Collision at Los Rodeos, Tenerife

Luis Casassa

Lynn College of Aeronautics

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Professor Jennifer A. Torres

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Abstract

On March 27, 1976, a KLM 747 initiated takeoff at Los Rodeos airport on the island of Tenerife. Just after the plane reached V1 speed, it collided with a Pan American 747 on the runway, resulting in the death of 583 individuals, including all those on board the KLM plane. That afternoon's low visibility prevented the KLM pilot from knowing that the Pan American jet was still taxing down the runway. This paper will detail the events that led to this tragic accident that occurred that day. It will describe, in chronological order, various incidents, decisions, and circumstances that culminated in the deadliest aviation accident in history. It will also discuss the changes that were implemented, in terms of rules and regulations, resulting from the accident.

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Introduction

Aviation Safety History

Since its infancy, safety has been the aviation world's highest priority. In the early years, aviation experienced a high frequency of accidents and, consequently, a high mortality rate. Deadly accidents throughout the 1920s and 1930s occurred on average five times a year (Laster, 2018). With each incident, aviation safety officials studied the causes of the crash and imposed new rules and regulations to avert a recurrence. As time went on, aviation's safety slowly improved. Jet-powered commercial aircraft, introduced in the 1960s, were crucial in further improving safety (Finlay, 2022). Turbine engines were far more dependable than the piston engines they replaced. New advancements in navigational equipment and automation made air travel safer. "In 1959, a total of 40 planes crashed fatally for every million flights in the United States." Ten years later, this figure had declined to "less than two fatal accidents for every million flights" (Finlay, 2022, para. 6). In the 1970s, however, the aviation industry experienced an upsurge in the number of deaths caused by accidents. The 1970s are the deadliest decade in terms of passenger deaths in aviation history (Ali & A, 2022). From 1970 through 1979, 3,133

plane crashes occurred, resulting in 24,512 deaths. John Frearson, a flight simulation expert, explained why the 1970s were such a dangerous time for aviation. “Frearson cautions against attributing too much significance to the record of any one year but says the early 1970s were a transition period in aviation with new wide-bodied aircraft entering service but with specific operating techniques and general safety culture evolving more slowly” (Writers, 2017, para. 13). Before the 1970s, passenger aircraft were smaller single-aisle planes with much lower passenger capacity as compared with the newer widebody aircraft introduced in the 1970s (Goebel, 2021). These larger aircraft included trijets such as the DC-10 and L-1011 and the more immense "super jumbo" quad-jet, the Boeing 747.

Clipper Victor

Introduced in 1970, the Boeing 747 could carry more than double the number of passengers the single-aisle jets of the 1960s could (Boeing Corporation, 2016). The 747-100 could seat 440–550 passengers, depending on seat configuration. The plane’s capacity to carry vastly more people resulted in greater access to air travel for the average consumer. On January 22, 1970, Pan American’s 747, Clipper Victor, performed the first scheduled flight by a 747 from New York’s JFK to London’s Heathrow airport (Swopes, 2022). This flight heralded a new era of aviation, securing Clipper Victor’s place in aviation history. Clipper Victor’s accolade would be overshadowed years later, in 1977, when it collided with another 747 on the island of Tenerife, causing the deadliest accident in the history of aviation (Pigott, 2016).

Chronology of Events and Locations March 27, 1976

Las Palmas

Located off Western Africa, the Canary Archipelago consists of eight volcanic islands. Official Gran Canaria Tourist Website, 2022). The archipelago, owned by Spain since the 1500s, became a popular destination for European tourists in the early 1960s. From the 1960s through the 1970s, the Canary Islands experienced a tenfold increase in the yearly number of tourists visiting the island (Cloudberg, 2022). Consequently, much of the island's infrastructure, particularly its airports, had not been suitably updated to manage the increased influx of tourist traffic. The archipelago's main airport, Gando International, is in Las Palmas, Gran Canaria, the third largest island. The airport serves as the main port of entry for travelers visiting the region (Cloudberg, 2021). Owing to the airport's importance to the Spanish tourism economy, it became a target of a pro-independence political group called "Fuerzas Armadas Guanches" (Markham, 1977). The Guanches were a political group by name only, having frequently executed acts of terrorism, including bombing dozens of public buildings in Spanish territory, including the Canary Islands (Davidson, 2013).

Terrorist Bombing

On Sunday, March 2, 1977, two men walked through the glass doors of the first-floor terminal of Las Palmas International Airport. Of the two men, only one carried a suitcase (Ziomek, 2018). Navigating the busy crowd of travelers, the men headed towards a small flower shop near the Pan American ticket counter. Once there, the men discreetly placed the suitcase by the front of the store. The florist's manager, Marcelina Sanchez, had not noticed the abandoned bag a few feet away. Like the passengers in the terminal, she was also unaware that the suitcase was ticking and the homemade bomb inside was about to detonate. At 1:15 pm, the bomb went off, causing an explosion that blasted out the shop's windows, hurling shards of glass throughout the terminal and filling the airport with smoke (New York Times, 1977). The blast injured eight

people (Rego, 2017). The bomb had been called into the authorities 15 minutes before it detonated (Markham, 1977). The caller also disclosed that a second bomb was somewhere else in the airport. All passengers were evacuated from the terminal after the call ended, and the airport was closed to all flight traffic. All incoming flights would be diverted to Los Rodeos Airport on the island of Tenerife until the other explosive device was found. The explosion in the terminal at Las Palmas that day would be the first in a series of events concluding with the worst accident in aviation history.

Los Rodeos Airport

In 1929, the Tenerife Island Council constructed a new airport in Los Rodeos, an area in the Aguere Valley on the island of Tenerife (Bird, 2022). At an elevation of 2,000 feet above sea level, the airport is located near the Atlantic coast to its west and the La Laguna and Anaga Mountain Ranges to its north (Cloudberg, 2021). As passenger traffic grew over the following 30 years, upgrades were made to the small airport. In the 1960s, a control tower was added, and the airport's runway was reinforced and lengthened to 3,400 meters (11,155 feet) to accommodate larger aircraft (AENA, 2022). A few years later, the airport added an ILS approach system. Charter operators operated most flights serving Los Rodeos. Although Los Rodeos had a runway that could accommodate large aircraft like the 747, the airport was ill-equipped in its capacity for large numbers of aircraft and passengers (Ziomek, 2018). The airport's terminal was small and often became overcrowded with passengers. Pilots have criticized the runway itself. During construction, the ground had not been adequately excavated, resulting in a large hump near the runway's center. The hump made it challenging to see one side of the runway from the other, especially in low-visibility situations. Although the airport had a control tower and an ILS, it had

little else in terms of navigational aids. “It certainly was not built to accommodate Boeing 747s; it had no radar, no runway visibility measuring system, and no taxiway markings; and the centerline lights were out of service” (Cloudberg, 2021, p. 9). The airport had a poor safety record. “There was one accident a year at Los Rodeos from 1965 to 1968, killing 98 people” (Ziomek, 2018, p. 82). In 1972, a Spantax Airlines flight crashed shortly after takeoff from Los Rodeos when it encountered heavy crosswinds, killing all 155 people on board (Correa, 2022).

Pan American 1736

In the 1970s, Pan American Airways was a worldwide symbol of American influence and prestige. Pan Am served several international destinations on both scheduled and charter services. On March 26th, 1977, Pan Am Flight 1736 took off from Los Angeles International Airport at 17:29 local time en route to New York as a stopover to its destination in Las Palmas in the Canary Islands (FAA, 2020). Most of the 380 passengers aboard were retirees from California (Nordheimer, 1977). Royal Cruise Lines chartered the flight as part of a package cruise tour. Once the plane arrived in New York, a new crew would operate the second leg of the journey. Once refueled, the 747 took off from JFK at 02:42 (FAA, 2020). The crew of Pan AM 1736 consisted of Captain Victor Grubbs, age 56; First Officer Robert Brag, age 39; and Flight Engineer George Warns, age 46 (Secretary of Civil Aviation Spain, 1978). Captain Grubbs was an experienced pilot, having logged over 21,000 flight hours in his career, 564 of which were with a 747. First Officer Brag had accumulated 10,800 total flying hours, 2796 on the 747. Flight Engineer Wars had a total flying time of 15,210 hours, 559 of which were on the 747.

KLM 4805

At 9:00 a.m., KLM flight 4805, a 747-200, departed Amsterdam Schiphol Airport for Gran Canaria, the same destination as Pan Am flight 1736 (Secretary of Civil Aviation Spain, 1978). Captain Jacob Louis Veldhuyzen van Zanten piloted the flight to Las Palmas. He was a well-experienced pilot, having logged 12,000 flight hours in his career, including over 1,500 hours operating the 747. Captain van Zanten was one of KLM's most esteemed pilots. Van Zanten was KLM's top pilot, head of safety, and chief flight instructor. "He spent the majority of his time training the company's pilots, and his face was on KLM's advertising around the world" (Corcoran, 2020, p. The flight crew accompanying the captain was also well-experienced. "With 9,200 flying hours under his belt, first officer Klaas Meurs (32) was nearly as experienced as captain van Zanten, despite being 18 years younger. "For flight engineer Willem Schreuder (48), who had already completed 15,000 flying hours" (J Hagen, 2013, p. 63). KLM 4805 was carrying 234 passengers. Like Pan Am 1736, the KLM flight was a charter hired by the travel agency Holland International (Ziomek, 2020).

Diversion to Los Rodeos

Two hours before landing in Las Palmas, the KLM crew was notified about the bomb that had detonated at the airport in Las Palmas. Most incoming flights were to be diverted to the Los Rodeos airport in Tenerife (FAA, 2020). The airport in Las Palmas would reopen once it was deemed safe. Interestingly, there were two options for redirecting the incoming flights. Another alternative was the airport in Fuerteventura, which, although slightly further away, was better equipped to manage the increased incoming traffic (Bird, 2022). Pan Am 1736 was also notified of the closure at Las Palmas and told to divert to Los Rodeos Airport (Cloudberg, 2021). Initially, Captain Grubs attempted to avoid diverting, asking Gran Canaria ATC if they could instead circle in a holding pattern and wait for the airport to reopen. "On arrival at Tenerife, the

Pan Am captain had requested to hold at altitude since they had adequate fuel. The Spanish controllers refused this request and ordered them to land (ALPA, 1977, p. 15). At 13:38, KLM 4805 touched down on the runway at Los Rodeos Airport. Pan Am 1736 arrived forty minutes later at 14:15 (Weick, 1990). The apron of the taxiway was congested with aircraft. The congestion would not allow for the taxiway's use due to the overflow of planes occupying this space. The Pan Am 1736 was parked behind KLM 4805. In total, five large jets were diverted to the airport that afternoon. (FAA, 2020). Fifteen minutes after the Pan Am jet landed at Los Rodeos, Las Palmas airport reopened, having found no additional bomb. Shortly after the reopening of Las Palmas was announced, three of the five large jets on the main apron would depart for Las Palmas. Those smaller aircraft could maneuver around the KLM 747, allowing them to take off almost immediately (Ziomek, 2018).

Delays

The crew of Pan Am 1736 also requested clearance permission to begin takeoff procedures (Cloudberg, 2021). The Pan Am passengers were increasingly agitated and wanted to reach their destination. Most passengers had departed Los Angeles the day before, and onboard the Pan Am jet, all the food and beverage provisions had been consumed (Cloudberg, 2021). At the time, Fernando Hernandez-Abad Gonzales was the controller in charge of ATC operations at Los Rodeos (Ziomek, 2018). He responded to Pan American’s request by informing them they would unlikely be able to maneuver around the KLM 747 due to its position on the tarmac (Firth, 2013). The Pan Am 747 could not do a 180-degree turnaround due to the small size of the apron. First officer Bragg and flight engineer Barns deplaned to measure the distance to the taxiway’s edge and the length of the KLM’s wing to see if they could maneuver around the KLM 747 (Cloudberg, 2022). However, after taking the measurements, they found they lacked about

twelve feet of space to get around the KLM 747. Making matters worse, Captain van Zanten permitted his passengers to deplane while waiting for the airport in Las Palmas to reopen (Cloudberg, 2022). When the time came to board the plane, two young passengers had gone missing, forcing staff to search the terminal and causing further delay. Additionally, while on the ground, Captain Van Zanten decided to refuel (FAA, 2020). Captain van Zanten ordered 55,000 liters (14,700 gallons) of additional fuel, allowing them to fly to Gran Canaria and subsequently to Amsterdam without refueling at Las Palmas. The refueling added another 30-minute delay for both KLM 4805 and Pan Am 1736. By the time the KLM 747 completed refueling, it was 16:51. The Pan American 747 had been stuck behind the KLM, waiting to depart for nearly two and a half hours.

Inclement Weather

The weather conditions at Los Rodeos had been deteriorating throughout that afternoon (Cloudberg, 2022). As noted earlier, the airport is located on a high plateau sandwiched between the Atlantic coast and the high slopes of the island's mountain ranges. This made the airport susceptible to drastic weather changes, especially regarding visibility (Hagen, 2013). The 1978 Spanish Official report on the accident states:

> "What frequently makes visibility difficult is not actually fog, whose density and therefore the visibility which it allows can be accurately measured, but rather layers of low-lying clouds which are blown by the wind and therefore cause sudden and radical changes in visibility. The latter can be zero meters at certain moments and change to 500 m or 1 km in a short space of time, only to revert to practically zero a few moments later" (Secretary of Civil Aviation Spain, 1978, p. 59).

The accident report submitted by the Airline Pilots Association Engineering and Safety Division stated, “In addition to the unusual cloud conditions, local high terrain around Tenerife causes a Venturi effect at the airport so that local condition of increased wind speed and decreased pressure can result in increased cloud density” (ALPA, 1977, p. 8).

Radio Communications and Deteriorating Conditions

At 16:56, Captain van Zanten contacted ATC, requesting start clearance (Secretary of Civil Aviation Spain, 1978). Per FAR Part 121.595 (a), no person may start a flight unless an aircraft dispatcher specially authorizes that flight (Code of Federal Regulations, 2022). It should be noted that the first officer usually contacts ground control for start clearance (ALPA, 1977). Additionally, he made this call to ATC before the prestart checklist had been completed. Due to the taxiways still being blocked by parked planes, Los Rodeos ATC Fernando Azcunaga instructed KLM to taxi out down the runway to reach the other side of the airfield (Hagen, 2013). Identical instructions were given to Pan American, next in line to depart. The plan was for both planes to use runway twelve until they reached taxiway Charlie 3, where they would turn left and use the unblocked portion of the taxiway to get to the end of runway twelve and position themselves for takeoff. The KLM and Pan Am crews were still determining which taxiway they were instructed to exit from the runway. This was partly due to the Spanish controller’s heavy accent when ordering the crews in English (ALPA, 1977). Outside, the low-lying clouds descended over the airport, reducing visibility so that both planes could no longer see each other on the runway (FAA, 2020). Under FAR Part 121.121, rules relating to navigation facilities

require that “no certificate holder conducting supplemental operations may conduct any operation over a route (including to any destination, refueling, or alternate airports) unless suitable navigation aids are available to navigate the airplane along the route within the degree of accuracy required for ATC (Code of Federal Regulations, 2022). An observation tower, located four hundred feet southwest of runway 30, was used to take weather readings and determine the runway visibility conditions using a transmissometer. A transmissometer determines RVR, or runway visual range, by measuring light through the atmosphere to measure how far a pilot can see out the runway (FAA, 2022b). When the Pan Am plane taxied down the runway, visibility was five hundred meters (ALPA, 1977). The low visibility made it difficult for both crews to find taxiway Charlie 3. “Bearing in mind that the pilots in a Boeing 747 are nearly twenty-eight feet above the ground, "At a small airport with limited signage and thick fog, it is hardly surprising that the crews found it hard to spot the taxiway” (Hagen, 2013, p. 3).

The KLM crew contacted the tower, reporting that they had just passed Charlie 4, the last taxiway before the end of the runway (ALPA, 1977). The air traffic controller, Fernando Azcunaga, who had taken over for Fernando Gonzales, instructed KLM 4805 to continue taxiing to the end of the runway and perform a 180-degree turn to position itself for takeoff (Ziomek, 2018). The controller informed KLM that the centerline lights were inoperable on runway 30 (FAA, 2020). Under FAR Part 139.311(a)(2), each certificate holder must provide and maintain marking systems for air carrier operations at the airport that are authorized by the Administrator and consist of at least the following: Runway markings meeting the specifications for takeoff and landing minimums on each runway (2) A taxiway centerline (Code of Federal Regulations, 2022). Unfortunately, this requirement did not exist in 1977. It was issued by the FAA in 2004 and would not apply to Los Rodeos, being that the airport was in Spain. If the centerline lights

are inoperable, the visibility value for takeoff increases, meaning an increase in the required minimum visibility. At 17:05, the KLM 747 had reached the end of the runway and completed its 180-degree turn, almost ready for takeoff. Meanwhile, Pan Am 1736 was advancing down the runway, encountering alternating levels of visibility (Hagen, 2013). Unlike the KLM crew, the Pan Am pilots did manage to find taxiway Charlie 3. However, due to the taxiway's 45-degree angle and its trajectory facing the opposite direction back to the terminal, the pilots decided they would use the next taxiway, Charlie 4, which was easier to maneuver the plane onto. Throughout the afternoon, Captain van Zanten had grown increasingly anxious. "A growing feeling of tension as the problems for the captain continued to accumulate" (Secretary of Civil Aviation Spain, 1978, p. 58). Captain van Zanten feared he might be unable to take off due to the deteriorating weather conditions. The KLM captain's urgency to depart was due to new legal limits on flight crew duty time recently implemented by the Dutch government. Previously, captains had more discretion in extending their duty time (ALPA, 1977). The new rules made flight crews liable if the time limits were not followed. This included the possibility of pilots facing fines, the loss of their license, or even imprisonment. Furthermore, if the KLM flight did not take off by the required time window, it would mean the cancellation of the flight. Not only would they not make it to Las Palmas, let alone back to Amsterdam, but it would also result in finding overnight accommodations for the 248 passengers on board, a challenging and expensive task considering it was the peak of tourist season (ALPA, 1977). Captain van Zanten knew that further delays would lessen his chances of returning to Amsterdam that day.

At 17:05, First Officer Meurs completed the pre-flight checklist (ALPA, 1977). Once the list was complete, Captain van Zanten advanced the aircraft's throttle levers, spooling up the engines for takeoff. Realizing the captain's actions, Officer Meurs advised the captain that they

had yet to receive ATC clearance (FAA, 2020). In response, van Zanten reduced the throttles to idle power and replied, “No, I know that. Go ahead, ask” (Secretary of Civil Aviation Spain, 1978, p. 42). First officer Meurs contacted the tower, stating they were ready for takeoff and requesting ATC clearance. The tower responded by giving ATC clearance, “KLM eight seven zero five [sic], you are cleared to the Papa beacon. Climb to and maintain flight level nine zero. Turn right after takeoff. Proceed with heading zero four zero until intercepting the three two five radial from Las Palmas VOR” (Secretary of Civil Aviation Spain, 1978, p. 42). The ATC clearance detailed the route they were to follow once airborne. It was not, however, a clearance for takeoff. A few seconds after Meurs began reading the ATC clearance back to the tower, Captain van Zanten initialized takeoff by advancing the throttles. The last part of Mears’s ATC readback cannot be heard in the flight voice recorder. He is heard stating, “We are now uh takin’ off” or “We are now at takeoff” (Secretary of Civil Aviation Spain, 1978, p. 43). The controller replied, “OK...Stand by for takeoff…I will call you, ending said message at 17:06:21.79” (ALPA, 1977, p. 44). Due to radio frequency congestion, the only part of the message the KLM and Pan Am crews heard from the controller’s standby instructions was the first word, “OK.”

Upon hearing the Meurs transmission with the tower, where he stated they were at takeoff, Pan Am first officer Bragg feared that the KLM might already be attempting to take off. Bragg promptly radioed out, "And we are still taxiing down the run- clipper one seven three six." The radio transmission by Bragg informing them that they were still on the runway was sent out simultaneously with the controller’s communication directing KLM to stand by for takeoff clearance, which the KLM crew did not hear. This is due to a phenomenon in radio communications called the "heterodyne effect," in which parts of a radio message can be drowned out. “Heterodyne Effect occurs when two or more transmissions cancel each other out,

causing a prolonged squeal" (Ricafort, 2005, para. 7). What the KLM crew heard was "OK" and then a high-pitched squeal. After that radio transmission, Captain Grubbs says: "Let's get the hell out of here" (Hagen, 2013, p. 6). Moments later, Grubbs peered out the cockpit window to see the takeoff lights of the KLM heading towards them. First officer Bragg was then heard repeatedly shouting, "Get off!" Captain Grubbs reacted immediately by pushing the throttles on both right-side engines to full power, attempting to turn left off the runway. As the KLM rolled down the runway, flight engineer Schreuder asked Captain van Zanten, "Is he not clear then?" (Secretary of Civil Aviation Spain, 1978, p. 45), referencing the Pan Am jet. To which Captain van Zanten replied, "Oh, yes!". At 15:06:43, six seconds before colliding with Pan Am 1706, KLM 4805 reached V1 (Ziomek, 2018). Captain van Zanten then noticed the Pan Am 747 still on the runway. Still short of takeoff speed, Van Zanten is heard saying, "Oh F—k." Attempting to lift off to avoid colliding with the other plane, he pulled up as hard as he could on the yolk. "Captain van Zanten, in his last moments, had pulled so hard on the steering yoke that the lowest portion of the KLM plane's tail cut a groove in the runway 68 feet long" (Ziomek, 2018, p. 155).

Collision

At 17:06:47, KLM 4805 collided with Pan American 1736 (Secretary of Civil Aviation Spain, 1978). Traveling at a rate of approximately 150 mph just before impact, the KLM 747 had become airborne, but not enough to miss the Pan Am jet. The KLM's landing gear struck the rear of the Pan Am cabin, as did the last rows in the first-class cabin on the first floor. The lower part of the KLM fuselage hit the upper part of the Pan Am fuselage (Ziomek, 2018). The KLM's right engine tore through the Pan Am jet's second-floor section, where the cockpit and first-class lounge were located. People seated in the lounge area were killed immediately. Reports state that the KLM's number one engine pulled out passengers seated in seats 47E and 49G, carrying them

several yards down the runway. The KLM was airborne for five hundred feet before crashing back onto the runway and instantly bursting into flames. All on board the KLM 747, 234 passengers and fourteen crew members, died instantly (ALPA, 1977). The Pan American jet had also caught fire. The top part of the Pan Am's fuselage was described as "peeled back like a giant sardine can, exposing the open sky to many of the passengers" (Ziomek, 2018, p. 158). Due to the heavy fog and low visibility, controller Azcuanga could not see anything indicating an accident (Ziomek, 2018). However, the sound of an explosion was heard by the controller. Only after a British Airlines pilot contacted the tower, stating a fire was on the runway. The controller sounded the alarm and contacted the airport's fire department, stating that a fire had been reported on the runway. At 17:08, the visibility at the airport had improved, allowing the tower's controllers to make out the flames on the runway. The fire teams drove through the fog, arriving at the source of the flames, encountering the KLM 747 engulfed almost entirely in flames, the tail fin being the only part of the jet not to be on fire. Visibility, having cleared somewhat, still shrouded the Pan Am wreckage in a fog. Only a few minutes after the firefighters arrived at the KLM wreckage, they realized another raging fire a few hundred yards farther down the runway. Initially, they had assumed it was part of the KLM wreckage. To their horror, the firefighters soon realized this was another aircraft, the Pan Am 1736.

Accident Investigation – Contributing Factors

A total of 583 people died from the collision of KLM 4805 and Pan Am 1736 (FAA, 2020). Only 61 of the 396 people on board the Pan American plane survived. American, Dutch, and Spanish teams investigated the accident in Tenerife. Each team's investigation came to different conclusions. The Dutch accident report blamed the air traffic controller and the weather as significant factors in the crash (Netherland Aviation Safety Board, 1977). The Spanish

Secretary of Civil Aviation published their findings on the causes of the crash. Like the Dutch report, poor communication did play a factor due to the language difficulties between the pilots and the air traffic controllers at Los Rodeos (Secretary of Civil Aviation Spain, 1978). Pilot van Zanten was Dutch, Captain Bragg was American, and ATC operators Fernando Hernandez-Abad Gonzales and Fernando Azcunaga spoke mainly Spanish. Although they communicated in English, the heavy Spanish accents degraded the information transmitted between the pilots and the air traffic controllers. This also caused the crews of Pan 1736 and KLM 4805 to have difficulty understanding the ground controller's taxi instructions. Captain Bragg had initially wanted to be clear of the runway when KLM was taxiing to take off. However, the controller had not heard this transmission from the pilot (ALPA, 1977). The American and Spanish reports concluded that stress played a large part, especially for the KLM crew (ALPA, 1977). Due to their concerns about exceeding the newly implemented Dutch duty time limits, the captain was under added stress, considering he could face prosecution if he exceeded the legally allowable operational flight time. The Pan Am crew also felt stress from their long delay on the tarmac due to the KLM plane blocking the Pan Am's access to the runway and the additional time they had to wait for the KLM flight to be refueled. Even though they could have left immediately had they not been blocked from the runway. By the time Pan AM 1736 began to taxi on the runway to head to Las Palmas, they had been on duty for over 11 hours (ALPA, 1977). The air traffic controllers at Los Rodeos were also under unusually high pressure that day due to the high volume of flight traffic being diverted from Las Palmas, causing elevated stress (ALPA, 1977). The elevated stress levels may have hindered the controller's ability to communicate clearly, often giving ambiguous instructions and pausing mid-sentence when transmitting information to KLM and Pan Am crews. Especially when giving clearance to the KLM and the vague

statement, “Okay—stand by for takeoff. I will call you”. The controller also misidentified the KLM flight number on several occasions.

The weather was another contributing factor. Visibility was clear when the KLM and Pan Am planes arrived at Tenerife, but conditions deteriorated soon after (Secretary of Civil Aviation Spain, 1978). The low-lying clouds that shrouded the airport shortly before the accident caused intermittent levels of visibility. "While the runway visibility was reported to be 2 - 3 kilometers 17 minutes before the accident, visibility reduced to just 300 meters 12 minutes later” (FAA, 2020b, para 6). The crew of the KLM flight was increasingly aware that further degradation of weather conditions and visibility might keep them from taking off. Overcoming the threat of being unable to take off led the KLM crew to hasten their departure recklessly. The report states that the training syndrome influenced Captain van Zanten’s growing impatience and premature takeoff. “Training syndrome is a condition where an individual who is heavily committed to training others may be susceptible to a blurring of the lines of distinction between the training environment (the unreal world) and the line operation (real world).” (ALPA, 1977, p. 16) Because there are no ATC constraints in a simulator and the role of the instructor is blurred by being able to issue ATC and takeoff clearance simultaneously, this may have led to the captain’s decision to take off before being cleared to do so. “The KLM captain assumed that he had received takeoff clearance due to the development under the stress of a false hypothesis that the runway was clear” (ALPA, 1977, p. 23). The training syndrome subsequently led to a filter effect in the decision-making process of Captain van Zanten. The filter effect is “the peculiar manner in which an individual screens and rejects or admits to the brain incoming physical stimuli” (ALPA, 1977, p. 21).

Crew management in the cockpit was another contributing factor (ALPA, 1977). In the KLM cockpit, Captain van Zanten was a pilot with an esteemed position in the airline. Being highly revered and the head of flight training made his presence in the cockpit intimidating to others in the crew. The other crew members may have felt uncomfortable questioning captain van Zanten's decisions. Only on a couple occasions did flight officer Meurs and flight engineer Schreuder attempt to comment on the captain's decision to begin takeoff. The report believes that the communication made by the first officer, stating, "We are- uh- taking off," signaled that he knew something was wrong with the captain's decision to take off and radioed out this comment as his way of alerting everyone listening in on that frequency. The issues with radio transmission, particularly concerning the heterodyne effect mentioned previously, also played a role. By blocking out the controller's last words when instructing the KLM flight to hold for takeoff clearance, the only thing the KLM pilots heard when the first officer said they were at takeoff from the operator was the first word, "OK," not the following statement, "Stand by for takeoff... I will call you" (Secretary of Civil Aviation Spain, 1978). "There are any number of things the airlines could do to preclude this. And one of these cannot be implemented fast enough: the long-needed installation of an inexpensive piece of equipment into the communications radios of airliners" (Smith, 2002, para. 3).

Other secondary factors mentioned in the Spanish report were the failure of the Pan Am crew to leave the runway on the left taxiway Charlie 3 and the controller's failure not to confirm and acknowledge by the KLM crew his order to "stand by for takeoff." (Secretary of Civil Aviation Spain, 1978). Additionally, the increased congestion, forcing planes to maneuver using an active runway rather than a taxiway, increased the chances of an accident.

Main Factor

Nevertheless, the report concluded that the most fundamental cause of the accident was that Captain van Zanten initiated takeoff without receiving clearance from the controller (Secretary of Civil Aviation Spain, 1978). He failed to abort the takeoff when the Pan Am crew reported they were still on the runway. Even after his flight engineer questioned van Zanten if the Pan Am plane was off the runway, he continued with the takeoff, not knowing if they were.

Recommendations and Changes Made in the Industry Due to Tenerife.

The conclusion of the Spanish Accident Board report made three recommendations. The first was to “Place great emphasis on the importance of exact compliance with instructions and clearances. Use of standard, concise and unequivocal aeronautical language. And avoid the word “takeoff” in the ATC clearance and adequate time separation between the ATC clearance and the take-off clearance” (Spanish Accident Report, 1978, p. 60). The effects the crash had concerning FAR were substantial. After the accident, new rules regarding communication between the tower and pilots were implemented (Finlay, 2022). It was clear that a lack of mutual understanding was a contributing factor to the disaster. Aviation authorities standardized the terminology used by ATC when communicating with pilots relating to instructions and replies. Both crew and flight controllers no longer reply using words or phrases such as “OK” and “Roger” (Finlay, 2022). “The word "takeoff" is now spoken only when permission is given for actual takeoff. Until actual permission is granted for takeoff, pilots and ATC controllers should use the word "departure.” All ATC clearance to aircraft already lined up on the runway for takeoff must include the prefix "hold position" (Finlay, 2022, para. 7). Furthermore, authorities emphasized that ATC operators and pilots alike be able to speak English proficiently in terms of operational communications.

In addition to the changes in air controller terminology, other safety regulations were implemented. These included expanding a traffic light system to warn taxiing aircraft crews when approaching a live runway. Shortly after the crash, the Spanish government installed a ground radar system at Los Rodeos to prevent future accidents like the one that occurred in 1977 from happening again. (Finlay, 2022). The crash was instrumental in the FAA's new initiative, "The Call-to-Action Plan," developed by the FAA and other industry members in 2007 to reduce the chances of runway incursions (FAA, 2010). The accident was one of the events that led to the beginning of the industry practice of emphasizing communication and teamwork in the cockpit, now called crew resource management. "CRM is a set of aviation training procedures to improve teamwork among crew members and reduce human error that can lead to accidents" (Ali & A, 2022, para. 16). The ethos, once based on the idea that the captain is always right and that their actions should never be questioned, began to change. Changes were made to train junior officer pilots not to hesitate in questioning a captain's decisions if they felt they were incorrect. Conversely, senior pilots are now being taught to listen to their crew and evaluate a crew member's objections or opinions. Had CRM exited before the accident, the first officer likely would not have hesitated in objecting to Captain van Zanten's decision to take off.

Conclusion

"Aircraft never crash because of one single issue. It is almost always a combination of factors that lead to an accident" (Flight Deck Friend, 2017, para. 1). There are a range of factors

that lead to aircraft accidents; however, human error is responsible for approximately half of all aircraft accidents (Simon Ashley Bennett, 2018). In the case of the Tenerife Air Disaster, human error did play a significant role in the events that transpired; however, it was also the culmination of external circumstances and coincidences, both large and small, that led to the crash, which ended the lives of 583 people. Implementing new protocols in both the cockpit and the control tower has helped reduce the possibility of such accidents. However, as the skies become more crowded, the opportunity for mistakes to occur increases. Pilots and the aviation community must remain vigilant in maintaining safety as their top priority.

References

AENA. (2022). *History Tenerife Norte Ciudad de la Laguna*. Www.aena.es. https://www.aena.es/en/tenerife-norte-ciudad-de-la-laguna/about-us/history.html

Ali, S., & A, C. (2022, April 4). *How Many Planes Crash a Year | InsightsArtist | Infographic*. Insights Artist. https://insightsartist.com/how-many-planes-crash-a-year/

ALPA. (1977). *Human Factors Report on the Tenerife Accident*. https://lynn.on.worldcat.org/oclc/1237048221

Aviation Safety Network. (n.d.). *ASN Aircraft accident Convair CV-990-30A-5 Coronado EC-BZR Tenerife-Los Rodeos International Airport (TCI)*. Aviation-Safety.net. Retrieved December 7, 2022, from https://aviation-safety.net/database/record.php?id=19721203-0

Bailey, J., & Pickett, R. (2022, September 8). *How Flying Today Is Safer Than At Any Time In The Past*. Simple Flying. https://simpleflying.com/how-safe-is-flying/

Bangs, K. (2017, March 29). *Calamity and Coincidence: 40 Years Later Are We at Risk of Another Tenerife?* Disciples of Flight. https://disciplesofflight.com/remembering-tenerife-airport-disaster/

Bird, E. (2022, May 12). *Tenerife — A Tragedy of Errors 1977*. Lessons from History. https://medium.com/lessons-from-history/tenerife-a-tragedy-of-errors-1977-21530b65430

Boeing Corporation. (2016). *Boeing: Historical Snapshot: DC-8 Commercial Transport*. Boeing.com. https://www.boeing.com/history/products/dc-8.page

Cloudberg, A. (2022, January 2). *Apocalypse on the Runway: Revisiting the Tenerife Airport Disaster*. Medium. https://admiralcloudberg.medium.com/apocalypse-on-the-runway-revisiting-the-tenerife-airport-disaster-1c8148cb8c1b

Code of Federal Regulations. (2022, November 22). *Code of Federal Regulations*.

Unblock.federalregister.gov. https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-121?toc=1

Corcoran, M. (2020, August 6). *The Worst Aviation Accident in History is a Case Study for Giving Employees a Voice*. NeuroLeadership Institute. https://neuroleadership.com/your-brain-at-work/speaking-up-can-prevent-aviation-accident/

Correa, J. R. (2022, December 3). *Fifty years since the accident of the Coronado de Spantax in Los Rodeos*. Tenerife Weekly News. https://tenerifeweekly.com/2022/12/03/50-years-since-the-accident-of-the-coronado-de-spantax-in-los-rodeos/

Cummins, N. (2020, August 27). *The Boeing 747-100 Vs The Boeing 747-8*. Simple Flying. https://simpleflying.com/boeing-747-100-vs-boeing-747-8/#:~:text=The%20747%2D100%20could%20seat

Davidson, P. (2013, January 11). *Antonio Cubillo: Activist who fought for the independence of the*. The Independent. https://www.independent.co.uk/news/obituaries/antonio-cubillo-activist-who-fought-for-the-independence-of-the-canary-islands-8448650.html

FAA. (2010). *REVIEW OF FAA'S CALL TO ACTION PLAN FOR RUNWAY SAFETY Federal Aviation Administration*. https://www.oig.dot.gov/sites/default/files/WEB%20FILE_FAA%20Call%20to%20Action.pdf

FAA. (2020a). *Lessons Learned*. Faa.gov. https://lessonslearned.faa.gov/ll_main.cfm?TabID=1&LLID=52&LLTypeID=2

FAA. (2020b). *Lessons Learned - Human Factors*. Faa.gov. https://lessonslearned.faa.gov/ll_main.cfm?TabID=1&LLID=52&LLTypeID=2

FAA. (2022a). *Lessons Learned*. Lessonslearned.faa.gov.

https://lessonslearned.faa.gov/ll_main.cfm?TabID=1&LLID=52&LLTypeID=10

FAA. (2022b). *Pilot Controler Glossary*. Faa.gov. https://www.faa.gov/air_traffic/publications/atpubs/pcg_html/glossary-t.html

Finlay, M. (2022, March 27). *45 Years Since The Tenerife Disaster: What Legacy Has Aviation's Deadliest Accident Left?* Simple Flying. https://simpleflying.com/tenerife-disaster-45-years-legacy/

Firth, R. (2013). *Aftermath*. eBookIt.com. https://lynn.on.worldcat.org/oclc/1100917883

Flavin, S. (2020, October 5). *What Tragedy Can Teach Us About Human Performance*? Captive Resources. https://www.captiveresources.com/insight/what-the-tenerife-disaster-can-teach-us-about-human-performance/#:~:text=In%201977%2C%20Captain%20Jacob%20Van

Flight Deck Friend. (2017, January 5). *Why Do Planes Crash? | FlightDeckFriend.com*. FlightDeckFriend. https://www.flightdeckfriend.com/ask-a-pilot/why-do-planes-crash/

Goeble, G. (2021, January 21). *The Douglas DC-10 & Lockheed Tristar*. Www.airvectors.net. https://www.airvectors.net/avdc10.html

Hagen, J. (2013). *Confronting Mistakes: Lessons from the Aviation Industry when Dealing with Error*. Palgrave Macmillan, Uk.

Karagianis, L. (2004). *Air Travel*. MIT Spectrum. https://spectrum.mit.edu/winter-2004/air-travel/

Laster, L. (2018). *Aircraft Dispatcher History Early Accident Rates*. The Aviation Vault. https://www.theaviationvault.com/early-accident-rates

Markham, J. M. (1977, April 2). Wreck of 747's Sets Back Cause of Insurgents on Canary Islands. *The New York Times*. https://www.nytimes.com/1977/04/02/archives/long-

island-opinion-wreck-of-747s-sets-back-cause-of-insurgents-on.html

Netherland Aviation Safety Board. (1977). *Final Report of the Investigation into the Accident With the Collision Of KLM Flight 4805 and Pan AM Flight 1736*.

New York Times. (1977, March 28). Canary Island Separatist Says Group Planted Bomb But Did Not Cause Crash. *The New York Times*. https://www.nytimes.com/1977/03/28/archives/canary-island-separatist-says-group-planted-bomb-but-did-not-cause.html

Nordheimer, J. (1977, March 28). 14-Day Cruise Lured Pan Am Passengers From the West Coast. *The New York Times*. https://www.nytimes.com/1977/03/28/archives/14day-cruise-lured-pan-am-passengers-from-the-west-coast.html

Northwestern University Transportation Library. (2022). *The 747 Takes Off – The Dawn of the Jumbo Jet Age*. Sites.northwestern.edu. https://sites.northwestern.edu/747anniversary/

Official Gran Canaria Tourist Website. (2022). *History - The Official Gran Canaria Tourist Website*. Www.grancanaria.com. https://www.grancanaria.com/turismo/en/the-island/history/

Pigott, P. (2016). *Brace for Impact* (1st ed.). Dundurn.

Rego, P. (2017, March 27). *La gran catástrofe de los terroristas canarios del MPAIAC de Cubillo*. EL MUNDO. https://www.elmundo.es/cronica/2017/03/27/58d65da4e5fdea3c568b4601.html

Ricafort, C. (2005, October 3). *The Danger of Airport Runway Crashes – USC Viterbi School of Engineering*. USC Viterbi School of Engineering. https://illumin.usc.edu/the-danger-of-airport-runway-crashes/

Roitsch, P. A., Babcock, G. L., & Edmunds, W. W. (Eds.). (1978). *Human factors report on the*

Tenerife accident. Air Line Pilots Association.

Secretary of Civil Aviation Spain. (1978). *Secretary of Aviation Report On Tenerife Crash* (pp. 22–68). https://lessonslearned.faa.gov/PanAm1736/Spanish_Findings.pdf

Simon Ashley Bennett. (2018, October 29). *The five most common reasons for airliner disasters*. The Conversation. https://theconversation.com/the-five-most-common-reasons-for-airliner-disasters-50100

Smith, P. (2002, March 29). *Air travel's communications killer*. Salon; Salon.com. https://www.salon.com/2002/03/28/heterodyne/

Swopes, B. (2022, January 22). *22 January 1970*. This Day in Aviation. https://www.thisdayinaviation.com/22-january-1970-2/

Tenerife Information Centre. (2022). *Los Rodeos - otherwise known as Tenerife North Airport*. The Tenerife Information Centre. https://www.tenerife-information-centre.com/los-rodeos.html

Vasquez, T. (2016, October 20). *Low Clouds and Fog*. IFR Magazine. https://www.ifr-magazine.com/weather/low-clouds-and-fog/

Weick, K. E. (1990). The Vulnerable System: An Analysis of the Tenerife Air Disaster. *Journal of Management*, *16*(3), 571–593. https://doi.org/10.1177/014920639001600304

Writers, S. (2017, January 12). *The year of flying dangerously: 1972 | Flight Safety Australia*. Flight Safety Australia. https://www.flightsafetyaustralia.com/2017/01/the-year-of-flying-dangerously-1972/

Ziomek, J. (2018). *Collision on Tenerife*. Post Hill Press.

Ziomek, J. (2020, September 28). *Disaster on Tenerife: History's Worst Airline Accident*. Historynet. https://www.historynet.com/disaster-on-tenerife-historys-worst-airline-

accident/