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Remembering Tenerife: 40 Years Later

Vaz Junior CA*

Federal University of Rio de Janeiro–UFRJ, E-209, Bloco E, Centro de Tecnologia, UFRJ, Ilha do Fundão. Rio de Janeiro, RJ, Brazil

Abstract

There is only one positive point in an accident: the lessons generated from it. This article is dedicated to light up our memories, remembering the biggest accident that ever happened in the aviation history: Tenerife, March 27, 1977. Two Boeing 747's collided on the runway, causing 583 fatalities. The present article focus on the ALPA's Report about the accident. ALPA's report analyzes the possible human factors related to the accident. Some human factors are discussed here: "stress factors", "training syndrome", "CRM" and "filter effect". ALPA investigators present some conclusions: external worries into the cockpit can elevate intensely the crews' level of stress, and airlines must give support to the decisions taken by the crews; non-fluency in English by pilots and ATC is a real problem; and CRM and Runway Incursion are two of the most important factors in aviation safety nowadays.

Keywords: Tenerife's Accident; Safety; CRM; Human Factors; Stress Factors; Runway Incursion

Introduction

To learn through the mistakes is the oldest and more natural way of learning. It is not admissible to allow, once again, the error that others have committed in the past. This way, it is fundamental to know and to learn with past accidents. This article is dedicated to light up our memories, remembering the biggest accident that ever happened in the aviation history: Tenerife, March 27, 1977. Even past 40 years of that date, this continuous to be one of the saddest days of the aviation: two Boeing 747's collided on the runway of the small airport of Tenerife, causing 583 fatalities.

To understand the facts that contributed to this accident became fundamental to avoid that something similar could happen again. Several studies were carried out and three public reports were issued: i. Spanish Report; ii. Dutch Report; iii. ALPA's Report. All of them are available at the address: <http://www.project-tenerife.com/engels/rapporten.html> [1].

The present article took as its base the results presented on the ALPA's Report. This paper does not have as its objective to point out causes or guilt of persons responsible for such a Tenerife's accident, whose causes were largely studied and analyzed by specialists of different countries. The objective of this article is to remember and, therefore, reflect on human factors involved on the tragedy. To maintain fidelity to those events some dialogues recorded at the occasion and parts of the ALPA's Report are reproduced here.

Description of the Event based on ALPA's Report

On March 27, 1977, at 12:30pm, local time, a terrorist bomb exploded at the terminal of the airport of Las Palmas, in the Canary Isles. Due to that explosion, and mainly with the possibility of there being other bombs, the airport was closed. From that moment on, all flights directed to Las Palmas were deviated, several of them to the airport of Los Rodeos, at the neighboring Isle of Tenerife (Figure 1).

This was the case of flight KLM 4805, from Amsterdam, that landed in Los Rodeos, Tenerife, at 13:38hrs., local time, and flight Pan Am 1736 (*Clipper*), from New York, which landed at 14:15 hrs. As many other flights were deviated to Tenerife, the parking area was packed when the KLM and Pan Am flights arrived. KLM and Pan Am stayed positioned in a taxiway (Figure 2).

Only 15 minutes after the Pan Am aircraft had touched the ground, the airport of Las Palmas reopened. Although the American crew wished to departure immediatly, the KLM equipment was positioned between them and the runway, blocking the way (Figure 2). As the Dutch aircraft was being fueled, it was impossible to move it. It was not possible for the Pan Am Clipper 1736' flight crew to start taxi. The weather conditions changed quickly. There was a real possibility that the

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*Correspondence:

Vaz Junior CA, Federal University of Rio de Janeiro–UFRJ, E-209, Bloco E, Centro de Tecnologia, UFRJ, Ilha do Fundão. Rio de Janeiro, RJ, Brazil.

Tel: 55-21-3938-7653

E-mail: cavazjunior@eq.ufrj.br

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Figure 1: Las Palmas' and Tenerife illustrative map (Search: Google Maps).

departures would be suspended due to the changing of the weather. This would certainly delay even more the take-offs.

Only at 16:51hrs. the fueling finished and the KLM crew called by radio the ground controller of the airport. As usual, an authorization to start the engines was requested, being immediately granted. Less than one minute after, the American crew asked for the same authorization.

At 16:53hrs., the Dutch captain of KLM, asked for an authorization to taxi. Most of the time, is the first officer (or co-pilot) who makes this request, but in the case of the KLM flight, the initiative came from the captain (or "commander"). In accordance to ALPA's report, this call was made before the conclusion of the departure check-list, that should have been operated by the first officer. The ground controller authorized the KLM to taxi up until the runway 12 (Figure 2), moment in which the captain should change the radio frequency.

As soon as arriving to the runway 12, the crew changed the radio frequency, calling the approach control frequency. Due to the wind of that moment, the taking off should happen from the runway 30. Taxi was authorized through the runway, but the aircraft should leave at the third exit lane (taxiway C-03, Figure 2). From this point on, it should go by the parking area, until runway 30. The KLM crew repeated the information, saying that they would leave by the "first exit" (Taxiway C-1, Figure 2). The controller corrected the information, now directing that the aircraft should go taxiing through the extension of the whole runway, until getting to the runway 30. At this point, a turn of 180 should take place (backtrack).

Along the taxi, in two different moments, the KLM 4805 captain showed to be in doubt concerning the procedure authorized, questioning the co-pilot. The first questioning relating to the use of the first exit, and on the sequence, about using the fourth exit. On both occasions, he was told by the co-pilot to continue through the runway.

Simultaneously, the American aircraft was also authorized to taxi through the runway, behind the KLM.

Pan Am should have abandoned the runway on the taxiway C-3 (Figure 2).

The ALPA's report points out a difficulty experienced by both flight crews, to understand the instructions given by the controller. The strong Spanish accent of the controller, while giving the instructions in English, could have been the reason for such a difficulty.

In the moment, the visibility was changing drastically. And when the American aircraft was authorized to start taxiing, the visibility was 500 meters, but when it really entered the runway, it had been reduced to 100 meters. This blocked the American crew from seeing the KLM aircraft a few meters ahead. At the same time, the controller, positioned at the control tower (Figure 2), did not have any visual contact with the two aircrafts.

The recording of the voices from the American cockpit indicates that, while taxiing, the crew had informed, in out loud sound, each crossing the taxiway. When the American crew crossed the first exit at left, it was mentioned "there's one", and when crossed the second exit, it was mentioned "that's two". But nothing was said when crossing the third exit.

While Pan Am was taxiing, the Dutch aircraft got to the runway 30 and carried out the backtrack. On the position in which the Dutch was, the visibility was better, but even so it was impossible to see Pan Am. Right after the backtrack, KLM's captain accelerated the engines. The co-pilot reminded him that they had not received the flight plan clearance yet. The captain slowed down and order the co-pilot to ask for it.

At 17:06hrs., the controller sent the requested clearance: "KLM eight seven zero five, you are cleared to the Papa beacon, climb to and maintain flight level nine zero. Right turn after take-off, proceed with heading zero four zero until intercepting the three two five radial, from Las Palmas VOR." Note that the controller sent a mistaken numeral of the KLM flight in this call, using 8705, instead of 4805.

As soon as the controller finished the transmission, the recording of the KLM cockpit registers the captain exclaiming "Yes!". Five seconds after, while the co-pilot was still repeating the received instructions, it is possible to hear the captain saying: "We go...check thrust", followed by the sound of the engines accelerating. The co-pilot then works faster and says a last sentence on the radio: "We are now - uh - takin off" or "We are now at take-off --". The investigators couldn't define precisely the words used.

As an answer to this last sentence, the controller said: "OK... stand by for take-off, I will call you". But KLM crew heard only the first part of the sentence ("OK!"). What followed it was received with noise and distortion, although the ALPA's report alleged that was possible to understand what had been said. The reason for the interference was that, simultaneously to the transmission made by the controller, the Pan Am co-pilot also transmitted his message on the same frequency. When the American co-pilot heard the controller saying simply "OK!", the Pan Am co-pilot wanted to inform that the lane wasn't clear yet ("And we're still taxiing down the runway - the Clipper one seven three six"). The controller heard only the final part of the message from Pan Am: "Clipper 1736". His answer then was: "Papa Alpha one seven three six, report runway clear". And the Pan Am co-pilot confirmed: "Okay, we'll report when we're clear" (ALPA's report).

Two distinct forms of denominating the American aircraft were used here. During all that afternoon, the American aircraft was being called by the expression "Clipper", as traditional at that time. Nevertheless, in this last call, the controller used the name, "Papa Alpha". This change of nomenclature by radio can be blamed as one of the factors responsible for the misunderstanding by part of the Dutch crew of what was to occur. Another factor could have been the final answer of the Pan Am co-pilot: "We'll report when we're clear",

not followed, this time, by the identification: “Clipper 1736”.

At the Dutch cabin, everyone heard the radio’s dialogue, but only the flight engineer questioned: “Is he not clear then?”. The captain said: “What did you say?” The engineer repeats: “Is he not clear, that Pan American?” Pilot and co-pilot answer, almost at the same time: “Yes!”. The co-pilot was responsible for the radio transmissions, the pilot was responsible for the take-off and carried an enormous experience. In face of both answers the engineer accepted the belief that he was certainly mistaken concerning his doubt, and that the runway was free. A few seconds after, the American crew saw the lights of the Boeing 747. The first officer exclaimed “get off, get off, get off”, the American Boeing was accelerated and turned left, trying to get away from the runway. And a little after it was possible for KLM’s cockpit crew to see the shapes of the Pan Am jet on the runway. The captain of the European company tried to take-off. But the Boeing 747 was not going fast enough to lift off. Both aircrafts caught on fire with the impact.

The Human Factors

ALPA’s report analyzes, on its Chapter 4, the possible human factors related to the accident. The following factors were indicated on the ALPA’s report as being direct or indirectly related to the accident.

Stress factors – KLM’s flight crew

In accordance with ALPA’s report, the main cause of stress for the KLM flight crew was related to the legal limits of the working hours, as well as with the possible consequences for the company, the passengers and the flight crew itself. Only four months before the Dutch government had modified the working legislation. The new labor law, not yet totally understood, added some difficulty to the exact calculation of the legal limits of the working time. With the new legislation, the captain was legally responsible for eventual excesses. To go back to Amsterdam on that same night, respecting the legal working time, was his preoccupation. Voice recordings in the European cabin registered conversations concerning eventual punishments if the labor law was not observed. But the captain did not have control over that situation. It was impossible specify the duration of the flight to Amsterdam, with a stop at Las Palmas. Eventual delays in the route, or a waste of time on the ground of Las Palmas Airport, could happen. To reduce the staying on the ground, the captain opted for fueling the aircraft while in Tenerife. With enough fuel to fly back to Amsterdam, the stop at Las Palmas should be used only for passengers boarding.

The psychological pressure to go back to Amsterdam on that same night had also other reasons. To not return to Holland that night would also carry enormous complications to KLM. The company would have to find hotels for passengers. Costs would be high. The captain considered it to be his duty to avoid such expenses. The flight crew was also worried about their families. Sooner the News on the explosion at the airport of Las Palmas would be heard on all the European news media. It would be much peaceful to their families if they were all at home already when that would be heard (ALPA’s report). Another important point was the meteorological conditions in Tenerife, which varied widely.

The KLM’s crew had shown up for that flight at 08:45 hrs. in Amsterdam, this corresponding to 07:45 Tenerife’s time – which represented at the exact moment of the accident a working time of 9 hours and 21 minutes.

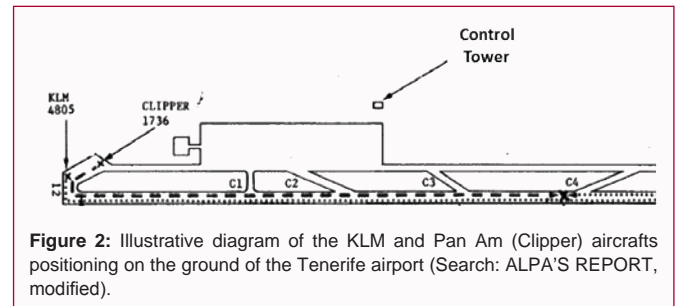


Figure 2: Illustrative diagram of the KLM and Pan Am (Clipper) aircrafts positioning on the ground of the Tenerife airport (Search: ALPA’S REPORT, modified).

Stress factors – Pan Am flight crew

Once Pan Am flight was deviated to Tenerife, stress and frustrations were getting worse in the American cockpit. Still in the air, the crew had asked the air traffic control (ATC) permission to stay orbiting, while waiting for a possible opening of the airport in Las Palmas in a few minutes. Fueled enough, they would be able to wait in the air. However, the request was denied and the aircraft had to land in Tenerife. The airport of Las Palmas opened a few minutes after the landing.

As soon as the airport reopened, the Pan Am crew asked for takeoff. Even though the flight plan was approved, it was not possible to authorize the taxiing, because KLM aircraft was blocking the way up until the runway (Figure 2). Very frustrating, as it seems clear in the voice recorded at the cabin: “We thought we would be gone an hour ago uh but all of a sudden he’s got two big truck-loads of gas... he said in a half hour he’d be gone and we’re going to be right behind him” (ALPA’s report). Besides the frustration with this waste of time, the flight crew of the American company was also observing the changes of the climatic conditions.

Finally, the time zone difference of five hours from Tenerife to New York, where the flight originated, as well as the duration of the flight itself, contributed to generate some fatigue level. The flight crew had showed up at the American airport at 05:42 (Tenerife time), the take-off happening only 2 hours later (after 7:42, Tenerife time). When the Tenerife’s control tower authorized the starting of the engines it was already 16:45 hrs.

Stress factors – ATC

The working conditions at the Control Tower of the Tenerife’s Airport were much different than usual on that day. The closing of Las Palmas Airport had caused an enormous increase of the traffic. The airport had not been designed to accommodate such an amount of aircraft. The Control Tower count on three positions: Clearance, Ground and Approach Control; however, only two controllers were on duty (ALPA’s report). This should not be a big trouble in normal days, with a small number of landings and take-offs. But with an abnormal amount of operations, this had generated a certain level of stress. There were also some worries concerning a possible terrorist attack.

It’s important to note that the language usually spoken by the controllers of Tenerife is Spanish. The use of a foreign language, like English, especially in a moment of an overload of work, was another complicating factor. In several moments, these factors reflected on the delay of the controller to finish his sentences. He would simply stop on the middle of the sentence, as if thinking in Spanish to continue in English, or else he was trying to understand what was going on.

Finally, moments before the authorization for the KLM’s aircraft

to take-off, the meteorological conditions deteriorated so much that they could not see the aircraft on the runway. The airport did not have a radar on the ground, and the controllers need to estimate the position of the aircraft on the ground by radio communications only (ALPA's report).

“Training syndrome”

ALPA's Report mentions the effect known as “*training syndrome*” as one of the factors that should explain the behavior of the KLM captain. On the last months, the captain had been strongly involved on the simulator training of other pilots of the company. The simulator training environment is different of the operation in a real world. The instructor acts as a controller, and delays are not commonly simulated. By being strongly involved with the training of other flight crews, the captain had not flown in the twelve weeks before the accident. For ALPA's specialists, an instructor that covers many hours in this environment, leaving the real flights behind will, eventually, not see the border line between one environment and the other.

Cockpit resource management (CRM)

Although personally responsible for the flight safety, and as a matter of fact, exactly due to it, the captain must create, maintain and promote a bilateral channel of communication with the other members of the crew. For ALPA's investigators, the behavior of the KLM flight crew was excessively centered in the captain. He had, until that day, 11.700 hours of flight, 1.545 hours of which experienced in a Boeing 747.

On the other hand, the co-pilot had 95 hours of flight in such a type of equipment.

The captain corresponded to the confidence deposited on him, making clear, through his acts, that all the factors had been analyzed and that the safety was guaranteed by him. Having the eyes of the whole flight crew on every one of his doings and sayings, plus several stress factors accumulating along the working hours, the captain became less and less open for the listening of any adverse opinions to his objective: the take-off. In parallel, the co-pilot was young and less experienced. In accordance to ALPA's Report, from a certain moment on, the co-pilot seemed to be really worried in not upsetting the captain anymore. However, co-pilot made two attempts to help. The first interference occurred immediately after the backtrack. The captain started promptly the acceleration of the engines. To the co-pilot was given the chance to intervene, recording that they had not received yet the approval of the flight plan: “*Wait a minute, we do not have a ATC clearance*”. As an answer, the captain deaccelerated the engines and spoke back: “*No, I know that, go ahead; ask*” (ALPA's report).

The second interference: while the co-pilot was still speaking on the radio, the captain accelerated the engines once again. The co-pilot made a faster speaking and ended by declaring: “*We are, uh, taking off*” (or “*We are at take-off*”). ALPA's investigators believe that the controller and Pan Am crew, also following the same radio frequency, did not understand exactly what the co-pilot was trying to say. The co-pilot sounded surprised with the situation and the sentence throughout the radio seemed more like an alert to all of them.

Third exit

After authorizing KLM to start taxiing up to the opposite runway and do the backtrack, the controller authorized Pan Am to follow the

Dutch Boeing 747. Nevertheless, the American Boeing should clear the runway at the 3rd exit. ALPA's Report states a few considerations: first, that exit corresponds to Charlie 3 (Figure 2). However, the airport ground maps don't number or identify the taxiways. There was no sign “C-3” on the maps. Not even on the ground it was possible to read such indication “C-3”. Other important point was that the C-3 angle did not favor its use on that position (Figure 2). For an aircraft taxiing from the runway 12 to make use of that taxiway would be necessary to make two curves of 148°: the first curve to the left, and the second curve to the right. An airplane with the dimensions of a Boeing 747 needs large spaces to make curves with such angulation. The ALPA investigators believe that the first curve would be possible, but the second curve (between one taxiway and the other) would not be feasible. As taxiways are usually much narrower than runways, there would not be seen space enough for such maneuvers. In case of such attempt, one of the tires would certainly end up sinking in the grass.

The crew probably believed that the controller was trying to instruct the usage of Charlie 4, the following exit, which had a favorable angulation (Figure 2). The use of C-4 would demand a 35° curve only. From the conversations recordings at the Pan Am cabin, it is possible to infer that the co-pilot reports the moment in which they pass by the taxiways C-1 and C-2, but nothing is said concerning the passing by C-3.

The investigators believe that, when the American aircraft got closer to C-3, the KLM flight crew asked, via radio, for the flight plan clearance. This, by itself, caused a certain ‘sound jam’, maybe inhibiting the American crew to clear out the doubt (C-3 or C-4?). Besides that, the Pan Am crew was not familiar with that airport, and was going to use the same departure of KLM. It should be normal to pay attention to the informations given to the other flight crew. To have this information in advance certainly helps the cabin work, allowing the anticipation of the radio adjustments, the selection of the charts, etc. To pay attention to the radio dialogue and, simultaneously, maintain the taxiing with reduced visibility, are factors that may have contributed to the lack of elucidation about the use of the taxiway announced by the controller (ALPA's report).

“Filter effect”

The expression “*filter effect*” was created by ALPA's group of investigators trying to explain the way each person observes, perceives, processes, accepts or rejects the external stimuli. According to this theory, the filters act during the feeling, perceiving and decision processes. Each external stimulus (received message) is processed in accordance to the relevance attributed to it. Stimuli considered much relevant should be processed in a form complete, while those of a minor relevance could be ignored. An important characteristic of these filters is that the amount of data discarded increases when the individual focus over other tasks. This way, during situations holding a high amount of work, almost anything would overcome the mental filters.

ALPA's Report attributes to “*filter effect*” the loss of three opportunities to interrupt a chain of events. The first opportunity would occur when the KLM co-pilot said: “*We are, uh, taking off*” (or “*We are at take-off*”) and the controller answered: “*OK... stand by for take-off. I will call you*”. The investigators believe that nothing after the “OK” escaped from the mental filters of the Dutch flight crew. The captain was focused on starting the take-off. The “OK” would confirm that his wishes would finally be met. The co-pilot was focused

on finishing the preparation of the aircraft for the take-off, trying to follow the rhythm imposed by the captain.

Other factor to take into account is that the second part of the message (“*stand by for take-off. I will call you*”) came followed by a strong noise /clatter, caused by the simultaneous transmission of the Pan Am co-pilot. For KLM’s crew to understand what had been radio transmitted would be necessary a high level of attention; an attention that, apparently, had been displaced for the take-off tasks right after they had heard the first “OK” (ALPA’s report).

The investigators evaluated, as well, that such interference changed the *voice tonality* of the controller, making it not so recognizable. And by not being familiar, his message sound more difficult to pass by the mental filters of the Dutch crew, already overloaded with such amount of work. The second lost opportunity had happened a few seconds after. The controller asked Pan Am to inform the moment it had left the runway (“*Roger Papa Alpha one seven three six, report the runway clear*”) (ALPA’s report). That was the first time, that day, that the controller referred to the American aircraft as “*Papa Alpha*”. In all transmissions made before the expression being used was “*Clipper*”. The filter of the Dutch crew should have blocked the continuation of the message, since it was not identified as coming from the Pan Am aircraft, which was taxiing behind it.

Seconds after, occurred the third and last opportunity lost. After the message initiated by “*Papa Alpha*”, the flight engineer of the Dutch crew asked his colleagues if the American aircraft had cleared the runway. That radio message had made the engineer a little bit confused. Pilot and co-pilot answered almost at the same time: “Yes”. At this moment, the European aircraft was already running on the runway and the visibility had been more and more reduced. Pilot and co-pilot were carrying a high level of work, trying to accomplish the take-off of a large aircraft, with bad visibility, in an airport with which they were not familiar. On the other hand, the engineer had basically finished his work before taking off. During the take-off, he had to monitor the systems’ performance, only. A smaller work load required of the engineer would have left his mental filter better open, allowing him to process the external stimuli under a clearer manner. In accordance to ALPA’s Report, even with a low work load, the engineer would not have completely associated the radio messages to the Pan Am aircraft. For the engineer, everything was very strange and confused, generating uncertainty.

Ambiguous words

For ALPA’s investigators, ambiguous sentences mark the history of this accident. First, although the investigators were not able to define exactly the used words, the fact is that their senses were not understood by ATC. When saying “*We are now at take-off*” or “*We are now uh taking off*”, with a trembling and rushing voice, the co-pilot did not make clear what was being communicated. He was only informing to be in a take-off position? Was he beginning to take-off? The controller did not understand and answered “*Ok*”, followed by a pause. Moments after the controller continued: “*Stand by for take-off*”, but his transmission was overlapped by the message of the American co-pilot.

Another ambiguous expression: the use of the word “*Ok*” by the controller. It could signify understanding of “*we are now at take-off*”. Or he was thinking about what was going on. It was impossible for the controller to see the aircraft on the runway, and all he could try to do, was to estimate the position throughout the radio messages. The radio silence, after the “*Ok!*”, left the American crew worried.

Finally, the use of the word “*take-off*” during the clearance, may have potentialized the confusion as well, concerning being or not being authorized, for sure, for the take-off: “*KLM eight seven zero five, you are cleared to the Papa beacon, climb to and maintain flight level nine zero. Right turn after take-off*”.

Conclusions

If there is a positive point about what happened in Tenerife, on March 27, 1977, that is the lesson generated from it. As a demonstration of respect to the victims, this learning must be used daily, in all flights, to avoid new tragedies. This paper was based on the report published by the Air Line Pilots Association of the United States (ALPA). ALPA’s report presents the contributing factors, such as: “*the stress of both flight crews and ATC*”; “*CRM*”, “*training syndrome*”, “*ambiguous words*” and “*filter effect*”. It became clear that to carry problems and external worries into the cockpit can elevate intensely the crews’ level of stress. And the airline must give support to the decisions taken by the crews, even if such decisions mean to cancel take-offs, delays and/or expenses with passengers’ accommodation. About ATC, the use of a language with which controllers are not familiar, especially on a scenario of a high work load, also increases the stress and creates opportunities for failures. Today, some airports, in countries that do not have English as its native language, are already performing all the radio communication in English. This elevates the situational conscience of all pilots.

Today, CRM and runway incursion are two important factors to safety. CRM is much better today than it was during the accident, and Tenerife’s accident is a strong reason why all crews, in all countries, should be trained in CRM – there are no more excuses. The problem with runway incursion is better handled today than in 1977, but there were several runway incursions in American airports each year. FAA work hard on the prevention of runway incursion (FAA, 2018), but it is a real problem today [2].

This text is in honor of all the victims of the Tenerife accident.

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