 flight that entered the runway into the path of a German Airbus A340 on the runway at JFK International airport, New York was just 37 feet from a catastrophe that could have claimed many hundreds of lives. The incident in June 2011 was the most dangerous near-miss of the year at the New York City airport, according to a new report from the Federal Aviation Administration (FAA). The German flight carried 286 passengers bound for Munich. The Egyptian aircraft carried 346 passengers headed to Cairo. If they had collided, it could have been the worst commercial air disaster in history.

The following diagram shows the radar plot of the German aircraft accelerating along the runway and the Egyptian aircraft beginning to turn left and enter the runway.



Air traffic controllers had instructed the Egyptian plane to turn left to another runway. Instead, the aircraft continued straight and headed into the path of the German aircraft that was accelerating down the runway on take-off. An aircraft controller realised that the Egyptian aircraft had not followed the taxy instructions and instructed the German pilot to make an emergency stop so that their brakes over-heated.

The FAA cited the Egyptian pilots for failing to turn onto a different runway, as their air traffic clearance had instructed.

Many capital city aerodromes are very busy and congested. There is no shortage of data about actual and potential runway incursions. What is needed are effective safety management systems which analyse the runway incursion data and build in procedural and physical barriers to prevent incursions. There are also technological advances for aircraft and air traffic controllers which can warn of potential risks of incursions. Ground based radar surveillance and on board traffic positional information could prevent these aerodrome operational risks.

10.4 Loss of Control

Rarer but far more severe are so-called "loss of control accidents." These are characterised by a functioning aircraft suddenly making a catastrophic manoeuvre. At a conference held in October 2011 about the phenomenon, no single factor was found to blame, so combating loss-of-control accidents "requires coordinated actions from multiple sectors in aviation," such as airlines, regulators and equipment makers. One immediate response from regulators has been to require increasingly realistic training in simulators, including teaching high-altitude stall recovery techniques. Training and education are essential elements of Safety Management Systems.

Another major safety threat stems from pilots who become confused by cockpit computers or who rely on automation too much. Such pilots can get into fatal difficulties when they are suddenly forced to revert to manual flying skills in an emergency. The increasing computerisation of jet-aircraft and similar big changes to flying mean "we need to admit that fundamental changes need to occur," including how pilots are recruited, trained and tested.

Historically, improvements have come largely from better equipment and pilot training. Experts believe that in the future, however, the biggest advances will come primarily from analysing huge volumes of data about a broad array of incidents, culled from multiple carriers across the globe, a global Safety Management System.

Early versions of such forward-looking data analysis played a major role in cutting U.S. accident rates since the late 1990s, and they are being embraced by regulators and airline executives in scores of other countries. Now, the FAA and U.S. carriers are trying to involve foreign counterparts in similar dissection of safety data retrieved from actual flights and voluntary pilot reports. The trend is gaining particular momentum in Russia and across Latin America.

Yet sharing safety data across borders poses huge technical and legal challenges. As a result, not a single foreign carrier is fully participating in - or providing safety data for - the FAA's most ambitious threat-analysis system. In seeking common causes of crashes around the world, "no longer is there a clear distinction between domestic and international accidents," said the head of the U.S. National Transportation Safety Board, at a speech to the United Nations' aviation body in Montreal.

11 Conclusion

In aviation we are very proud of our safety record and the advances in safety over the years through technology and improving human performance. We are often compared with other modes of travel, and depending how you analyse the statistics, aviation comes out as the model for safety. However, as many analysts have commented we may have reached a plateau, and further improvements may be very hard.

In conclusion, in the 32 years since the worst accident in the Australasian region, there have been many important advances in technology, in systems, in understanding, and influencing human behaviours and in safety assurance. However, it appears that we have reached a plateau in the quest for improved safety. We still have accidents that have the same elements of many previous ones and should therefore have been preventable. There is no shortage of reports, but the challenge for safety investigators is to have effective Safety Management Systems through detailed investigation findings and actions so that we can eliminate accidents such as runway excursions, loss of control, and CFIT once and for all.

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