

Dutch comments on the Spanish Report

KLM, B-747, PH-BUF and Pan Am B-747 N736 collision at Tenerife Airport Spain on 27 March 1977

Report dated October 1978 released by the Subsecretaria de Aviacion Civil, Spain, in both Spanish and English

The following comments have been made by the authorities of the Kingdom of the Netherlands, being the State of Registry of one of the aircraft involved, on the causes of the accident as set out in the Spanish report.

In accordance with paragraphs 5.20 and 5.26 of Annex 13 to the Convention of Chicago, an accredited representative of the Kingdom of the Netherlands and qualified technical advisers to assist him, participated actively in the investigation with a view to contributing to the real causes of the accident. The results of their investigation have been presented to the Spanish accident investigation commission.

There is no disagreement on the facts and evidence established in the joint investigation. With regard to the interpretation of the facts and evidence, however, the views of the Netherlands investigation authorities differ substantially.

The considerations concerning the cause of the accident as mentioned in the Spanish report do not answer the question which factors explain the action or inaction of the KLM crew. In order to reach this conclusion the Spanish report over-emphasizes the influence of human factors on the KLM crew only and bases its view on assumptions and suppositions, the correctness of which cannot be found in the available evidence and, on certain points, is in contradiction with it. The inevitable consequence is that the essential lessons, which must be derived from this accident are missing in this report.

The comments contain in Part One the interpretation by the Netherlands investigation authorities of the facts and evidence established in the joint investigation, and in Part Two the considerations and conclusions as done by the Netherlands Aircraft Accident Inquiry Board in its verdict.

It should be noted that the Netherlands Aircraft Accident Inquiry Board, in its public session on 28 and 29 May 1979, has limited itself to the lessons to be drawn from the accident. The analysis and interpretation contained in Part One should be seen totally separate from the verdict of the Board.

PART ONE

Comments of the Netherlands Department of Civil Aviation

Analysis

Based on the total available evidence this analysis discusses the following items:

- a. Human factors of the KLM crew, Pan Am crew and air traffic controller, which could have been of influence on the course of events.
- b. The radio-communications, which can be shown to have caused a mutual misunderstanding between the KLM crew and the air traffic controller, which misunderstanding has arisen from normal, but ambiguous terminology.
- c. The coincidence of a number of circumstances, which coincidence directly influenced the course of events and ultimately resulted in the collision.

a) Human factors

KLM

- The voice recorder of the KLM cockpit shows an almost relaxed atmosphere and an orderly progress of the preparations for take-off and taxiing. The weather deteriorations have been highly variable in intensity, due to drifting layers of low clouds. The crew of the American aircraft saw the landing lights of the KLM aircraft 9.5 seconds before the collision.

From the DFDR-data it has been established that the relative distance was then 700m, which illustrates that the visibility at that moment far exceeded the KLM limit of 300m. Nor does the Spanish report mention any doubt about a visibility-value of more than 300m.

The actual visibility left the KLM captain with no doubt about the legal and practical aspects to perform the take-off. An unacceptable factor of human stress cannot be demonstrated here.

- When the cockpit checklist had been completed, the captain, keeping the aircraft on the brakes, applied standard engine power, i.e. 1.10 EPR, this value being slightly higher than idle power. This is done to check the so-called spin up of the engines prior to take-off; it is normal practice and does not imply an indication of haste.
- From the voice recorder of the KLM cockpit it is evident that the captain was aware that the ATC clearance was not yet received and he allowed himself normal time for it.
- It is an essential part of the take-off procedure that no take-off will be started without a take-off clearance, which is demonstrated by the fact that the first officer also requests for take-off clearance. This item will be further explained under paragraph b).
- After the tower had issued the clearance, the captain started the take-off run while the first officer was reading back the clearance. It is considered a normal human way of thinking of the captain that, where the entire preparation of the take-off was finished and the captain on the basis of the radio-communication was convinced to have a take-off clearance, he no longer wanted to lose time where the conditions of visibility at that moment allowed a safe take-off. Also taking into account the preceding calmness and discipline in the cockpit, this operational deviation of 6 seconds is not considered a factor which indicates an already pre-existing general picture of hurry, nor does it imply a serious operational error. It has also no direct connexion with the misunderstanding that had already arisen from the radio-communication.
- The cockpit conversation clearly indicates that the captain had the intention strictly to adhere to the official work and rest-time regulations. No factual information shows that compliance with these regulations has subjected him- to a higher than, normal stress. Nor does any factual information suggest that he-made haste to comply with the work- and rest-time regulations.

- During taxiing out the captain several times asked the first officer information which was already supplied. This might indicate some form of absent-mindedness. However, it must be taken into account that he was occupied with the performance of the cockpit check-list.

When the first officer remarked that they had not yet received an ATC clearance, the captain replies "Nee, dat week ik, vraag maar" (No, I know, ask for it). It cannot be construed that he had forgotten it.

The request for take-off clearance is part of the standard procedure and such request was made some moments later in the message of the first officer.

- The fact that the captain, being the chief instructor on this type of aircraft, had a certain prestige in relation to the first officer, is in practice a normally occurring situation in a cockpit.

If a condition like this is not accepted as a perfectly normal situation in flight operations, the composition of a cockpit crew might in numerous cases be practically impossible.

Considering the large flying experience of the first officer, there certainly existed no such relationship of authority between the captain and the first officer, that it would have withheld the latter from taking the correct action in case of essential shortcomings of the captain. This is already shown by the fact that the first officer drew the captain's attention to having not yet received an ATC clearance.

- Influences on human activities due to cockpit noise have been recognized over the years as an additional factor; nevertheless, it can certainly be overcome. The noise level in a B-747 cockpit during the take-off cannot be considered a factor of serious disturbance.

The following can be concluded:

On the basis of the available evidence it cannot be demonstrated that the cockpit crew of the KLM aircraft performed its duties in haste or was under greater stress than can be considered normal in the light of the prevailing circumstances of the delay and the weather changes. The evidence also shows no excessive fatigue either.

The influence of human factors as applicable to all types of human activities will certainly have applied to the activities of the crew of the KLM aircraft. Yet the causal influence of the human factors on the premature take-off has not been shown in the findings of the Spanish or Netherlands investigation. Assumptions to that effect are not supported by the established facts.

PAN AM

- From the cockpit voice recorder of the Pan Am cockpit it shows that during the taxiing on the runway, the Pan Am crew was highly irritated by the extra delay caused by the refuelling of the KLM aircraft. The departure of the Pan Am aircraft was indeed

However, the possibility that this irritation caused them to taxi past the intersection which they were instructed by the tower to use, is not evident from the facts.

The explanation of the missing of the intersection in question may be found with greater probability in the facts established by the investigation, such as: the fog that made a complete view of all intersections impossible, the absence of markers alongside the runway; the small size of the map which was used as a reference to the correct intersection, and the circumstance that during the passing of the intersections C2 and C3 the crew was performing the check-list. Also here, factors such as the rapidly varying visibility, which was far below the take-off limits applicable to Pan Am might have had an influence.

- All these human factors, however, are inherent in the normal aspects of flight operation.

The unacceptability of these factors has never been shown in practice.

The tower controller

- The investigation has shown that the tower controller was on duty the whole day already and had to handle an unusually high traffic load.

In the transmissions of the tower, background noises are audible which suggest a football match, which could imply a distraction. This will be discussed later.

- During taxiing on the runway the tower controller asked KLM to report when they were ready to copy the ATC clearance. Since at that moment the KLM crew was performing the check-list, copying of this clearance was postponed until the moment that the aircraft was lined up in take-off direction. This had as a result that the requests for take-off clearance and for ATC clearance were made simultaneously.

This procedure is not considered abnormal. A disturbing influence of a human factor-in this procedure cannot be evidenced.

- The tower controller intended the Pan Am aircraft to leave the runway at the third intersection. Due to the sharp angle this intersection was more difficult than the next intersection. The controller had relatively little experience with B-747 aircraft. This instruction to use the C3 intersection might have been the consequence of. a limited appreciation of the manoeuvrability of a B-747.

From tests with a B-747 at Schiphol Airport, carried out as a part of the Netherlands investigation, it is evident that this manoeuvre could reasonably be performed.

- In the radio-communication the tower controller has been clearly audible. Nothing but usual, if not formally prescribed terminology, was found to have been used. The misunderstanding that arose from the terminology in the radio-communication is certainly not the result of errors in it. The misunderstanding will be further discussed in paragraph b). There are no human factors to be indicated as evidently disturbing influences, Only usual terminologies are employed in the communication. Even the word "O.K.", used by the controller and meaningless as it is, is often used

in aviation communication. Due to coincidences, it has had a confirmative effect which was not intended.

- Due to the fog there existed no visual clues for information. A picture of the situation could only be obtained by means of the radio-communication.

Two aircraft were taxiing simultaneously on the active runway. After the tower controller had given his instruction to the KLM aircraft to hold with the words "Stand by for take-off, I will call you", it would have been more careful if he had asked the KLM for a confirmation of his instruction.

If a confirmation had been asked for it would, in all probability, have been a timely warning to abort the take-off.

However, it is to be considered that from none of the preceding messages the controller had received the impression that the KLM aircraft was not stationary. His statement that he thought to have heard: "We are at take-off position", also indicates this.

From the tower tape and from the cockpit voice recorders of both KLM and Pan Am, however, it is evident that the word "position" was not used by KLM.

Even when considering the factor as is just discussed, the tower controller has applied usual terminologies and procedures. He could not know that due to a coincidence, a squeal made his message unreadable and so he was in no way alarmed.

It is thought that no more importance should be given to this circumstance than to all other normally occurring circumstances, which were, as shows from the investigation, applicable to all involved. Those circumstances can, however, be considered as indicative of a non-optimal functioning.

- The background noises in the tower transmissions, which suggest a football match, were not analysed in the Spanish investigation. These background noises are also audible on the cockpit voice recorder of the KLM aircraft.

This indicates that they were really present in the tower, could be heard by the controller and were transmitted together with the communication. Listening to or looking at a football match on radio or television would imply a serious distraction. Nevertheless, the real indications that they actually caused distraction are considered not sufficiently strong to warrant any conclusions as to the human actions of the controllers.

b) The radio-communications

Due to the fact that during taxiing the KLM crew had not accepted the offer of the tower to copy the ATC clearance, both the take-off clearance and the ATC clearance had to be requested at the moment that the aircraft was lined up, ready for take-off and the checklist had been completed.

The first officer remarked to the captain that they had not yet received the ATC clearance, whereupon the captain replies: "Nee dat weet ik, vraag maar" (No, I know, ask for it). The subsequent message of the first officer was made with the words: "We are now ready for take-off and we are waiting for our ATC clearance."

The use and meaning of the phrase "We are ready for take-off" has been extensively examined and illustrated in the Netherlands investigation report, for the Purpose of which a worldwide review about its habitual meaning was made. From this part of the investigation it has been clearly established that in this phrase, two requests are made: the request for take-off clearance as well as the request for ATC clearance.

With regard to the reply to this question the following applies. The reply of the tower was: "You are cleared to the Papa beacon etc.", on which the first officer, with an increasing rate of speech, reads back the clearance and at the end adds: "We are now at take-off" or "We are now taking off"

From the CVR and the DFDR of- the KLM aircraft it is evident that during the readback of this clearance, engine thrust was increased to take-off thrust, that 5 1/2 sec before the end of the readback, i.e. halfway the message, which lasts 8 seconds, the captain says: "We gaan - check thrust" (We go - check thrust), that the brakes were released and that the take-off run was started.

From these factual events it shows that the KLM crew has understood from the clearance issued by the tower, to have been cleared for take-off as well.

From the fact that the take-off run was started and from the course of events during the take-off, it is evident that the KLM crew had the absolute conviction that they were cleared for it. Considering the fog, this conviction can only be obtained through the radio-communication .

With regard to the misunderstanding which evidently resulted from the radio-communication, the following can be considered. With his message: "You are cleared to the Papa beacon etc.", the tower controller only replies to the second request, which concerned the ATC clearance. He replies on the first request, concerning the take-off clearance, only after the readback. In view of the two requests, the wording in which the clearance was given holds the possibility for the misinterpretation that on that moment clearance was given to depart actually via the indicated route.

In the context of the two requests, it is this wording from which with almost certainty, the misunderstanding of the KLM crew has arisen.

After the readback the tower controller reacts with the message: "O.K." - approx. 2 seconds pause - "stand by for take-off, I will call you."

This O.K. from the tower can only have promoted the misunderstanding, it contains a confirmation of which was just previously reported by the first officer, i.e. that they were - at take-off - or - eh, taking-off.

The tower controller stated during the joint hearing by the investigation commission, :! to have understood that the KLM aircraft had reported to be "at take-off position". This indicates the stationary condition of the aircraft, . so that he was not alarmed by it. It is evident that, emanating from the radio-communication , a mutual misunderstanding has arisen.

For the KLM crew this resulted in the conviction that they were cleared for take-off; for the tower controller it gave the conviction that the aircraft remained stationary-

A confirmation of the possibility that a misunderstanding could arise from the way in which the radio-communication was carried out, is found in the prompt reaction of the captain and the first officer of the PanAm aircraft, On hearing the radio conversation up to and including the word O.K...this crew feared that the issued clearance could possibly be understood as a take-off clearance as well. A tape recording, made shortly after the accident, on which the Pan Am captain gives his first impression, as well as the combined statement of the Pan Am crew members as contained in the NTSB contribution to the Spanish investigation, clearly substantiates this.

Their fear of a misunderstanding was so urgent that immediately after the O.K. from the tower, they reported to the KLM aircraft that they were still taxiing on the runway. The pause of approximately 2 seconds which the tower allowed between "O.K." and "Stand by for take-off, I will call you", gave the Pan Am crew the impression that the message was ended with the "O.K.", on which they immediately transmitted their warning message.

The coincidence of the message of the tower and the warning of Pan Am: "No - eh - and we are still taxiing down the runway -" caused, exclusively in the KLM cockpit, a squeal, which seriously mutilated both messages and prevented them from being received by those for whom the messages were meant.

The continuation of the take-off indicates that this message has not been intelligibly audible to both pilots.

It is noted in the Spanish report that during the investigation the sounds on the KLM CVR tape were filtered in order to improve the quality of the audibility of the tape.

In this stage of the take-off the crew was fully concentrated on the take-off run. It is not surprising that these messages, strongly disturbed by the squeal, could not be effective.

Two remarks should be made here:

- The tower controller, in no way alarmed, has in his routine, not requested a confirmation of his order to KLM: "Stand by for take-off".
- Neither the Pan Am crew nor the tower could hear the squeal, so they were not aware of this or its effect.

The messages exchanged shortly thereafter between tower and Pan Am aircraft containing the order and the confirmation of the Pan Am aircraft to report when clear of the runway, were heard by the flight engineer of the KLM aircraft. These messages came after the squeal had stopped and on the KLY CVR they are clearly audible.

On the question of the flight, engineer: "Is hij er niet af dan?" (Did he not clear the runway then?), repeated with: "Is hij er niet af, die Pan American?" (Did he not clear the runway, that Pan American?). both pilots reply with: "Jawel" (Yes, he did).

This again shows that they were absolutely convinced that the runway was clear and that take-off clearance had been given. The fact that the flight engineer puts this question shows that he, too, had the same conviction. The way in which he puts this question shows that this last received message was not consistent with the mental picture of the situation he had so far. If from this last message the flight engineer would have been convinced that the runway was not clear, he would, to all reasonability, have taken action to abort the take-off, such as a.o. an exclamation to that effect.

Also the fact that he did not interfere in the take-off, for instance by closing the throttles, for which action he would have been fully authorized in case of real doubt, indicates that the preceding communication has caused a wrong conviction.

It should be remarked that from the DFDR data can be derived that at the moment of the word "Jawel" (Yes, he did) an abort of the take-off could still be carried out successfully.

It is evident that the message heard by the flight engineer was not heard by the pilots, causing that they also did not understand the reason of his question. Seen from a point of view of operational practice, it is understandable that in this phase of the take-off, an exchange of communication, - which did not contain the call-sign of the KLM aircraft - was not registered in the minds of the unsuspecting pilots.

Summarizing, it can be stated:

- The radio-communication has not at all been exceptional in nature or contents and can be considered the usual practice.
- It is considered evident that from the radio-communication a mutual misunderstanding has arisen. This applied to both the KLM crew and the tower controller.

From this conversation the KLM crew obtained the conviction that they were cleared for take-off; the tower controller obtained the conviction that the aircraft remained stationary. The Pan Am crew recognized and feared the possibility that the KLM could understand the clearance as a take-off clearance as well and got alarmed by it.'

- Due to the generation of the squeal the audibility of essential messages of the tower and of Pan Am, were strongly disturbed in the KLM cockpit and the meaning of these messages did not reach the crew.
- The convinced reply of both pilots to the question of the flight engineer can be explained from the fact that, as no KLM call sign was used, the conversation between Pan Am and tower, from which the flight engineer derived his doubt, was not intelligibly registered in the minds of the pilots; such took place in a phase of the flight in which they were fully concentrated in performing the take-off.
- The misunderstanding did arise exclusively from the radio-communication, without other interfering circumstances. It can be stated that even without the fog; the misunderstanding could have arisen from the radio-communication.
- The procedures which in the course of events have been followed for the request and issue of the clearances; do not contain circumstances which can be considered unusual or abnormal; be it that in practice only incidentally, take-off clearance and ATC clearance are handled simultaneously,

Possibly this explains the fact that the tower controller handles the two requests in a reversed order than in which they were made, with all consequences thereof.

- In the radio-communication terminologies were used which, though generally accepted in practice, do not express their meaning unambiguously.

Standard procedures and terminologies for radio-communication are contained in ICAO Doc 4444, Procedures for Air Navigation Services - Rules of the Air and Air Traffic Services (PANS-RAG) and ICAO Annex 10. However, standard terminologies

for the communication of aircraft with regard to requesting take-off clearance or ATC clearance are not given.

Therefore, there can be no discussion about a standard terminology which the KLM crew should have used in requesting their clearances.

In cases where no standard terminology is prescribed, in practice a phraseology is applied which, due to its uniform unambiguity, is considered usual and as such can be indicated as standard.

In the relevant case "We request", could have been used instead of "We are ready for"

In a world-wide examination, carried out as part of the Netherlands investigation concerning usual phraseology, it has positively been established that the latter terminology is in common international use as well.

The word "O.K.", which implies a confirmation, is non-standard. The ICAO standard term for a confirmation is: Roger, that is correct, wilco or affirmative, However, the word "O.K." is also often used.

c) Coincidences

From the facts which were established in the investigation it is evident that the coincidence of a number of circumstances had a direct influence on the occurrences related to the take-off, A chain of coinciding circumstances made the accident almost inevitable. If any of these circumstances had not been there, it is almost certain that the accident would not have occurred.

The following circumstances are considered coinciding:

1. The fog, due to which the radio was the only means of communication and the three parties involved were not visible to each other.
2. The congestion on the airport; due to which the two aircraft were taxiing simultaneously on the only available and active runway.
3. The fact that the KLM crew initially did not accept the offer by the tower to deliver the ATC clearance. As a result of this, the request for the ATC clearance coincided with the request for take-off clearance, at such a moment that the KLM aircraft stood lined up in take-off direction.
4. The misunderstanding between KLM and tower arisen from the radio-communication and from which erroneously the respective convictions resulted; for the KLM that they were cleared for take-off and for the tower, that the aircraft remained stationary.
5. The coincidental misleading effect of the word "O.K." of the tower, after the KLM - had reported "We are at take-off" or "We are -eh-, taking off". Only the word "O.K." has been clearly audible in the KLM cockpit, which could be taken as a confirmation for the correctness of the message transmitted by KLM.
6. The pause of about two seconds after the word "O.K.", from which the Pan Am crew concluded that the message of the tower had been ended and on which moment they jumped in to warn the KLM crew.

This pause had as a result that due to the unintentional transmission of two essential messages, i.e. the message of the tower: "Stand by for take-off, I will call

you" and of the Pan Am: "And we are still taxiing down the runway", a squeal was generated, by which noise both messages were lost. This pause, as an ultimate of coincidence, has proven fatal.

7. The squeal, primarily caused by the fear of the Pan Am crew that from the terminology of the clearance a misinterpretation of the KLM crew could arise.
8. The KLM crew apparently did not follow the communication between Pan Am and tower.
9. The predominant coincidence, ultimately resulting in the collision, consists of the premature take-off of the KLM aircraft coinciding with the taxiing too far of the Pan Am aircraft.

Performance calculations and taxi tests with a B-747 turning off on an intersection comparable to the C3 at Tenerife, as part of the Netherlands investigation, indicate that in all probability no collision, and almost certainly no fatal collision would have occurred if the Pan Am aircraft had not taxied farther than the third intersection, which was emphatically instructed by the tower controller.

Although the Pan Am aircraft, which unintentionally taxied too far, has clearly reported that it was still on the runway this operational deviation coincided with: the early take-off of the KLM aircraft; it has been a causal coincidence to the, ultimate fatal collision.

General Summary

From the investigation it can be established that the accident was not due to a single cause.

The misunderstanding arose from generally used procedures; terminologies and habit-patterns.

The unfortunate coincidence' of the misunderstanding with. a number of other factors has nevertheless resulted in a fatal accident. Neither in the operation of the KLM crew, nor in those of the tower-controller -or the Pan Am crew, actions can be indicated which should be considered as 'serious' errors However,. in varying-degrees a non-optimal functioning can be recognized with all parties.

Cause

The KLM aircraft has taken off without take-off clearance, in the absolute conviction that this clearance had been obtained, which was the result of a misunderstanding between the tower and the KLM aircraft.

This misunderstanding has arisen from the mutual use of usual terminology which, however, gave rise to misinterpretation. In combination with a number of other coinciding circumstances, the premature take-off of the KLM aircraft resulted in a collision with the Pan Am aircraft, because the latter was still on the runway since it had missed the correct intersection.

PART TWO

Considerations and conclusions of the Netherlands Aircraft Accident Inquiry Board

No evidence was found that any air traffic controller or any crew member of the aircraft in question was not or to a lesser degree capable for the execution of his function. Neither was it found that with any of them a particular state of mind has played a significant role.

Considering the stresses to which members of an aircraft in their work situation are subject on the one hand and, on the other, taking into account the experience of these crew members, the Board does not find it plausible that the stresses on the crew members, emanating from the work situation, were too heavy for any one of them.

As far as can be verified, the technical condition of each aircraft has not contributed to the accident.

From the investigation - especially considering the aforementioned sequence of events leading to the accident, particularly the presented coincidence of occurrences, and the statements of the experts given during the session, everything as seen in their mutual connexion and relation - the Board found that, in order to prevent such an occurrence in the future:

I. It is desirable that regulations are issued, according to which:

- A. A pilot (if circumstances permit) does not request a taxi clearance until after he has requested, received and confirmed by read-back, a departure instruction and/or an en-route clearance.
- B. A pilot never combines the request for a take-off clearance with any other message.
- C. If practicable, a departure instruction and/or an en-route clearance and a take-off clearance are issued on different radio frequencies.
- D. The phrase "take-off" is used exclusively in the request, the issue and confirmation of a take-off clearance.
- E. The safety of traffic (aircraft taxiing, taking-off and landing, as well as other traffic which is simultaneously on a take-off and/or landing runway) is guaranteed, especially when the air traffic controller only has radio- communication at his disposal and is unable to observe that take-off and/or landing runway continuously.
- F. Exits of a take-off and landing runway are provided with clearly distinguishable markings, whereby every marking corresponds with the relevant marking on the layouts which are used for taxiing.
- G. In the radio-communication between the crew of an aircraft and air traffic control, additional use of standard terminology is regulated for crews, and which is in conformity with the regulated standard terminology, which is used by air traffic control.

II. It is recommendable that:

- A. Air traffic control has, besides radio-communication, other systems at its disposal such as: ground radar, block safety systems, visual confirmation by means of lights and the so-called data-link, in order to control by such means more effectively the traffic on take-off and landing runways and when necessary on taxiways, during conditions of bad visibility.
- B. In the cockpit voice recorder of an aircraft a signal is incorporated appearing at regular intervals, for synchronization with the flight data recorder in the aircraft.