TENERIFE — a survivor's tale

By Robert L. Bragg (Capt., Pan Am and United, Ret.)

It's just over thirty years since Aviation's worst accident

On 27 March 1977, one Boeing 747 slammed into another on the runway at Tenerife in the Canary Islands. 583 people died in the impact and the resultant flames and explosions. No-one escaped the first plane; 65 managed to flee the inferno of the second.

The factors

An unexpected diversion, the advent of heavy fog and, crucially, a fatal series of seemingly simple misunderstandings and false assumptions.

Robert L Bragg

Mr Bragg was first officer aboard the Pan Am 747 that was hit, having a window seat to the horrors that ensued. His survival seems miraculous. The following is his firsthand account of that day's terrible events.

Our charter flight, Pan Am's Flight 1736, had departed Los Angeles the previous day, 26 March 1977, and made an intermediate stop at JFK in New York for a fuel and a crew change. This is where I joined the flight. I was the co-pilot.

Our B-747 was destined for Los Palmas in the Canary Islands, but we had to divert unexpectedly to Tenerife – some 43 miles from our destination. After parking and talking to the ground staff, we learned that a terrorist's bomb had exploded in the terminal at Los Palmas and the airport would be closed for an indefinite time. [The attack was claimed by the Canary Islands Independence Movement.]

The captain, Victor Grubbs, elected not to allow the passengers to disembark, as he wanted to be ready to leave as soon as possible. Our wait lasted about three hours – during which time we allowed the passengers to visit the cockpit, which most seemed to really enjoy.

At about that time, we heard the KLM plane, directly in front of us on the ramp, request a fuel truck. Fatefully, they had decided to add fuel while they were waiting. Within a very few minutes, the tower called and informed every plane waiting to fly to Los Palmas that the airport had re-opened. We called and asked KLM how long their refueling would last. The answer was that it would take about 30 minutes.

As you can imagine, this additional

delay didn't make any of us in the Pan Am cockpit very happy. I then volunteered to measure the wing tip clearance between the KLM B-747 and ours. The flight engineer and I walked out and measured the difference. We were 12 feet short of having the required distance and, consequently, we were then forced to wait until KLM's refueling was complete.

As the Dutch plane was refueling, I looked over and saw a female passenger, with her carry-on bags leaving the KLM plane. This lady turned out to be the only KLM passenger to survive the day. Every other passenger and all crew members would die within the next 45 minutes. As soon as the woman left the plane, the entry door was closed and the boarding steps were removed. The fueling trucks disappeared at about the same time.

Immediately thereafter, KLM called for his start clearance. I commented that it looks like KLM is getting ready to leave and indicated that I was ready to call for our start clearance. The captain agreed, and I called for and received our clearance.

Although we still had three passengers from the upstairs lounge in the cockpit, the captain asked if they'd like to see the engines started and called for the start checklist, which was followed by the starting of the four engines.

The two planes ahead of the KLM and us on the ramp called for taxi clearance; the first plane was instructed to back track down RW 15, continue to the end, make a 180 degree turn, and hold in position on RW 33. As for the second plane, it was given basically the same taxi clearance – but it was to clear the runway at the last taxiway on the left and report clear of the runway.

Both planes did as instructed, and after receiving their ATC clearance were given takeoff clearance and departed for Los Palmas.

The visibility was unlimited and you could see the entire runway from end to end. KLM was given the same taxi clearance, namely to back track and upon reaching the end make a 180 degree turn and hold their position.

Our plane, PA 1736, was given the same clearance, but, instead of saying 'Depart the runway at the last taxiway on your left', the air traffic controller stated, 'Depart the runway at the third taxiway on your left'.

As we were parked on the last taxiway, we assumed he meant the last taxiway on our left. As we began to taxi down the runway – back tracking down RW 15 – the visibility was still unlimited and we could easily see the KLM plane in front of us.

Within a very short time, however, I saw a fog bank roll off the hill on our

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right and onto the runway. Our visibility went from unlimited to 500 metres in under one minute. The tower even made a call stating, 'Gentlemen, be advised that runway visibility is 500 to 700 metres'.

We immediately checked our takeoff minima and found that the minima for take off were 750 metres. We naturally assumed the runway was closed for all takeoffs.

As the fog was so thick, the captain slowed the plane down to about 3 kt as indicated on the INS (inertial navigation system). We then proceeded to complete the taxi checklist.

We were looking very hard for our taxiway on the left so we could depart the runway. As we began to see the taxiway we were looking for, I looked up and saw the nose of the KLM B-747. This was not immediately surprising as we knew the plane was there, supposedly waiting for us to depart the runway.

I then noticed his landing lights shaking and very excitedly said, 'I think he's moving'. It was then very obvious that he in fact was moving at a very rapid rate directly toward us. I started yelling, 'GET OFF, GET OFF!' The captain had made the same decision at exactly the same time I shouted.

He immediately applied full power and turned the plane hard left. We were told later the plane turned about 27 degrees to the left before being hit by the KLM B-747. The captain, by his quick action, saved the Pan Am crew and the few passengers who survived the crash.

As we were turning left, I looked back to my right out of the cockpit's right hand window. I couldn't believe what I was seeing – that the KLM B-747 was actually taking off. In a second or two, the KLM plane had rotated and the entire fuselage had lifted off the runway. The last thing I remember seeing was the red rotating beacon on the bottom of the fuselage.

I ducked, closed my eyes, and prayed, 'God, let him miss us…' When it did hit our plane, it was only a very short, quiet shudder. I actually thought that he had, in fact, missed us – until I opened my eyes. The first thing I noticed was that all of the windows in the cockpit windshield were completely and totally gone. I looked to the right and saw that the right wing was totally engulfed in flames.

I looked to the left and saw that the entire upstairs lounge and its 28 passengers were gone. The cockpit floor and upstairs lounge floor were also gone. I could see all of the way to the very rear of the cabin of the plane. I have always thought that it looked as if someone with a giant knife had simply cut the entire top of the cabin off.

I immediately looked and reached up to pull the fire-control handles which shut down the engines in addition to accomplishing several other functions. After I noticed that the entire top of the cockpit was missing, I reached down and shut off all four of the engines' start levers. Nothing happened. The engines were operating at full throttle prior to our being hit, and they continued to operate the same way after the impact – at full power. I again started yelling, 'Get out, get out!'

At that point, I decided it was time to heed my own call and get out of the cockpit. When I stood up, there was only about a foot of the cockpit floor still in place. I stood on that and, facing left, held on to the back of the captain's seat, placed my foot onto the cockpit side and, without even thinking of the distance to the ground – which was about forty-eight feet – I jumped.

It was an awfully long way to the ground. I really think I'm the only crew-member ever to have actually jumped from a B-747 cockpit to the ground, and I sincerely hope I continue to hold that record forever.

When the B-747 was designed, the cockpit was given three different means of emergency escape: 1.) an emergency escape hatch in the aft top of the cockpit – which was gone; 2.) an emergency door on the right side, aft, of the cockpit – which was also missing; and, 3.) a passenger staircase going from the upper lounge and cockpit area – leading down to the first class section – which had also disappeared.

When I hit the ground, I hit on grass. The very last thing I remember hearing prior to our being hit was the planes nose gear dropping off the runway unto the grass. I did the same. Landing on grass was very lucky for me. I'm sure if I had landed on the cement that I would have broken a lot of bones.

I immediately looked back at the plane and it was burning furiously, especially the section over the central fuel tank. What was most surprising was that a large number of passengers had made their way out onto the left wing of the plane.

I also remember that the engines were still running at full power when I went back up to the plane, as close as I could get, and started waving and yelling to the passengers to jump off the wing, as I expected the entire plane to explode at any minute. All of the passengers did as I had hoped. They jumped from the wing – which was about 25 feet above the ground.

I saw one male passenger running as fast as he could, dragging a lady by the ankle. I found out later that the woman was his wife and that she had broken both legs, both arms, as well as her back when she jumped from the wing. She had been among the first to jump and nearly everyone behind her landed on top of her when they jumped.

All during this time, I was motioning for the passengers to get as far away from the plane as they could. At one point I stopped to see what I thought were passengers coming back up to the plane and I wondered why in the world they were doing that. Then, I stopped and took a better look. I soon realised that these people were local inhabitants, whose homes were located near the airport, who had voluntarily came out to the crash site to assist in any way they could.

Of the Pan Am passengers, sixty-five managed to survive the crash, as did the three cockpit crewmembers, four flight attendants, and two Pan Am staff members who were in the cockpit.

No one in the KLM plane survived. When it hit us, the plane severed its landing gear, exploded, and crashed back to the runway some 1500 feet beyond our plane. The total loss of life was 583 people.

There are numerous and obvious lessons to be learned from what turned out to be the worst aviation accident in history:

1.) Airport weather can change in a moment.

2.) Airports can close in an instant and crew must always have an alternate plan readily available, e.g., appropriate and current charts of airports in the general vicinity.

3.) Crew must constantly guard against getting into too big of a hurry

4.) Crew must always practice CRM (crew resource management) and if an obvious mistake is seen, it must be corrected without delay. ▪

Reflections on Tenerife

By Rob Lee

Excluding terrorist attacks and sabotage, the collision between two B747s on the runway at Los Rodeos Airport, Tenerife, on 27 March 1977 remains the worst disaster in the history of aviation. 583 people lost their lives.

Captain Bragg is now the only surviving member of the technical crew involved in the accident, and his personal account makes harrowing reading.

So, what more can be said about this tragic accident that occurred so long ago, and which has been subject to extensive detailed analysis and evaluation over so many years?

Rather than re-evaluate and analyse the accident yet again, this article considers the disaster in the context of the contemporary systems approach to safety in aviation.

A consequence of the international adoption of the systems safety approach, relevant to the Tenerife disaster, is that, under the provisions of ICAO Annex 14, the requirement for airports to have a safety management system became an ICAO standard on 24 November 2005.

A key factor driving this development is the continuing, and increasing, incidence of runway incursions in the industry, which have manifested themselves in accidents involving multiple fatalities, such as the B747 collision with construction equipment at Taipei on 31 October 2000, and the collision between a Cessna Citation and an MD 87 at Linate Airport, Milan on 8 October 2001.

Could an effective, modern integrated safety management system at Tenerife

COURTESY R L BRAGG

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airport have prevented the collision there?

Before discussing this aspect of the Tenerife accident, a number of points should be made to place the views to be expressed in this article in context.

In virtually all aviation accidents, the key contributing systemic factors prior to the accident were known, and in many cases had been well documented.

However, little, or nothing had been done to rectify these factors until after the accidents occurred. Often a detailed, comprehensive, time-consuming, and extremely expensive investigation has served merely to identify independently these pre-existing factors, and confirm their existence prior to the accident.

Typically, the reactions of 'organizations and their management involved in influencing the operation of the aircraft' involved in accidents, to use the words of ICAO Annex 13, have been along the lines that it is impossible to predict accidents, and that air safety investigators make recommendations with the benefit of hindsight.

Invariably, accident investigations reveal systemic factors that were well known, and which had not been effectively addressed by those agencies that had the responsibility to do so. To use the 'hindsight' argument as an excuse for having done nothing is simply an attempt to avoid both accountability and responsibility.

In essence, when the total domain of knowledge gathered by an accident investigation is considered, the only really new knowledge within this domain typically relates to the immediate circumstances of the accident – such as collision vectors, angles of impact, technical malfunctions, structural failures, errors or violations by ATC, aircrew, or maintenance personnel, and so on.

In addition, the specific pathways linking systemic factors, such as training, design, procedures, equipment, communication, and so on, to the specific occurrence are identified by the investigation on the basis of the evidence it obtains.

However, for the reasons outlined earlier, there is generally little, or no, new knowledge regarding the core systemic factors that contributed to the accident, because these were known *before* the accident.

The present adoption of a proactive risk-based systemic approach to safety management, as manifested in the ICAO standards for safety management systems in all categories of aviation operations, has been driven by the adoption of the systemic approach to air safety investigation that began in the early 1990s, largely influenced by the pioneering work by James Reason and his colleagues in the oil and gas industry.

The then Australian Bureau of Air Safety Investigation was the first international air safety investigation agency to adopt the Reason Model as a guide to the systemic investigation of aircraft accidents. The first output of this new approach was the publication in 1994 of the Bureau's investigation report of the 1993 Monarch airlines accident. The Monarch report triggered wide ranging, and major changes to the Australian aviation system. In 2005, ICAO issued its first ever safety management manual.

Several key lessons have been learnt as a result of the systemic approach to safety. Perhaps the most important of these is that the same underlying systemic, or organisational, factors can lead to, or give rise to, a multitude of potential accident scenarios, none of which can be predicted exactly.

In practice, this means that underlying systemic factors such as poor communication, inadequate training, inappropriate design, faulty documentation, and poor procedures, can all be common factors in dozens of different specific accident and incident scenarios, each one having a unique combination of events and circumstances.

Returning to the Tenerife accident, there are many points in the immediate and unique sequence of events and circumstances leading up to this accident at which it could have been prevented.

For example, if there had been sufficient clearance on the ramp between the Pan Am 747 and the KLM 747 that would have enabled the Pan Am 747 to make its departure before the KLM aircraft completed its refueling, it would have been unlikely that the accident would have happened.

Contemporary systems safety thinking places an emphasis on the combination of events and circumstances that can create an accident, rather than looking only at the causal pathways involved.

It is this combination that is the critical determinant of the outcome, rather than the individual factors on their own. What this means in practice is that there may be many latent conditions in the system which are not individually important from a safety perspective, unless specific combinations of events and circumstances occur, in which case they do become critical.

To simply illustrate this point, a dim emergency exit sign in an aircraft cabin may be tolerated indefinitely, as it is not important most of the time; but it may become a critical factor in passenger survival when the cabin is full of smoke, and it then cannot be seen.

Practical risk management tools, such

as the 'Bow Tie' methodology developed in the oil and gas industry and now being used in aviation, are extremely useful in analysing and managing the risks associated with various aviation hazards – for example, in preparing a safety case for a particular category of operation.

It should also be recognised in this era of systems safety that the process of investigation is only one component of an overall integrated safety management system (ISMS).

The other ISMS components, such as senior management commitment, hazard identification, risk management, reporting and safety information systems, education and training, documentation, proactive accident prevention programs, are equally, if not more, important elements than the post-occurrence investigation process itself.

In the words of Captain Don Gunther, Senior Director of Safety and Regulatory Compliance at Continental Airlines, 'We should aim to investigate accidents before they occur'.

An integrated safety management system facilitates this proactive investigative process in a highly cost effective manner. In contrast, in major accident and incident investigations, a great deal of time, effort and expense goes into determining the specific circumstances of the event. Of course, this is always an essential process.

At this point, it should be noted that runway incursions, such as those that occurred at Tenerife, remain a major, and increasing problem in aviation safety.

Many of the systemic lessons from the Tenerife accident were not learned by the industry at the time, because the causal emphasis in investigation was still primarily focused on the errors and violations of people at the 'sharp end', such as pilots and air traffic controllers. However, with safety management systems now becoming ICAO standards, albeit belatedly, hopefully the situation will improve.

Captain Bragg's account does not address systemic issues related to the airport itself, such as the layout of the taxiways, which made it physically impossible for the Pan Am B747 to exit the runway at taxiway C3, as instructed by ATC.

As noted earlier, on 24 November 2005, ICAO Annex 14 required airports to have in place a safety management system. Essential components of any safety management system are processes of hazard identification and risk management – to evaluate and manage the risks associated with these hazards.

In managing the risks associated with each hazard, the way in which the hazard presented a threat would be determined.

Preventive controls would be identified to maintain control of the individual hazards, and in the event that control of the hazard was lost, recovery measures, or controls, would be identified to prevent the ultimate consequences resulting from the loss of control of the hazard – such as death or injury, loss of assets, environmental damage, and so on.

For each preventive and recovery control, factors that could reduce its effectiveness would be determined, and measures put in place to counter these problems to ensure that all controls are effective.

The levels of risk associated with each hazard are dependent upon the number and effectiveness of the preventive and recovery controls.

In the case of the Tenerife accident, the hazards involved were the aircraft themselves. From the Pan Am aircraft's perspective, the hazard was the KLM B747, and vice versa.

Other aircraft on a runway can present threats in a number of ways; for example, in being obscured by fog or heavy rain. Typical preventive controls to stop aircraft getting into a potential collision situation in reduced visibility are surface movement radar, and low visibility taxiing procedures.

The effectiveness of these controls can be reduced by unserviceability of the radar, and non-compliance with procedures by aircrew and air traffic controllers. Measures to prevent these controls being degraded include regular maintenance of the radar, clear and unambiguous procedures, and regular training in these procedures.

Once aircraft get into a situation in which they could collide, recovery controls should be in place to prevent an actual collision. These recovery controls include pilot detection of the other aircraft on a collision course in time to avoid a collision, monitoring and advice by ATC, and aircraft performance to take effective avoidance actions.

These recovery controls can be degraded by loss of situational awareness on the part of a crew, poor visibility, and degraded aircraft performance, such as reduced braking effectiveness as a result of a contaminated runway surface. In turn, these degrading factors can be addressed through crew resource management training, and communication to pilots by ATC regarding the state of the runway.

With an integrated safety management system, this type of comprehensive risk management analysis, which identifies and rectifies systemic deficiencies, is carried out proactively, in the absence of, and prior to, a serious incident or accident. Lessons from previous accident and incident investigations should always be incorporated in this process.

In this way, tragic accidents such as that which occurred at Tenerife can be prevented. With the imminent introduction into service of the A380, it is even more critical that airports, operators and air traffic service providers implement effective integrated safety management systems.

Had what is now known about systems safety been in place at Los Rodeos Airport in March 1977, it is unlikely that the collision would have happened.

Hopefully, the systemic lessons learned from the bitter experience of Tenerife will be universally incorporated into today's integrated safety management systems, and there will be no further repetitions of what Captain Bob Bragg experienced on that fateful day in March, 30 years ago. ▪

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