

# Air Crashes: Why Do They Happen?

By Chip Hartman



*Airline accident investigators know that fatal air crashes are rarely the result of one isolated cause. Most of them result from seemingly disconnected, inconsequential factors — none of which, by itself, would cause the accident — but all of which, as an aggregated set of conditions, will.*

Whether for business or pleasure, millions of us routinely board commercial airliners and rarely consider the possibility of not reaching our destinations safely. In fact air travel has become so safe (discounting acts of terror and criminal acts) that "getting there" is simply taken for granted.

Current estimates from a variety of sources put the odds of being killed in a commercial aviation accident at something close to 1 in 4.7 million.<sup>[1]</sup>

[1] Source: OAG Aviation & PlaneCrashInfo.com accident database, 20 years of data (1993 - 2012)

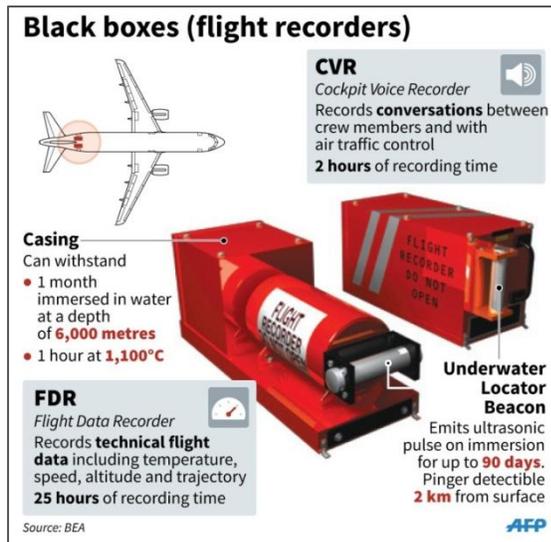
Statistics like this are comforting when buckling our seatbelts for takeoff, but for some, the math brings little relief. There will always be nervous flyers who experience a twinge of worry as the plane taxis onto the runway. That's when they recall those unfortunate souls who boarded flights with similar expectations of arriving safely — because the mathematical odds were in **their** favor, too — but who perished instead.

## Accident Investigations: Tools, Techniques, Theory

As horrific as they are, air tragedies expose all sorts of weaknesses such as language barriers, human error, weather anomalies, runway incursions, and latent mechanical failures just to name a few. From an organizational perspective, they may uncover things like reductions in budget for

pilot training, pushing unrealistic maintenance schedules, and breakdowns in strict adherence to safety regulations.

More often than not, the findings of accident investigators trigger corrective actions so that similar accidents can never reoccur. It's the cumulative effect of those corrections that, over time, keeps safety and survival metrics on a continual climb in the passenger's favor.



Investigators rely heavily on a wide range of tools and techniques for piecing together the complex accounts of aircraft accidents, most notably the recording devices on all commercial aircraft — the so-called "black boxes"— the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR).

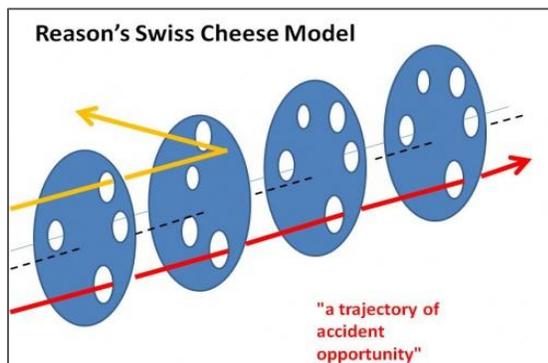
The two black box tapes are routinely studied in synchronized playback so that investigators can correlate cockpit conversations with the systems controlling the aircraft at any given moment.

Beyond the familiar, hands-on analyses mentioned above, investigators are also highly trained in the theory of accident causation since modern models uncover causal factors using a more holistic approach than traditional "cause and effect" models.

Investigators have found one particular model of accident causation to be especially helpful in piecing together the causes for some of the most baffling air crashes of all time.

## The Modern Model of Accident Causation

It's known as the Swiss Cheese Model of Accident Causation. It was developed by British cognitive psychologist Dr. James T. Reason at the University of Manchester in 1990.



The Swiss Cheese Model suggests that, although there are many layers of defense that lie between hazards and accidents, there are flaws (holes) in each layer that, if they should ever become aligned from layer to layer, will allow one unique "hazard thread" to pass unobstructed through all of the layers, making the possibility of an accident very real. Dr. Reason named this "a trajectory of accident opportunity."

Each **layer** in the Swiss cheese block represents a line of defense starting with the airline organization, its policies, procedures, and protocols. Each successive slice gets closer to the operation and piloting of the aircraft.

Each **hole** in a slice can be made up of both **active failures** and **latent failures** and is constantly changing size and position (i.e., its likelihood of being detected and corrected is high, thus shrinking or eliminating the hole; — **or** — its failure to be detected and eliminated enlarges the hole, thus passing the failure on to the next layer of defense).

- **Active failures** include unsafe acts that can be directly linked to an accident, such as pilot error.
- **Latent failures** are the conditions that have remained dormant for days, weeks or months prior to the flight but that eventually reach critical mass after passing through all of the previous slices undetected.

One of the best ways to understand the Swiss Cheese Model is to apply it to an actual event, a disaster of epic proportions which remains the single deadliest accident in aviation history.

## The Tenerife Disaster, 3/27/1977 (Canary Islands, Spain)



The event occurred on Sunday, 3/27/1977 on the small Spanish island of Tenerife, part of the Canary Islands, some 62 miles off the northwestern coast of Africa.

**KLM Flight 4805** and **Pan Am Flight 1736**, both B-747s, collided on a small runway just after the KLM jet lifted off in a dense fog. In total, 583 people were killed.

Reactions from witnesses and the media were quick and predictable: Poor visibility was unmistakably the cause of the crash. As it turned out, weather was just one of several causes.

Accident investigators from the Netherlands, Spain, and the United States eventually uncovered nine discrete factors that, against all odds, formed a deadly "trajectory of accident opportunity" on the tarmac that afternoon shortly after 5 pm.



*departed from Las Palmas safely and on time.*

**Terrorist Activity at Las Palmas Airport:** Both jets were originally bound for Las Palmas Airport on the large island of Grand Canary but **Air Traffic Control (ATC)** declined to let them land because a terrorist bomb had exploded in the passenger terminal only moments before. They were diverted to the smaller airport on the island of Tenerife. *Had it not been for the bombing, the planes would have*



directed KLM 4805 to "back-taxi" down the runway, then make a 180-degree turnaround so it

**Size & Limitations of Los Rodeos Airport:** Tenerife's Los Rodeos Airport was a small, one-runway airstrip unaccustomed to handling high traffic and far from ideal for jumbo jets requiring maximum takeoff space. But it wasn't just these 747s taking up space at Los Rodeos; there were dozens of other, smaller jets that had also been diverted from Grand Canary due to the terrorist bombing. ATC

would have the full distance of the runway for takeoff. The Pan Am plane was instructed to taxi down the runway behind the KLM jet, exit the runway at the third taxiway, then stand by so the KLM plane would have the runway clear. *Had the airport been large enough to handle the congestion caused by the influx of planes from Grand Canary, the accident might not have happened.*



**Dense Fog in Tenerife:** As the Pan Am 747 was following the KLM jet down the runway, thick fog started to roll in from the surrounding hills and finally enveloped the entire airport. It became so dense that neither plane could see the other. Worse, Air Traffic Control (ATC) couldn't see either of the 747s and had to rely on cockpit radio communications to establish each plane's position. *Had it not been for the poor visibility that settled in only 1/2 hour before the crash, the accident would not have happened.*



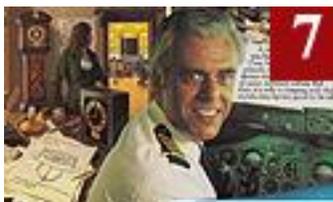
**No Ground Radar at Los Rodeos Airport:** The absence of ground radar (Surface Movement Radar, or SMR) prevented ATC from locating the exact position of the planes. *If Los Rodeos had had ground radar, ATC could have determined that the two planes were far too close to each other and halted any further movement.*



**KLM 4805 Refuels Before Takeoff:** Prior to back-taxiing down the runway, the KLM captain (Captain van Zanten) had ordered a full refueling of his plane, even though the junior officers advised him that they had plenty of fuel for the return flight to the Netherlands. In the time it took for this procedure, the fog thickened even more. Worse yet, the extra weight of the fuel would require a greater takeoff distance to get the 747 airborne, a fact that Captain van Zanten should have known. *Had Captain van Zanten heeded the advice of his co-pilot and flight engineer, KLM 4805 might have had sufficient lift to clear Pan Am 1736 still parked on the runway.*

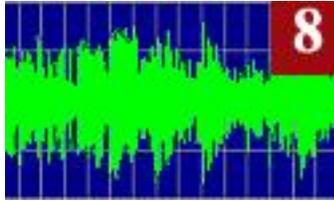


**Pan Am 1736 Misses its Taxiway Turn:** The Pan Am 747 had been instructed by ATC to turn off of the runway so that the KLM plane could be cleared for takeoff. The fog was so dense, however, that the Pan Am pilot, Captain Victor Grubbs, was unable to see the assigned turnoff onto the taxiway despite making numerous requests to ATC for clarification. Unfamiliar with the airport's geometry to begin with, Captain Grubbs was now unknowingly positioned directly in the path of KLM 4805. There were some radio exchanges between Pan Am 1763 and ATC to confirm the designated "exit taxiway," so a minor language miscue may have been a contributing factor. *Without this communication glitch, the Pan Am plane might have made it off of the runway — and onto the taxiway — in time to prevent the accident.*



**Personality of KLM 4805 Captain:** Among the most controversial factors in the entire case (based on CVR tape) was the behavior of the KLM captain, Captain van Zanten. A distinguished and decorated pilot for many years with KLM (even the face of KLM in much of its advertising), Captain van Zanten did not appreciate being questioned by subordinate crew members. On two occasions, he had actually increased input to the throttles with the intention of taking off prior to receiving final ATC

clearance; on the second occasion, the KLM First Officer spoke up pointing out that ATC had not yet granted them final clearance for takeoff. Captain van Zanten ignored the junior pilot's advice, said "We're going" and began his takeoff anyway. *Had Captain van Zanten heeded the advice of his junior officers, the lives of 583 people would have been saved.*



**Heterodyne Squelches Critical Message to KLM 4805:** Aircraft communication with ATC uses a 2-way VHF radio — similar to a walkie-talkie in that only one person can speak at a time. If two individuals speak simultaneously, there is a loud "squeal" (called a **heterodyne**) that effectively cancels out each transmission. Against all odds, that's what happened just 30 seconds before the accident, based on investigators' analysis of the CVR from both planes and ATC tapes. ATC had tried to warn KLM 4805 that it did not have final clearance for takeoff .... just at the very moment the Pan Am co-pilot was broadcasting an urgent message that his plane was still on the runway. All the KLM crew heard was a loud, sustained "squeal," picking up only the last fragment of the ATC statement. *Had the full transmission been received by the KLM crew, the accident might have been prevented.*



**ATC Has Only Two Controllers:** In what has to be one of the great ironies of this case, the accident happened on a Sunday afternoon, when ATC staff was reduced to just two controllers. *On any other day of the week, the full complement of controllers on duty might have been able to manage the unusual congestion and traffic, allowing for a more focused control of the two jumbo jets.*

Within seconds after lifting off, the crew of KLM Flight 4805 finally saw the Pan Am 747 sitting squarely ahead of it and frantically tried to get enough lift to clear the other plane, but it was too late.



The right engine of the KLM jet "clipped" the top of the Pan Am plane then literally peeled away the upper part of its fuselage, causing both planes to burst into flames. Still travelling at takeoff speed, KLM 4805 broke apart as it fell back onto the runway followed by massive explosions of jet fuel. There were no survivors on KLM 4805, a statistic made all the more egregious with regard to Captain

van Zanten's decision to take on 50 tons of jet fuel — fuel that wasn't even needed.

Miraculously, 61 passengers aboard Pan Am 1736 **and** the cockpit crew managed to crawl out of the burning wreckage to safety.

A careful analysis of these conditions revealed that if any one of these factors had not been in play, the disaster might never have happened.

## Crew Resource Management (Cockpit Resource Management)

Spurred on by the Tenerife Disaster in 1977 and the United Airlines Flight 173 crash over Portland, Oregon a year later, the National Transportation Safety Board (NTSB) issued a call for specialized

training to break down the hierarchical boundaries in the cockpit so that junior officers would feel comfortable supplying critical input to senior pilots if there was any indication of potential danger to the aircraft and its passengers.

**Crew Resource Management** eventually fostered a less authoritarian cockpit culture and helped to create an environment in which the crew functioned as a cohesive team in piloting the aircraft.

## Conclusion

Even though air disasters may never be 100% preventable, investigators learn crucial lessons with every new incident that makes air travel safer than ever before. The survival statistic quoted earlier of "one chance in 4.7 million" represents a margin of safety no one would have thought possible in the 1980s. But with each new accident, each new investigation, and each new set of corrective policies, the mathematical odds for a safe flight are increased dramatically.

As one rehabilitated nervous flyer recently commented, "Now I fly all the time. Why worry? I have a better chance of winning the state lottery jackpot — twice in a row — than being in an air crash!"

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*This article was written in memory of the 230 people who were killed on July 17, 1996 when TWA Flight 800 (New York to Paris) exploded less than half an hour after takeoff from JFK Airport.*

*For those who find the causality theory of accident investigations interesting, consider reading a book by Malcolm Gladwell (author of The Tipping Point) called Outliers. In Chapter 7 of Outliers, Gladwell probes the causes for air crashes and presents a theory about why junior officers are so reluctant to confront their superiors in the cockpit, despite the best intentions of Crew Resource Management.*

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