Tenerife airport disaster

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1 Problem/system description

1.1 Introduction

This a report on the aircraft accident that occurred on 27th of March in 1977, between a Boeing 747-121 operated by Pan American World Airways and Boeing 747-206B operated by KLM Royal Dutch Airlines, on the Tenerife-Los Rodeos International Airport(Spain). This was considered the worst airplane accident in history before 2001, and now is the second worst, after the 9/11 terrorist attack. The crash resulted in both aircrafts being destroyed and written off(damaged beyond repair), 583 people killed and 61 injured.

1.2 History

On the 27th of March at 12:30, a bomb explodes on the Las Palmas terminal, and due to the treat of a second bomb the airport is closed. Most of the flights were redirected to the Tenerife-Los rodeos International Airport(TCI), Spain. Two of them were the KLM Flight 4805 from Amsterdam en route to Las Palmas, and the PanAm Flight 1736 from Los Angeles en route to Las Palmas.

Initially the KLM passengers were not permitted to leave the airplane, but after 20 minutes, they were transported by bus to the terminal.

When the Las Palmas airport was operational again, the PanAm 1736 crew prepared for departure to Las Palmas, the final destination. When they attempted to taxi on the taxiway leading to runway 12, they discovered that they were blocked by KLM 4805. Due to the insufficient clearance for the aircraft to pass the KLM aircraft, they were compelled to wait for the former to start to taxi. The passengers were not allowed to leave the aeroplane, the whole time the airplane was in the airport.

At 16:65, KLM 4805 requested permission to taxi. It was authorized and at 16:58 it had to backtrack on runway 12 for take-off on runway 30. The air traffic controller(ATC),in this case the airport tower controller,controller cleared the KLM flight to taxi in the holding position for runway 30 by taxiing down the main runway and leaving it by the third taxiway to its left. KLM 4805 acknowledged the message, and then the ATC issued an new instruction, that stated to continue the taxi until the end of the runway, where it should backtrack. The KLM 4805 confirmed receiving the message and immediately asked the ATC again if they should leave by the taxiway one. The ATC responded negative and repeated the last instruction.

At 17:02, the PanAm airplane requested confirmation if they could taxi on the runway. The ATC confirmed, adding that they should leave trough the third taxiway to their left. At 17:03, the ATC confirmed the location of the KLM 4805 on the runway, that they just passed the taxiway C-4, instructing that they should perform an 180°turn at the end of the entrance and report for ATC clearance.

As a response to the previous query, the ATC warned both airplane that the runway center lights were out of service. Furthermore, the controller repeated the instruction that the PanAm 1736 must leave the main runway trough the third taxiway to their left and report when they have left the runway.

At 17:05 KLM 4805 reported that they are ready for take-off and were given instruction for a Papa beacon departure. The airplane's crew repeated the instructions and followed up with "We are now at takeoff". The brake were released and the take-off roll started.

The ATC knew that PanAm 1736 was still on the main runway and replied "OK …Stand by for takeoff, I will call you.". This message was sent at the same time with the PanAm's transmission "No …we're still taxiing down the runway, the Clipper 1736.". This simultaneous transmissions, caused a shrill noise in the KLM's cockpit.

The ATC replied with "Papa Alpha 1736 report runway clear.", at which point the PanAm responded with "OK, will report when we're clear.". The KLM flight engineers asked the Capitan: "Is he not clear then?". After the captain repeated the question, he answers emphatically with "OH, yes".

Subsequently, KLM 4805 ran for 20 seconds before the previous communication took place and collided with the PanAm aeroplane. The KLM crew tried to climb and the PanAm crew turned the aircraft to the left and applied full power. The KLM aircraft was airborne but the two fuselages skidded and the tail of the PanAm's tail. The KLM aircraft flew 150 meters and crashed, sliding 300 meters and in the end bursting into flames.

The control ATC received no further communications from either aircrafts. There were no eyewitnesses to the collision.

1.3 Losses

From the KLM 4805 aircraft all the crew members(14) and passengers(234) died and from the PanAm 1736 9 crew members and 317(+9 due to injuries) passengers died. Both aeroplanes were completely destroyed to the collision and the post-impact fire. The runway of the airport was also damaged by the impact and the fire. The cost of repairs amounted to more than 16 million pesetas at the time of the report. On top of that, the whole operation of the airport was halted.

1.4 Relevant information

One important aspect that has to be mentioned is the weather conditions that made it extremely difficult to identify objects in the proximity. The runway visibility was reduced from 3km at 16:30 to 300m at the time of the impact.

Moreover, the runway center lights were out of service at that time, which made difficult the assessment of the position in the case of PanAm, which missed the taxiway, on which it was supposed to exit trough.

Another thing that must be mentioned is that all the crew members of both KLM and PanAm aircraft were highly experienced personnel, with thousands of hours of flying and hundreds of hours of Boeing 747 flight time.

2 Defining accidents

An **accident** can be define as an undesired or unplanned event that results in a loss, including loss of human life or human injury, property damage, environmental pollution, mission loss, etc. In order to find a cause for the accidents, they have to be put in context. In this case, the following accidents occurred:

- (A1): KLM aircraft took off without clearance;
- (A2): Misunderstanding between the ATC and the KLM crew;
- (A3): PanAm aircraft still present on the runway

The severity of the accidents could further be assessed using the following scale:

Level	Human loss	Equipment loss	Airport loss
4	Loss of life	Complete destruction of the equipment	Significant damage to facilities and airport shutdown
3	Severe injuries	Partial destruction of equipment	Partial Damage to facilities and major delays
2	Minor injuries	Minor destruction of the equipment	Minor damage to facilities and delays
1	No injuries	No destruction of the equipment	Delays

Considering the table above, the Tenerife airport accident, resulted in the following:

1. Loss of life - Human loss 4
2. Both airplanes were completely destroyed - Equipment loss: 4
3. Significant damage to the airport facilities and major disruption of the airport operations - Airport loss: 4

3 Identifying hazards

In order to identify the hazards, the definition of the accident or loss is used with the additional safety criteria that will be imposed:

- (H1): Runway Incursion:

  Runway Incursion[1] is defined, in this case, as an occurrence at an airport involving the incorrect presence of aircraft on the runway.

- (H2): Conflict of trajectories that resulted in insufficient distance between aircraft, vehicle or people.

[1] source

- (H3): Misunderstanding between ATC & KLM 4805.

4 Defining safety constraints corresponding to hazards

Considering the previously identified hazards, the following safety system constraints can be defined:

- (SC1 for H1): The ATC must ensure that there is no aircraft, vehicle or people on the runway when an aircraft is landing or taking-off.
- (SC2 for H1): The ATC must ensure that there is no aircraft, vehicle or people on the runway when an aircraft is in a position for landing or taking-off.
- (SC3 for H2): The ATC must ensure that separation between the aircrafts is maintained.
- (SC4 for H2): The ATC must provide conflict alerts
- (SC5 for H3): The ATC must use proper clear and simple terminology.

5 Creating the control structure of the system

In order to fully understand the situation, the control structure of the system in shown, which displays all involving parties.

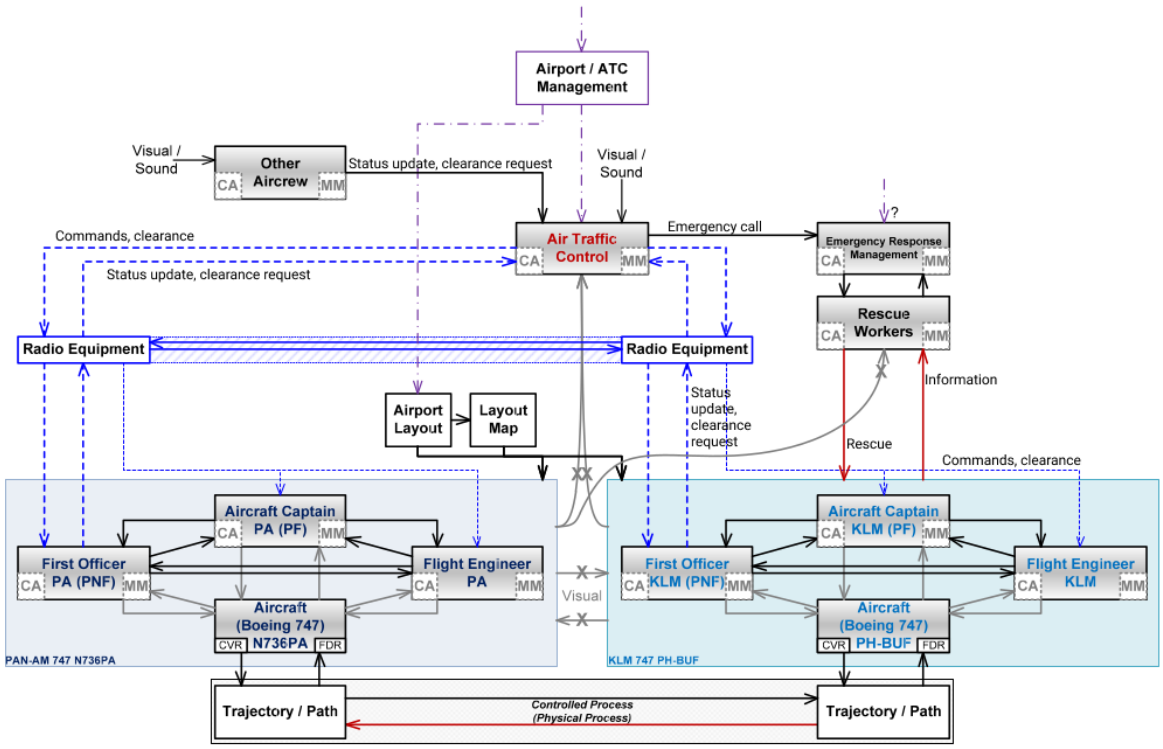

Figure 1: Control Structure

The diagram contains commands and feedback mechanisms given among the involved parties:

- The ATC gives commands and clearance to both aircrafts.
- The Aircrafts request clearance or give status updates
- The interaction between the two aircrafts is only trough the radio equipment which can be only used by one party at a time.

6 STPA

System-Theoretic Process Analysis(STPA), is hazard analysis method based on the STAMP causality mode. This technique of analyzing includes design errors, software flaws, cognitively complex human decision making and organizational factors that contribute to accidents.

6.1 Identifying unsafe control actions (STPA step 1)

In this section I will identify the inadequate controls of the system that lead to hazardous state.

6.1.1 Control action required for safety that is not provided not followed

- CA01: Stand-by for clearance command not respected by the KML crew(H2).

6.1.2 Unsafe control action performed

- CA02: The KLM crew decided to take off without checking again, after the interference.(H3)
- CA03: The use of ambiguous language. (H3)

6.1.3 Control action provided at the wrong time

- CA04: The PanAm aircraft missed the exit from the runway. (H1)
- CA05: The PanAm transmission, interfered with the ATC transmission.(H3)

6.2 Identifying causes of the unsafe control actions (STPA step 2)

In this section I will determine the cause for each of the violations of the safety constraints:

- The KLM had waited for a long time in the airport, and the passengers had to wait in the aircraft during this time. Moreover, the KLM captain was under great stress due to concern about the legal aspects of the Dutch duty time limits and worsening weather conditions. (CA01, CA02).
- The fog and the out-of-service runway lights, made it difficult for the PanAm crew to navigate and find the runway exit. (CA03).
- Due to the technology limitations, two equipment cannot broadcast at the same time on the radio channel. (CA04)
- Both crews had difficulty understanding the instructions. (CA03)

7 Defining safety controls

After the investigation, the following recommendations were made:

- The used of precise standardized terminology. Furthermore, all personnel involved in commercial aeronautical communications are fluent In English and speak with minimal accent.
- The words “take off” should never be used in an ATC clearance.
- Ground radars should be installed at all air carrier airports.
- Commercial aircraft should not taxi when the visibility is under 150 meters unless taxi indicators or other visual aids are operational.
- Landing lights should be on, when an aircraft is moving.
- Redundant means for takeoff clearance confirmations should be used at all airport.
- In order to minimize human error, the optimum number of crew members should be researched.

All the upper mentioned points above, if incorporated, will lead to less accidents. Another important aspect that is revealed is that a low number of hazards is not correlated to the severity of the accident.

8 References:

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- Telegraph accident article