Review of Interim Report Version V17

by Experts J.-L. Françon, L. Bloncourt, D. Kügler

with

Remarks & Questions of Claimants

The HAGUE DISTRICT COURT (Chamber of Commercial Affairs)

Case Number C/09/434236/HA Z 13-17

27 September 2016

Limited Review

By an expert-team, consisting of:

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1. Introduction

1.1. Scope

1.1.1. On 21 Dec. 1992, a Martinair DC-10 crashed during landing at Faro airport; 56 people died and many more were severely injured. The accident investigation was carried out by an International Civil Aviation Organization (ICAO) "Annex 13" compliant Portuguese Commission of Investigation, led by the Portuguese Civil Aviation Authority, with support of the Dutch Aviation Safety Board (DASB), the US National Transportation Safety Board (NTSB) and others. A few years after the accident, a number of victims started collecting documents on the accident because they had no faith in the formal investigation, had serious doubts about the answers given to their questions by the DASB during two meetings and to the press. They subsequently contacted a personal injury lawyer.

Following an independent analysis by AvioConsult, the lawyer subpoenaed the DASB, and therefore the State for:

1. Inappropriate, careless investigation of the cause of the accident, and
2. Misinforming the survivors and the next of kin of the deceased.

In the view of claimants, the Portuguese report contained many errors; the DASB should have noticed these, but they ignored them. Still, they tried to emphasize the weather conditions and constructed their own truth (different from the Portuguese).

During information meetings, DASB misinformed the survivors by answering elementary questions inappropriately (143 questions) with their own opinion of the cause of the accident, which was not in agreement with the formal Portuguese Report. Based on the DASB truth, claimants have made important decisions in settling their personal injury cases. They trusted and relied on the supposed independence of the DASB.

The Court in The Hague assigned three experts, J.-L. Françon, L. Bloncourt and D. Kügler, to provide independent expertise on the functioning of the DASB following the accident. The Experts published their findings in Interim Report V17, dated 15 June 2016.

1.2. Review

1.2.1. This Review was written by a team of four experts:

1. **W. Benschop**, *Aircraft Design and Certification Consultant, Pilot and Flight Instructor.*
Structural Test Engineer in the Experimental Department of Fokker. Engineering support for aircraft production, manager Weight & Balance in engineering-department Strength and Construction. Head of Airframe Engineering/Sustaining Department, Senior Consultant Aircraft Design and Certification. Projects performed for i.a. the Dutch CAA (IVW) on Transport Airship Requirements, EMBRAER (EMB-170/190 EASA certification), Stork-Fokker (GLARE qualification).

2. **E.H. Boucher**, *lawyer-pilot*.

3. **A. Cats**, *Inspector-pilot Flight Operations / DC-10 Type Rating Examiner / captain B-757, 767 (RLD, ret.)*.
Military pilot Fokker S-11, Fouga Magister, Grumman Tracker, Beechcraft TC45J, Breguet Atlantic.
Dutch CAA: Saab Safir, Beechcraft Bonanza, Piper Navajo PA-31, Cessna Citation C-500,

Fokker F-27, Boeing B-737, McDonnell Douglas DC-10, Boeing B-757/B-757. Inspector-pilot Flight Operations; CPL-, instrument rating-, type rating examiner (amongst them DC-10); simulator evaluator (FAA course Oklahoma), ETOPS expert; captain B-757 / B-767.

4. **H. Horlings**, *Flight Test Engineer, Graduate USAF Test Pilot School (Lt-Col RNLAF, Chief Flight-test, ret.).*
Private pilot and instructor, Avionics Officer RNLAF, Experimental Flight Test Training at USAF Test Pilot School (entry level MSc), 15 years' experience in operational research and evaluation, including experimental flight testing many different (>30) types of airplanes and helicopters, member of a scientific committee at NLR, operational lead of modification Martinair DC-10 aircraft into KDC-10. Founded AvioConsult. Consultant for EADS/CASA A330 tanker aircraft. Expert witness General Electric.

1.3. Structure

1.3.1. This review is limited, due to the time constraints and the size of the Experts' report. Hence, not all of Experts' statements were reviewed and commented on, but only the most important ones.

1.3.2. The expert team chose to split the accident flight in segments. In each segment, the applicable Rules and Regulations, the Facts out of the formal Accident Investigation Report (RvO), formal Aircraft and Operations Manuals are presented that were applicable at the time of the accident and ICAO manuals. Comments on the subjects from DASB and Experts are included, as well as remarks and questions on behalf of the Claimants. It could not be avoided that the same texts appear more than once in this review. The referenced pages out of formal manuals are attached as Appendices for easier access by the reader.

1.3.3. On behalf of the claimants, the Experts assigned by the court are requested to take note of the remarks and to comment all questions.

2. Flight preparation

2.1. Landing gear

2.1.1. Rules and Regulations

2.1.1.1. ICAO Annex 13 requires in § 1.6 Aircraft information, subparagraph a: a "*Brief statement on airworthiness and maintenance of the aircraft (indication of deficiencies known prior to and during the flight to be included, if having any bearing on the accident*)".

2.1.2. Facts

2.1.2.1. The aircraft departed Schiphol while the replacement of the right landing gear, which failed after touchdown on the airport of Faro, was postponed already three times at the request of Martinair. The Dutch airworthiness authority authorized the postponement (statement KLM maintenance planner Mr. Dick van Polen on TV2, Dossier EénVandaag on 16 Jan. 2016).

2.1.2.2. As the Commission of Investigation states in RvO § 1.6.3, Pending Deficiencies: *"The technical log was recovered on site and the inputs from 05 Dec. 92 up to the date of the accident were verified. Additionally, the Operator supplied the list of pending deficiencies since 10 Nov. 92 up to the date of the accident.*
The items pending at the date of the accident did not affect the aircraft airworthiness. However, dispatching the aircraft from Amsterdam with #2 Engine reverse unserviceable, violated the dispositions stated in the AOM (dispatch Deficiency Guide) which made landings in Amsterdam mandatory with 3 operating reversers".

2.1.2.3. At the day of the accident, the aircraft was already sold to the Ministry of Defence of the Netherlands to become a KDC-10 tanker/ transport, but leased back to Martinair.

2.1.3. Comments DASB

2.1.3.1. DASB had no comments on the postponement, but must have been aware, as accredited representative. DASB did not report to the Commission of Investigation that the replacement of the landing gear was postponed three times at the request of Martinair.

2.1.4. Remarks and questions Claimants

2.1.4.1. Replacement of a landing gear might have been required for maintenance or, because during an inspection, one or more hairline(s)/cracks were found that eventually could lead to fracture. Postponement, if granted, is usually for a limited number of landings.

2.1.4.2. The postponement of the landing gear must have been recorded in the aircraft maintenance/technical logbook. The DASB must have reviewed the maintenance logbooks and should have noticed the postponement, but they did not inform the Portuguese Commission. Since there are no records, the Experts could not comment on this subject. The Experts should have been alerted by the families' questions and conclude that the landing manoeuvre was not in agreement with the landing technique prescribed in the Aircraft Operations Manual (AOM) for landing on a wet or otherwise contaminated runway (AOM 3.3.5 – 15, refer to Appendix 2), which will also have contributed to the fracture of the gear, which is discussed § 5.11 below.

2.1.4.2.1 *Questions*. Did Experts review the maintenance logbooks? Should DASB not have reviewed the technical and maintenance records in great detail?

2.2. Thrust reverser

2.2.1. Facts and Regulations

2.2.1.1. The aircraft took off from Schiphol airport at 04:53 UTC with a defective, though stowed thrust reverser to prevent accidental deployment in-flight.

2.2.1.2. The relevant regulations regarding a defective thrust reverser are presented in AOM 3.1.17 Dispatch Deficiency Guide (Appendix 3):

"One fan thrust reverser may be unserviceable provided:

- *the aircraft shall not depart a station where repair or replacement can be made".*

2.2.1.3. The Dispatch Deficiency Guide that had to be used by the captain was a Minimum Equipment List (MEL), approved by the Dutch Civil Aviation Authority (RLD), which is based on the FAA approved Master Minimum Equipment List (MMEL).

2.2.1.4. The repair or replacement of the defective thrust reverser could be made at Schiphol airport, which was a main repair station at the time of the accident flight.

2.2.1.5. There was no communication between Martinair and/or the captain with the Dutch Aviation Authorities in order to obtain permission to deviate from the Dispatch Deficiency Guide. The aircraft departed Schiphol with an unserviceable thrust reverser.

2.2.2. Comments DASB

2.2.2.1. "*There were no indications of faults on the aircraft or its systems that could have contributed to the degradation of safety nor could have increased the workload on the crew during the final phase of the flight*".

2.2.2.2. "*Martinair is prepared to give the competent authorities and bodies access to faults, maintenance and repairs to the aircraft concerned*" (Answer to question 4 of 143 questions – lijst 4 - 6). "*The inoperative items at departure from Amsterdam, did not affect the aircraft operation*" (quoted in V17 § 8.4.1 - indent 4).

2.2.3. Comments Experts

2.2.3.1. "*The technical story of an aircraft is at all time followed in details by the specialists*", and "*The aircraft was "good for fly" except for the reverser n°2 (approved technical deviation)*". "*This aircraft was finished entirely in accordance with the rules and declared as technically airworthy by the Maintenance Department and checked as such by the crew*".

2.2.3.1.1 *Question*. How do Experts know that the technical story is at all times followed by the specialists? Was that the case here, did Experts see the 'story'? Did Martinair show the maintenance/ technical logbooks to the Experts?

2.2.3.2. Even if the landing distance is not a contributing factor to the accident, the Experts evaluation is that the stowage of the reverser N°2 is a concern that the crew should have taken into account, according to the weather condition (V17 § 8.4.1 – indent 3).

2.2.3.3. The Experts quote a Minimum Equipment List (MEL, V17 § 8.6.4.1.2). (Abbreviations are presented in Appendix 1).

2.2.3.3.1 *Remark*: Neither the quoted MEL, nor the applicable AOM and the Dispatch Deficiency Guide thereof give additional information on how the regulations should be interpreted. For this, the highest available authority is the ICAO itself. For interpretation of the meaning and status of a MEL and its subsidiary documents, the ICAO has issued a clear statement (Master Minimum Equipment List/ Minimum Equipment List Policy and Procedures Manual, page 11; Appendix 4). Refer to § 2.2.4.1 below for more remarks and questions about a MEL. The ultimate decision/permission to deviate from the Dispatch Deficiency Guide was in the hands of the Dutch CAA.

2.2.3.3.2 *Question*. What are the origins of the quoted MEL in V17 § 8.6.4.1.2? Was the quoted MEL approved by the Netherlands Aviation Authorities in 1992 and where did the Experts get this information which was not provided by the court?

2.2.3.4. The Experts state that the additional questions in relation to the interpretation of the definition of an airport where repair or replacement can be made are:

- *"Is repair or replacement possible on the same day?*
- *Are spare parts immediately available or not"?*

2.2.3.5. The Experts state that Martinair was a subsidiary of KLM and must comply with the commercial agreements made by KLM regarding maintenance.

2.2.3.6. The Experts conclude that: "*If the captain made the decision to take-of, it means that he did not plan the fact that the runway might be contaminated at arrival*".

2.2.4. Remarks and Questions Claimants

2.2.4.1. A Master Minimum Equipment List (MMEL) is an approved document created specifically to regulate the dispatch of an aircraft type with inoperative equipment. It establishes the aircraft equipment allowed to be inoperative under certain conditions for a specific type of aircraft and still provide an acceptable level of safety. The MMEL contains the conditions, limitations and procedures required for operating the aircraft with these items inoperative. The MMEL forms the basis for development and review of an individual operator's Minimum Equipment List (MEL).

A (Insert country) operator will frame its MEL based on the MMEL duly approved by the authority of the country of manufacture of the aircraft.

"The MEL is an alleviating document. Its purpose is not, however, to encourage the operation of aircraft with inoperative equipment. It is never desirable that aircraft be dispatched with inoperative equipment and such operations are permitted only as a result of careful analysis of each item to ensure that the required level of safety is maintained. A fundamental consideration in permitting the dispatch of aircraft with inoperative equipment is that the continued operation of an aircraft in this condition should be minimized".

Clearly, the purpose of a MEL and its derived document, called the Dispatch Deficiency Guide in the AOM, is to guarantee continuous airworthiness and safety of flight; nothing more. Certainly, commercial or logistical considerations may never play a role in interpreting the meaning or scope of a MEL or related document, let alone in altering this meaning.

In case of a deficient thrust reverser the requirement clearly and simply states that the aircraft shall not depart a station where repair or replacement can be made. No reference is made on timing or immediate availability of replacement parts. Schiphol, in 1992 was a main station with extensive maintenance facilities, well able to perform the repair. The Dispatch Deficiency Guide in the AOM that is derived from the MMEL and the MEL lists are all subject to prior approval of the aviation authorities and are inextricably linked to the continuous airworthiness requirements and therefore with the certificate of airworthiness. No MMEL, MEL or AOM can be amended or ignored at airline let alone pilot level without prior written approval by the competent aviation authorities. MEL and AOM contain vital flight safety procedures and regulation.

2.2.4.1.1 *Question*. In this context, how do the Experts find that the contents and meaning of regulations originating from a MMEL, MEL and AOM are open to (ad hoc) interpretation of a commercial or logistical nature by the airline or by the pilot, more specifically that the KLM AOM applicable in1992 would have given room for the interpretation that a station where repair or replacement can be made can only qualify as such if the repair can be made on the very same day or when a spare part is immediately available on site?

2.2.4.1.2 *Question*. In this context, how do the Experts comment on the fact that MP-495 nonetheless left for an airfield (FARO) at which the repairs certainly could not be made, instead of to Paris where, according to the Experts, the part was available?

2.2.4.1.3 *Question*. On what basis do the Experts conclude that a spare part was necessary in the first place and if so, that the required spare part was not available at Schiphol, especially given the facts that:

- KLM provided all maintenance of Martinair DC-10 aircraft at that time at the extensive KLM Maintenance Facilities at Schiphol Airport
- KLM themselves operated their own DC-10's from Schiphol and would have many spare parts in storage.
- KLM in 1992 had its own large motor repair and maintenance shop.
- Paris is only 1-hour flight from Schiphol, even if a spare part was necessary and unavailable at Schiphol, could MP-495 have not waited for the repair as required?

2.2.4.1.4 *Question.* Do the experts have any information substantive to the fact that the captain and/or the maintenance crew actually checked for the nature of the defect and the availability of a spare part at Schiphol and/or REVIMA in Paris?

2.2.4.1.5 *Questions*. The Experts state that "This aircraft was finished entirely in accordance with the rules and declared as technically airworthy by the Maintenance Department and checked as such by the crew" and that the stowed thrust reverser was an "approved technical deviation" (§ 8.8 question 4).

- How can the Experts draw these conclusions when the decision to depart was obviously in clear violation with the norms defined in the Dispatch Deficiency Guide (MEL)?
- In the 143 questions, in response to question 102, Martinair answered that "*the aircraft was finished entirely in accordance with the rules*". However, this was clearly not the case given the unambiguous AOM requirements with regard to the thrust reverser. Do the Experts concur that the DASB gave an incorrect answer and should, additionally, have added a comment on the decision of the captain to break the rules defined in the Dispatch Deficiency Guide and that the DASB

should, thus, have informed the victims about this transgression in response to their question?

- Please answer the above question also with regard to the remark made by DASB member Snoek during the information meeting on December 1, 1994 [26] with the victims that: *"you can take off without number 2"* thereby ignoring the relevant AOM regulations.

2.2.4.1.6 *Remark*. According to their comment (§ 8.4.1-indent 3) the Experts agree that, given the weather report which, at the time of departure, predicted thunderstorms and related heavy precipitation at Faro Airport at the Estimated Time of Arrival the defective thrust reverser is a concern that the crew should have taken into Account.

2.2.4.1.7 *Question*. In view of this comment, do the experts agree that:

- The known weather conditions at FARO aggravated the decision by the captain to disregard the regulations set forth in the Dispatch Deficiency Guide with regard to the thrust reverser and that the DASB should have commented on this?
- The DASB was wrong in its conclusion that:
"There were no indications of faults on the aircraft or its systems that could have contributed to the degradation of safety nor could have increased the workload on the crew during the final phase of the flight."

2.2.4.1.8 *Question*. on what basis do the Experts conclude that if the captain made the decision to take-off, it means that he did not plan the fact that the runway might be contaminated at arrival. Do the experts not agree that it is possible the crew made a mistake regarding this issue? All the more so given the fact that the Experts have stated (§ 8.4.1-i3) that, given the weather report, the defective thrust reverser is a concern the crew should have taken into account. It seems the Experts contradict themselves at this point.

2.2.4.2. *Question 107 of 143 questions*: Did the pilot by departing in this way, act in accordance with written or unwritten instructions from the Martinair management? Martinair answered: *"Yes, fully*".

2.2.4.2.1 *Question*. Experts wrote in their remarks to this question: "*The only cases for which a pilot can take the decision to take off with a defect are listed in a certified document: the minimum equipment list*". This list was available in AOM § 3.1.17 (Appendix 3). The captain however, did not make his decision to depart in agreement with the list and therewith violated Martinair's own written instructions. Refer to RvO 1.6.3 page 32 and RvO § 1.17.1.4 page 94. Isn't the answer by DASB a wrong answer?

2.2.4.2.2 *Question.* Given the above mentioned facts and questions, and the comments, answers and information given by DASB, do the experts feel that the DASB handled the information it had at the time with due care?

2.3. Flight crew experience

2.3.1. Facts

2.3.1.1. From the CVR transcript it became clear that the co-pilot would land the aircraft. The co-pilot however, had no experience in landing with crosswinds exceeding approximately 15 kt, as Martinair informed DASB (Archive I&M 1-4, 1993-04-19; Appendix 5). This fax, containing the remark *"cross wind till approx. 15 kts"* (while 15 kts was double-underlined with a pencil), was not forwarded by DASB to the Portuguese Commission, because the listed recent experience of the co-pilot in RvO § 1.5.1.2 is not in agreement with the recent flight hours listed in the fax. It was not clear whether the captain was made aware of this limitation. Normally, a co-pilot must inform the captain of his training standards and relevant flight (in)experience before or during the flight.

2.3.2. Comment DASB

2.3.2.1. DASB stated that the crew was correctly licensed, qualified and certified for the operation of the aircraft (Report RVDL3, lijst 4 tab 23, page 8).

2.3.2.1.1 *Remark*. However, DASB were made aware by Martinair (fax referenced above) that the co-pilot had no experience, and hence was not qualified in landing the aircraft in crosswinds in excess of 15 kt as explained in the previous paragraph. The DASB received this information and withheld this information from the Commission. DASB also failed to take this relevant aspect of crew experience into account in their assessment of the causes of the crash.

2.3.3. Comments Experts

2.3.3.1. The three crew members are experienced and qualified for the aircraft type involved in this accident. Generally speaking, a pilot who spends more than 600 hours flying a specific aircraft is subsequently considered as an expert, in regards to the *"human factor*" principles. In other words, the crew members have the capacity to react swiftly and naturally in case an unexpected event occurs during routine procedures (V17 § 8.6.1 page 73).

2.3.3.1.1 *Questions*. The co-pilot flew 118,2 hours as PF during the 6 month prior to the accident and logged 19 landings (Appendix 5). Is a pilot with 600 hours on a specific aircraft to be considered an expert? A pilot is licensed to operate a type of airplane, not to be an expert. Don't Experts agree, after reading this review, that both the captain and the co-pilot did not react "*swiftly and naturally*" during this flight? If not, please explain.

2.3.3.2. Experts, on V17 page 74: "*Let us ask a few questions without answering them (since it is not our mission):*

- *Why did one of the pilots seem to override the functioning of the ATS by decreasing or increasing the thrust in a way that seems to be not adequate to the specific conditions of this phase of the flight?*
- *Why did one of the pilots make such an excessive use of the rudder pedal at an altitude where such actions are neither usual, nor recommended?*
- *Why did a "go-around" procedure seems to be engaged but immediately stopped?*

These questions are not directly listed as potential contributing factors to the accident.

Answers must not be given following mere impressions or without being properly illustrated".

2.3.3.2.1 *Question*. While reading these questions, how can Experts state in the previous paragraph that the pilots with 600 hours are experts? And why are conclusions elsewhere in the interim report different? Please explain.

2.3.4. Remarks and Questions Claimants

2.3.4.1. The NTSB concluded (letter 26 Oct 1994, RvO Appendix) that the Control Wheel Steering (CWS) and Autothrottle System (ATS) were inappropriately used by the flight crew. The co-pilot proved not being able to control the aircraft during the landing with a crosswind higher than 15 kt at Faro in accordance with the procedures in the AOM.

2.3.4.1.1 *Question*. Should not the DASB have concluded that the captain should have taken the control of the aircraft given the fact that the conditions during the approach and landing phase clearly exceeded the experience level of the co-pilot. If not, please explain.

2.3.4.2. The 143 questions posed by the victims were answered in a joint document drafted by Martinair and the DASB. This means that the DASB was well aware of the answers by Martinair before the formal reply was released to the victims, agreed with these answers and thereby took joint responsibly for them. It is important to realise this in the context of every reply to the 143 questions, irrespective of whether the specific question was formally answered by Martinair or by the DASB.

2.3.4.3. *Question 112 of 143 questions*. Does Martinair have company regulations stating that the co-pilot is not permitted to land at a particular crosswind and if so, was the crosswind the crew were aware of above or below this standard? Martinair answered: "*Martinair does have such company regulations. The crosswind the crew were aware of was below this standard*".

2.3.4.4. However, the crosswind, read aloud by the captain from the Area-Navigation system (R-Nav) 10 seconds before landing, was 190°/20 kt, 25% over the maximum crosswind experience of the co-pilot (Appendix 5). Please consider in your reply to the following questions that:

- If windshear is expected, the Pilot-not-flying is required to monitor the R-Nav and, clearly, is not allowed to disregard its readings. BIM 3.1.7 (Appendix 6) states:

  "*If a wind shear in the approach area is expected or known to exist: monitor Inertial/Omega data, IAS, rate of descent, pitch and power, closely for early shear recognition.*
  Do not make large power reductions until beginning of the flare.
  Delay approach or divert if severe thunderstorms are present in the approach area."

- The captain did read the R-Nav wind under conditions with thunderstorms present, i.a.w. BIM 3.1.7 (Appendix 6), at 3.5 minutes and at 10 sec before the landing.

2.3.4.4.1 *Question*. Did the company regulations of Martinair allow for a landing to be performed by the co-pilot with a crosswind that substantially exceeded his experience?

2.3.4.4.2 *Question*. If the answer to the aforementioned question is negative, do the experts agree that the DASB should not have allowed Martinair to give an intentionally faulty reply to the victims?

2.3.4.4.3 *Question*. Was the wind indeed below the standard as Martinair answered, given the large wind correction angle during approach and landing? Should DASB not have intervened here? If not, please explain.

2.3.4.5. *Question 137 of 143 questions*: What about the authority and experience of the Anthony Ruys cockpit crew to fly on a DC-10? Martinair answered: "*All were fully authorised and had more than enough experience to fly on a DC-10*".

2.3.4.6. *Remark*. DASB was informed by Martinair that the co-pilot had no experience in landing in crosswinds exceeding 15 kt (fax Martinair to AIB; Appendix 5). Clearly, the co-pilot was not 'fully authorised' nor did he possess 'more than enough experience to fly on the DC-10', and certainly not enough to perform an approach and landing under the crosswind conditions prevailing at Faro during the landing phase.

2.3.4.6.1 *Question*. How do the experts rate the fact that the DASB failed to comment on this issue and allowed Martinair to answer the victims in this way?

2.3.4.6.2 *Question*. Don't the Experts agree that the inexperience of the co-pilot was a contributing factor to the accident? If not, please explain.

3. En-route and initial descent

3.1. Weather changes en-route and initial descent

3.1.1. Facts

3.1.1.1. During the flight, the weather at Faro airport deteriorated. The CVR transcript (RvO Annex 5) provides the facts from 40 minutes before landing. During the approach briefing at 06:54:56 (UTC – padrão, meaning standard), the co-pilot acknowledges a *"wet runway*". At 06:57:50, the captain said "*you have to make it a positive touchdown*".

3.1.1.2. The weather data the crew received during the last 40 minutes of the flight are included in Appendix 1. The descent started at 07:03:57 when MP495 was cleared to leave flight level (FL) 370 for FL 250.

3.1.1.3. The reported wind to TP120, who took off at 07:21, was 150°/24 kt, meaning a 17 kt crosswind component on the runway. The actual wind at Faro airport had increased to a value higher than the crosswind limit of a DC-10 for both a wet and a flooded runway already 13 minutes before the landing of the DC-10. The crew were aware of the increase, given the recorded remarks on the CVR, but continued the approach.

3.1.1.4. Having heard the wind reports, the crew should have been very alert during the approach. The wind was strong and the direction varied. The runway was contaminated with standing water.

3.1.2. Comments DASB

3.1.2.1. DASB stated in the Report RVDL3 (lijst 4 tab 23, page 2) that *"During the progress of the flight the reported weather did not change. The weather conditions mentioned in the forecast prior to the flight until the final part of the approach remained generally the same, with a reported wind of 150° with a speed of 15 knots, with gusts up to 20 knots only reported at the last moment*". "*The presence of the thunderstorm West of the field at about 8 nm DME was also evident from the increased turbulence encountered at that position, as recorded on the DFDR, and the crew's report of rain intensity and turbulence*".

3.1.2.1.1 *Question*. The facts listed above make it clear that the weather conditions remained not generally the same. The wind varied quite a bit, the runway condition was reported "*flooded*" not only to flight MP495. There might not only have been a thunderstorm at 8 nm west of the field, but a departing flight also reported a local thunderstorm at or near the airport. DASB wrote "*increased turbulence at that [8 nm] position*", but the NTSB only provided graphs of DFDR data from 80 seconds, ≈ 3.2 nm before landing (DFDR data; Appendix 7). Is the statement correct?

3.1.2.2. "*The reported weather at Faro was not of exceptional concern to the crew, since, with the precautions they had taken in view of the wet runway, all conditions were within the operational limits of the aircraft*" (Report RVDL3, lijst 4 tab 23, page 3).

3.1.3. Comments Experts

3.1.3.1. Experts responded with "*Yes*", without motivating this answer.

3.1.3.1.1 *Questions.* Shouldn't the answer of the experts have been "no", the DASB answer is not correct? Wasn't the answer "yes" for the weather conditions the crew was informed of before arrival in the Faro Control Zone, but "no" after they were informed of the actual weather? In the RvO, one of the causes stated by the Commission in RvO § 3.2 is: "*The crosswind, which exceeded the aircraft limits and which occurred in the final phase of the approach and during landing*". Was it not a fact that the runway was flooded, which required either waiting or diverting, i.a.w. AOM 3.3.5 – 15, Appendix 2? The crosswind not only exceeded the aircraft limits, but also the personal limit of the co-pilot; in addition, the approach was not stable at 500 ft. The captain did not timely take control. Both conditions individually required aborting the landing at that time. Don't you agree?

3.1.4. Remarks Claimants

3.1.4.1. The numerous weather reports received en-route, the observations of the on-board weather radar and the wind, precipitation and runway condition reports from both ATC and on-board systems should have led to the conclusion that limitations would be violated when the approach would be continued, already before commencing the final approach.

3.2. Arrival briefing

3.2.1. Required

3.2.1.1. Before commencing the descent for landing, the pilot who conducts the approach and landing will give an arrival crew briefing to inform the other crew members of his intentions and plans, i.a.w. AOM 3.3.5 – 05 (Appendix 8). The Landing Data Card, containing runway, weather data and the three braking actions with the actual landing distances to be used by the pilots, was prepared by the Flight Engineer and handed over to the pilots. The LDC was recovered and included in the RvO Annex 3.

3.2.1.2. During the arrival crew briefing, the co-pilot assigned the captain the task *"you call approaching minimums and field in sight … you looking outside … runway is 2490 … wet runway*" (CVR transcript).

3.2.1.3. AOM 3.7.3 – 04 (Appendix 9) presents the Restrictions for maximum wind components for the runway conditions that were used to complete the Landing Data Card. For *"standing water*", the table lists "*Braking Action POOR*", for which the maximum crosswind component is 5 kt for a runway width of 45 m or more. The maximum component for a runway 40 – 45 m wide is 0 kt. The runway at Faro was 45 m.

3.2.2. Facts

3.2.2.1. The CVR transcript included the last part of the arrival crew briefing. The pilot mentions during the briefing that a runway length of 2490 m would be available, while the actual length was 2445 m, as was also written on the landing data card.

3.2.3. Comments DASB. None.

3.2.4. Comments Experts

3.2.4.1. Experts refer to the Landing Data Chart in the AOM. "*We note that it was possible to plan landing at "maximum structural landing weight", which corresponds to 186,4 tons for both dry and wet runways (as defined by the JAR OPS 1.480 – Terminology)*" (V17 § 8.6.4.4.3, page 101).

3.2.4.1.1 *Question*. This landing weight is not correct for Martinair DC-10. The top line in the graph has the legend "MAR", for Martinair. The maximum landing weight was 192300 kg. The text in the remainder of the paragraph is irrelevant for pilots, the calculation of the landing distance by the Experts is incorrect. Don't you agree?

3.2.5. Remarks and questions Claimants

3.2.5.1. The Landing Data Card showed clearly that the runway of 2445 m would be just long enough for a landing on a wet runway (2400 m), but way too short for a braking action poor (flooded runway – standing water, 3055 m).

3.2.5.1.1 *Question*. A pilot is not authorized to argue these numbers, i.e. to 'amend' the formal restrictions in the Manuals; he simply has to apply them. Don't you agree?

3.2.5.1.2 *Question*. The captain mentioned a possible diversion to Lisbon and the procedure to execute a missed approach, meaning they were prepared to divert (CVR transcript). Don't you agree?

4. Approach

4.1. Approach Stability

Approach stability is often misinterpreted, therefore a brief explanation using the definitions in appropriate manuals.

4.1.1. Rules and Regulations

4.1.1.1. An approach path is considered stabilized if the glide slope is 3° ± 0.5 from the PAPI (1 to 3 white and 3 to 1 red of 4 lights) and the lateral deviation is ± 2° (1 dot on the course deviation display of the Horizontal Situation Indicator - HSI) from the approach radial above 200 ft (AOM 3.3.5 – 11; Appendix 10). In addition, the airspeed is the specified approach speed and the engine thrust is stable to maintain that airspeed and to maintain the correct glide path (rate of descent).

4.1.1.2. Approach stability is also discussed in BIM 3.4.4 – 06 (Appendix 11). "*Early stabilization on the final approach path with respect to glide path and centre line is considered essential. At not less than 500 ft above threshold elevation this flight path stabilization must also be accompanied by a basic stability of speed and thrust, thus ensuring that any disturbing influences or deviations in the latter stage of the approach can be readily recognized and rapidly corrected*".

"*It is therefore strongly recommended that no landing be attempted if the desired stabilization has not been achieved when passing 500 ft above threshold elevation*."

4.1.1.3. "*Should circumstances prevent such stability being achieved before reaching 500 ft, then it must be realized that safe continuation of the approach to landing becomes questionable*" (BIM 3.4.4 – 06, Appendix 11).

4.1.1.4. Stabilized aircraft conditions below the descent limit (500 ft) "*include that the aircraft is in a position from which a descent to landing on the intended runway can be made at a normal rate of descent, using normal manoeuvres and where that rate of descent will allow touchdown to occur within the touchdown zone of the runway of intended landing*" (Stabilized aircraft conditions, BIM 2.3.6 – ii); Appendix 13).

4.1.2. Remarks and Question Claimants

4.1.2.1. Approach stability means that during an approach, the aircraft must be in an imaginary square cone that becomes narrower when the aircraft approaches the runway. If during the approach, with the VOR set on the 111° approach radial, the course deviation needle is more than the above specified number of dots from the centre, or if the aircraft is not on the PAPI indicated glide slope, the approach is no longer a stable approach. If the path of the aircraft is not, or cannot be corrected, a go-around should be considered; if the altitude is below 500 ft, a go-around is mandatory.

4.1.2.2. An aircraft is stable if, following a disturbance form outside, for instance due to the weather, the aircraft returns by itself to the stable point it had before the disturbance. All aircraft are flight-tested prior to certification to determine whether the lateral and longitudinal stability are within the required specifications of the applicable Airworthiness Regulations. Only licensed Test Pilot School graduates are authorized to conduct such flight-testing.

4.1.2.3. An aircraft cannot be called unstable if the pilot induces motions by unnecessary control inputs, as happened during the approach, or if motions are the consequence of atmospheric disturbances.

4.1.2.3.1 *Question*. Don't Experts agree with this established theory?

4.2. Outbound radial, inbound turn and establishing on the approach

4.2.1. Rules and Regulations

4.2.1.1. The Approach Chart (RvO Annex 12; Appendix 12) presents the approach path for landing on runway 11 as published by the Aviation Authorities of Portugal. The proper use of approach charts reduces required radio communications and eases traffic separation. Aircraft are to be established on the approach radial at a specified altitude prior to commencing the descent. This procedure has proven to prevent approach and landing accidents.

4.2.1.2. As Faro airport was not equipped with an Instrument Landing System, but only with a VOR/DME, MP495 had to conduct a so-called non-precision VOR/DME approach, i.a.w. the Faro approach chart mentioned in the previous paragraph. AOM 3.3.5 – 08 (Appendix 14) provides the non-precision approach procedure.

4.2.1.3. AOM 3.7.3 – 04 (Appendix 9) presents the Restrictions to maximum wind components that were used to complete the Landing Data Card i.a.w. AOM 6.4.2 (Appendix 15) and 6.4.3 (Appendix 18). Calculations of maximum allowable wind components for landing should be based upon the Tower reported surface wind (AOM 2.15.4 – 06; Appendix 16), not on the forecasted winds. The crew used the forecasted winds

(140°/14 kt), not the Tower reported winds (150°/ 15 – 20 kt) as the Landing data card proves (RvO Annex 3).

4.2.1.4. "*Information that water is present on a runway shall be transmitted to each aircraft concerned on the initiative of the controller*". One of the terms to be used is "*Flooded*" (ICAO Doc 4444, in 1992 called PANS-RAC; Appendix 17).

4.2.1.5. "*A landing on or a dispatch to a runway with POOR braking action is undesirable. This operation should not be planned unless other factors make it imperative*". "*Decide which braking action has to be taken into account. If with adverse conditions the braking action is not known, request same. When braking action and/or friction coefficient are/is still not known, refer to AOM 3.7.3 [– 04]* [Appendix 9] *to determine braking action by reference to runway condition*" (AOM 3.5.2 – 06; Appendix 20).

4.2.1.6. "*Several conditions may require early stabilization, such as non-precision approaches*" (AOM 3.3.5 – 06; Appendix 19). "*Non-precision Instrument Approaches are approaches without electronic glide slope guidance*" (AOM 3.3.5 – 08; Appendix 14).

4.2.1.7. The approach initiation procedure in AOM 3.3.5 – 08 (Appendix 14) prescribes: "*At 2 nm prior to point "D"* [at Faro 9 nm] *select gear down, at 1 nm prior to point "D"* [at Faro 8 nm] *select landing flaps, set the final approach speed, and perform the landing checklist*". Start of the descent is at 0.5 nm before point D, in this case at Faro 7.5 nm, to allow the aircraft to 'settle' in the selected rate of descent.

4.2.1.8. Although Faro airport did not provide electronic glideslope guidance, it did provide lateral guidance from a VOR/DME ground beacon of which the approach radial can be set in the VOR receiver in the aircraft, that is required by the published procedure, after which the deviation from that radial is displayed on instruments in the cockpit. The ground track of the aircraft above 200 ft must be within 2° of the approach radial, i.e. 111° ±2°, from the moment of interception.

4.2.2. Facts

4.2.2.1. The aircraft was overhead Faro at 07:25:57 out of 4000 ft to 3000 ft i.a.w. instructions from ATC and were cleared for a VOR/DME approach to runway 11 that started with 269° radial outbound from the VOR station.

4.2.2.2. The ATC controller asked a few times whether the aircraft conformed to this requirement.

4.2.2.3. While MP495 was on the outbound radial, at 07:26:20, the air traffic controller advised Martinair flight MP461: "*cleared to land, now 130/18, 21 maximum*".

4.2.2.4. At 07:26:43, the captain advised the co-pilot "*you may turn at 8 nm*".

4.2.2.5. As shown by the ground radar track in RvO Annex 12 (Appendix 12), the aircraft followed the 269° outbound radial quite accurately. Just prior to reaching the turn to final approach, the heading, according to the DFDR data, was ≈ 257°, the airspeed ≈ 168 kt. The correlated crosswind component would then have been ≈ 35 kt (168·tan (269° – 257°)), well above the limits for both a wet and a flooded runway.

4.2.2.6. Just prior to the turn to final approach, the captain said: "*I'll give you 111*" and set this approach radial in in the VOR course window. The co-pilot then ordered "*over right 080*" after which the captain set this heading in the autopilot with the heading selector.

4.2.2.7. Ground radar data, added by the Commission to the approach chart of runway 11 (RvO Annex 12, Appendix 12), shows that the aircraft, rather than establishing on the 111° approach radial at or before 8 nm, crossed the 111° approach radial instead under an angle of 30° at approximately 7.4 nm from the VOR/DME. The autopilot established the aircraft on a heading 080 as requested by the pilot-flying. The ground radar plot in RvO Annex 12 (Appendix 12) shows that the radius toward the end of the final turn was too large to establish timely on the 111° approach radial due to the large crosswind. The result, eventually, was an overshoot of 0.7 nm to a bearing of 118° from the VOR. The radar data also show that the aircraft never returned to and established on the 111° approach radial.

4.2.2.8. During the turn, ATC informed MP495 of the runway being "*flooded*".

4.2.2.9. At Descent point D, the aircraft was not yet in the landing configuration. At 2 nm prior to reaching point D, the landing gear should have been selected down (AOM 3.3.5 – 06, Appendix 19), in this case 2 nm prior to reaching 7 nm DME. At 8 nm the land flaps should have been selected. At ½ nm before point D, the rate of descent must be set in the autopilot so that the descent starts at Descent point D, 7 nm from the VOR/DME station.

4.2.2.10. Twenty seconds after crossing the 111° radial, at 07:29:53, the captain said "*wind is from the right*", and at 07:30:47 "*wind is coming from the right, 30 kt, drift 12°, so you make it 123 or so*" (CVR transcript).

4.2.2.11. Although the heading was adjusted to fly towards the airport, this was not large enough to return to the prescribed 111° approach radial during the remainder of the approach. The deviation from the obligated approach radial became as large as 0.7 nm or 7°, as evidenced by the radar data plot in RvO Annex 12 (Appendix 12), which is much too large. The ground track (shown by the radar plot) of the aircraft above 200 ft should have been within 2° of the approach radial, i.e. 111° ± 2°, meaning that the early stabilization, as intended in AOM 3.3.5 – 06 (Appendix 19), was not achieved.

4.2.2.12. The captain did not urge the co-pilot to return to and follow the 111° radial; no remarks were recorded on the CVR. The early stabilization on the approach radial, as required by BIM 3.4.4 – 06 (Appendix 11) for warranting the safety and prevent accidents, was not achieved; the deviation was much too large and not reduced. The flight crew did not comply with the stable approach criteria (§ 4.1.1 above).

4.2.2.13. The captain confirmed to see the runway from 4 nm out.

4.2.2.14. Having heard the wind reports, a professional flight-crew should have been very alert during such an approach. The wind was strong (peaks of 5 Beaufort) and the direction varied; a thunderstorm was reported by departing flight TP120 at or near the airport. The runway was reported flooded, i.e. contaminated with standing water, for which the braking action is POOR (AOM 3.7.3 – 04; Appendix 9 and AOM 3.3.5 – 15; Appendix 2).

4.2.2.15. During the information meeting on 1 Dec. 1994, Mr. Snoek said [8]: "*In the right turn here the pilot did all of the checks he was supposed to do before the landing - flaps and wheels - and had finished them when the aircraft was here at 7 miles inbound*".

4.2.3. Comments DASB

4.2.3.1. DASB did not comment on the large deviation from the approach radial, and that the aircraft should have returned to that radial (for meeting the stable approach criteria).

4.2.4. Comments Experts

4.2.4.1. "*Turning at 8 NM DME allows then to avoid the stormy zone while respecting, first, the trajectory as defined by the approach map, and second, the descent point as established by the procedure*" (V17 page 90).

4.2.4.2. "*Experts also consider that the choice by the pilot flying to stabilize the flight path for a few seconds to heading 080° was an excellent decision, allowing both a clear final approach path interception without going above the final descent path*" (V17 page 90).

4.2.4.2.1 *Remark*. The radar approach path in RvO Annex 12 (Appendix 12) shows that the autopilot steered the aircraft exactly to heading 080 despite the strong southerly wind. However, the pilot did not anticipate the effect of the crosswind by timely selecting a new heading to remedy the overshoot and intercept the 111° radial from the North.

4.2.4.2.2 *Question*. Why do Experts call "*the choice by the pilot flying to stabilize the flight path for a few seconds to heading 080° an excellent decision*" given the fact that this choice of heading led to an overshoot of 0.7 nm?

4.2.4.2.3 *Question*. Why do Experts call heading 080 an excellent decision when the autopilot can be used to establish on the 111° approach radial, without overshooting it?

4.2.4.2.4 *Question*. What do the Experts mean when they state that the decision to select the heading of 080° was excellent because it allowed a "*clear final approach path interception without going above the final descent path*", given the fact that the aircraft was already at 2000 ft during the inbound turn?

4.2.4.3. "*The only critique we could make towards the crew is not to have sufficiently anticipated the beginning of interception because of an unfavorable wind that pushed the aircraft outside of the planned trajectory. Moreover, the turn toward the final approach radial was performed with only a 25° bank angle because it was performed through the autopilot, which induced a slight overshoot from the approach axis that should have been adjusted immediately*" (V17 page 90).

4.2.4.3.1 *Remark.* DFDR roll data shows that the roll angle was only maintained up to 30° until approximately halfway the final turn; then the wings were kept level. The data shows that no attempt was made to continue the turn to establish on the 111° radial.

4.2.4.3.2 *Questions*. An overshoot to an offset of 0.7 nm, to a bearing of 118° rather than 111°, cannot be called a *"slight overshoot"*. Experts correctly say that this overshoot "*should have been adjusted immediately*". The pilots must have noticed the large drift angle on the outbound radial, given the fact that they stayed perfectly on this radial. Doesn't this mean that they should have extended the outbound leg in anticipation of a larger radius resulting in a probable overshoot of the inbound radial? Shouldn't this also mean that the pilot-flying should have set a proper heading for a radial intercept taking into account the prevailing drift angle which is standard practise for professional pilots?

4.2.4.3.3 *Questions*. Why do Experts call the overshoot a slight overshoot while the radar plot in RvO Annex 12 (Appendix 12) shows a considerable overshoot? Does the radar plot not show that the turn might have started with a bank angle of 25°, but that the bank angle reduced, increasing the turn radius? Can you call this pushing the aircraft outside of the planned trajectory by the unfavorable wind? Would it not just be an obvious failing of the pilot-flying in not intercepting a VOR radial under the existing winds?

4.2.4.4. "*The statements made by the Flight Engineer (F/E) show that the flight goes through a stormy and bumpy area ("…experienced turbulences that could be classified as stronger than moderate.") at around 8 nautical miles during the right hand turn towards the final path, before settling at the right axis for final approach. The flashing of the feed pumps lights demonstrates a major flight path correction made by the automatic pilot in order to maintain the actual altitude" and explain that "these lights would flash… due to a strong nose up action*"(V17 § 5.2.2.2 page 19).

4.2.4.4.1 *Questions*. Since the DFDR data during the turn only once show a small increase of the normal g to 1.4, which is less than occurred during final approach, and that the DFDR data do not show a major flight path correction, neither a strong nose up action, nor a change in roll exceeding 4° at all, the question raises what the Experts are talking about. Did Experts conclude these facts using objective data? Where do Experts have these data from? Please explain. Don't Experts think this statement is misleading?

4.2.4.5. Experts question the accuracy and the source of the maps used in the investigation (V17 § 8.6.4.5, page 105) and ask *"what are the sources from which the maps are designed*?". And that *"depending on the type of radar, especially the angular accuracy can be strongly different*".

4.2.4.6. Experts conclude that their analysis shows that the crew respected the published approach procedure (V17 § 6.4, page 35).

4.2.4.6.1 *Question*. Are the experts aware of the fact that the approach was not executed in accordance with AOM 3.3.5 – 06 (Appendix 19) and 3.3.5 – 08 (Appendix 14).

4.2.5. Other Remarks and Questions

4.2.5.1. At 07:24:58, 8.5 min before landing of MP495, MP461 was informed by the ATC controller: "*the runway is flooded and the wind 150/20 kt*". The crosswind component of this wind was 14 kt (9 kt too high for a flooded runway, 1 kt below the limit for a wet runway); the MP495 crew heard this message. At 7 min before landing of MP495, the ATC controller transmitted to MP461 that the wind was 130/18-21 (crosswind component 8.5 kt). The wind at the airport was obviously strong and varying.

4.2.5.2. The remaining flight time of the DC-10 to the landing would be too short for the water to drain from the runway, which takes 15 – 20 min, according to the DC-10 AOM 3.3.5 – 15 (Appendix 2). The runway would still be flooded upon arrival, so at this moment, the crew should already have decided to discontinue/abort the approach and either wait or divert. Twenty minutes earlier at 07:05:30, the captain had said: "*If we don't make it we go directly to Lisbon*".

4.2.5.3. As mentioned in the facts above, the crosswind during the outbound leg must have been ≈ 35 kt given the heading and the airspeed recorded in the DFDR. This crosswind would be much too high for a landing on a wet runway, let alone a flooded runway (for which the limits were 15 kt, resp. 5 kt; AOM 3.7.3 – 04, Appendix 9). Shortly thereafter, ATC informed MP495 also of the runway being flooded.

4.2.5.4. The 111° approach radial must have been set with heading select by the pilot-flying and visible on both Horizontal Situation Indicators. These indicators must have timely indicated that the approach radial was going to be overshot, but the co-pilot took no action. The result was an eventual overshoot of 0.7 nm to a bearing of 118° from the VOR. The aircraft should have returned to the 111° radial at once, but did not. The captain did not take action either (RvO Annex 12; Appendix 12). The radar data also show that the aircraft never returned to and established on the 111° approach radial which is against the published procedures of both the airport and the aircraft.

4.2.5.5. The captain obviously used the 30 kt wind to advise heading 123° (§ 4.2.2.10 above). This wind was not much lower than the wind that they experienced on the outbound radial and was not provided by ATC, so the captain must have obtained it from reading the appropriate display of the R-Nav system. As the DFDR data and radar plot shows 123° was the approximate heading required to fly near parallel to the 111° VOR radial, not to return to it. The captain should have commanded to return to the approach radial first, then to go along the 111° radial to the runway while descending. By not doing so, the safe continuation of the approach to landing became questionable, as warned for in BIM 3.4.4 – 06 (Appendix 11).

4.2.5.6. The strong 30 kt wind from the right would be way too high for landing. This should have led to a go-around also at this point, 3.5 min before landing.

4.2.5.7. Being established at 7 nm requires being on the approach radial at 9 nm. This was not the case.

4.2.5.8. The aircraft did not return to the 111° VOR approach radial; this would increase the workload during the remainder of the flight, and lead to failure of meeting the stable approach criteria when passing 500 ft (BIM 3.4.4 – 06; Appendix 11). The captain should have commanded a return to the approach radial.

4.2.5.9. Not being in a stable approach is a contributing factor to the accident.

4.2.5.10. DASB should have remarked the large crosswind and the overshoot of the final turn and comment on. These were also 'contributing factors' that should have been concluded and included by DASB.

4.2.5.10.1 *Question*. Was the lack of intervention by the captain for not returning to the approach radial for meeting the stabilized approach criteria acceptable at a distance of less than 8 nm from the airport?

4.2.5.10.2 *Question*. Do Experts still insist that the crew indeed respect the published approach procedure? If Experts don't agree, please explain.

4.2.5.11. Experts question the accuracy and the source of the maps used in the investigation (V17 § 8.6.4.5, page 105) and present three possibilities. Only one of these options was used by the Commission; RvO § 1.11.1 states that the recordings of DFDR, AIDS and Radar were used to reconstruct the last flight phase; the legend of RvO Annex 12 (Appendix 12) therefore states that the aircraft path is "*Trajectória Radar*". The ranging and the angular accuracy of the Air Traffic Control radar was very accurate, as the plot of the outbound track shows; the outbound track and the turn at 8 nm are accurately shown. Hence, the plot of the inbound track is accurate as well.

4.2.5.12. In the same NOTE, the Experts state: "*For the DC10 inertial systems, the accuracy is of 1 NM/hour, constantly maintained depending on the useful radio-aids systems. The best performance happens with a dual-DME updating system and is therefore maintained around 1 NM, meaning an imprecision radius of 2 km*"! This is not true.
The drift of an INS is 1 nm/hr if not updated by VOR/DME (on this DC-10). The error is not maintained, as Experts write, but is a growing error over the hours if the INS is not automatically updated by VOR/DME, and relevant for pilots to realize when flying long

stretches over oceans when no land-based VOR/DME updates are available. After 6 hours over water, the INS error, in this case, might be up to 6 nm. When automatically updated by VOR/DME, the accuracy of the INS will continuously have the accuracy of the VOR/DME stations used for updating. For this case, at distances of less than 8 nm from a VOR/DME, the accuracy of the INS must have been quite good, but the Commission used ground radar data though, not INS data. Experts are obviously not familiar with the operation of an INS and have no expertise of ground radar and other positioning systems for logging the track of an aircraft. They should not have mentioned this.

4.2.5.12.1 *Question*. Would Experts consider rewriting their statements about the ground radar and airborne navigation systems to standard engineering and/or flight-test knowledge and practises, and use the correct symbols as defined in the SI unit's system? If not, please explain.

4.2.5.13. The ground radar plot in RvO Annex 12 (Appendix 12) shows that the radius of the final turn was larger because of the crosswind, and that the aircraft was not established on the approach radial 111°. The CVR transcript and DFDR data prove that the aircraft at 7 nm was not configured for landing either. At Descent point D, 7 nm from the VOR/DME, the aircraft should have been in the configuration for landing, but it wasn't. AOM 3.3.5 – 06 (Appendix 19) states that for non-precision approaches, the landing gear needs to be selected down at 2 nm prior to point D and the landing flaps selected 1 nm prior to point D; both were selected too late (refer to AOM 3.3.5 – 06; Appendix 19). Not being established on the approach radial in-time increased the workload and is a contributing factor to the accident which the DASB should have identified.

4.2.5.13.1 *Question*. Don't Experts agree that the crew was too late configuring the aircraft for landing (at the keypoints). If Experts don't agree, please explain.

4.2.5.14. The landing gear was selected down too late, as were the landing flaps. When the vertical speed is set in the autopilot 0.5 nm prior to reaching 7 nm DME (AOM 3.3.5 – 08; Appendix 14), then the aircraft will start its descent accordingly at 7 DME, which will lead to a stabilized glide slope. Stable approach criteria were never met as DFDR data shows; a go-around should have been initiated i.a.w. BIM § 3.4.4 – 06 (Appendix 11).

4.2.5.14.1 *Question*. Why do experts rely on statements by the pilots, and not on objective DFDR and ground radar data?

4.2.5.15. *Question 39 of 143 questions*. Is it true that the Anthony Ruys flew over Almanville while one would normally fly over Villamoura, 20 km away? AIB answered: "*According to the radar plot, the Anthony Ruys followed the normal, specified approach path, as instructed by traffic controllers*".

4.2.5.15.1 *Remark*. Experts remark that "It is the normal work of the ATC-system to provide more direct routes (“Direct to...”, Radar vectors, etc.)". This is not the answer to the question.

4.2.5.15.2 *Question*. The answer given by the DASB pertains to the entire radar plot and not just to the initial approach. Did the aircraft indeed follow the normal, specified VOR approach path as instructed by the traffic controller throughout the whole VOR procedure, as assigned to them? No deviations, no overshoot that was not corrected and well established on the 111° radial? Did the DASB not purposely give an incorrect answer? If not, please explain.

4.2.5.15.3 *Question*. Was the answer that Mr. Snoek formulated during the information meeting on 1 Dec. 1994 in accordance with the CVR transcript and radar plot, and did Mr. Snoek tell the truth?

4.3. Approach speed

4.3.1. Rules and Regulations

4.3.1.1. The runway threshold speeds are prescribed in the AOM and depend on flap setting and landing weight (AOM 6.4.3; Appendix 18). The approach speed is always a minimum of 5 kt higher than the threshold speed for all normal configuration approaches. If steady state wind and/or gusts exceed specified values, an additive, called Wind Correction Factor, must be added to the approach speed to ensure a safe approach (AOM 3.3.5 – 03; Appendix 21).

4.3.1.2. When using autothrottle, the speed command must be set to at least the threshold speed + 5 kt, the sum of which is called the ATS reference speed.
In addition, "*During gusty wind conditions, the ATS will add up to a maximum of 5 kt to the ATS reference speed*" (AOM 3.3.5 – 03; Appendix 21).

4.3.1.3. The AOM requires a speed increment above the threshold speed and/ or a gust wind correction to be added for a safe approach speed under gusty winds (AOM 3.3.5 – 03; Appendix 21).

4.3.2. Facts.

4.3.2.1. The threshold speed for the 50° flaps and the actual landing weight of 161400 kg was 139 kt (RvO page 104, AOM 6.4.3; Appendix 18). The approach speed for the configuration and weight of the aircraft had to be 5 kt higher.

4.3.2.2. The approach speed was set at the threshold speed of 139 kt, not at the threshold speed + wind correction factor, 144 kt (AOM 3.3.5 – 03; Appendix 21).

4.3.3. Comments DASB.

4.3.3.1. *"The reference speed Vref was mentioned as 139 knots*". According to AOM procedures a Wind Correction Factor with a minimum of 5 knots should be added to this value, and this value (144 knots) should be inserted into the ATS Speed Window. The captain was positive in his statement that he indeed had inserted 144 knots. After the accident the value in the ATS Speed Window was found to be 139 knots, not 144 knots (RVDL3, lijst 4 tab 23, page 5).

4.3.4. Comments Experts.

4.3.4.1. In V17 § 5.2.2.4, Experts state that the REF speed was 139 kt, they mean threshold speed, because in the AOM of 1992, "REF speed" did not exist.

4.3.4.2. *"Regarding the speed to be inserted if the ATS speed window, and regarding the KLM Flight Crew Operating Manual, the REF speed was 139 knots*". Experts conclude "*the value of the actual indicated airspeed to monitor during the final approach should be around 144 knots*". In V17 § 8.6.4.2.2, Experts however state that "*the approach command speed bug (yellow bug) should also be set at 139 knots*".

4.3.5. Remarks Claimants.

4.3.5.1. The AOM prescribes a threshold speed, which in this case was 139 kt (AOM 6.4.3; Appendix 18. The approach speed is always higher than the threshold speed, for the DC-10 at least 5 kt higher (AOM 3.3.5 – 03; Appendix 21). During gusts above 5 kt, the airspeed has to be increased, up to a max. of 15 kt. In addition, during gusty wind conditions, the autothrottle system will add up to a max. of 5 kt to the speed above the speed set in the autothrottle system by the pilots.

4.3.5.2. The approach speed for the reported wind had to be 139 + min. 5 kt = 144 kt. Until 80 sec before touchdown, DFDR data show no or very little turbulence. The recorded airspeed however was ≈ 139 kt, 5 kt too low. Thereafter the recorded turbulence was light. From that moment, the airspeed started varying because the autothrottle system increased the thrust for adding 5 kt until the gusts decreased again. The airspeed graph shows several airspeed increases and decreases during the last 80 sec of flight. The average of the airspeed however, was 5 kt too low.

4.3.5.3. The reported wind with the landing clearance was 150°/ 15 – 20 kt, hence the gust was 5 kt. The steady state wind was below 20 kt, so the minimum wind correction factor was still 5 kt (AOM 3.3.5 – 03; Appendix 21). The gust was 20 – 15 = 5 kt, which required no gust wind correction. Hence, in this case, the required approach speed was 139 + the greater of steady state (5 kt) and gust increment (0 kt) = 144 kt (AOM 3.3.5 – 03; Appendix 21). The airspeed set in the ATS however was 139 kt, 5 kt too low.

4.3.5.4. When the arrival briefing was given by the pilot-flying, there was no gust in the received weather reports, so the final approach speed (threshold speed + wind correction factor) should have been 144, not 139 kt.

4.3.5.5. In one paragraph Experts want 144 kt, in another 139 kt. It seems that the Experts do not agree amongst themselves. The AOM is clear: 144 kt.

4.3.5.6. As the airspeed graph in DFDR data (Appendix 7) proves, the airspeed was an average of 139 kt, with several temporary 5 kt increases during the last 80 sec of the approach by the autothrottle system to increase the safety of the approach during gusty winds (when the vertical g increased). The airspeed decreased back to 139 kt when the turbulence decreased. If set to 144 kt, the airspeed would not have decreased below this minimum approach speed; a 5 kt increase by the autothrottle system during gusts (to 149 kt) would have increased the safety of the approach in case the aircraft would indeed have encountered windshear. By setting a too low speed, which was not in accordance with the AOM 3.3.5 – 03 (Appendix 21), the pilots did not maintain a high level of approach safety, but jeopardized it in the known bad weather conditions with large crosswind and nearby thunderstorms.

4.3.5.6.1 *Question*. Do Experts now agree which approach speed was as required by the AOM, and was this safe for the weather conditions? If not, please explain.

4.4. Alleged windshear during the glide path

4.4.1. Rules and Regulations

4.4.1.1. Operating Manuals describe operations in windshear environment (BIM 3.1.7, Appendix 6) and windshear recovery techniques (AOM 3.3.8 – 02, Appendix 22). This AOM paragraph also presents guidelines that *"marginal flight path control may be indicated by deviations from target conditions in excess of: ± 15 KIAS, ± 500 ft/min, ± 5° pitch attitude and unusual throttle position for a significant period of time"*.

4.4.1.2. "*If flight path control becomes marginal at low altitudes, initiate the recommended Windshear Recovery Technique without delay. Accomplish the first two steps simultaneously*" (AOM 3.3.8 – 02; Appendix 22):

- "*disengage the auto-throttles and aggressively apply the necessary thrust to ensure adequate aircraft performance*".
- "*Increase the pitch attitude as necessary toward an initial target attitude of 15°*".

4.4.1.3. BIM 3.1.7 (Appendix 6) describes windshear environment. Two quotes, that are of relevance:

- "*Delay approach or divert if severe thunderstorms are present in the approach area*", and
- "*If windshear has been encountered, this should be reported immediately to ATC. Reports should include altitude and amount of shear*".

4.4.2. Facts

4.4.2.1. At no point during the approach, the deviations from the target conditions of airspeed, rate of descent and attitude, as recorded on the DFDR, increased above the values that would indicate the crossing of a windshear area, i.a.w. § 4.4.1.1 above.

4.4.2.2. From a detailed analysis of the SIO data, the Commission determined a wind gust of 220° and 35 kt occurred, a strong gust from the side and from behind. The published SIO data however, do not support this conclusion. The SIO data table was not synchronized with UTC and had a time lag of 1.5 minute. The accident occurred in the SIO time between 07:31:30 and 07:32:00. The SIO in this period measured a wind direction between 160 and 180 degrees and a wind speed between 22 and 35 kt. This is within the bandwidth of the wind the captain read from the R-Nav. Nothing indicates that the wind direction was between 40 and 60 degrees larger than was registered by the SIO. The SIO did not issue a windshear warning notwithstanding the fact that the system was capable of this and was functioning properly.
The Commission stated that SIO records the average and maximum wind speeds every 30 sec, as well as the average wind direction during the last 2 minutes. No data is recorded about variation of wind direction nor sudden wind and minimum wind. Therefore, it is impossible to conclude from the displayed average wind direction from the SIO table at the time of the accident (from 160 to 180 degrees), that a wind direction of 220 degrees occurred. DASB should have noticed this. Moreover, DFDR data do not support the thesis that such a wind occurred. On the contrary.

4.4.3. Comments DASB

4.4.3.1. "*The Dutch Aviation Safety Board remains cautious in regards to the vertical speed values as it seems that these values are merely computed, and not recorded by sensors.*
The Experts agree here that such caution is appropriate" (V17 page 25).

4.4.3.2. *"The calculations of the NLR showed three areas of downburst/microburst activity along the aircraft approach path (Report RVDL3, page 5). The first one, a downburst, which the aircraft crossed at about 700 ft, has been discussed in the Portuguese report. The two others were microbursts, classified as small. The aircraft flew through the second one while descending from 600 ft to 300 ft. This microburst could have had an influence on the instability of the approach. The position of the third microburst was approx. 1 km in front of the runway, with the aircraft descending from 200 ft to 110 ft. This microburst, according to the calculations made by NLR, caused headwind to tailwind changes of a magnitude which would have triggered a windshear alert system, if such a system had been installed in the aircraft. The NLR study also showed that the experienced windshear occasionally was beyond the aircraft performance limits, and* *that one such occasion took place when the aircraft was at about 150 ft altitude*" (Report RVDL3 page 4).

4.4.3.3. "*The aircraft in the final phase of the approach passed a turbulence area associated with windshear and downburst phenomena that initiated a longitudinal instability of the aircraft*" (Report RVDL3 page 9).

4.4.4. Comments Experts

4.4.4.1. *"The NLR has identified three situations of downbursts and areas of turbulence with microbursts; as it happened, it seems to be the third one that could really be of interest since the two previous ones were passed successfully, even though it caused instability of the aircraft on its trajectory.*
For this last situation of downbursts and areas of turbulence with microbursts, it corresponds to a wind that would go from 170° to 190° (in average) in 20 seconds, and a speed of 27-28 knots to 45 knots.
This could very well explain the leaning leftward, but not necessarily, the brutal variation of bank angle. These variations of wind, whatever its effects, are significant" (V17, page 30).

4.4.4.1.1 *Question*. Do Experts agree with the occurrence of windshear/downbursts after reviewing the DFDR data? If not, please explain. And how did Experts derive or verify the mentioned winds?

4.4.4.1.2 *Question*. Do Experts really agree to the *"brutal variation*" of bank angle? Doesn't the DFDR roll data show a slow increase over 8 sec that was the side effect, the consequence of the near maximum rudder input to the left without proper aileron to the right? If Experts don't agree, please explain.

4.4.4.1.3 *Question*. Experts wrote: "*the commission has no reason to reject the NLR conclusions*" (V17, page 32). Since Experts used NLR data and graphs, they must agree with the data. But have Experts reviewed the NLR report with their aeronautical knowledge? Are the data correct? Do these agree with the RvO, taking into account the clock time differences? Experts were asked for their expert opinion. Please explain.

4.4.4.2. "*The NLR has conducted two studies that both confirmed that the aircraft went through three windshears below 1000 feet/ground, after 07:30:30 UTC*" *(V17, § 6.1 page 34).*

4.4.4.2.1 *Remarks*: The NLR issued two reports, "Windshear analysis using flight data from the DC-10 crash at Faro airport", CR 93080 C, that was never officially published and hence should not be used, and "Analysis of additional flight data of the DC-10 accident at Faro airport", CR 94238 C, that was included in RvO Annex 4.
The NLR research engineer and his chiefs who wrote and approved these reports were obviously not aviators, and were neither (made) aware of the non-precision (VOR-DME) approach procedures and the requirements for intercepting a visual (PAPI) glide path using the autopilot and autothrottle systems, nor of the effects of windshear and downdrafts on a DC-10 as presented in AOM 3.3.8 – 02 (Appendix 22). This procedure includes: "As guidelines, marginal flight path control may be indicated by deviations from target conditions in excess of: ± 15 KIAS, ± 500 ft/min vertical speed, ± 5° pitch attitude and unusual throttle position for a significant period of time". BIM 3.1.7 (Appendix 6): "If wind shear has been encountered, this should be reported immediately to ATC. Reports should

include altitude and amount of shear". The crew reported nothing; neither did the crew of MP461. Refer to § 4.5.5.1 for additional information.

4.4.4.2.2 *Question*. Did Experts verify the analysis by the NLR on the existence of windshear? What would you see on the altitude graph when the pilot transitions from the vertical speed mode of the autopilot to CWS for manual glideslope following a little late? Don't Experts think that the short ≈ 12 sec near-level flight from 50 secs before touchdown was the consequence of the transition from auto flight in vertical speed mode to a manual descent in CWS mode? If Experts don't agree, please explain.

4.4.4.3. "*The third windshear — through which the aircraft went at a very low altitude —has caused an important flight path deviation followed by a loss of control; the latter led to a descent rate way above the value that the landing gear could support*" (V17, § 6.1 page 34).

4.4.4.3.1 *Remark*. The PAPI may be only followed down to 200 ft above the runway threshold. "Thereafter the aircraft must be brought gradually above the "on glide slope" indication to provide a 30 to 40 ft wheel clearance at the threshold" (AOM 3.3.5 – 14; Appendix 23). The captain obviously knew this which was the reason that he said three times "bit low" just below 200 ft because the aircraft might have descended a little below the PAPI glide path. The pitch angle increased and aircraft indeed reduced the rate of descent for 5 sec. This glide path correction cannot be explained as windshear; it is normal procedure. The radar altitude graph is a near straight line and does not at all show an important unintentional flight path deviation. The airspeed did not yet decrease during this routine glide slope correction, hence no sudden increase of wind.

4.4.4.3.2 *Remark*. The DFDR graphs do neither show an important flight path deviation at all, nor a loss of control. The airspeed was well above stall speed all the time; controls in all three axes were never maximal deflected. The aircraft responded to control inputs until the touchdown. Experts should be required motivating their answer in physics and engineering terms. The rate of descent and the landing gear failure will be discussed in § 5.11.

4.4.4.3.3 *Question*. Don't Experts think that the short near-level flight at 200 ft was the consequence of the captain's concern not to descent too low as described in the PAPI approach procedure in AOM 3.3.5 – 14 (Appendix 23), and that it had nothing to do with windshear? How did Experts derive the winds mentioned in V17 § 5.2.3.3.2 for the last situation of downburst? Is this not an assumption, rather than objective data? How did Experts conclude that the flight path correction at an airspeed well above the stall speed resulted in a loss of control? Please motivate your answer using objective data of DFDR and/or AIDS.

4.4.4.3.4 *Questions*. Did the airspeed, altitude and thrust changes as recorded on the DFDR come near to what can be expected when crossing a zone with downdraft or worse (as defined in AOM 3.3.8 – 02; Appendix 22)? Could it be that the scientist of the NLR, who was or might have never been made aware of the manual approach procedures, misinterpreted the resulting change in the rate of descent as being windshear, while this was a consequence of the procedural requirement to provide a 30 to 40 ft wheel clearance at the runway threshold?

4.4.4.3.5 *Question*. The NLR used computer based models for the windshear analysis. Were these models and the analysis of the NLR correct?

4.4.4.4. *"The Experts estimate that these variations of speed and direction of the calculated wind have to be taken into account, and as a result, they induced accelerations and turbulences" (V17, § 6.1 page 34)".*

4.4.4.4.1 *Remarks*: The DFDR airspeed data indeed shows variations. But these had nothing to do with the wind. The ATS system receives input from many sources: central air data computer (airspeed), thrust rating computer, engine speed sensors, elevator control input (control column), attitude (pitch angle), acceleration sensors (g's) and from other significant parameter transducers. The DFDR data graphs in RvO Annex 15 (Appendix 7) show that as soon as the pilot inputs elevator (pitch) commands with the control column, the ATS responds with increasing or decreasing the engine rpm.
The gust filter in the ATS not only receives the actual airspeed of the aircraft and the commanded airspeed, but also the normal (vertical) g, longitudinal g, Mach no. and altitude rate. Please refer to DC-10 Schematic Diagrams ATA no. 22-31. When the gust filter detects gusts, then the ATS increases the airspeed with 5 kt instantly. When the vertical acceleration and/or the other parameters decrease again, the airspeed increment is reduced. The gust filter did its work as can be confirmed by analysing vertical g, airspeed and data of the DFDR data graphs in RvO Annex 15 (Appendix 7).

4.4.4.5. "*It seems likely that certain actions taken by the pilots had contributed to the increase of the rate of descent, which ultimately was excessive*".

4.4.4.5.1 *Remarks*: Agreed, but not with 'likely'. The throttles were closed at 150 ft, the airspeed decreased and when the captain initiated a go-around, the engines needed too much time to spool up. We would just say that the pilots made catastrophic mistakes despite being trained, and despite the airport and aircraft procedures that were in place and had to be, but were not respected.

4.4.4.6. "*All that being said, it is not in the Dutch Aviation Safety Board competencies to requalify the NLR's conclusions. This makes no sense since the Dutch Aviation Safety Board has neither the expertise not the responsibility to did it*".

4.4.4.6.1 *Remarks*: The DASB contracted the NLR, represented the Commission in The Netherlands as accredited representative and should have provided better guidance to and assisted the engineers who obviously had no flying experience and did not know about manual, non-precision approach procedures using a PAPI. Instead, the DASB's only objective seemed to receive a report in which the existence of windshear was proven.

4.4.4.7. A major change of meteorological conditions actually occurred during the very last part of the approach, inducing an instability of the flight. The Expert's investigation shows that this instability has started at around 800 feet height. The Experts however, *"do not feel confident enough to affirm that the intensity of these wind shears was sufficient to be a contributing factor to the accident*" (V17 § 5.2.2.2 page 21).

4.4.4.8. The Experts say that "*it is very likely, not to say certain that the weather conditions at arrival disturbed the approach and that the crew could simply not control the aircraft in these conditions*" (V17 § 5.2.2.2. page 21).

4.4.4.8.1 *Question*. On what factual basis do the Experts draw this conclusion?

4.4.4.9. "*The Dutch Aviation Safety Board is on the same position as the Commission of Investigation about the beginning of instability, calling it, « oscillations in pitch, air-speed and engine power ».*
The Dutch Aviation Safety Board regards the beginning of instability as being likely due to the first downburst the aircraft had to go through.
The Dutch Aviation Safety Board believes that oscillations might have increased following the second and third microburst that occurred during final approach, and also following interactions coming from the ATS and the pilot's control inputs" (V17 § 5.2.2.4, page 24).

4.4.4.10. "*The Experts confirm that instability increased until the loss of control. However, the Experts do not confirm the interactions of the ATS and the pilot's control inputs because neither the Dutch Aviation Safety Board nor the Commission of Investigation substantiated this theory*" (V17 § 5.2.2.4 page 25). The Experts agree that a caution is appropriate for using the calculated vertical speed values as DASB did.

4.4.4.11. "*The Dutch Aviation Safety Board indicates that the crew was not informed of the existence of windshear, and, in the Expert's opinion, this is correct. At this time, there was no instrumentation related to windshear conditions available on-board, and the crew was only able to suppose that this kind of conditions could be effective because of thunderstorms*" (V17 § 5.2.2.2).

4.4.4.12. "*The Experts estimate therefore, that the comment made by the Dutch Aviation Safety Board — "the crew did not expect the existence of windshear phenomena"— is not fully appropriate*".

4.4.4.12.1 *Question*. Do Experts agree that there was no windshear, but just bad weather, a large crosswind and light turbulence and misuse of aircraft automated systems by the co-pilot, and that the aircraft should not have continued the approach? If not, please explain.

4.4.4.12.2 Question. Was the DASB correct in stating that "The aircraft in the final phase of the approach passed a turbulence area associated with windshear and downburst phenomena that initiated a longitudinal instability of the aircraft"? If Experts don't agree, please explain.

4.4.5. Other Remarks and Questions Claimants

4.4.5.1. Claimants do not agree that the meteorological conditions induced an instability of the flight. Variations (inappropriately called instability by Experts) were caused by the pilot-flying, who did not fly the procedure according the AOM, starting from turning to final approach radial. Incorrectly applied procedures disturbed the approach in the first place.

4.4.5.2. At no point below 1000 ft during the approach, the flight path control became marginal, as DFDR data confirms. There were no large deviations recorded on the DFDR from the target airspeed, vertical speed, pitch attitude and unusual throttle position for a significant period, caused by external factors that would support the occurrence or existence of any windshear or downdraft. There was no mention of these factors in the CVR transcript, while the pilots would have been obligated to report encountered windshear (BIM 3.1.7; Appendix 6). The pilot-flying, who was late in correcting the glide path to the PAPI glideslope and who did not understand how to control an aircraft with the autopilot in CWS mode (see below), caused the deviations that occurred.
Martinair CEO Martin Schröder introduced the strategy of windshear being the cause

of the accident already on the day following the accident during a press conference. Objective DFDR and AIDS data do definitely not confirm the occurrence of any windshear. Although the data shows perturbations due to wind and light turbulence, control inputs in all three axes were never maximal, meaning that the aircraft remained controllable down to touchdown.

4.4.5.3. The NTSB accredited representative wrote in his letter of 26 Oct 1994 to the Commission (Appendix to the RvO): *"If the Commission feels that windshear was present during the approach then consideration should be given to recommending implementation or review of crew training for windshear recovery*". A diplomatic way of saying there was no windshear. The NTSB had investigated many windshear events, but Faro airport is today still not on the list of airports where windshear occurs (SKYbrary).

4.4.5.4. At 65 sec before touchdown, the pilot decreases the pitch angle; the ATS immediately reduces the required thrust in anticipation of an airspeed increase. From 60 sec, the pilot started pulling the control column to again increase the pitch angle, after which the ATS again immediately started increasing the thrust level to prevent the loss of airspeed. This happened at the instant that the co-pilot noticed being below the PAPI glide path. The thrust increase was not due to windshear. From 20 sec before touchdown, the co-pilot again increased the pitch angle, to which the ATS responds with a large increase of engine rpm. The increased engine noise 15 sec before crossing the runway threshold might have caused the co-pilot to close the throttles by hand and not allow an acceleration that would lead to a landing further down the (short) runway.
As the DFDR data in RvO Annex 15 (Appendix 7) shows, only a small movement of the control column results in engine rpm variations and hence also to changes of airspeed and longitudinal acceleration. The co-pilot did not control the aircraft with the autopilot in the CWS mode as it is designed to be used. Unnecessary additional control inputs above the normal CWS controlled inputs result in the ATS over-responding, hence in large thrust variations, and consequently also in airspeed and acceleration changes.

4.4.5.5. The variations of speed were only small and can be explained fully by the pilot behaviour and the operation of the ATS, which is designed to protect against the negative influence of gusts and to respond quickly to pilot inputs. The variations cannot be attributed to variations of speed and direction of the wind. The NTSB accredited representative to the MP495 investigation wrote in his letter dated 26 Oct 1994 (RvO Appendix): *"Once the autopilot was disengaged, CWS with ATS remained: functions which were inappropriately used by the flight crew*". It was not the variations of the wind that induced accelerations and turbulences, but the pilot-flying by inappropriately using the automated control systems of the aircraft.

4.4.5.6. Frequently, variations are called oscillations, but they are not. Oscillations are variations in magnitude, but with a constant periodic time. DFDR data do not show oscillations, that might indicate longitudinal static instability of phugoid instability, flight-path instability or adverse longitudinal manoeuvring characteristics such as short period response of residual oscillations. The airspeed variations were caused by the ATS that automatically added 5 kt to the airspeed due to the light turbulence for a few seconds, and by the co-pilot who was not correctly using the CWS mode of the autopilot. DASB also stated this being caused by inappropriate pilot inputs to which the autothrottle responded. The autothrottle system reacts immediately to any small change of force on the control column resulting in engine rpm and hence, speed changes.

4.4.5.6.1 *Question*. There was no instability that could be confirmed to increase, and absolutely no loss of control. On V17 § 5.2.2.4 page 26, Experts state that the stall speed for the landing weight was 112 knots, and *"At 126* *knots, the aircraft is technically still able to fly*". How did Experts determine the loss of control?

4.4.5.6.2 *Question*. A crew does not depend on windshear indicating instrumentation on-board. A flight crew is well educated, and procedures are in place to assist in recognizing windshear (AOM 3.3.8 – 02; Appendix 22). The variations in airspeed and altitude as evidenced by DFDR data, were not as high as would be the case by crossing a zone of windshear.

4.4.5.7. *Question 88 of the 143 questions*: If the thunderstorm was on the other side of the runway, then can there actually have been a microburst on the side where the Anthony Ruys started the landing? DASB answered: *"It can be concluded from the weather data which became available after the accident that a thunderstorm front approached the airport at a right angle to the runway. Microbursts can occur in the vicinity of a thunderstorm*".

4.4.5.7.1 *Question*. Was this a good answer by the DASB? The answer, given by the Experts (V17 § 8.8, page 146) is: "It is rather impossible to anticipate the position of a microburst. This is exactly why such meteorological phenomena are dangerous". Claimants agree.

4.4.5.8. *Question 89 of the 143 questions*: If there was a thunderstorm, even if it was on the other side of the runway, then was it responsible to land at that time? The DASB answered: *"As answered in response to question 18 the crew did not have information about the approaching front or about the fact that it would reach the airport so quickly*".

4.4.5.8.1 *Question*. The crew was informed by ATC of "*present thunderstorm*" at the airport 24 min before arrival. In addition, departing flight TP120 reported thunderstorm near or above the airport 10 min before the landing of MP495. Refer to other weather messages included in Appendix 1. Don't the Experts agree that the answer was wrong?

4.4.5.8.2 *Question*. Don't the Experts agree that it is obvious that DASB tried to influence the Commission to delete all references to pilot errors and also to make good the decision not to make an earlier go-around?

4.4.5.8.3 *Question*. Do Experts agree with the NTSB (RvO Appendix, letter 26 Oct 1994) that "If the commission feels that windshear was present during the approach then consideration should be given to recommending implementation or review of crew training for windshear recovery"? If not, please explain.

4.5. Glide path

4.5.1. Rules and Regulations

4.5.1.1. At Faro, a visual PAPI glide path was the only option, but since the red and white PAPI lights, showing the 5.2% (≈3°) glide path ± 0.5 degrees, cannot yet be distinguished from 8 nm, the aircraft starts the descent with a vertical speed set in the autopilot command mode as strongly recommended in AOM 3.3.5 – 08 (Appendix 14). The required vertical speed is dependent on the ground speed, but usually 750 ft/min (AOM 3.3.5 – 09, Appendix 24) for intercepting the 5.2% (≈3°) PAPI glide path from above. This rate of descent has to be set in the autopilot at 0.5 nm before reaching 7 nm, so that the aircraft, after a short transient period, establishes at the set descent rate at 7 nm precisely. The resulting (automatically achieved) descent path will intercept the appropriate PAPI indicated glide path at some point, approximately 4 nm from the runway threshold. The PAPI lights are located approximately 300 m further than the runway threshold, on both sides of the runway. When the distance to the PAPI lights decreases and the pilot can see the individual red and white PAPI lights and therewith the required glide path, the pilot takes manual control (using CWS) to follow that exact (5.2%) glide path down to the runway. The minimum height to change from CMD (Vertical Speed) to CWS is 500 ft (AOM 3.3.5 – 08, Appendix 14).

4.5.1.2. Since a DC-10 is a large aircraft, specific attention is required to not descent below the visual glide path guidance of the PAPI and therewith to avoid an early touch-down. The PAPI *"may be followed down to 200 ft above the runway threshold. Thereafter the aircraft must be brought gradually above the "on glide slope" indication to provide a 30 to 40 ft wheel clearance at the threshold*" (AOM 3.3.5 – 14; Appendix 23).

4.5.2. Facts

4.5.2.1. The co-pilot of MP495 transitioned from the vertical speed mode of the autopilot to the CWS mode just prior to descending through 500 ft. This caused a change of glidepath, of the rate of descent. This transition was in accordance with AOM 3.3.5 – 08, Appendix 14.

4.5.2.2. At 200 ft, the glidepath was again corrected after the captain said *"a bit low*", three times.

4.5.3. Comments DASB

4.5.3.1. According to the crew statements the aircraft was correctly in the slot for landing, down to an altitude of 200 ft. The PAPI indication showed the aircraft to be on the correct glidepath, with some minor corrections.

4.5.3.1.1 *Questions*. Was the aircraft indeed correctly in the slot for landing, both lateral and vertical? Was the PAPI indication mentioned by the DASB objectively recorded?

4.5.4. Comments Experts

4.5.4.1. Experts in V17 § 8.6.4.6: "*The descent path management was well performed*:

- *Anticipation of the key points,*
- *Flight data checks when overflying these key points,*
- *Evaluation of the position of the aircraft regarding the required flight path,*
- *Corrections to be initiated".*

4.5.5. Remarks and Questions Claimants

4.5.5.1. During the glidepath between 2000 and 500 ft altitude, the autopilot was engaged in the vertical speed mode, set at a rate of descent of 750 ft/min just prior to 7 nm from the VOR/DME station at the airport, which is in accordance with the procedures in AOM 3.3.5 – 09 (Appendix 24) for a visual approach. Whatever the disturbance from outside the aircraft or from the inside, the autopilot maintains the set vertical speed and adjusts the pitch to maintain the rate of descent (after which the autothrottle adjusts the rpm of the engines to maintain the set approach speed). It is the intention of the approach procedure that the auto-pilot controlled descent path intercepts the PAPI indicated approach path, which actually happened around 500 ft, after which the pilot disengages the command mode (vertical speed) and continues in the CWS mode of the autopilot. This also happened with MP495. With the autopilot engaged and the PAPI lights becoming discernible, the pilot disengaged the command mode (vertical speed) and continued in the CWS mode. He must have seen three red PAPI lights though, reason for him to reduce the rate of descent to near level flight for some 12 seconds until he would see 2 red and 2 white PAPI lights, indicating the correct 5.2% approach path. He mentioned *"PAPI hè*", as motivation or excuse for the 12 sec near level flight to intercept the correct approach glidepath and to let the captain know that he noticed undershooting the PAPI approach path. The cause of the short level flight can therefore not be called an effect of windshear or downdraft. This is what happens during the normal procedure for a visual, manual approach in turbulence, strong winds, etc. The co-pilot could have switched to CWS a bit earlier for a smoother transition.

4.5.5.2. The flight path control did not become marginal at low altitudes, so there was no reason to initiate the recommended Windshear Recovery Technique (AOM 3.3.8 – 02, Appendix 22). The autothrottle system was not disengaged and the pitch attitude was only changed to maintain the manually flown glidepath below 500 ft as described above. The autothrottle system responded with engine rpm changes, as designed.

4.5.5.3. If the aircraft during the approach is subject to atmospheric disturbances and thereafter maintains or returns to a stable approach path, this may not be called instability. On the contrary, it proves that the aircraft is stable. An aircraft is flight tested to ensure this happens following perturbations in all three axes; an aircraft is built and flight-tested to stringent stability requirements; see § 4.4.5.6 above.

4.5.5.4. The Experts present lots of irrelevant data in § 8.6.4.6. The Experts refer to the *"perfect descent slope*", 1.5 minute before landing. But how can the Experts tell, how do they know? To determine that, Experts would need the exact ground speed; from where did Experts get this? It is not in the RvO. The wind was varying, so did the ground speed. The DFDR data graphs in RvO Annex 15 (Appendix 7) only show data of the last 80 sec of flight below 1000 ft. In addition, the autopilot was in vertical speed mode and set at a higher rate of descent than required to reach the runway threshold because the PAPI glideslope needed to be intercepted from below and at a little above 500 ft altitude to meet the stabilized approach criteria.

4.5.5.4.1 *Question*. Did Experts truthfully analyse approach data before stating *"perfect glide slope*"? Experts should motivate their answer.

4.5.5.5. Any reference to being at, above or below the 'perfect glide slope' while the autopilot is in vertical speed mode, is completely irrelevant and in this 'visual' case impossible to ascertain. There were thunderstorms in the area, the wind was strong and varied and the turbulence was light. These circumstances make it impossible for the glideslope to be perfect. The autopilot only maintains the set rate of descent.

4.5.5.6. The pilots were fully aware of the glide slope deviations from the moment they could see the individual PAPI lights, after which they made the appropriate corrections. This altitude correction was inappropriately explained by NLR as a downdraft, while it is nothing else than the transition from an initial automatic descent at a fixed rate of descent to a manually controlled final descent using PAPI descent guidance.

4.5.5.7. From the AIDS data it became obvious that the co-pilot interfered with the autopilot pitch control by pushing and pulling the control column while the autopilot was engaged in the CWS mode. The co-pilot was obviously not proficient in using these systems, as the NTSB also concluded in their letter dated October 26, 1994 to the Commission (RvO Appendix).

4.5.5.8. The Experts present data graphs of unknown origin and without proper title and legend and not without verifying whether the presented data is correct, which is not a practise that could be expected from proficient Experts. They added for instance, the computed vertical speed without realising whether these data would be correct; it is inappropriate for experts to use the derivative of discrete altitude data, whoever did so before them. The experts did not show high level expertise in the analysis of the vertical approach path; nevertheless, they concluded that the *"computed vertical speed value at touchdown is around 850 feet per minute*". This is not exceptionally high for a landing that had to be made with a positive touchdown. The experts did not show how they calculated this rate of descent. Refer to § 5.11 for reliable expertise and conclusions.

4.5.5.8.1 *Questions*. Did the co-pilot handle the aircraft control systems correctly? Should DASB not have commented on this? If Experts don't agree, please explain.

4.6. Flooded runway, definition and awareness

4.6.1. Rules and Regulations

4.6.1.1. All airline pilots and air traffic controllers are required to be fluent in official ICAO radiotelephony phraseology and use this as prescribed in ICAO Annex 10 Volume II, Aeronautical Telecommunications, examples of which are provided in ICAO Doc 9432.

4.6.1.2. ICAO Doc 9432, Manual of Radiotelephony, presents in chapter 10 (Appendix 25):

> *"10.3.3 Whenever a controller deems it necessary, information that water is on a runway shall be passed to aircraft using the terms "DAMP", "WET", "WATER PATCHES" or "FLOODED" according to the amount of water present.*
>
> *10.3.4 Other runway surface conditions which may be of concern to a pilot shall be transmitted at an appropriate time".*

4.6.1.3. PANS-RAC, already in Nov. 1985 (Appendix 17), determined that Air Traffic Control Services had to inform aircraft about water present on a runway *"to enable the pilot to make proper use of the information*", in the following manner:

> *"4.3.4.2 Information that water is present on a runway shall be transmitted to each aircraft concerned, on the initiative of the controller, using the following terms:*
>
> *DAMP - the surface shows a change of colour due to moisture,*
>
> *WET - the surface is soaked but there is no standing water,*
>
> *WATER PATCHES - patches of standing water are visible,*
>
> *FLOODED - extensive standing water is visible".*

In 1992, it was not required to include the water depth in the transmitted runway condition message.

4.6.1.4. These ICAO terms were not (yet) included in the Martinair and KLM DC-10 AOM. The pilots had to "*translate*" the ICAO term into the applicable braking action in their AOM for the ATC reported runway condition. For moderate to heavy rain, the braking action is medium; for standing water, the braking action is poor as presented in AOM 3.7.3 – 04; Appendix 9.

4.6.1.5. The DC-10 had stringent restrictions to maximum wind components for operation on wet or otherwise contaminated runways: the maximum approved crosswind component for a flooded runway with braking action poor was 5 kt, for a wet runway with braking action medium 15 kt (AOM 3.7.3 – 04; Appendix 9).

4.6.1.6. *"The landing and deceleration on a runway where reduced braking action or risk of hydroplaning exists must always be considered critical*". "*Under crosswind conditions above 10 kt, drainage can be seriously affected, but a 15 – 20 min waiting period after a downpour is usually sufficient to drain the water*" (AOM 3.3.5 – 15; Appendix 2).

4.6.2. Facts

4.6.2.1. The captain had already informed the crew that the runway was *"wet*" during the arrival crew briefing 35 minutes before landing, and also instructing the co-pilot: *"you have to make it a positive touchdown"* which the co-pilot confirmed with: *"Yes"*.

4.6.2.2. The crew of MP495, in the last 30 minutes before touchdown, was informed multiple times that thunderstorms were present at the airport leading to the co-pilot to remark, less than 20 minutes before touchdown: *"it's raining cats and dogs over there"*.

4.6.2.3. 27 Minutes before touchdown the captain told the crew*: "if we don't make it we go immediately to Lisboa"*; the co-pilot confirmed with: *"yes".*

4.6.2.4. Eight minutes before landing, the flight crew of MP595 heard the Faro ATC inform Martinair flight MP461 that the runway conditions were flooded; the message was recorded on the CVR of MP495.

4.6.2.5. Sixteen seconds after initiating the inbound turn, about 4.5 minutes prior to landing, Faro ATC informed MP-495 that the runway was flooded; the controller did so at his own initiative, as required in ICAO PANS-RAC. The captain confirmed the 'flooded' message with his response "*Roger*", in aviation radio telephony terms meaning *"I have received all of your last transmission*" (ICAO Doc 9432; Appendix 26) and verbally repeated 'flooded' in the cockpit (CVR transcript, RvO Annex 5). If he would not have understood and comprehended the term, he would have had to ask immediately "*say again*", meaning "*Repeat all, or the following part of your last transmission*"(ICAO Doc 9432 page 24), or would have had to ask for the meaning of the word '*flooded*'.

4.6.2.6. At 07:31:33, the flight engineer reminded the pilots "*The runway is …*". The transcript in folder 2624 in the National Archives does not show "…", but the term "*flooded*"; the transcript in RvO Annex 5 was obviously changed by someone. Hence the flight engineer, an ex-pilot, must have understood the meaning of term flooded as well. The pilots did not respond. A wind of 150°/15 max. 20 kt, with a crosswind component 14 kt on the runway, was much too much for a flooded runway, and just 1 kt below the limit for a wet runway (AOM 3.7.3 – 04; Appendix 9).

4.6.2.7. The captain made two different statements with regard to his understanding of the term flooded at the time of the accident.

The first statement made in an interview to the police at Schiphol airport on 29 Dec 1992 read as follows:

> *"If the runway is actually flooded that means "standing water" to me. In that case the braking action is "poor" and the crosswind limit is reduced to 5 kt. In my mind this condition did not exist during our approach"*

This statement was withheld by the DASB from the general public and kept in secret files for 20 years. Only during the Court hearing and upon request of the presiding judge did the Dutch government representative admitted to its existence.

The second statement was made several months later, in April 1993, and read as follows:

> *"The term "the runway is flooded" is not a standard call but I took it to mean that the runway was wet".*

In short: in the first statement the captain confirms his knowledge to be in accordance with PANS-RAC and he repeats the exact ICAO definition of the term to the Police. In the second statement the captain claims to have no knowledge of the meaning of the term flooded.

4.6.2.8. AOM 3.3.5 – 15 (Appendix 2) states that the drainage of a flooded runway may take 15 – 20 min. The captain received information sent to MP461 that the runway was flooded 8 min prior to the landing of MP495. Four minutes and a half prior to the landing, the runway was still flooded.

4.6.3. Comments DASB

4.6.3.1. "*The Board is of the opinion that the crew of MP495 has been fully aware about the prevailing weather at Faro Airport, with the exception of the extreme conditions at the time of the accident*" (Report RVDL3 page 1).

4.6.3.1.1 *Remark*. There were no extreme conditions at the time of the accident, as evidenced with data on the DFDR, except for the strong crosswind requiring a heading of 125° during the approach to get to the airport. In § 4.6.5.8.1, it is explained that the crosswind was 35 kt during the last 80 sec of the approach, not only at the time of the accident.

4.6.3.2. DASB confirms in Report RVDL3 (lijst 4 tab 23) page 4: During the final approach of both MP461 and MP495 the ATC controller reported: "*The runway conditions are flooded*". "*According to the ICAO document Doc 4444 (PANS-RAC), the ATC Controller, when informing the crew of the presence of water on the runway, can amongst others use the word "Flooded", indicating that: "extensive standing water is visible"* "(§ 4.6.1.4 above). "*This word should, if possible, be accompanied by a figure indicating water depth. The word "Flooded" however did not trigger the crew's mind, and its significance was not realized by the crew*" (RVDL3, page 4).
"*According to the statement of the captain he "took it to mean that the runway was wet*". In the AOM no reference is given to the word *"Flooded*"".

4.6.3.2.1 *Remark*. The quoted statement of the captain is not out of the first statement of the captain during interrogation by the Police.

4.6.3.2.2 *Question*. How do the experts rate the fact that the DASB withheld the statement of the captain in which he clearly displayed an accurate understanding of the term "*flooded*" from the victims and the general public for 22 years?

4.6.3.2.3 *Question.* How do the Experts rate the fact that the DASB used a statement by the captain which they knew to be false in their official statements to the victims and the general public?

4.6.3.2.4 *Question*. Considering the fact that the captain had a proper understanding of the term flooded, was the captain allowed to continue the approach after hearing that the runway was flooded 8 min before touchdown, knowing that it would take 15 – 20 min for the water to drain from the runway? Please answer this question also with regard to the "*flooded*" message to the captain of MP495 directly 4.5 min before touchdown.

4.6.3.2.5 *Question*. Was the DASB allowed to ignore the first statement of the captain in which he gave a precise definition of the term flooded and was the DASB at fault when it chose use the statement in which the captain said that flooded was not a standard term and that he took word flooded to mean that the runway was wet?

4.6.3.3. During the information meeting of the DASB for the victims on 1 Dec 1994 (lijst 2 nr. 5), DASB board member Mr. Snoek told the victims that the captain did not understand the meaning of flooded (see [18]):

"*So let's say: he didn't translate "flooded=poor braking action*".

"*If it had been properly processed and had "flooded" been associated with the fact that you have to include a braking action of "poor" in your calculation, yes, then it was a mistake."*

4.6.3.3.1 *Remark*. However, the captain stated in his first statement:

"If the runway is actually flooded that means "standing water" to me. In that case the braking action is poor and the crosswind limit is reduced to 5 kt."

4.6.3.3.2 *Remark*. Clearly, the captain did indeed translate 'flooded' into 'poor braking action'. The DASB admitted in court to possessing the first statement of the captain who made this statement to the police at Schiphol airport just days after the crash on 29 December 1992. This allows for no other conclusion than that the DASB already knew for almost two years, that the captain had a precise understanding of the term flooded and knew the effects on the braking action and that, consequently, the DASB deliberately misinformed the victims on the awareness of the captain concerning the meaning of the word 'flooded' and its related consequences for flight safety.

4.6.3.3.3 *Question*. How do the Experts rate the misinformation by the DASB to the victims?

4.6.3.3.4 *Remark* with regard to the consequences of the knowledge of the captain, the DASB also misinformed the victims. The relevant questions were:

4.6.3.4. *Question 17 of the 143 questions*: Was it responsible to land in the weather conditions at Faro? The DASB answered: "*It was responsible to land under the weather conditions which the crew were informed of*".

4.6.3.4.1 *Question*. Was this a correct, honest and comprehensive answer to the question, especially given the fact that the crew was informed twice that the runway was flooded and that the captain determined that the aircraft experienced a 14° drift angle at an airspeed of 139 kt?

4.6.3.4.2 *Question*. Experts answered "*Yes*", without motivating this answer, and consider the DASB’s position valid since the information received by the pilots regarding the runway status did not strike them as important enough to make it a top priority in their assessment of the situation.
The claimants agree that the answer is yes for the weather conditions the crew were informed of before arrival in the Faro Control Zone, but no after they were informed of the actual weather with a flooded runway condition and after reading the actual RNAV wind in the cockpit. In the RvO,

one of the causes is: The crosswind exceeded the aircraft limits. Was it indeed responsible to land? If Experts don't agree, please explain.

4.6.3.5. *Question 18 of the 143 questions*: Did the crew have sufficient information to judge if a landing with a DC10 was responsible with 100% certainty? The DASB answered: "*With the weather conditions which the crew were informed of they had enough information to decide whether or not the landing was responsible. The rapidly changing weather conditions during the last stage of the flight were not known to the crew. Hence these conditions could not be included in the decision-making about the landing*".

4.6.3.5.1 *Question*. Was this answer correct given the knowledge of the captain concerning the meaning of term flooded? If not, please explain.

4.6.3.5.2 *Question*. The crew was made aware of the runway condition, did hear several times about thunderstorm at or near the airport and the too strong wind in ATC messages to other aircraft and from their own RNAV system. The crew were aware of the change of conditions (PF asked for windshield anti-ice, while he meant windshield wipers) and of the crosswind, why else would a wind correction angle of 11° be required? Refer to all of the meteo messages the crew received in Appendix 1. Do Experts still agree with the DASB answer? Please explain.

4.6.3.6. The PANS-RAC term "*Flooded*" was a standardized term already for many years, as explained above. AIB was made aware, following the accident, that ATC controllers can use this term and that controllers and pilots need to be aware of this phraseology. KLM (and Martinair) did not amend their manuals yet to include this phraseology. Nevertheless, the captain was aware of the meaning, because he answered "*Roger*" after receiving the "*flooded*" message from ATC. His initial statement was changed a few months later to "*I took it to mean that the runway was wet*", most probably under pressure by Martinair management. The DASB obviously did not criticise the change.

4.6.3.7. On 12 April 1994, lead investigator Frans Erhart was informed by Rob … that "*Flooded*" was a standard term (NA 2622 – note to Erhart); this term was defined by ICAO in PANS-RAC many years before the accident. He included a copy out of PANS-RAC, dated 12 Nov 1985, § 4.3.4 Messages, containing information on aerodrome conditions, refer to Appendix 17.

4.6.3.8. Rob included that "*Mr. Guy Oomen of KLM had to acknowledge that KLM did not include this term in the Flight Reference Guide (also called AOM and BIM*)" (AOM 3.7.3 – 04; Appendix 9), and "*He will do something about that from today*". RvO § 2.2.3 on page 107 includes: "*It was established that the AOM, to describe the runway condition, did not make use of the ICAO phraseology*".

4.6.3.9. DASB should have recommended KLM and Martinair to expedite changing the manuals to include the long existing ICAO phraseology in PANS-RAC on runway conditions as soon as possible.

4.6.3.10. DASB response: The Portuguese report clearly stated that the crew did not interpret the term flooded correctly. AvioConsult did not state anything new. However, the AvioConsult report left out the text from the Portuguese report about not communicating wind information (220°/ 35 knots; tailwind and an exceedance of the crosswind limit of the aircraft, V17 page 59).

4.6.3.10.1 *Remark*. DASB only read the summary of the AvioConsult report, in which the wind 220°/ 35 kt was indeed not mentioned. This wind, by the way, never occurred as will be discussed in § 5.2.2 below.

4.6.3.10.2 *Questions*. Why do Experts validate the DASB response? Could the wind 220°/ 35 kt indeed be communicated before landing, even if it was not measured by the SIO? Was this wind not exactly the wind that was required to explain that the aircraft exactly followed the 111° approach radial because the DFDR heading data proved that the aircraft heading was 125° during the last 80 sec of flight? Additional questions on this subject in § 4.6.5.8.1.

4.6.3.11. DASB wanted the Commission to delete the last four words in: "*The aircraft was informed by Approach Control that the runway was flooded and the crew did not consider this information when calculating the landing distance, <u>for braking conditions POOR</u>*" (Report RVDL3, lijst 4 tab 23).

4.6.3.11.1 *Question*. Why would DASB try to 'encourage' the Commission to delete all references to pilot errors and also to make good the decision not to make an earlier go-around?

4.6.3.12. DASB should have recommended KLM and Martinair to expedite changing the manuals to include the long existing ICAO terminology in PANS-RAC on runway conditions as soon as possible.

4.6.3.13. "*The landing and deceleration on a runway where reduced braking action or risk of hydroplaning exists must always be considered critical*"; AOM 3.3.5 – 15; Appendix 2. The stringent crosswind limits in the AOM exist because of the probability of aquaplaning, not only of the main landing gears, but also of the nose landing gear that is not provided with brakes and an anti-skid system. On a contaminated runway, the side forces generated by the crosswind on the large vertical tail after touchdown cannot be counteracted by the friction of the wheels of the nose gear on a contaminated runway at higher crosswinds than the AOM published limits for the runway condition. Then the aircraft cannot be steered along the centreline of the runway, but will experience a runway excursion, departing the runway to the upwind side after which a fatal accident might be unavoidable. This is also one of the reasons that crosswind limits exist.

4.6.3.14. The presence of thunderstorms may not be predictable at the time of accident, but facts are that MP495 monitored their on-board weather radar, was informed by ATC about "*present thunderstorm*", and heard departing flight TP120 reporting a thunderstorm at or near the airport. The crew was fully aware of the presence of thunderstorms during the approach.

4.6.3.15. Mr. Erhart of AIB was made aware that "*According to regulations (attached) flooded can be used by an ATS unit in R/T (and in ATIS transmissions) without problems and both ATS and pilots need to be aware of this phraseology*" (note in NA 2622). This statement is in agreement with ICAO PANS-RAC.

4.6.3.16. DASB wanted the Commission to change the sentences "*The crew did not integrate. The instability and the momentary visibility degradation in the final approach and the runway service conditions which were transmitted to them, in order to take the decision to discontinue the approach*" into: "*The instability and the momentary visibility degradation in the final approach were not of such a magnitude that the crew should have made take the decision to discontinue the approach*" (Report RVDL3, page 11).

4.6.3.17. The Commission did not accept this change proposal, but changed the line in the final version of the report into: "*The crew did not integrate the informations concerning the instability and the momentarily visibility degradation in the final phase of the approach, and having wrongly interpreted the communication of the runway condition (flooded), did not take the decision to abandon the approach*" (RvO).

4.6.3.17.1 *Question*. Don't the Experts agree that DASB tried to prevent all references to the flooded runway condition from being published in the final report? And that, like the Portuguese Commission said, they did not take the decision to abandon the approach?

4.6.4. Comments Experts and Remarks and Questions

4.6.4.1. "*The Experts have no evidence to confirm that the crew was not aware "of the extreme conditions at the time of the accident", as the Dutch Aviation Safety Board seems to suggest in the same sentence*". "*As it happened, the crew indicated several times that the weather conditions were expected to be difficult and the captain clearly spoke about a possible diversion towards Lisbon*" (V17 § 5.2.2.2).

4.6.4.2. "*The crew was aware of the presence of thunderstorms, even of the one that apparently disturbed the approach, because it was located only 8 to 12 nautical miles west of the airport*". "*The statements made by the Flight Engineer show that the flight goes through a stormy and bumpy area ("…experienced turbulences that could be classified as stronger than moderate.") at around 8 nautical miles during the right hand turn towards the final path, before settling at the right axis for final approach*". The flashing of the feed pumps lights demonstrates a major flight path correction made by the automatic pilot in order to maintain the actual altitude. (V17 § 5.2.2.2).

4.6.4.2.1 *Question*. How do Experts know that the flashing of pump lights happened in the first place, and second that it demonstrated a major flight path correction? A flight path correction? Ground radar doesn't show this. Objective data, facts and an explanation please.

4.6.4.3. "*Actually, the ATC controller (ATCO) does not know whether or not the crew will understand precisely what he means when he transmits information regarding the status of the runway. Based on his training, he transmits the information to the crew to improve the flight safety: he should therefore ensure that he is well understood*" (V17 § 5.2.2.3).

4.6.4.4. "*Workload in cockpit was high when flooded message was received*" (V17 § 6.8, 6.9). In V17 § 8.4.1 no reference to high workload; was not recorded on CVR either.

4.6.4.4.1 *Question*. How do the Experts know that the workload in the cockpit was high when the "*flooded*" message was received? The autopilot and autothrottles were engaged to reduce the workload. The CVR transcript never shows signs of high workload and stress. Although it took 9 sec to answer "*roger*", the captain did not ask "*say again*". When the workload and stress in the cockpit are high, short commands are given. Nevertheless, at 07:29:32 the captain said "*7 DME*", after which the co-pilot said "*yes then the gear may be selected down*" instead of the short command "*gear down*" as usual, which means that there was no stress in the cockpit.

4.6.4.5. "*It is possible then that the captain did not immediately understand the word "flooded". Even though he did not understand it right away, he at least heard it. This is what his answer "ROGER" suggests; "ROGER" is a general expression that means "I got it", and we cannot neglect it*" (V17 § 5.2.2.3 page 23).

4.6.4.5.1 *Remark*. ROGER does not "*suggest"* anything. This term is defined by ICAO meaning: "*I have received all of your last transmission*" (ICAO Doc 9432 page 24; Appendix 26).

4.6.4.6. Experts notice "*that the expression "flooded" has not even been defined in Martinair's FCOM nor has it been defined in KLM's FCOM*" (V17 § 8.6.4.4.3, page 99).

4.6.4.6.1 *Remark*. But "*standing water*" is, as is included in a table in AOM 3.7.3 – 04, Appendix 9. "*Flooded*" was introduced many years before the accident by ICAO in PAN-RAC (now 4444 Chapter IX and X; Appendix 17). Martinair (and KLM) did not timely amend the manuals. Nevertheless, the captain confirmed to understand. "*If the runway is actually flooded, that means standing water to me*".

4.6.4.7. "*The captain, in his statement, indicates what the term "flooded" might mean for him", "if the runway is actually flooded that means "standing water" to me. In that case the breaking action is "poor" and the crosswind limit is reduced to 5 kt. In my mind this condition did not exist during our approach".*
"The term "flooded" should then have resulted in a request for further information. But there was no further communication with ATC, related to this topic, which means that the captain did not fully grasp the meaning and the importance of this word" (V17 § 5.2.2.3 page 23).

4.6.4.7.1 *Remark*. The captain did not state "*what the term flooded might mean for him*", but he firmly stated the exact ICAO definition standing water, and he summed up the related consequences "*In that case the braking action is "poor" and the crosswind limit is reduced to 5 kt*". This means that the captain had a precise knowledge of the meaning of the word flooded and of its importance. In addition to this, the captain stated: "*In my mind this condition did not exist during our approach*", which means that, upon hearing the message from ATC, he gave the term some thought and decided to ignore it. Had he had any doubts about the meaning of the term "*flooded*", he would have checked with ATC instead of replying "*roger*". This leaves no room for another conclusion that the captain wilfully ignored the information given to him by ATC.

4.6.4.7.2 *Question*. Why did Experts change the statement?

4.6.4.8. In V17 § 5.2.2.3 page 22 Experts say that the term "*flooded*" "*does not exist in JAR-OPS 1, which was at the time of the accident the reference in regards to national regulations*".

4.6.4.8.1 *Remark*. The experts refer to JAR-OPS 1 as a source of ATC phraseology. JAR-OPS 1, however, was first issued on 22 May 1995 (Appendix 27), and could not have served as a reference with regard to national regulations, because it had not even been adopted by the JAA, let alone by member nations at the time of the accident. ICAO PANS-RAC was the proper reference. In PANS-RAC the term flooded is defined as: "*extensive standing water is visible*".

4.6.4.8.2 *Question*. Why did the Experts not verify the effective date of JAR-OPS 1, as being 22-05-1995?

4.6.4.9. "*The presence of thunderstorms was not predictable at the time of accident*" (V17 § 5.2.2.2 page 20).

4.6.4.10. *"The Experts consider that the Dutch Aviation Safety Board's position is valid since the information received by the pilots regarding the runway status did not strike* *them as important enough to make it a top priority in their assessment of the situation, and in the list of problems to solve"* (V17 § 5.2.2.3 page 24).

4.6.4.11. "*The Experts validate the OvV remark*" about not communicating the wind 220°/ 35 kt (V17 page 59).

4.6.4.11.1 *Remark*. This wind was not measured before landing, but 1.5 min thereafter.

4.6.4.11.2 *Question*. Will Experts consider to study the time references and the different clocks used in the Portuguese report more accurately, or read the AvioConsult report on this subject more closely? If not, please explain.

4.6.4.12. "*The runway surface condition — flooded, wet, short, long, etc. — had no impact on the accident whatsoever, and is therefore irrelevant*" (V17 § 8.6.4.4.1).

4.6.4.12.1 *Remark*. The crew continued the approach while they were made aware and understood that the runway and the weather conditions were such that the airworthiness of their aircraft during the landing and thereafter could not be guaranteed. The Landing Data Card showed clearly that the available runway length of 2445 m would be just long enough for a landing on a wet runway (2400 m), but way too short for a braking action poor (flooded runway – standing water, 3055 m). A pilot is not authorized to argue these numbers; he simply has to apply them. Applicable runway and weather condition limitations published in their RLD approved manuals were violated.

4.6.4.12.2 *Question*. Don't Experts agree that continuing an approach to a runway where limitations (surface conditions and crosswind) will be exceeded is deliberately putting the aircraft and its passengers at large risk?

4.6.4.12.3 *Question*. Don't the Experts agree that the available runway and applicable weather condition limitations, published in their approved and applicable manuals, were violated by the crew, and that DASB should have noted that?

4.6.5. Other Remarks and Questions Claimants

4.6.5.1. *Remark, the understanding by the captain of the term flooded.* The captain clearly stated that his understanding of the term "*flooded*" was "*standing water*", because he said "*if the runway is actually flooded, that means standing water to me*". However, the Experts state that the fact that there was no further communication with ATC leads to the conclusion that the captain did not understand the meaning of the term "*flooded*" because he did not request further information. This is directly opposed to the abovementioned statement of the captain himself. Moreover, if a term is understood, there is no cause for further communication with ATC.

4.6.5.2. It is standing practice in aviation that if a pilot does not understand a communication or term he must immediately ask ATC to clarify it. Stronger yet, a pilot has the responsibility to ensure that he properly understands the information given to him. If he does not recognize a term used by ATC or if he has any doubts about its exact meaning, he is obliged to ask ATC to clarify.

4.6.5.2.1 *Question*. On what factual basis do the Experts doubt the correct understanding of the term "*flooded*" by the captain when the captain repeated the exact ICAO definition of this term to the police shortly after the accident.

4.6.5.2.2 *Question*. Why do the Experts use the word "*might*" in the context of the captains understanding of the meaning of "*flooded*" when he himself (correctly) stated that the term flooded means standing water to him?

4.6.5.2.3 *Question*. In the event that the captain did not have a proper understanding of the term "*flooded*", should he not have asked ATC for clarification after hearing the "*flooded*" message to MP461, 8 min before landing knowing the runway was at least wet and subject to regular and heavy precipitation, or should he not at least have asked ATC for the meaning when this term was repeated directly to him 4 min later?

4.6.5.2.4 *Question*. Given the fact that the captain already knew that the runway was wet, that it was raining "*cats and dogs*", that thunderstorms were present during the approach and that there were multiple messages regarding the weather from ATC and other aircraft, are the Experts not of the opinion that the captain was sufficiently alerted to the fact that the runway conditions could have deteriorated further during the approach. Should this knowledge not have been connected to the repeated use by ATC of the term 'flooded' which, in the normal English meaning, leaves no room for misinterpretation?

4.6.5.2.5 *Remark*. The experts state that the term 'Flooded' was used by ATC only. It was defined in the PANS-RAC (4.3.4.2.) of 21 November 1985 (Appendix 17). ATC phraseology is meant exclusively for communication between ATC and Pilots. Professional pilots are obliged to maintain a high level of currency in their knowledge of ATC phraseology.

4.6.5.2.6 *Question*: The Experts stated that PANS-RAC phraseology "*is more destined to be used by air traffic controllers*" and "*does not constitute a reference for pilots*" (V17 § 5.2.2.3 page 22). Are the experts of the opinion that pilots do not need to understand this phraseology?

4.6.5.3. The captain mentioned a possible diversion to Lisbon already 30 min before landing ("*If we don't make it we go immediately to Lisboa*"). The co-pilot briefed the procedure to execute a missed approach, which is a standard item in an approach briefing, meaning they were prepared to divert (CVR transcript).

4.6.5.3.1 *Question*. What human factor could have driven the pilots to press on to land at Faro and not to divert to Lisbon?

4.6.5.4. *Question 19 of the 143 questions*: According to several newspapers, at 06.00 hours GMT (7 hours' Dutch time) the Portuguese aviation authorities gave a special warning for hazardous weather conditions with heavy thunderstorms and heavy icing. Did the warning from Portugal at 06.00 GMT reach the crew of the Anthony Ruys? DASB answered: "*The Portuguese authorities did indeed issue such a warning. The correct text is included in the report. This warning was not communicated to the crew of flight 495*".

4.6.5.4.1 *Question*. Don't the Experts agree that the crew were informed about the thunderstorms at or near Faro airport in time from several sources, including from departing flight TP120.

4.6.5.5. *Question 26 of the 143 questions*: Did the Anthony Ruys crew, during the last contact with the control tower, receive specific information about the weather and what was that? DASB answered: "*The Anthony Ruys received the latest weather information from the traffic control tower, one minute before the accident. This was: "The wind 150, 15 knots maximum 20"*".

4.6.5.5.1 *Question*. This is indeed the wind information received during the last contact with the tower, but this did not include specific information about the weather, as was asked. The aircraft received the last information about the weather during the final turn. This message included "*the runway is flooded*". Earlier the aircraft received the alert that there was a thunderstorm. Don't the Experts agree that the question was not answered fairly.

4.6.5.5.2 *Question*. Experts wrote: "*The crew could not know that the information provided is not correct*". But did the captain not read the wind from the R-NAV system?

4.6.5.6. *Question 27 of the 143 questions*: Was it stated, as it appeared in some messages in the press, that there was still 1/8 thunder cloud on the horizon? DASB answered: "*This was not indicated at the time*".

4.6.5.6.1 *Question*. At CVR time 07:08:32, current weather was transmitted by ATC to MP495, including "*1/8 CB 2500 ft, wind 150/18 and present thunderstorm*". Ten minutes before the landing, departing flight TP120 reported a thunderstorm while in a turn very close to or above the airport. Don't the Experts agree that the DASB answer was not correct and that they should have informed the victims about the reported thunderstorms present? The answer should have been yes, although the info was not issued during the last contact which, by the way, is never done. This is always limited to actual wind info. There was a thunderstorm nearby, though.

4.6.5.7. *Question 28 of the 143 questions*: If so, could it have been known to the crew that it is risky to land in that, as downdraughts (microbursts) just above the ground can occur in that? DASB answered: "*This was not indicated at the time*".

4.6.5.7.1 *Question*. Experts have no comment. The captain was aware of the possibility of the thunderstorm, turbulence or worse, because he checked the wind a few times on the RNAV display. Reference should have been made to the AOM for necessary actions when windshear is suspected (AOM 3.3.8 – 02; Appendix 22). Although there is no objective evidence on the DFDR that windshear occurred, it is considered risky to land in those conditions; the captain was aware, even without indication at the time. Don't the Experts agree that the DASB answer was wrong?

4.6.5.8. *Question 29 of the 143 questions*: In that case, what made the crew decide to start the landing despite that? DASB answered: "*The last weather information received confirmed the picture the crew had formed of the weather and did not impede the landing*".

4.6.5.8.1 *Questions*. Experts say "Not applicable", and add the comment: "The question is not to begin an approach but to continue it, depending on the actual conditions" (V17 page 137). ATC told the crew 24 min before arrival "present weather thunderstorm"; thunderstorm was reported a few more times (Appendix 1). Should the crew then begin an approach? Or wait at altitude? Or be very alert? And when they hear from ATC at least twice that the runway is flooded, and notice they need a heading of 125° to get to the runway because of an obviously large crosswind component, should they then continue? The captain even said 3.5 minutes before landing: "*wind is coming from the right 30 kt, drift 12° so you make it 123 or so*". At 140 kt, a 12° drift angle corresponds with a 30 kt crosswind component. The fact that the captain took the R-Nav wind information as

the basis for the heading to fly means that he took it seriously. The 125° heading selected was adequate to compensate for the drift, given the 7° deviation from the approach radial. This correlates with a crosswind of 17 kt. If there would have been no deviation from the 111° approach radial, the correlated crosswind component at an airspeed of 140 kt would have been 35 kt (140·tan (125° – 111°)). Irrespective of whether the aircraft was following the prescribed 111° approach radial or not, the captain continued the approach during at least 80 sec, as proven by the DFDR and CVR data from his "*so you make it 123 or so*" command, notwithstanding a known crosswind component that exceeded the aircraft limits for a wet, let alone flooded runway.
Don't Experts think DASB was less than candid to the victims about the captain's knowledge of the crosswind conditions?

4.6.5.8.2 *Question*. The DASB concluded that there must have been a 35 kt crosswind just before landing. DFDR data in RvO Annex 15 (Appendix 7) shows that from 80 sec before landing, the heading was 125°. Can Experts calculate what the crosswind component in this case, i.e. for a wind correction angle of 14° must have been? Can Experts also calculate the crosswind component when the approach ground track was as the radar plot in RvO Annex 12 (Appendix 12) shows? Would this value not be more practical? Could it therefore be that the aircraft was not on the 111° approach radial? The flight-crew was definitely aware of the weather, the large crosswind and the bad runway condition.

4.6.5.8.3 *Question*. Don't the Experts agree that the answer by DASB was definitely wrong?

4.6.5.9. Refer to § 6.3 for more on conclusions Experts on "Flooded".

4.7. Conclusion of the Experts on the Approach

If this question calls for the Expert to evaluate the decision of the crew to engage the last turn at 8 nautical miles, then the answer resides in the relevant Portuguese procedure published at the time.

The Experts' analysis as shown in paragraph 8.6.4.5 of this report, shows that the crew respected the published approach procedure.

In addition, this flight path clearly avoided a stormy area that was very active, west of the airport at about 10 nautical miles.

4.7.1. Comments DASB

4.7.1.1. "*According to the crew statements the aircraft was correctly in the slot for landing, down to an altitude of 200 ft. The PAPI indication showed the aircraft to be on the correct glidepath, with some minor corrections*" (Report RVDL3 page 6).

4.7.2. Comments Experts

4.7.2.1. "*The final turn is performed with the autopilot engaged and acting in Heading Select (HDG SEL) mode. In this configuration, the bank angle is set at 25°, matching with the value used to define this turn. But, with a wind coming from the south/southeast, the path on ground will obviously "overshoot" the approach radial and a correction should be performed to come back as soon as possible on the centerline or on the scheduled radial. As shown by the chart issued in the official report Annex 12 "Plotting*

Radar da trajectoria da aeronave", the end of the intercepting phase of the final turn has not been correctly managed by the pilots" (V17 § 8.6.4.5, page 104).

4.7.2.2. "*According to the captain's statement, the flight was on the extended centerline of the runway at 200 feet". The following chart provided by the NLR (see report CR93080C) confirms the captain's statement about the position of the aircraft in short final. From 2000 meters from the threshold, the aircraft was on the extended center line of the runway*" (text and chart in V17 § 8.6.4.5, page 106).

4.7.2.3. Experts in V17 § 8.6.4.6: "*The descent path management was well performed*:

- *Anticipation of the key points,*
- *Flight data checks when overflying these key points,*
- *Evaluation of the position of the aircraft regarding the required flight path,*
- *Corrections to be initiated".*

4.7.3. Remarks and Questions Claimants

4.7.3.1.1 BIM 3.4.4 – 06 (Appendix 11) states: "Should circumstances prevent such stability being achieved before 500 ft, then it must be realized that safe continuation of the approach to landing becomes questionable. Vital factors such as speed, descent rate, threshold height and point of touchdown can be all be adversely influenced. On short or wet runways such factors become of paramount importance. It is therefore strongly recommended that no landing be attempted if the desired stabilization has not been achieved when passing 500 ft above threshold elevation."

4.7.3.2. DFDR and ground radar data prove that MP 495 was not established in a stable approach at 500 ft as required in BIM 3.4.4 – 06 (Appendix 11).

4.7.3.3. The Experts state (V17 page 106):

- " The overshoot requiring to turn right towards, at least, the heading 150° then to turn left, on heading 125°, to balance the wind and to establish the mandatory drift angle;
- The handling of the early stage of the final descent.

These two actions were performed in accordance with the BIM".

4.7.3.4. Given the fact that the aircraft made an overshoot which, according to the Experts (V17, page 105), and as shown in the radar chart (RvO Annex 12; Appendix 12) was 0.7 nm, and given the facts that the DFDR data do not show a heading larger than 130° for a few seconds following the final turn at all, and that the radar chart shows that this overshoot still existed at ≈4 nm from the threshold when the DFDR graphs start, it is clear that:

- No course correction to 150° was made;
- The aircraft did not return to the 111° approach radial;
- Given the heading of 125° during the last 80 sec of flight, the pilots ignored a crosswind that was at least 17 kt which is above the crosswind limit for a wet runway, let alone for a flooded runway;
- The aircraft did not perform the mandatory 5° course correction to 106° at 1 nm in front of the threshold.

These facts lead to the inescapable conclusions that:

- The aircraft was not established at 500 ft on the 111° radial, and should have made a go-around because of this unstable approach condition towards a contaminated runway with strong crosswind, refer to AOM 3.4.4 – 06; Appendix 11;
- The aircraft experienced a crosswind during the whole approach that was well in excess of the 15 kt limit for a wet runway, which also necessitated a go-around.
- The crew did not perform these two actions in accordance with the BIM.

Note that if the aircraft did indeed return to the 111° approach radial, a heading of 125° at an airspeed of 140 kt would have meant crosswind of 35 kt (140·tan (125° – 111°)).

4.7.3.4.1 *Question*. Do not the experts agree that the DASB should have noted these basic facts and comment on them instead of stating that the aircraft was well established on final?

4.7.3.5. During a non-precision approach, the aircraft needs to be established on the approach radial towards the runway at 9 nm from the VOR/DME station. At 9 nm, the landing gear is selected down and the landing flaps are selected at 8 nm. The final approach speed is entered in the ATS and a rate of descent is selected and entered in the vertical speed mode of the autopilot at 7.5 nm for the descent to start at 7 nm, after a short transient period (AOM 3.3.5 – 06, – 08; Appendix 19, Appendix 14).

4.7.3.6. The pilots, knowing about the strong crosswind, should have extended the outbound leg to 10 nm to be able to establish and stabilize in time on the approach radial with the aircraft configured for landing. If there still was a thunderstorm at 8 nm west of the airport, it was not mentioned in the CVR transcript.

4.7.3.7. When approaching 8 nm outbound, the captain said "*I'll give you 111*", to set 111° approach heading, being the inbound radial, in the VOR control panel, whereupon the co-pilot asked for heading 080 in the autopilot to intercept the 111° radial (CVR transcript). During the turn, both the captain and the co-pilot must have noticed the decreasing deviation from the 111° approach radial on the Horizontal Situation Indicator and the distance to the VOR/DME station, but neither took appropriate action. They should have started to configure the aircraft for landing during the turn because the distance to the VOR/DME station during the turn was less than 9 nm. The autopilot established perfectly on heading 080 and crossed the 111° approach radial with an angle of 30°, at a distance of 7.4 nm from the VOR, as radar data proves.

4.7.3.7.1 *Question.* Don't Experts agree with the paragraphs above?

4.7.3.7.2 *Question*. The radius of the final turn was too large, also caused by the crosswind. DASB should have remarked /identified the overshoot of the final turn and commented on it. Not being established on the approach radial in time increased the workload and is a contributing factor to the accident, which the DASB should have identified. Don't Experts agree?

4.7.3.7.3 *Question*. Intercepting a VOR radial under an angle of 30° is a standard procedure. The turn should be continued until the lateral deviation from the selected radial is ± 2° (1 dot on the course deviation display of the Horizontal Situation Indicator – HSI). In this case, although the HSI must have indicated that the aircraft was about to cross the approach radial, the pilot-flying did not change the heading to re-intercept the 111° radial.

After overshooting the radial, they did not continue the turn either in order to return to the 111° approach radial, as they should have, but rather selected a heading that seemingly took them directly to the runway (RvO Annex 12; Appendix 12). Don't Experts agree?

4.7.3.8. Hence, the heading was not set to return to the 111° approach radial that was set in the VOR control panel as soon as possible after overshooting the radial, as the ground radar plot in RvO Annex 12 (Appendix 12) shows. The captain told the co-pilot "*you make it 123 or so* (CVR transcript)". Under the crosswind condition at the time, this was not a large enough heading to re-intercept the approach radial in time. The captain obviously did not tell the co-pilot to re-intercept the 111° approach radial, which is an intentional deviation from the published non-precision VOR/DME approach in the AOM.
The co-pilot, as pilot-flying, did not respect the formal requirements for a stable approach and the captain did not require him to ensure an early stabilization at the key distances and on the approach radial. When descending through 500 ft, the aircraft was still not within the lateral constraints for meeting the stable approach criteria; it did not pass through the required horizontal and vertical constraints of the 'approach gate' as RvO Annex 12 (Appendix 12) proves. Since the captain, as pilot non-flying, was responsible for monitoring the approach procedure, which he did not, it cannot be concluded other than that he acted negligent and made grave errors. Not being stable on the approach is a contributing factor to the accident. A go-around should have been initiated.

4.7.3.9. At 1 nm from the threshold, a course correction would be required to intercept the extended runway centreline. This correction, requiring a small turn using a small bank angle to the left, resulting in a ground track on the extended runway centreline but with a wind correction angle to the right, should have been recorded on the DFDR and AIDS, but it was not; the bank angle did not change at that time as to show the turn. The heading did not change either. The course correction was not made, also proving that the aircraft never reached the extended runway centreline.

4.7.3.9.1 *Question.* Don't Experts agree with the theory outlined in the paragraphs above?

4.7.3.9.2 *Question.* The Experts seem to have read statements by the pilots only, but the objective evidence of the DFDR data proves an intentional navigation error. The captain was not ahead of the aircraft throughout the approach. The descent was definitely not well performed. Don't Experts agree?

4.7.3.10. The "*chart provided by the NLR confirms the captain's statement about the position of the aircraft on short final*", as Experts wrote. Experts should question how these data were acquired, and whether these can be correct, or whether the crew statements are made-up. The NLR made a mistake in the drawing; the VOR station is not located on the runway centreline, but 240 m south of runway and 1000 m from threshold. The 111° radial therefore crosses the extended runway centreline at 1 nm from the threshold. This drawing is therefore in error. Is not in agreement with RvO Annex 12 (Appendix 12) either. In the drawing, the NLR suggests a heading change at 7 km, but this was beyond the presented DFDR data in RvO Annex 15 (Appendix 7). The report from which the drawing was copied was never officially published, let alone approved by the Commission of Accident Investigation.

4.7.3.10.1 *Question*. Why did the Experts not use the graphs of the objective DFDR report (DFDR data; Appendix 7), rather than incorrect drawings and graphs without verifying using their expertise whether these were correct? Please explain.

4.7.3.10.2 *Questions*. Why did Experts use this unofficial NLR report? How did NLR make this drawing? How do Experts know that the airplane was on the extended centreline? Did you analyse the DFDR data - control inputs, motions, accelerations, etc. for you to confirm the captains statement yourself? Why did the aircraft need a heading of 125 degrees during the last 80 sec as recorded on the DFDR? Why was no attempt (rudder, aileron) recorded on the DFDR to align the aircraft with the runway? Is a crew statement made months after the accident still objective?

4.7.3.11. Analysis of aircraft trajectory data in RvO Annex 12 (Appendix 12), of heading, bank angle, rudder and aileron data of the DFDR in RvO Annex 15 (Appendix 7) and control input data of AIDS in RvO Annex 9 proves that the aircraft was never on the prescribed (stable) approach path at all, was never aligned with the runway. In fact, stable approach criteria were never met as DFDR data shows; a go-around should have been initiated i.a.w. BIM § 3.4.4 – 06 (Appendix 11).

4.7.3.12. *Question 31 of the 143 questions*: Are there any statements on the tapes of the Cockpit Voice Recorder, which could suggest overconfident or irresponsible action on the side of the crew? The DASB answered: "*Such statements are not included on the tape"* (see transcript).

4.7.3.12.1 *Question*: Experts answer "*no*". Don't Experts agree that there definitely were such statements? Experts made several comments in the CVR transcript in V17 § 8.6.5.2 themselves. The prescribed calls for a manual non-precision approach, were not given; as required in AOM 3.3.5 – 08; Appendix 14. Isn't the DASB lying here? If not, please explain.

4.7.3.12.2 *Questions.* Was the aircraft correctly in the slot for landing, down to an altitude of 200 ft as DASB concluded? DASB stated: "*The PAPI indication showed the aircraft to be on the correct glidepath, with some minor corrections*", but how could objectively be shown that the aircraft was on the correct glidepath while the PAPI lights that the pilots saw were not recorded? Don't Experts agree that this answer is wrong? If not, please explain.

5. Final Approach and Touchdown

5.1. Minimum Decision Altitude

5.1.1. Rules and Regulations

5.1.1.1. The crew coordinating procedure to be applied during non-precision approaches is prescribed in AOM 3.3.5 – 08 (Procedures for Non-Precision Approaches, Appendix 14):

- "At ≈ 500 ft", the PNF must call: "500", after which the PF responds with "cleared" or "not cleared". The call is included "to protect against subtle incapacitation and to serve as an awareness call for the landing clearance".
- *"At MDA + 100 ft"*, the PNF must call "*Approaching minimums*", after which the PF responds "*checked*". The PNF goes head-up and reports: "*Contact*", "*Approach lights*", "*Runway*".

- "Not later than MDA", the PF must call: "Landing" or "Go-around", after which PNF must "resume monitoring task".
- At 50 ft, the flight engineer calls "*fifty*".

5.1.1.2. "*The PNF occasionally goes head up, and goes fully head up after his call APPROACHING MINIMUMS*" (AOM 3.3.5 – 08; Appendix 14).

5.1.1.3. *"If a captain is not satisfied with the manner in which a pilot under his command handles the flight, verbal instructions will normally be sufficient to remedy the situation. During critical phases of the flight, however, there may not be time to wait for response and the only alternative will be to take immediate control of the aircraft. If this action is considered necessary, the captain shall fully take-over control while calling out "My Controls""*.
"*Changes in e.g. power settings, flight instrument set-up, configuration, shall not be made without informing the PF, as this may lead to uncoordinated actions*" (BIM 3.1.1 – 06; Appendix 28).

5.1.1.4. Operation below the descent limit is authorized if the captain is convinced that a safe landing and roll-out can be made on the intended runway. Required are visual references and stabilized aircraft conditions which include hat the aircraft is in a position from which a descent to landing on the intended runway can be made at a normal rate of descent, using normal manoeuvres and where that rate of descent will allow touchdown to occur within the touchdown zone of the runway of intended landing (BIM 2.3.6; Appendix 13).

5.1.2. Facts

5.1.2.1. At 07:32:30, after passing 500 ft, the flight engineer said: "*you missed the 500*" (CVR transcript), which is an awareness call. At Faro, the minimum altitude at which the decision is made to land or go-around was 400 ft (MDA). Then the captain, rather than the co-pilot said "*cleared hé*" and the co-pilot responds "*yes*" (CVR transcript).

5.1.2.2. The approach was not stabilized at 500 ft according to the definition in BIM and AOM. The deviation from the approach radial was >2° (one dot on the HSI), i.a.w. radar data plotted on the approach plate in RvO, Annex 12. In addition, with the other vital factors not stabilized and for the short and wet (or worse) runway of Faro, the BIM 3.4.4 – 06 (Appendix 11) "strongly recommended" a go-around.

5.1.2.3. At 07:33:00, twenty seconds before landing, the co-pilot said: "*windshield anti ice, I don't see anything*". The co-pilot as pilot-flying obviously lost view of the runway due to heavy precipitation. BIM prescribes: "*A go-around shall be made at any time when the required visual reference is no longer available*" (BIM 2.3.6). A time constraint is not given. "*The captain must be prepared for a go-around from any point of the visual approach*" (BIM 3.4.4 – 02; Appendix 29).

5.1.2.4. The captain, as PNF, did not fully go heads-up as required in the crew coordination procedure, because 10 sec before touchdown, he did read the RNAV derived wind head down from the R-Nav display (CVR transcript) which was located on the centre console, which he was not supposed to do.

5.1.3. Comments DASB

5.1.3.1. On Report RVDL3 page 6: According to the crew statements the aircraft was correctly in the slot for landing, down to an altitude of 200 ft. The PAPI indication showed the aircraft to be on the correct glide path, with some minor corrections.

5.1.4. Comments and conclusions Experts

5.1.4.1. V17 § 6.5 page 35 on the (alleged) missing of calls by the crew.

"*If this question calls for the Experts to evaluate the fact that the crew forgot the "500 feet" call out, the Experts confirm that the crew forgot it even if it was partially corrected by the F/E' remind.*

The instructions published by Martinair in its BIM indicate that, if the aircraft is not stabilized at this altitude, it has to engage a missed approach procedure. This specific instruction is customary in most airlines.

The pilots call this window the "stabilization floor".

The exact altitude may vary from one company to another, but it always has the same purpose.

What matters is not going through this window in a specific configuration, but to do it with respect to the trajectory as defined by the actual procedure.

The configuration will then be different whether the pilots carry-out a visual or an instrument approach.

Moreover, this stabilization floor means that all destabilization below this level has to be followed by a missed approach procedure immediately.

In our case, the pilots should have initiated a missed approach procedure since the aircraft became destabilized at a very low altitude.

So taking this into consideration, the fact that the pilots forgot to make the announcement verbally could be considered as a contributing factor to the accident: the announcement constitutes a verbal reminder of the procedure to follow, and it was not done".

5.1.4.2. The Experts consider that the Dutch Aviation Safety Board is right not to highlight this specific point, that visibility did not seem to be an issue during the approach.

5.1.5. Remarks and questions Claimants

5.1.5.1. During the approach briefing (CVR 06:54:56) the PF briefed captain and flight engineer amongst other, that he would fly the approach with 50° flaps, manual crew coordination procedure (AOM 3.3.5 – 06 and 08). "*You call approaching minimums and field in-sight, you looking outside, runway is 2490, wet runway*". During the crew briefing, the pilots should have noticed that the 500 ft and the Approaching Minimums calls (at MDA 400 ft + 100 ft) would conflict, i.e. happen together.

5.1.5.2. The PNF (the captain) should have called "*500*" and "*Approaching Minimums*" as instructed by the PF during the approach briefing, but he didn't. PF did not call "*LANDING*" after passing MDA (AOM 3.3.5 – 08; Appendix 14). The PF did not call "*CLEARED*" either, but the captain did 4 sec later. PF continued the approach, but he should have executed a go-around as he did not call "*Landing*". The captain allowed deviation from critical safety procedures and should have called for a go-around or take control of the aircraft. He eventually did, but too late.

5.1.5.3. Twenty seconds before landing, the co-pilot said: "*windshield anti ice, I don't see anything*" (CVR transcript). This proves that the PF lost visual reference of the runway at approximately 300 ft, well below the Minimum Descent Altitude, which should have led to an immediate go-around at that very moment, or the captain should have taken control, assuming he did have the runway visual. "*A go-around shall* *be made at any time when the required visual reference is no longer available*" (BIM 2.3.6; Appendix 11). A time constraint is not given. "*The captain must be prepared for a go-around from any point of the visual approach*" (BIM 3.4.4 – 02; Appendix 29). Hence, the loss of visual reference below MDA should have led to an immediate go-around.

5.1.5.4. "*Windshield anti ice, I don't see anything*" (CVR transcript) was a wrong command, should have been: "*windshield wipers*".

5.1.5.5. The captain, as PNF, went heads down to read the wind from the R-Nav display at an altitude of 150 ft, while the PF instructed him to "*look outside*" during the approach briefing. The procedure also required him to be heads-up below MDA + 100 ft and monitor the approach.

5.1.5.6. The flight engineer did not call "*50 ft*" as required in the approach procedure (AOM 3.3.5 – 08; Appendix 14).

5.1.5.7. RvO on page 19 explains the words "*cleared hé*" as clearance from the ATC controller to land, while it was the word out of the crew coordination procedure that the co-pilot should have said to confirm the clearance to land, but the captain said it instead 4 sec later, because the co-pilot forgot. The call is included "*to protect against subtle incapacitation and to serve as an awareness call for the landing clearance*" (AOM 3.3.5 – 08; Appendix 14). The co-pilot must have been too busy controlling the aircraft; he was busy because the approach path was not as it should have been, not on the 111° radial as radar data in RvO Annex 12 (Appendix 12) shows and as can be analysed from DFDR data. The decision to land was not communicated in the cockpit as required in AOM 3.3.8 – 08 (Appendix 14) at an altitude of 500 ft, i.e. not later than MDA. A go-around should have been initiated at that time.

5.1.5.8. The captain did not call "*my controls*" or “*go-around*” (as stated by the Flight Engineer), when he initiated the go-around, see AOM 3.3.5 – 08 (Appendix 14).

5.1.5.9. ATS and CWS were inappropriately used by the flight crew. The NTSB reported in letter 26 Oct. 1994 that "*It appears that the aircraft and auto flight systems worked properly*", see RvO Appendix.

5.1.5.10. The AOM § 3.3.5 – 13 (Appendix 30) Caution above describes the effects of using CWS during the flare for landing. When the pilot continues to pull the control column, the pitch continues to increase leading to a pronounced floating tendency. Releasing the column to the neutral position will only stop the attitude change but maintains pitch angle (is a CWS design characteristic). Forward pressure is a must to stop excessive floating under CWS. But as the CWS was disengaged after conflicting control wheel inputs from PF and PNF, pitch control was no longer supported by the autopilot; pitch control was manual; forward or aft column inputs would then directly change the pitch angle, which would be noticed easily by the pilots.

5.1.5.10.1 *Question.* Don't the Experts agree with the remarks stated above?

5.1.5.10.2 *Question*. The PF gave no indication that he saw the runway after the windshield wipers were set at fast. He should then have called "*landing*" although this should have been done at an altitude not below MDA = 400ft. DASB should have noticed the missed calls. This procedure is important for flight safety; why did experts not consider that DASB is wrong not to highlight this point? Please explain.

5.1.5.10.3 *Question*. If the call "Landing" is not made at the latest at 400 ft (MDA), then a go-around must be initiated (AOM 3.3.5 – 08; Appendix 14). Don't you agree?

5.2. Wind just before touchdown

5.2.1. Rules and Regulations

5.2.1.1. The maximum crosswind components for landing a DC-10 on several runway conditions is defined in AOM 3.7.3 – 04 (Appendix 9).

5.2.1.2. Calculations of maximum allowable wind components for landing should be based upon the Tower reported surface wind (AOM 2.15.4 – 06; Appendix 16).

5.2.2. Facts

5.2.2.1. At 07:32:15, MP495 is *"cleared to land runway 11, the wind 150°/ 15 max 20 kt"*, of which the crosswind component was 12.3 kt.

5.2.2.2. According to the RvO § 1.7.2.4 page 39, the SIO prints the wind data every 10 minutes. Next, the wind at 07:40 meteo time is given (= 07:41:30 UTC): 170°/24 kt max. 220°/35 kt. This was the wind 8 minutes and 10 seconds after the accident. The wind at 07:30 (07:31:30 UTC), 1 minute and 50 seconds before the accident, was not included among the facts listed by the Committee. However, it was stated that the wind speed might have been higher than 20 - 25 kt during the passage of a Cumulonimbus (Cb - a thundercloud). According to the weather information, the Cb covered 1/8-part of the sky and was at an altitude of 2,500 ft. Apparently at 07:30 UTC a heavy rainstorm was approaching and according to the Portuguese RvO heavy rain fell from it. The Portuguese RvO mentions *"violent down pour*" (heavy precipitation); the English translation by the DASB states that "*a violent storm arose*", which is rather exaggerated. The weather will have been bad, but in the RvO everything is done to give the impression that it was very bad. If that was indeed the case, then the pilots made a gross error by continuing the approach. DFDR data does not show that the aircraft did experience major accelerations, large altitude excursions and large airspeed variations (defined in AOM 3.3.8 – 02; Appendix 22) and was therefore not subjected to a "*violent storm*". Similarly, there are no comments made by the flight-crew in the transcript of the CVR about very bad weather during the approach.

5.2.2.3. The wind 220°/ 35 kt was never communicated to the aircraft (CVR transcript), because the wind never occurred before the landing of MP495. The meteo clock was not synchronized to UTC.

5.2.2.4. In RvO § 1.7.2.4 it is stated that a *"detailed analysis*" indicated that the wind started turning and increased in strength. § 1.7.4.4 contains a table with the wind information communicated to aircraft, but the numbers given do not correspond with the table in the same chapter with the average and maximum wind, as recorded every half minute by the SIO. Hence, the source of these "*facts*" in the "*detailed*" analysis is therefore unclear. The chapter should only provide factual information, but the authors of the RvO were seduced into adding analyses and their own interpretations (Avio*Consult*, § 2.3.4).

5.2.2.5. In RvO Annex 5, from 07:32:40, the columns with wind data of runway 11 show three times a wind of 220/max 35 kt, but each time the value is preceded by the label *"Valores calculados*". Hence, these data were not factual. These wind data are not in agreement with the data elsewhere in the RvO.

5.2.2.6. At 10 sec before landing, the captain looked down at the R-Nav control panel to read the RNAV derived wind data (CVR transcript) after which he said: "*wind is uh 190 with 20*". He was not supposed to do so; he had to be heads-up to monitor the approach (BIM 2.3.6 ii, Appendix 13 and AOM 3.3.5 – 08, Appendix 14). Reading the RNAV derived wind diverted his attention from monitoring the approach. After looking up again, he grabbed the controls and initiated a manual go-around; he should have commanded *"my controls*", "*go-around*" and pushed the go-around button, but he did not (BIM 3.1.1 – 06; Appendix 28 and AOM 3.3.6 – 02; Appendix 31).

5.2.2.7. During the last 80 sec of flight, the heading recorded on the DFDR was 125°. If the aircraft was on the 111° approach radial, the resulting crosswind component would have been 35 kt during at least the last 80 sec (DFDR data). If the aircraft was at the 7° larger ground track as indicated by the ground radar in RvO Annex 12 (Appendix 12), i.e. at 118°, the crosswind component would have been 17 kt. Fact is that the large drift angle should have alerted the crew that the crosswind was large, too large for landing.

5.2.3. Comments DASB

5.2.3.1. "*During the progress of the flight, the reported weather did not change. The weather conditions mentioned in the forecast prior to the flight until the final part of the approach remained generally the same, with a reported wind of 150° with a speed of 15 knots, with gusts up to 20 knots only reported at the last moment*" (Report RVDL3 page 2).

5.2.3.1.1 *Remark*. DASB must have read the CVR transcript (RvO Annex 5), including the wind and weather changes that were reported on the ATIS and by the ATC controller to other flights. There were indeed changes, not only during the last moment, also 20 min before landing when a wind of 150/24 kt was reported and departing flight TP120 reported passing through a thunderstorm.

5.2.3.1.2 *Remark*. The crosswind component, based on the Tower reported surface wind of 150/15-20, was 14 kt, 9 kt higher than the limit for a flooded runway, only 1 kt less that the 15 kt limit for a wet runway. The crew was aware of the wind varying in direction and magnitude.

5.2.3.2. "*During the final approach the captain monitored wind readings of the R-NAV. This action is not required in the AOM procedures*" (Report RVDL3 page 3).

5.2.3.2.1 *Remark*. The captain monitored the R-Nav calculated winds during the approach several times. It is required to do this in case windshear is expected. BIM 3.1.7, Appendix 6: "*If a wind shear in the approach area is expected or known to exist:*

- use speed increment as indicated in the AOM;
- consider the use of a reduced landing flap setting, runway length permitting;
- use autopilot and autothrottle, if possible;
- monitor Inertial/Omega data, IAS, rate of descent, pitch and power, closely for early shear recognition".

Indeed, as DASB wrote in Report RVDL3, the AOM did not require to monitor wind readings, but the BIM did, and that is what the captain did. There were obvious no changes in indicated air speed, rate of descent, pitch and power that would let the captain believe that there were signs of windshear. DFDR data objectively shows there were none either.

5.2.3.3. "*Approach Control did not transmit to the aircraft the wind information on runway 11 that reached 220° with 35 kts between 07.32:40 and 07.33:30 UTC*".. DASB wanted to delete from the RvO the sentence "*The crew was not aware of the turbulence intensity due to the influence of the automatic flight control systems operating correctly, degrading the crew's perception of the seriousness of the situation*" (Report RVDL3 page 9).

5.2.3.3.1 *Remark.* The wind 220°/35 kt was indeed never communicated to the aircraft (CVR transcript), because it was not measured on the ground, prior to the landing of MP495.

5.2.3.3.2 *Remark*. If the wind 220°/35 kt ever occurred, it was after the aircraft had landed. None of the data recorded by the DFDR supports the DASB statement on the 220°/35 kt wind which would result in a (small) tailwind. A wind of 220°/35 kt, by the way, would require a 4° larger crab angle on touchdown than the 11° that was recorded on the DFDR. The scratches in the asphalt were straight and in the runway direction. The "*crab angle*" was therefore not only a crab angle into the wind, but also an increase to the heading to fly to the runway. The aircraft was north of the extended runway centreline until touchdown.

5.2.3.3.3 *Question*. How did the Experts validate the DASB remark? Please explain.

5.2.4. Comments Experts and Remark Claimants

5.2.4.1. *"It is undeniable that the aircraft has encountered destabilizing meteorological conditions during the last phase of its final approach"* (V17 § 6.1 page 34).

5.2.4.1.1 *Remark*. Objective DFDR and AIDS data do not show destabilizing meteorological conditions. The aircraft never became destabilized; none of the control inputs were maximal at any time during the approach. The airspeed did not vary very much, except as caused by the pilot-flying. The pilot-flying caused aircraft motions because of inappropriate roll and pitch control inputs, even against the autopilot. From 43 sec before the landing, the pilot-flying already applied left rudder to align the aircraft, but at 18 sec before landing, he released the rudder; the heading returned to 125°. At 12 sec before the landing, near full left rudder was applied. The heading decreased from 125° to 112°, but did not reach the runway heading 106°. Rudder inputs cause side effects and unnecessary motions and sensations. During the same period, the co-pilot also applied pitch inputs that caused pitch angle changes. The autothrottle immediately responds to even small changes of pitch commands by immediately in- or decreasing the engine thrust. All of these pilot induced variations might be explained as destabilizing (meteorological) conditions while, in fact, the co-pilot induced them. The co-pilot had no experience in landing a DC-10 in crosswinds exceeding 15 kt (Fax Martinair, Appendix 5) and the NTSB concluded that the autothrottle and autopilot (CWS) functions were inappropriately used (RvO Appendix).

5.2.4.1.2 *Question.* Claimants do not understand this statement, and ask the Experts to motivate their statement in engineering terms, rather than in informal language.

5.2.4.2. The experts refer to the statement of the Flight Engineer: "*the captain said Go-Around*".

5.2.4.2.1 *Question*. This statement was not recorded on the CVR and hence not an objective statement. Don't Experts agree?

5.2.5. Other Remarks Claimants

5.2.5.1. The wind data used for calculating the landing data on the Landing Data Card was not based on the Tower reported actual wind data, as should have taken place. The reported winds by Faro approach to MP495 and other traffic varied considerable. At 07:19:51, the controller reported a wind of 150°/24 kt with the take-off clearance to departing flight TP120. The captain said … (illegible), the flight engineer responded: "*Hè what?*", the captain "…"(illegible), after which the flight engineer says "*yeah, I'll check them*". This must have been the response to the increased wind, because the flight engineer prepared the Landing Data Card (using forecasted data) approximately half an hour before landing and was going to review the data. The Landing Data Card found in the wreckage however, showed the old, forecasted wind data. The landing data were not updated to the most recent weather data provided by the Tower controller, while the "*calculations of maximum wind components for landing should be based upon the Tower reported surface wind*" (AOM 2.15.4 – 06; Appendix 16). The Landing Data Card found in the wreckage showed the old wind data.

5.2.5.2. The crew were made aware that the winds varied in strength and direction, and that there was a thunderstorm nearby, reported by the departing flight TP120. Although the captain did not have to read the wind from the R-Nav display, he did and reported aloud: wind 190/20. Once he did, this value should have become leading. The crosswind component of this wind was 20 kt, much higher than the limits for both a flooded and a wet runway. AOM 2.15.4 – 06 (Appendix 16) advises that "*the crosswind component might be up to 5 kt in error and is strongly influenced by slide-slip manoeuvres, such as de-crabbing*". At that moment, the co-pilot indeed applied full rudder in an unsuccessful attempt to de-crab the aircraft. This means that the actual crosswind was even higher, and increased even more above the runway limits. The unsuccessful de-crabbing and a heading 11° right of the runway centreline should also have rang a bell in both pilots' minds of the magnitude of the crosswind.

5.2.5.2.1 *Question*. Is careful review of objective and actual DFDR and AIDS data of the final approach not more reliable for flight path reconstruction than using ATC provided wind data (150°/15 – 20 kt)? Such data is never actual. Did the captain not read the wind from the R-Nav 10 sec. before landing (CVR transcript)? Please explain.

5.3. Rate of Descent

5.3.1. Rules and Regulations

5.3.1.1. During landing on a wet or otherwise contaminated runway, AOM 3.3.5 – 15 (Appendix 2) requires pilots to "*aim for a positive touchdown*", "*avoid a long float*" and "*be prepared to go-around at any time during the flare*".

5.3.1.2. "*At 30 – 40 ft, initiate flare. A slight flare (2° à 3°) is required. Touchdown attitude is approximately 7°*" (AOM 3.3.5 – 13; Appendix 30).

5.3.1.3. A manual landing requires the pilot-flying "*at 50 ft, to monitor throttle lever retardation*". The pilot-flying monitors by laying his hand on the throttle levers. "*If autothrottles fail to retard, retard throttles manually*" (AOM 3.3.5 – 13; Appendix 30).

5.3.2. Facts

5.3.2.1. The captain told the co-pilot to "*make it a positive touchdown*", meaning to not flare to a 'soft' touchdown, which might lead to aquaplaning.

5.3.2.2. In the draft of report CR 94238 C (numbered CR 94xxx – Lijst 4 tab 24, file NA 2616), successor of CR 93080 C, the NLR concluded "*a mean rate of descent of 760 ft/min during the last part of the flight*". This can be confirmed by analysing the DFDR radar altitude data.

5.3.2.3. The DFDR data (RvO Annex 15; Appendix 7) includes two altitude graphs. One is showing the barometric altitude, the altitude measured using the pressure of the ambient air, and the second trace is the radar altitude, i.e. the altitude measured by a radio detection and ranging (radar) altimeter (radalt), which shows the altitude from the antenna underneath the fuselage to the ground. While the DFDR radalt graph is straight, i.e. showing a constant rate of descent during the last 10 sec of flight, the barometric altitude is a convex curve that shows an increase of the rate of descent during the last 3 sec of flight. Air data measurements though, are influenced by many error sources, the most important of which is the ground effect, caused by the (reflecting) bow wave of the aircraft when the aircraft is close to the ground, influencing the air pressure in the pitot tubes that are connected to the airspeed indicators. During the experimental flight test phase of an aircraft, airspeed and baro-altitude correction tables and graphs are prepared to be published in the Aircraft Flight Manual; these corrections were most probably not applied to the baro-altitude data of the DFDR. The radar altitude needs no correction and is a reliable source for accurate altitude data provided the ground underneath the aircraft is level, not undulating.

5.3.2.4. During the last 7.5 sec before touchdown, the average pitch angle increased from 2.5 to 9 degrees, the normal touchdown attitude. The vertical/normal g increased as well to 1.2, indicating a decreasing rate of descent. This g increase was caused by the increasing pitch angle and increasing thrust of the engines following the initiation of the go-around.

5.3.2.5. The bank angle during touchdown was 5.62° to the right (DFDR data RvO Annex 15; Appendix 7).

5.3.3. Comments DASB

5.3.3.1. "*Due to the premature large and sustained power reduction and the tailwind component in the final approach phase, the aircraft attained a rate of descent of about 1000 ft/min*" (RVDL3, page 11).

5.3.3.1.1 *Remark*. There is no evidence on DFDR data that this number is correct. See § 5.3.5.1 below.

5.3.3.2. In Report RVDL3 page 6 DASB wrote: "*Only when the pre-set limits of the Ground Proximity Warning System are exceeded, the rate of descent during an approach is considered excessive, and in that case an autoprint of the AIDS will take place. Such an autoprint did not occur, as evident from the AIDS registration*". Hence, a fact is that the rate of descent was not excessive.

5.3.3.3. DASB tried to persuade the Commission during a visit to Portugal and with the Report RVDL3 (lijst 4 tab 23, page 13) to change the causes paragraph to include:

"Subsequently a high rate of descent and an extreme lateral displacement developed, causing a hard landing on the right-hand landing gear, which in combination with a considerable crab angle exceeded the aircraft structural limitations."

5.3.3.3.1 *Remark*. Both DASB and Commission conclude that the rate of descent increased to 1000 ft/min or more as consequence of the microburst/windshear. The increased rate of descent led to a hard landing on the right main landing gear that, together with the large crab angle exceeded the structural limits of the aircraft. These factors should have led to the

fracture of the right landing gear.
These conclusions are not supported by the measured facts. The radar altimeters in the aircraft do not show an increase of the rate of descent. The rate of descent is not 1000 ft/min, but substantially lower.
In addition, the DFDR vertical acceleration graph does not show variations that increase above the values for light turbulence. When a microburst/windshear would have occurred that led to an increase of the rate of descent, the vertical acceleration data would have shown this. Fact is that the vertical acceleration did not increase just prior to the landing, but actually even decreased because of the nose-up manoeuvre for the go-around.

5.3.3.4. With letter 13-04-1995 (NA 2608), the NLR asked AIB/ Mr. Erhart permission to use, include and publish a few pages and figures out of the report CR 93080 C in a GARTEUR (Group for Aeronautical Research and Technology in EURope) publication on windshear occurrences in Europe. The NLR letter included an attachment with the requested data. The copy of this letter in the National Archives (2608) shows the notes made by chief investigator Mr. Erhart on the individual pages. He did not want the NLR to publish data on lateral and vertical flight profile, on the vertical speed, a paragraph on the traverse landing, about closure of the power levers and the remark "*more flight data is needed, however, to substantiate this.*" Figures showing the pitch increase, roll angle, airspeed, normal acceleration and vertical speed just prior to the landing were not allowed to be published either. Allowed were only figures showing data obtained from models of downburst and the downburst-influenced flight path (which were also inappropriately used by the Experts, because these were not out of the final report in RvO Annex 4, hence were not official), adverse wind components graphs and graphs that show the windshear. These graphs were all obtained from theoretical models or inappropriately crunched DFDR and AIDS data, and from assumptions by an engineer who was not aware of the procedures that the pilots had to use during a VOR approach, i.e. set a rate of descent with the vertical speed wheel in the autopilot and take over manually when PAPI lights are in sight (AOM 3.3.5 – 08 & 09; Appendix 14 & Appendix 24). It is obvious that Mr. Erhart realized that real experts could use the report to conclude that the 'fabricated' cause of the accident, as desperately desired by Martinair and DASB, could not be genuine. Therefore, to avoid blame, the data should not be made available to an international scientific organization as GARTEUR is.

5.3.3.5. "*To all probability the aircraft encountered the third microburst which was calculated by NLR to be present there. Immediately thereafter engine thrust reduced to flight idle*".

5.3.3.6. "*The Board agrees that to all probability an action of the F.O. [first officer] resulted in the sustained flight idle thrust*".

5.3.4. Conclusion Experts

5.3.4.1. "*A vertical speed above 850 feet/minute as calculated by the Experts is clearly beyond the limitations imposed by certification*" (V17 page 27).

5.3.4.1.1 *Question*. The Experts are requested to motivate their answer by showing how this is calculated (after reading § 5.11).

5.3.4.2. Experts on V17 § 6.3 page 35:

"The value of the descent rate was calculated by both the NLR and the NTSB in its analysis of recorded parameters on the DFDR. Both have similar conclusions. The Experts also obtained similar results.

Moreover, the analysis of the mechanical collapse of the right main landing gear illustrates the problem generated by an excessive vertical speed.

Even though the Experts mission is not to find out the origin of this vertical speed, it is difficult to deny its existence at the time of the accident".

5.3.4.2.1 *Question.* The NTSB did not present a rate of descent, i.e. it is not published in the DFDR factual report, DCA-93-RA-011 dated 12 Feb 1993 (RvO Annex 15; Appendix 7). Where did the Experts find the NTSB calculated descent rate?

5.3.4.2.2 *Remark*. As for the collapse of the gear, please refer to § 5.11 below.

5.3.5. Remarks and Questions Claimants

5.3.5.1. The NLR, in the draft of report CR 94238 C (numbered CR 94xxx – Lijst 4 tab 24, file NA 2616, successor of CR 93080 C), concluded a mean rate of descent of 760 ft/min during the last part of the flight. The chief investigator of the AIB returned the report with the comment to delete this line, because he obviously wanted a higher rate of descent to be able to support the conclusion that the landing gear failed due to the high rate of descent; 760 ft/min is not a high enough rate of descent to fail the landing gear. The pitch up during the last seconds (which reduced the rate of descent) on page 13 also needed to be deleted. All references to a lower rate of descent than a rate that would cause the landing gear to fail had to be removed.
In April 1995, NLR asked DASB permission to make the first NLR report (CR 93080 C) available for international scientific windshear research. The answer is presented in § 5.3.3.4;

5.3.5.1.1 *Question*. Do Experts agree that it is strange to delete rate of descent and flight path data from the report? Can Experts explain why this important information were not to be included in the NLR report?

5.3.5.2. DASB enforced a few changes to the draft of th**e** NLR report. This report would be included in RvO Annex 4. DASB was also responsible for the contents of the NLR report; they knew exactly what they were doing.

5.3.5.2.1 *Questions.* Didn't the NLR, by granting the required changes, give up its independency as scientific institute? Behaved the DASB as an independent investigator? Please explain.

5.3.5.3. The Experts have calculated 850 ft/min (V17 pages 27 and 112), but did not present the calculation. The design rate of descent of 600 ft/min (AOM 3.7.1 – 09; Appendix 32) is not the only parameter that determines the energy that is to be dissipated by the landing gear during landing. Neither a rate of descent of 760 ft/min, nor of 850 ft/min results in a collapse of the landing gear as will be discussed in § 5.11 below. A DC-10 landing gear is designed and tested to withstand a rate of descent of 900 ft/min with a bank angle of 8° and 1024 ft/min with the wings level at max. landing weight without bottoming the shock struts.

5.3.5.3.1 *Question*. If the Experts say it is not their mission to find the origin of the vertical speed, then an answer to the Court cannot be given. Don't Experts agree with the observation from DFDR data that the rate of descent was less than DASB tried to believe? If not, please explain.

5.3.5.4. In the draft report, NLR also mentions in § 2.2.3 b): "*This may explain the rather short flare that occurred at touchdown (i.e. pitch-up to about 9 degrees)*". The words between parentheses were also deleted by Mr Erhart, because they would refer to a decrease in vertical speed just prior to touchdown. This decrease can also be observed on the DFDR normal (vertical) g graph, as already mentioned above. The pitch before touchdown was increasing from 2° and was 9° at touchdown, as required by AOM 3.3.5 – 13 Manual Landing.

5.3.5.5. DASB stated that at 80 ft radar altitude a high rate of descent developed. Radar altitude data of the DFDR in RvO Annex 15 (Appendix 7) doesn't show this, though; wishful thinking not backed-up by objective DFDR data.

5.3.5.6. The increase of the pitch angle prevented the rate of descent to increase, but at the cost of reducing the airspeed and increase of drag. The airspeed above the threshold was only 3 kt below the required threshold speed of 139 kt but decreased thereafter.

5.3.5.7. The speed command of the ATS proves that the ATS tried hard to open the throttles (letter NTSB), but the co-pilot prevented that from happening, while he only has to monitor throttle retardation by the ATS at 50 ft (by resting his hand on the throttles, AOM 3.3.5 – 13; Appendix 30). The co-pilot however, kept the throttles closed which caused the engine rpm to reduce to flight idle, much lower than the requirements for allowing an immediate go-around from any moment during the approach, including during the flare (AOM 3.3.5 – 15; Appendix 2).

5.4. Premature thrust reduction

5.4.1. Rules and Regulations

5.4.1.1. The primary method of executing an approach, regardless of weather conditions, is by means of the autopilot(s) and autothrottles. To avoid inadvertent autopilot disconnection by overpowering, hold the controls lightly (AOM 3.3.5 – 04; Appendix 8).

5.4.1.2. "*During approach, all control actions shall be followed with hands and feet on the controls by the pilot flying, in order to resume manual control immediately after a disconnect*" [of an automatic system] (BIM 3.4.3 – 01; Appendix 33).

5.4.1.3. When the autothrottle is engaged and the aircraft descends below 50 ft radio height for landing, the ATS engages the Retard mode, in which the throttles automatically retard at a programmed rate (AOM 1.3/4 page 1; Appendix 34).

5.4.1.4. At 50 ft, the pilot-flying always needs to "*monitor throttle lever retardation*" by the ATS, by holding his hand on the throttles, to be able to 'feel' what the Auto Throttle System is doing. "*If both autothrottles are disengaged, or fail to retard, retard the throttles manually*" (AOM 3.3.5 – 13; Appendix 30).

5.4.2. Facts

5.4.2.1. During the approach, the autothrottle system was engaged and set at the threshold speed of 139 kt, rather than at the obligated 5 kt higher approach speed of 144 kt (§ 4.3.2 above).

5.4.2.2. Both DFDR and AIDS data show a decrease of N1 rpm of all three engines below an altitude of 150 ft, 14 sec. before touchdown, down to the flight idle thrust level (≈55% N1) at a retard rate higher than the normal retard rate of the engaged auto throttle system on four earlier occasions during the last 70 sec of flight (DFDR data, RvO Annex 15; Appendix 7).

5.4.2.3. Although the auto throttle system is designed to control the throttles until after touchdown, "*manual override of the auto throttle is possible at all time*", meaning that a pilot can forcefully pull the throttle handles to idle, even with the auto throttle system engaged (AOM 1.3/4 page 1; Appendix 34).

5.4.2.4. The NTSB reported in letter 26 Oct 1994 (RvO Appendix): "*It appears that the aircraft and autoflight systems worked properly. Information from the quick access recorder indicates that the speed error (which is one of the parameters controlling the auto throttle computer and translates how hard the computer wants to push the throttles forward) suddenly increases when the throttles were reduced to idle at 150 feet radio altitude, rather than at 50 feet when the normal auto throttle retard mode would have been in effect*". The NTSB recommended in this letter also to include "*manual intervention by the crew*".

5.4.3. Comments DASB

5.4.3.1. The DASB wanted to delete the line from the RvO: "*The power was reduced at 150 ft instead of at 50 ft by autothrottle action*" (report RVDL3) and change this line into: "*At 150 ft the power was reduced to flight idle. This power reduction was in all probability initiated by the ATS with a follow through by the F.O. [First Officer]. Also the sustained flight idle thrust condition was most probably a result of action of the F.O.*".

5.4.4. Comments Experts

5.4.4.1. "*There are two points to address regarding this question:*

- *First, the records show a strong thrust increase that reached a value comparable with a missed approach procedure;*
- *Then next, a decrease down to flight idle thrust.*

Several scenarios have been mentioned but, for the Experts, it clearly appears that the increases in thrust were consequential to the destabilization, not a cause of it.

However, even though the thrust increase showed the pilot's intentions to go around, it also showed that he became aware of the situation but the variations of bank angle, whatever their origin, changed his order of priorities" (V17 § 6.6).

5.4.4.2. The Dutch Aviation Safety Board estimates that the Portuguese report is correct in regards to the thrust decrease probably initiated by the ATS and confirmed by one of the pilots (V17 § 5.2.2.4, page 25).

5.4.4.3. "*A lack of certainty about the thrust variation is the reason for the Experts to be cautious*" (V17 § 5.2.2.4 page 25).

5.4.4.4. As already said, the Experts do not validate the official assertion related to the reduction of thrust. The rate of thrust variation is the same as if done by the ATS. It is then impossible to define definitely who initiate the thrust reduction (V17 § 4.3, page 59).

5.4.5. Remarks and questions Claimants

5.4.5.1.1 *Question.* Have Experts included the DFDR data (RvO Annex 15; Appendix 7) to determine the cause of the *"thrust increase that reached a value comparable with a missed approach procedure"?* Please explain in detail.

5.4.5.1.2 *Question.* If Experts mention that "*the increases in thrust were consequential to the destabilization",* what do they exactly mean? Which destabilization, if any? Please motivate your answers.

5.4.5.1.3 Question. What do Experts mean by "the variations of bank angle, whatever their origin", that "changed his order of priorities"? Please explain in detail by analysing DFDR data.

5.4.5.2. The Commission included in the final report: "*At 150 ft (RA) power has been reduced to flight idle through ATS and kept at flight idle, probably by co-pilots action. Under normal conditions the ATS retard mode starts at 50 ft (Radar Altitude)*".

5.4.5.3. An ATS is not programmed to reduce the thrust to a level below approximately 55% N1 when the altitude is above 50 ft AGL, refer to the DFDR N1 data where three instances prove this during the last 60 sec of flight (DFDR data RvO Annex 15; Appendix 7).

5.4.5.4. Hence, the ATS functioned; no lack of certainty, except if the Experts didn't read the NTSB letter, although they state in V17 § 5.2.3.2 page 29 "*that the equipment the NTSB possesses is probably one of the best in the world*".

5.4.5.4.1 *Question.* The rate of thrust decrease during the last 12 sec of flight is larger than the rate of thrust decrease by the ATS during the four instances at 67, 55, 37 and 25 sec before touchdown, and definitely not "*the same as if done by the ATS*". Did the Experts review the DFDR N1 graphs in RvO Annex 15 (Appendix 7) in their analysis?

5.4.5.4.2 *Question*. Why do Experts have a different opinion of the ATS than the NTSB, and why do Experts not validate the NTSB statement?

5.4.5.4.3 *Question*. Do Experts agree that the NTSB was right in concluding that "*It appears that the aircraft and autoflight systems worked properly"?* If not, please explain in an objective analysis using facts and figures.

5.4.5.5. For pilots always counts during an approach: Hands on throttle and stick, meaning to monitor or control the roll and pitch of the aircraft with one hand, and monitor the motions of the throttles under ATS control with the other, as prescribed in AOM 3.3.5 – 04 (Appendix 8). If the ATS varies the thrust too vigorously, or reduces the thrust too prematurely, the pilot should take control of the throttles as well. There was no error in the system, and because abnormal operation indeed occurred, this must have been a pilot error which should have been addressed by both the DASB and the Experts.

5.4.5.6. The intention of the procedures is that the aircraft lands while the ATS stays in control of the throttles. In this case, the pilot overruled ATS and closed the throttles, not below 50 ft, but already at 150 ft. One of the reasons might be that the co-pilot had the custom of closing the throttles, not waiting for the ATS to enter the retard mode. Another reason could be that the co-pilot estimated that the DC-10 should touchdown too far down the runway, which he tried to prevent by closing the throttles early, a beginners' mistake. The co-pilot apparently was not very accustomed to and proficient in managing the automated control systems of a DC-10.

5.4.5.7. *"During the approach, use of flaps 50, the low airspeed, and throttle movement to idle, minimized the flight crew's options for recovery and increased the recovery time required. Once the autopilot was disengaged, CWS with ATS remained: functions which were inappropriately used by the flight crew*" (letter NTSB 26 Oct 1994, RvO Appendix).

5.4.5.8. "*If a manual landing must be performed*" on a wet or otherwise contaminated runway: "*be prepared for a go-around at any time during the flare*"(AOM 3.3.5 – 15; Appendix 2). Keeping the throttles closed is not being prepared, because increasing the throttles from idle to take-off thrust takes many precious seconds, while the increase of thrust from a higher level is almost instantaneously.

5.4.5.8.1 *Question*. Do Experts agree that decreasing the thrust to flight idle in-flight is not in agreement with the AOM, and not with windshear recovery techniques either? (AOM 3.3.8 – 02, Appendix 22). If not, please explain.

5.4.5.8.2 *Question*. Do Experts agree that DASB wanted to focus on the weather, rather than on the mishandling by the pilots? If not, please explain.

5.4.5.9. The conclusion of the Commission was not in agreement with NTSB, the reason might have been that the NTSB response letter arrived in Portugal after the deadline for comments (i.a.w. Annex 13). The letter was included in the Appendix of the RvO, though.

5.5. Control inputs during final approach

5.5.1. Rules and Regulations

5.5.1.1. The minimum height to change from Command mode (Vertical Speed) to CWS is 500 ft (AOM 3.3.5 – 08, Appendix 14).

5.5.2. Facts

5.5.2.1. The co-pilot switched the autopilot from Command to CWS mode above 500 ft, as required.

5.5.2.2. DFDR and AIDS data show unnecessary rudder, and large pitch and roll control inputs against the autopilot that was engaged in the vertical speed mode and later in CWS mode.

5.5.3. Comments DASB

5.5.3.1. The Dutch Aviation Safety Board holds the First Officers actions on the controls responsible for the inclination leftward (V17 § 5.2.2.3, page 25).

5.5.3.2. "*A bank to the left developed when the First officer applied left rudder to decrab the aircraft*" (RVDL3, page 6).

5.5.4. Comments Experts

5.5.4.1. The flight analysis conducted by the Experts tends to agree with this statement that the First Officer is *"responsible for the inclination leftward*".

5.5.4.2. The bank angle gradient to the left, surprises both pilots who react at the same time to control and reverse it, which ultimately created a banking inversion twice as strong (V17 § 5.2.2.4 page 25).

5.5.4.3. "*It is technically possible that this probably strong action by the pilots provoked the automatic pilot to disengage the CWS mode. This is validated by the Dutch Aviation Safety Board.*
However, a double-click, which was signalled and recorded by the CVR seems to prove that this disengagement was voluntary" (V17 § 5.2.2.4 page 26).

5.5.4.4. The statement according to which the disengagement of the autopilot (switching from CWS to MAN) occurred spontaneously is therefore not validated by the Experts (V17 § 5.2.2.4 page 26).

5.5.5. Remarks and Questions Claimants

5.5.5.1. The NTSB, wrote to the Commission: "*Once the autopilot was disengaged, CWS with ATS remained: functions which were inappropriately used by the flight crew*" (letter NTSB 26 Oct 1994, RvO Appendix).

5.5.5.2. As already discussed in § 5.2.4.1.1, the pilot continued to interfere with the CWS mode operation of the autopilot of the aircraft. AOM 3.3.5 – 04 (Appendix 8): "*To avoid inadvertent autopilot disconnection by overpowering, hold the controls lightly*", with thumb and finger, as pilots call this. The co-pilot did not "*hold the controls lightly"*, but continuously entered large commands. This had the effect that the autopilot overreacted and as a consequence, the engaged autothrottle system also responded to the control inputs by in- and decreasing the thrust of the engines, giving the impression of "longitudinal instability". In addition, the co-pilot applied pressure on the left rudder pedal already 40 sec prior to the landing, at ≈ 1.4 nm from the threshold. If this was an attempt to align the aircraft with the runway, it was not only too early, but also too small (DFDR and AIDS data in RvO Annex 15; Appendix 7, resp. Annex 9).

5.5.5.2.1 *Question*. Don't experts agree that many control inputs were excessive and unnecessary? If not, please explain.

5.5.5.2.2 *Question*. The aircraft banked a few degrees to the left over 8 sec as side effect from the rudder input that was not adequately counteracted by the ailerons, as shown by DFDR data. The roll rate though, following this increasing bank to the left was not twice as strong, but the same as the roll correction to the right. The roll was not continued to the right though to compensate for the crosswind, as might be expected for a landing under large crosswind conditions. Can Experts explain why this happened? Could it be possible that the aircraft was not approaching on the extended runway centreline, but under a 7° angle as the ground radar data proves?

5.5.5.2.3 *Question*. It is not only technically possible that a strong action disengaged the CWS mode. The system is designed to disengage autonomously when opposite control force inputs are sensed between the captain and co-pilot pitch and roll controls. Experts use "*however*", but this mode switch can neither be called voluntary, nor spontaneously, don't you think?

5.5.5.2.4 *Question*. The rudder and aileron control inputs during final approach were not as you would expect for a crosswind landing. During the approach the heading was 125°, so there must have been a strong crosswind. Can experts explain why the pilots did not use standard crosswind landing control inputs? Why would the pilots allow the bank angle to increase to the left over 8 sec and not attain and maintain a bank angle to the right to counteract the crosswind component? Could it be possible that the approach was not on the extended runway centreline?

5.6. Autopilot disengagement

5.6.1. Rules and Regulations

5.6.1.1. "*The primary method of executing an approach, regardless of weather conditions, is by means of the autopilot(s) and autothrottles. To avoid inadvertent autopilot disconnection by overpowering, hold the controls lightly"* (AOM 3.3.5 – 04; Appendix 7).

5.6.2. Facts

5.6.2.1. At 6 sec before touchdown, the CWS mode of the autopilot disengaged because of the conflicting roll control inputs of the captain and the co-pilot. The co-pilot was not made aware that the captain took control of the aircraft because the captain did not say "*My controls*" when taking over the control of the aircraft.

5.6.3. Comments DASB

5.6.3.1. *Both pilots took opposite corrective control wheel action simultaneously most probably causing the autopilot CWS mode to disengage*" (RVDL3, page 6).

5.6.3.2. "*Disengagement of the autopilot CWS mode could have resulted in less pitch increase than could be expected from the control wheel input, as the crew was not aware that the CWS mode had disengaged. The reason that the crew was not aware of the disengagement could have resulted from the fact that the aircraft was in the final stage of the landing and the attention of the crew was focused on outside references and therefore missed the Autopilot red flashing warning light.*
Obviously the crew tried to correct the situation and to bring the aircraft back to the runway centreline" (Report RVDL3, page 7).

5.6.4. Comments Experts

5.6.4.1. The Experts only refer to the double click in the CVR transcript 5 sec before touchdown, and present no comments.

5.6.5. Remarks and Questions Claimants

5.6.5.1. The captain did **not** say "*My controls*", when taking over the control of the aircraft; it was not recorded on the CVR, though required in BIM 3.1.1 – 06 (Appendix 28). The captain applied a roll control force opposite of the roll control force by the co-pilot (RvO Annex 9), which was the reason why the autopilot CWS mode disengaged.

5.6.5.1.1 *Question*. Why do Experts refer to the CVR transcript and don't provide comments to the DASB answer? Please explain.

5.6.5.1.2 *Question.* Was the cause of disengagement of the CWS mode of the autopilot not the failure of the captain to call "*My controls*"? Please explain.

5.6.5.1.3 *Question.* DASB wrote that the crew tried to correct the situation and to bring the aircraft back to the runway centreline. Would not a bank angle to the right be required to achieve that (which was not shown on the DFDR data)? Was the answer of the DASB not incorrect? Please explain.

5.7. Go-around attempt

5.7.1. Rules and Regulations

5.7.1.1. AOM 3.3.6 – 02 (Appendix 31) presents the Go-around Crew Coordination Procedure.

5.7.2. Facts

5.7.2.1. Approximately 3 sec before touchdown, the captain grabbed the controls and the throttles, and initiated a manual go-around (his statement 29 Dec. 1994). He did not push the Take-off - Go-around (TOGA) button.

5.7.3. Comments DASB

5.7.3.1. The crew intervention for power increase of the engines was too late to stop the high rate of descent (Report RVDL3 page 11; V17 indent 26, page 53).

5.7.4. Comments Experts

5.7.4.1. "*No comment from the Dutch Aviation Safety Board. The Experts cannot validate this sentence* [§ 5.7.3.1 above]. *Out of stall conditions and also in specific conditions, the rate of descent is directly linked to the elevator. The thrust then allows the control of the speed. This sentence has been deleted in the final version and changed* *for the following: « The captain's intervention during the whole approach seems to have been too passive, and concerning the last power increase, it came too late. » The Experts do not validate this assertion of the Commission. The captain's intervention during the first part of the approach was highly professional, given that he was monitoring the descent as required by the airmanship for such a case*".

5.7.4.1.1 *Remark*. Experts comment is not at all applicable to this subject.

5.7.4.1.2 *Questions*. Don't Experts think that "*highly professional*" is doubtful, regarding not following the AOM procedures and missing the calls '500 ft' and 'approaching minimums' and letting PF to fly left of inbound radial? If not, please explain. Ten seconds before touchdown, the captain, as PNF, went head down to read the wind; is this the proper way for the captain to handle? Please explain your point of view.

5.7.5. Remarks and Questions Claimants

5.7.5.1. The PNF, the captain, looked down at the R-Nav control panel to read the wind data (CVR transcript), which he was not supposed to do at an altitude below 500 ft (AOM 3.3.5 – 08; Appendix 14). This diverted his attention from monitoring the approach. After looking up again, he must have noticed a desperate situation, grabbed the controls and initiated a manual go-around; he should have commanded "*my controls*" and pushed the TOGA (take-off/go-around) button on the throttles to initiate the thrust increase in the quickest possible way as prescribed in AOM 3.3.6 – 02 (Appendix 31).

5.7.5.2. Although AOM 3.3.5 – 15 (Appendix 2) requires to "*be prepared to go-around at any time during the flare*", the go-around failed because the thrust was decreased to a level far below flight idle by the co-pilot. The spool-up time of the engines to go-around power was too long for a successful go-around.

5.7.5.2.1 *Question*. DASB stated that "*The crew intervention for power increase of the engines was too late to stop the high rate of descent*". Do Experts agree that this statement is wrong? That it was not the intervention for power increase, but the intervention that decreased the power against the autothrottle? And that by keeping the throttles closed, the crew was no longer prepared to go-around at any time during the flare? If Experts don't agree, please motivate the answer.

5.8. Alleged Lateral Displacement Just Prior To Touchdown

5.8.1. Rules and Regulations

5.8.1.1. To avoid a lateral movement during a crosswind landing the pilot must, i.a.w. AOM 3.3.5 – 15 (Appendix 2):

- *"Apply the normal crosswind technique",*
- *"Do not allow the aircraft to drift during the flare, land on the centreline, aim for a positive touchdown", and*
- *"Be prepared to go-around at any time during the flare".*

5.8.1.2. The combination of rain and crosswind, especially at night, may cause a wrong impression of yaw-rate during the de-crabbing phase (BIM 3.4.4 – 02, Appendix 29).

5.8.2. Facts

5.8.2.1. During application of the normal crosswind technique, the longitudinal axis of the aircraft must be yawed towards the runway direction by using the rudder. Simultaneously, the bank angle needs to be increased into the wind to avoid lateral movement and drifting away from the (extended) runway centreline. The rudder increased to near full deflection ≈ 13 sec before touchdown, but was released again 6 sec before touchdown, with one small reversal to the right. The deflection continued to the other side 2.5 sec before touchdown. The bank (roll) angle data recorded on the DFDR however, do not show any bank angle to the right during the last 10 sec of flight, while the large 11° crab angle to the right between the longitudinal axis of the aircraft and the runway heading proves that there was a considerable crosswind. The heading at touchdown was 117°, the crab angle 11° (117° – runway heading 106°), refer to DFDR data in RvO Annex 15 (Appendix 7).

5.8.2.2. Ground radar data, added by the Commission to the approach chart of runway 11 (RvO Annex 12; Appendix 12), shows that the aircraft was north of the 111° approach radial during the whole approach from 7 nm out, and neither reached the 111° approach radial, nor the (extended) runway centreline (at 1 nm).

5.8.2.3. Until touchdown, no lateral acceleration was recorded by the objective DFDR data that would support a lateral movement to have occurred. During the last 70 sec of flight, light turbulence was measured that not only shows up in the vertical g graphs of the DFDR, but also in the lateral acceleration graph, but only very little, hard to see; turbulence is never purely vertical. The DFDR accelerometer system operated correctly, because at touchdown with a crab angle, the graph shows the resulting lateral g's.

5.8.2.4. The co-pilot tried to align the aircraft from 12 sec before touchdown with near maximum rudder deflection to the left during 5 seconds, but released the rudder 7 sec before touchdown followed even by a small peak to the right. The captain, 3 sec before touchdown, initiated a go-around, but this failed. The aircraft touched down with the left main landing gear outside of the left side of the runway as proven by the rubber marks, the scratches of engine cowling and wheel rim of the centre landing gear. These markings were also in the runway direction (statement police, and drawing in RvO Annex 11 (Appendix 36) and photographs in RvO Annex 16).

5.8.2.5. The Commission included as Established Fact in § 3.1: "*According to the values registered in the SIO, there has not been a significant variation of wind speed and direction in the last 20 seconds*" (RvO page 127), and "*Approach Control did not transmit to the aircraft the wind information on runway 11 that reached 220° with 35 kt between 07.32:40 and 07.33:30 UTC*" (RvO page 126).

5.8.3. Comments by DASB

5.8.3.1. "*Both in the preliminary and the final comments, DASB concluded that the accident was initiated by a sudden and unexpected wind variation in direction and speed (windshear) in the final stage of the approach. Subsequently a high rate of descent and an extreme lateral displacement developed, causing a hard landing on the right-hand main gear, which in combination with a considerable crab angle exceeded the aircraft structural limitations*" (RvO Appendix).

5.8.3.1.1 *Remark.* Basically, there are three objective sources to determine if the conclusions of the DASB are correct: the SIO wind measurements, the data recorded by the DFDR and the forensic data on the crash site. None of these support the conclusion of the DASB in any way.

- SIO did not register a sudden increase in direction and magnitude of the wind at the time of the accident. The wind speed increase began 1.5 minute after the crash, as did the increase in direction. A tail wind was never measured (refer to § 4.4.2.2 above).
- The indicated airspeed never decreased by another cause than the premature throttle reduction and the subsequent pitch up manoeuvre. Given the claimed sudden 220°/35 kt wind, the indicated airspeed should have dropped by another 10 kt, which it did not. Moreover, the airspeed graph of the DFDR shows a gradual, not a sudden decrease.

  The DFDR and ground radar data confirm that the aircraft never reached the 111° approach radial, did not transition from the approach radial to runway heading 106° at 1 nm in front of the runway but remained well north of the extended runway centreline up and until the moment of touchdown which explains why the left main landing gear touched down left of the runway. The lateral g graph of the DFDR shows no acceleration before touchdown.
- The tyre marks of all three main landing gears from the touchdown and the scratches of the right engine nacelle on the runway surface (RvO Annex 11; Appendix 36) clearly indicate that the aircraft moved in the direction of the runway from the moment of touchdown, which is not consistent with the statements by DASB and in the RvO that the aircraft was subjected to an extreme lateral displacement to the left. It is impossible to reduce the displacement of a weight of 161400 kg to zero in a fraction of a second. The conclusions of DASB that an extreme lateral displacement developed are contrary to the laws of physics. The aircraft did not approach on the (extended) runway centreline.

5.8.3.1.2 *Question*. Don't Experts agree that the DASB conclusion was wrong? If not, please explain.

5.8.3.2. "*With the wings level again the aircraft was displaced rapidly to the left side of the runway, obviously by the abrupt change in wind direction and speed*" (Report RVDL3 page 7).

5.8.3.3. "*Obviously the crew tried to correct the situation and to bring the aircraft back to the runway centreline"*.

5.8.3.4. In the draft of the second report (CR 94xxx) the NLR wrote on page 11 about the 5° bank angle at touchdown: "*In view of the crosswind existing at landing this bank angle is too small to compensate for the left drift of the aircraft*". The chief investigator of the DASB returned the report with the comment to change this line. He wanted to change "*this bank angle is too small to compensate …*", into "*this bank angle apparently did not compensate…* ", because he obviously wanted to prove a lateral displacement of the aircraft just before touchdown, because the aircraft landed on the left side of the runway. However, the aircraft was never lined up, the DFDR data do not show normal crosswind approach control inputs and the scratches on the runway were on the left side and in the runway direction; absolutely not indicators of any lateral displacement.

5.8.3.5. DASB tried to change the line in the draft report: "*The premature power reduction and the sudden wind variation in direction and intensity created a crosswind*

*component which exceeded the aircraft limits in the AOM aggravating the rate of descen*t" into: "*The sudden wind variation in direction and intensity during the last phase of the final approach created a crosswind component which exceeded the aircraft limits in the AOM*" (Report RVDL3 page 11).
The Commission did not accept this change proposal but changed the line in the final report into: *"The premature power reduction and the sudden wind variation probably increased the rate of descent, which reached values exceeding the operational limits of the aircraft. According to the values registered in the SIO, there has not been a significant variation of wind speed and direction in the last 20 seconds*".

5.8.3.6. DASB tried to persuade the Commission with the Report RVDL3 (lijst 4 tab 23, page 13) to change the causes of the accident to:

> *"The commission of inquiry determined that the accident was initiated by:*
> *- a sudden and unexpected wind variation in direction and speed (windshear) in the final stage of the approach.*
>
> *Subsequently a high rate of descent and an extreme lateral displacement developed, causing a hard landing on the right-hand landing gear, which in combination with a considerable crab angle exceeded the aircraft structural limitations."*

But the Commission did not accept this change.

5.8.4. Comments and Conclusion Experts

5.8.4.1. "The Dutch Aviation Safety Board did not issue any comment on this sentence. This is the exact feeling of the Experts: 220° at 35 kts is the crosswind limit for the DC10. With a runway wet as indicated by the captain and flooded as indicated by the ATC controller, a go-around decision would have been a highly probable consequence" (V17 page 51).

5.8.4.1.1 *Remark*. 220°/35 kt is resulting in a 32 kt crosswind component on the runway (106°). This is much higher than "*the crosswind limit of the DC-10*" for both the runway conditions wet and flooded (15 kt, resp. 5 kt). In addition, the crosswind limit of pilots is of relevance too. The co-pilot had only experience with crosswinds of max. 15 kt (Fax Martinair to DASB, Appendix 5).

5.8.4.1.2 *Question*. Should the sentence "*Would have been a highly probable consequence*", not be "should have been made"? If not, please explain.

5.8.4.2. In V 17 § 6.2, Experts state:

"All the elements analyzed by the Experts (the wind effects or the pilot's actions on the flight controls) lead to the same conclusion that there is a lateral movement towards the left of the runway.

It is a coherent conclusion with:

- *The statement made by the pilots during their interviews, according to which the aircraft was on the runway extended center line at 200 feet height;*
- *The impact that occurred on the left hand side of the runway as proven by the markings on the ground".*

5.8.4.2.1 *Remark*. The pilot statement that the airplane was on the extended centreline at 200 ft is not supported by objective data from ground radar and DFDR.

5.8.4.3. "*The suggestion requested by the Dutch Aviation Safety Board [“during the last phase of the final approach”] is correct*" (V17, indent 24 page 52).

5.8.4.3.1 *Question*. This subject is discussed elsewhere. Is this suggestion based on the NLR's computer model?

5.8.5. Remarks and Questions Claimants

5.8.5.1. The statements of the pilots were made quite a few weeks after the accident and might have been neither truthful nor factual anymore.

5.8.5.1.1 *Questions*. What elements did the Experts analyse? Wind effects? Or the pilots' actions? How did Experts objectively determine the winds that affected the lateral movement of the aircraft to the left of the runway?

5.8.5.1.2 *Question*. Markings on the runway indeed prove the impact on the left hand side, but the direction of the markings was not used for the Experts' conclusions. Did Experts indeed analyse the pilots' actions on the flight controls using DFDR data? Please motivate this conclusion by providing a detailed scientific analysis.

5.8.5.2. The approach path from 8 nm to touchdown was continuously north of the approach radial, as shown by Radar data in RvO Annex 12; Appendix 12). The required ground track correction at 1 nm in front of the runway from the 111° approach radial to the 106° runway heading was not made. As DFDR data shows, the pilot-flying tried to align the aircraft from 12 sec before touchdown with near maximum rudder deflection to the left during 5 seconds, but released the rudder 7 sec before touchdown followed even by a small peak to the right. The bank angle was initially a few degrees to the right for 5 sec as side effect of releasing the rudder after 27 sec left rudder, but then increased to the left as side effect of the yawing again to the left, now with full rudder, and thereafter returned to zero degrees, wings level, while a bank angle to the right would have been required to maintain avoiding drift during the flare. Hence, this DFDR recorded sequence does not show a normal crosswind landing manoeuvre. The only reason for these control inputs can have been that aircraft was not (yet) on the extended runway centreline.

5.8.5.3. Knowing the existence of a large crosswind, given the average heading of 125° during the approach, and not applying a bank angle into the wind during the last seconds of flight and even the large remaining wind correction angle of ≈7° at 5 sec before touchdown with near full rudder, also supports the conclusion that the aircraft was not approaching on the (extended) runway centreline.

5.8.5.4. An increase of wind direction on short final, or just prior to the landing would eventually have resulted in a drift to the left, but the momentum of the heavy, 161400 kg aircraft would have prevented that to happen on short notice. It takes time for such a large, heavy body to change its physical path. The lateral acceleration data recorded on the DFDR did not prove a sideward acceleration to have occurred. If the aircraft would have been on the runway centreline, as stated by the Experts, then the landing would have taken place on the centreline. But the aircraft touched down with the left main landing gear outside of the left side of the runway and not in a sideward lateral movement but – as the tyre rubber, engine cowling and wheel rim groove on and in the runway surface prove – in the direction of the runway (RvO Annex 11, Appendix 36). If there was a wind increase just prior to touchdown, either in angle or in magnitude, it had no effect on the path of the aircraft during the last seconds of flight. The Commission reported in the RvO there has been no wind increase during the last 20 sec of flight.

5.8.5.5. The immediate effect of a sudden change of wind would only be visible on the airspeed graph, which indeed showed a small decrease, but not as result of a tailwind, but as result of the throttles being kept close and the increase of pitch angle during the last 7.5 sec of flight (DFDR data).

5.8.5.6. DASB states that the aircraft was displaced rapidly to the left side of the runway, obviously by the abrupt change in wind direction and speed. This then should have happened 4 sec before touchdown. The Commission did not, and the Claimants do not agree with this statement of DASB, following the analysis presented above and in Avio*Consult* report § 4.6.

5.8.5.7. Go-around must be initiated by calling "*go-around*" and pressing the TOGA button to initiate thrust application (AOM 3.3.6 – 02, Appendix 31). The captain who just had taken control of the aircraft jammed the throttles forward, rather than pressing the TOGA button.

5.8.5.7.1 *Question*. Do Experts agree with the statements and points of view presented in the paragraphs above?

5.9. Touchdown heading/crab angle

5.9.1. Rules and Regulations

5.9.1.1. The approach procedure at Faro requires a 5° heading change from the 111° approach radial to the runway heading (106°) at 1 nm from the runway threshold. DFDR data shows no control inputs and no other attempt to turn the aircraft to the left to achieve the required heading change at that distance.

5.9.1.2. During landing on a wet or otherwise contaminated runway, AOM 3.3.5 – 15 (Appendix 2) requires pilots to "*apply normal crosswind techniques*", to "*not allow the aircraft to drift during the flare, land on the centreline and aim for a positive touchdown*", and to "*be prepared to go-around at any time during the flare*".

5.9.2. Facts.

5.9.2.1. The aircraft touched down with an 11° crab angle (DFDR data; Appendix 7).

5.9.2.2. The captain initiated a go-around just 3 sec prior to touchdown (RvO Annex 15; Appendix 7). The go-around failed.

5.9.3. Comments DASB

5.9.3.1. **"***The aircraft touched down on the right hand main gear first, with a rolling motion to the right, a crab angle of about 11°, and a high rate of descent. Touchdown was on the far left side of the runway***"** (report RVDL3, page 7).

5.9.4. Comments Experts

5.9.4.1. "*The heading at touchdown is 117°, which a runway axis of 106°, meaning a crab angle of 11°"* (V17 § 5.2.2.4, page 26).

5.9.4.2. "*The Experts' conclusion* <u>*should*</u> *be that the crab angle could be a contributing factor to the collapse of the gear*" (V17 § 5.2.2.4, page 27).
But, the load factor (1,9533~~55~~ G) and the high vertical speed at touchdown are, <u>without any doubt</u>, not only contributing factors but causes of the collapse of the gear.

5.9.4.3. "*Based on the NLR's analysis, the conclusion of this document is that the collapse of the gear is due to two reasons: (V17 § 8.6.4.3.2 page 93)*

- *A vertical speed out of the limits because of thrust reduction itself induced by longitudinal instability;*
- *A crosswind stronger than the aircraft limits, whose crew was unaware".*

5.9.5. Remarks and Questions Claimants

5.9.5.1. As consequence of the VOR station being located 240 m south of, and approximately halfway down the runway, the inbound track is offset 5° from the runway bearing of 106° and intercepts the extended runway centreline at 1 nm in front of the threshold of runway 11 (RvO Annex 12 (Appendix 12). During the approach, the pilots use lateral guidance of the VOR which should have been set on the 111° radial to the VOR. At 1 nm, a course correction should be required to intercept the extended runway centreline. This correction, requiring a small bank angle to the left resulting in a ground track on the extended runway centreline but with a wind correction angle to the right, should have been recorded on the DFDR and AIDS, but it was not.

5.9.5.2. The heading at touchdown was 117°, the crab angle 11° (DFDR, NTSB). During de-crabbing, the longitudinal axis is brought in the runway direction by using the rudder. Simultaneously, the bank angle needs to be increased into the wind to avoid lateral movement and drifting away from the (extended) runway centreline. The objective bank (roll) angle data recorded on the DFDR do not show any bank angle to the right during the last 10 sec of flight, while the large 11° angle between the longitudinal axis and the runway direction proves that there was a considerable crosswind. The pilot did not apply the normal crosswind landing technique as required by AOM 3.3.5 – 15 (Appendix 2).

5.9.5.3. The Experts do not mention here that the DC-10 is not approved (not certified airworthy) for landing with a crab angle (AOM 3.3.5 – 15, Appendix 2). The Experts do not mention here either, that the initiated go-around 2 sec before touchdown was impossible without touching down because the thrust of all engines was inappropriately reduced to flight idle by the co-pilot.

5.9.5.4. As was reported by the NTSB (Appendix 35 – refer to § 5.11 below), the combination of the rate of descent and the 1.9533 g load factor was not high enough to lead to the collapse of the right landing gear. This was definitely not the cause of the collapse. Pressure on the brake pedals before this was authorized (AOM 3.3.5 – 15, Appendix 2), and a large crab angle "*should*" not be a contributing factor, but are the cause of the collapse of the gear.

5.9.5.4.1 *Question.* Experts claim that NTSB and NLR have similar conclusions. What was the NTSB's conclusion on the vertical speed, based on analysis of recorded parameters on the DFDR? Please explain.

5.9.5.4.2 *Question*. Why do Experts say "*conclusion should be*" and "*the crab angle could be*"? Was it or was it not? The conclusion now is very vague. Please explain why you are not sure, if you are?

5.9.5.5. *Question 113 of 143 questions*: Are there standards where it is a requirement to land a DC-10 manually and not with the autopilot in certain weather conditions and if so, were those standards exceeded in Faro? Martinair answered: "*Yes, there are such standards. They were not exceeded in Faro*".

5.9.5.5.1 *Question.* Experts give irrelevant comments. A landing at Faro can only be a manual landing. There are procedures how to conduct a manual landing. The autothrottle and the CWS (mode of autopilot) should be engaged and were indeed used (AOM 3.3.5 – 15). However, the AOM also prescribes to apply a normal crosswind technique, if applicable (in crosswinds), which is landing de-crabbed and to be prepared to go-around at any time during the flare. The aircraft was not de-crabbed by the pilots (DFDR data), and manually closing the throttles against the autothrottle system is not "*being prepared*", since it takes 6 - 7 sec. for the engines to spool up from flight idle and generate adequate go-around thrust. These standards were exceeded. Do Experts agree that the answer by DASB was wrong? If not, please explain.

5.9.5.6. *Question 114 of 143 questions*: Is the conclusion justified that Boeing aircraft are generally easier to control than the DC10; and certainly under extreme weather conditions? Martinair answered: "*No*".

5.9.5.6.1 *Question*. Experts answer "*No*" as well, but Boeing aircraft, like the 747, are allowed to touchdown with a crab angle on a wet runway. Experts even agree with this on V17 page 128 for "*for instance, the Boeing 747*". Boeing 747 pilots do not have to line up (de-crab) their aircraft prior to touchdown. Do Experts agree that the DASB answer was wrong? If not, please explain.

5.9.5.7. *Question 115 of 143 questions*: Is the conclusion justified that the Boeing 767, which landed at Faro just before the Anthony Ruys, is more agile and easier to manoeuvre the around 20 years old Anthony Ruys? A) Because it is a Boeing. B) Because it is a much more modern aircraft. Martinair answered: "*No*".

5.9.5.7.1 *Question*. Experts answer "*No*" as well, but as a Boeing 767 may be landed while not de-crabbed in crosswind conditions, was the DASB answer a correct answer? If Experts don't agree, please explain.

5.10. Point of Touchdown on the runway

5.10.1. Rules and Regulations

5.10.1.1. An aircraft is required to touchdown in the touchdown zone of a runway, which at Faro was 268 m (RvO § 1.10.2, page 51).

5.10.1.2. "*A PAPI can cause insufficient runway threshold clearance. These systems establish a visual aiming point that is only about 300 meters down the runway instead of the required 500 m. Also the on-glide slope indication is not sharply defined, but is an area with considerable vertical dimension. The aircraft is as likely to be in the bottom area as in any other part of it*" (AOM 3.3.5 – 14; Appendix 23).

5.10.2. Facts.

5.10.2.1. The aircraft touched down with the left main landing gear left of the left runway edge and ≈400 m from the runway threshold, but in the direction of the runway (RvO Annex 11, Appendix 36).

5.10.2.2. Prior to touchdown, the lateral acceleration data on the DFDR (RvO Annex 15; Appendix 7) does not show any sideward accelerations, but only very minor accelerations around zero due to the light turbulence. The system worked properly, because the lateral accelerations due to the crabbed landing are indeed recorded (RvO, Annex 15, Appendix 7).

5.10.2.3. The normal crosswind technique as prescribed in the AOM was not applied (AOM 3.3.5 – 15, Appendix 2). The angle between the runway direction and the longitudinal axis of the aircraft had to be 0°, but was 11° (DFDR data, RvO Annex 15; Appendix 7), because the main landing gear of a DC-10 is not designed to land with a crab angle.

5.10.2.4. Following touchdown, the aircraft skidded (aquaplaned) along the runway while the heading slowly increased to the right (RvO Annex 11, Appendix 36). After approximately one second, the roll angle started to increase to the right as shown in the DFDR data. 93 m further than the touchdown point, the right engine nacelle touched the runway. The full weight of the aircraft was not yet on the main landing gears, because the pitch attitude was not yet zero. 240 m from the point of touchdown, a centre gear tyre failed, most probably because of the increased weight on that landing gear after failure of the right main gear and of the skidding. The rim of this wheel caused a deep scratch in the asphalt of the runway, initially in the direction of the runway, from 240 m after first contacting the runway (RvO Annex 11, Appendix 36).

5.10.3. Comments DASB

5.10.3.1. "*Touchdown was on the far left side of the runway*" (Report RVDL3, page 7).

5.10.4. Conclusions Experts

5.10.4.1. Experts in V17 § 6.11, page 39:

"The Experts assume that this question refers to the fact that the region of Faro could have been a cause, or a contributing factor of the accident.

General instructions regarding Faro airport do not provide any alert on this specific topic. The Faro region was comparable, meteorologically speaking, to Lisbon or to other places on the other side of the Gibraltar strait, which are not famous for their dangerous conditions.

This affirmation does not include stormy situations in which meteorological phenomenon such as windshear, microburst, or downburst can occur".

5.10.5. Remarks and Questions Claimants

5.10.5.1. The point where the aircraft touched down on the runway was a question of the Court. The Experts only considered the regional weather and conclude that stormy situations with windshear, microburst or downburst can occur. Annex 11 of the RvO (Appendix 36) shows exactly where the aircraft touched down on the runway: The centre main landing gear touched down 3 m right of the left runway edge, almost 20 m left of the runway centreline on the 45 m wide runway. The left main landing gear touched down 2 m left of the runway edge. Appendix 36 also shows that the path of the aircraft following touchdown was initially in the direction of the runway, then started to move to the right slowly.

5.10.5.2. The aircraft touched down with the left main landing gear to the left of the left runway edge and ≈400 m from the runway threshold, which is 350 m further than the usual touchdown point 150 m from the threshold for a 3° glideslope, as illustrated in the figure in AOM 3.3.5 – 14 (Appendix 23, page 2). This is also an indication that the aircraft was not pushed down by a downdraft, otherwise the aircraft would have touched down earlier.

5.10.5.3. *Question 58 of 143 questions*. Why did the aircraft not land in the centre of the 120-metre-wide runway but at 10 metres from the edge"? The DASB answered: "*This was the consequence of the sudden wind change shortly before the landing, which moved the aircraft to the left. Incidentally, the runway has a width of 45 metres*".

5.10.5.3.1 *Question*. Experts remark: "*A runway is 45 meter-wide. Understanding why the aircraft land on the left hand side of the runway is the beginning of the whole explanation of the accident*". DFDR data shows that the final approach was not i.a.w. the requirements for a crosswind landing, because de-crabbing did not take place and the runway heading was not reached. No sideward acceleration and no sudden wind-caused heading change were recorded on the DFDR just prior to touchdown; hence, there was no sudden wind change that moved the aircraft to the left. The scratches of the tyre rubber, the engine nacelle and the centre gear wheel rim were not to the left but in the runway direction. Hence, during the whole approach, the aircraft was neither on the approach radial, nor on the extended runway centreline. Please answer the question why the aircraft did not land in the centre of the runway. Was the DASB answer right? Was there a sudden change of wind that had effect on the aircraft, and that is visible on the DFDR data? Don't the Experts agree again, that the DASB misinformed the victims in their answer? If not, please explain.

5.10.5.4. *Question 59 of the 143 questions*. Is the length of the braking distance of a fully-loaded DC10 in accordance with the place where the aircraft first touched the runway? Martinair answered: "*Yes, the length is more than adequate. During the approach the aircraft was on a correct glide path to touch down at such a distance from the runway threshold that there would be enough distance for a safe stop*".

5.10.5.4.1 *Question*. The answer of the Experts was "*Yes*". The landing data card (RvO Annex 3) showed a required 2400 m for braking action Medium (45 m less than available) and 3055 m for braking action poor (610 m more than available). The aircraft touched down further than the 268 m touchdown zone. Hence, for the flooded runway condition that existed at the time of the accident, the runway would be too short. In addition, the crosswind was much higher than the approved 5 kt for a flooded runway. The aircraft would have suffered a runway excursion (skidded off the runway). Can Experts confirm with DFDR data analysis that the aircraft was indeed on the correct glide path and that the aircraft touched down to leave enough distance for a safe stop on the asphalt of the runway? If not, please explain.

5.10.5.5. *Question 126 of 143 questions*: Was there actually any chance of saving the fully loaded (weight 180 tonnes) Anthony Ruys after it had landed, given: A. The speed of over 260 km per hour, B. The place where it first touched the runway. C. The failure of all electricity, as a result of which it may not have been possible to engage the thrust reversers in the engines, D. The probable fire in the right-hand engine shortly before the landing. Martinair answered: "*The aircraft did not weigh 180 tonnes but 161.4 tonnes. Given the question if there was any chance of saving the fully laden Anthony Ruys after it had landed the answer is unequivocally Yes, with respect to the statements under items A - C. There was no fire in the engine (item D)*".

5.10.5.5.1 *Question*. This question is about this landing, under the existing weather conditions. The place where it first touched the runway was not where it had to be; the left main gear touched down left of the runway (RvO Annex 11, Appendix 36). If indeed the runway was still flooded, the braking action would be POOR, and the aircraft would most probably have overrun the runway, or vacated the runway to the right, because of the too high crosswind, generating side forces on the vertical tail that would not be counteracted by the friction of the nose wheels on the runway. Don't Experts agree that the DASB answer is a wrong answer? If not, please explain.

5.10.5.6. *Question 140 of 143 questions*: At what point would the Anthony Ruys first have touched the runway had there not been a vertical downdraught which suddenly pushed the aircraft 50 metres down? DASB answered: "*The Anthony Ruys touched down in the normal landing area. The Portuguese report indicates that during the last part of the approach, from approximately 80 ft, there was a high descent rate. This was preceded by a period during which the aircraft descended only little, also due to the microburst which occurred. Given the average descent line, the place where the Anthony Ruys would have touched down on the runway, without the effect of the microburst, would not have been significantly different from the place where it actually touched the runway*".

5.10.5.6.1 *Question*. It did touchdown abeam the longitudinal touchdown zone, 392 m from the threshold (NLR), however not within the lateral limits of the touchdown zone; the left main gear touched down outside of the runway. The indicated high descent rate in Portuguese report could not be confirmed with DFDR data. The period during which the aircraft only descended little was not due to the microburst, but due to the fact that below 200 ft, "*the aircraft must be brought gradually above the 'on glide slope' indication to provide a 30 to 40 ft wheel clearance at the threshold", as required by AOM 3.3.5 – 14 (Appendix 23). The captain said three times "too low*", after which the co-pilot reduced the rate of descent a little. The aircraft touched down nearly 400 m from the runway threshold. If there were a downdraft that would have pushed the aircraft down, it would not have landed that far from the threshold. Hence, there was no downdraft; the aircraft was not pushed down 50 meters. Don't the Experts agree that the DASB did give a wrong answer?

5.10.5.7. *Question 141 of 143 questions*: Measured from that virtual point, would there have been enough braking distance to bring the aircraft, weighing 180 tonnes at a landing speed of 260 km per hour, to a stop before the end of the runway? Martinair answered: "*The aircraft weighed 161.4 tonnes, not 180 tonnes. The answer to this question is unequivocally: YES*".

5.10.5.7.1 *Question*. In RvO on page 105: "Taking into account the actual Faro conditions at the time of the accident, this commission calculated the real distances for MEDIUM and POOR braking conditions according to the AOM procedures. The result values for MEDIUM and POOR exceed the LDA" (Landing Distance Available). Don't the Experts agree that this answer is unequivocally wrong? If not, please explain.

5.10.5.8. *Question 142 of 143 questions:* Could the point where the Anthony Ruys first touched the runway be due to a combination of poor visibility and the lack of an ILS (Instrument Landing System) at that airport? The DASB answered: "*No, the visibility and the lack of an ILS did not affect this*".

5.10.5.8.1 *Question*. The aircraft did not follow the 111° approach radial, as proven by the ground radar data in RvO Annex 12 (Appendix 12) and as can be proven with a heading/wind and control inputs analysis. An ILS includes a (fixed) localizer radial, the use of which would have been more forceful for the pilots, to maintain the correct approach path, than a VOR approach radial that can be set by hand to any value. An ILS could have been coupled to the autopilot thus ensuring a more stable approach. Wasn't the DASB answer wrong for the ILS part? If not, please explain.

5.10.5.8.2 *Question*. The Experts in their conclusion only considered the regional weather and concluded that stormy situations with windshear, microburst or downburst do not occur in Faro (V17 § 6.11). Why did the Experts not answer the question by the Court on the location where the aircraft crashed (V17 § 6.11)? The answer is in RvO Annex 11 (Appendix 36).

5.11. Landing gear failure

5.11.1. Rules and Regulations

5.11.1.1. The maximum load factor for ground contact is, i.a.w. AOM 3.7.1 – 09 (Appendix 32), "*comparable to, at maximum structural landing weight: A rate of descent of 10 fps or 600 ft/min*". The design rate of descent was higher (safety factors), see below.

5.11.1.2. The general requirement for applying brakes after landing is: After nose gear touchdown, the pilot-flying is to apply brakes as required (AOM 3.3.5 – 13, Appendix 30).

5.11.1.3. AOM 3.3.5 – 15 (Appendix 2) presents the procedure for deceleration on a wet or otherwise contaminated runway: "*As the wheels must spin up before effective braking can commence, do not commence brake application until ground spoilers are extended (automatically or manually) and the nose gear is firmly on the ground*".

5.11.2. Facts.

5.11.2.1. As written in § 2.1 above, the aircraft departed from Schiphol while the replacement of the right landing gear, which failed after touchdown on the airport of Faro, was postponed three times at the request of Martinair. The Dutch airworthiness authority authorized the postponement (statement Mr. Dick van Polen, maintenance planner KLM, ref. TV2 Dossier EénVandaag) 16 Jan 2016. Replacement of a landing gear might have been required for routine maintenance purposes or, because during inspection, one or more cracks were found that eventually could lead to fracture. Postponement, if granted, is usually for a limited number of landings.

5.11.2.2. The aircraft touched down on the runway with a crab angle of 11° to the right, rather than being lined up with the runway (DFDR data). Procedures require a de-crabbed landing under crosswind conditions (AOM 3.3.5 – 15 (Appendix 2).

5.11.2.3. The right main landing gear failed shortly (≈ 27 m) after touchdown (RvO Annex 11; Appendix 36). The impact of the nacelle of engine #3 on the runway occurred 1.5 sec later, 93 m further down the runway as evidenced by marks on the runway (Point E in Appendix 36). The DFDR data at that point shows an increase of the bank angle to the right.

5.11.2.4. AIDS data (RvO Annex 9) shows that the pilot-flying depressed the brake pedals during the last 40 sec of flight up to near maximum, while the procedures only allow starting braking after nose gear touchdown on the runway (AOM 3.3.5 – 13, Appendix 30) and (AOM 3.3.5 – 15, Appendix 2).

5.11.2.5. Following an accident with an MD-11 in 1997, the NTSB asked Boeing questions about the design capabilities of the MD-11 landing gear (Appendix 35). Boeing stated that "*the MD-11 landing gear certification was based on drop tests conducted on DC-10 landing gear, which are nearly identical to MD-11 landing gea*r". The Boeing submission to the NTSB, which described Douglas' landing gear design philosophy for the DC-10 and MD-11, added the following: "*The landing gear is designed to fail on overloads that act in the upward and aft directions*", called sacrificial shedding (i.a.w.

FAR 25.721(a), see Appendix 35 page 4), to avoid rupturing the fuel tank in the wing box above the landing gear. Boeing also added: "*This was validated by tests done on full scale DC-10 landing gear and wing test structure. By analysis this was shown to be true for vertical loads up to 2.0 g's (i.e., twice the weight of the aircraft is distributed between the two [right and left] [MLG], the center [MLG] and the nose landing gear with no aerodynamic lift) at the aircraft ramp weight*".
Certification Regulation FAR 25, subsection 25.723(b) also states that the "*landing gear may not fail in a test, demonstrating its reserve energy absorption capacity, simulating a descent velocity of 12 fps [720 ft/min] at design landing weight, assuming aircraft lift not greater than the aircraft weight acting during the landing impact*".

Boeing continues: "*For vertical loads above 2.0 g's, the [MLG] is not designed to separate from the wing. Instead, the landing gear and its back-up structure are designed to be very robust, i.e., they are designed to withstand significantly greater descent rates than the 12 fps (ultimate) required per Part 25.723 (b). Analysis has indicated that for a maximum landing weight, typical-landing-configuration landing, the MD-11 [MLG] can withstand up to a 16.9 fps* [1014 ft/min] *descent rate without bottoming the shock struts or failing its backup structure including the wing rear spar. Similarly, for a rolled landing (8 degrees one-wing-low attitude, with lift equal to aircraft weight), the landing gear can withstand up to 15 fps descent rate without bottoming the shock strut or failing its back-up structure including the wing rear spar*" (Appendix 35, page 4).

5.11.2.6. The landing weight of the MP495 at landing was 161400 kg, 31000 kg less than the maximum approved landing weight of 192300 kg (AOM 3.7.1 – 01, Appendix 37).

5.11.3. Comments DASB

5.11.3.1. In the Report RVDL3, page 7, DASB wrote: "*The failure of the right main gear truck beam was to all probability caused by the high torsional forces imposed on this truck beam by the combination of a large crab angle, a high rate of descent and touchdown on the aft right hand wheel first*".

5.11.3.2. DASB tried to change the line in the draft RvO: "*The fracture of the right landing gear was caused by the combination of the high rate of descent and <u>the significant sideslip</u> to the right*" into: "*The fracture of the right landing gear was caused by the combination of the touchdown on the right hand aft wheel, <u>the crab angle</u> and the high rate of descent*" (Report RVDL3 page 11 and V17 § 8.4.1-indent 27, page 53). The Commission in the final report wrote: "*The fracture of the right main landing gear was due to the combination of the high rate of descent and the drift correction taking place at the moment of contact with the runway*".

5.11.3.3. Experts, in V17 § 8.5 on page 61, seem to quote AvioConsult, while this was a statement by DASB: "*The collapse of the right-hand landing gear was due to a combination of the high descent rate with the correction for alignment at the time of contact with the runway (*)*", and the DASB response: "*The rupture happened exclusively due to the impact on landing which produced the overload which induced in the components and critical zones instantaneous levels of tension which exceeded the material static limit resistance.*"

5.11.3.3.1 *Remark*. AvioConsult did not write this; the Experts misinterpreted the source. A (*) means AvioConsult does not agree with the statement.

5.11.3.4. "*Information from the manufacturer of the aircraft indicated that landing with blocked wheels is not possible given the system design. Only once the main landing gear of the aircraft is on the ground and the wheels are turning made the brake* *pressure available. Hence the aircraft cannot land with blocked wheels*" (V17 § 8.5 page 62).

5.11.3.4.1 *Remark*. DASB did not report to the Commission of Investigation that the replacement of the landing gear was postponed three times at the request of Martinair, because the aircraft was already sold to the Ministry of Defence of The Netherlands to become a KDC-10.

5.11.4. Comments Experts

5.11.4.1. "*The certification of the landing gear of the DC10 follows the FAA Part 25.473 « Landing load conditions and assumptions »* (V17 page 27).
These conditions are:

- *(2) a limit descent velocity of 10 ft/sec at the design landing weight … and*
- *(3) a limit descent velocity of 6 ft/sec at the design take-off weight…"*

5.11.4.1.1 *Remark*. The Experts however, forgot to include the first paragraph to this quote. This paragraph is:
"(i) In the attitude and subject to the drag loads associated with the particular landing condition".
The full text is included NTSB Accident Report DCA97MA055 in Appendix 35, page 3. By the way, the title of FAR 25.473 in 1992 began with "*Ground load*", not "*Landing load*".

5.11.4.1.2 There is more to *remark*: The accident investigation report of the NTSB (DCA97MA055) of a crash during landing with an MD-11 in Newark, 31 July 1997, included a paragraph on Landing Gear Energy and Load Limit Certification. A few quotes out of this report, paragraph 1.16.1, which is in Appendix 35:

- *"Boeing indicated that the MD-11 landing gear certification was based on drop tests conducted on DC-10 landing gear, which are nearly identical to MD-11 landing gear"*
- *"For vertical loads above 2.0 g's, the [MLG] is not designed to separate from the wing. Instead, the landing gear and its back-up structure are designed to be very robust, i.e. they are designed to withstand significantly greater descent rates than the 12 fps (ultimate) required per Part 25.723 (b). Analysis has indicated that for a maximum landing weight, typical-landing-configuration landing, the MD-11 [MLG] can withstand up to a 16.9 fps [1014 ft/min] descent rate without bottoming the shock struts or failing its backup structure including the wing spar. Similarly, for a rolled landing (8 degrees one-wing-low attitude, with lift equal to aircraft weight), the landing gear can withstand up to 15 fps [900 ft/min] descent rate without bottoming the shock strut or failing its back-up structure including the wing rear spar."*

Boeing in fact states that the landing gear of a DC-10 does not fail when the rate of descent is less than 1014 ft/min when the wings are level, and 900 ft/min when the bank angle is 8 degrees. The bank angle at touchdown was only 5.6°; the landing weight 84% of the max. landing weight.

5.11.4.2. "*The Experts' conclusion should be that the crab angle could be a contributing factor to the collapse of the gear*" (V17 § 5.2.2.4 page 27).

5.11.4.3. Experts continue: "*But, the load factor (1,9533~~55~~ G) and the high vertical speed at touchdown are, without any doubt, not only contributing factors but causes of the collapse of the gear*".

5.11.4.4. Experts wrote: "*The final version of the sentence as issued in the official report has been: « The fracture of the right landing gear was caused by the combination of the touchdown on the right hand aft wheel, the crab angle and the high rate of descent (V17 § 8.4.1-indent 27, page 53). "Generally speaking, landing on a single gear is not abnormal: each time a landing is performed with crosswind, it is the case. That being said, the remark of the Dutch Aviation Safety Board is true*".

5.11.4.5. As also stated in § 2.2.2.1 above, "*There were no indications of faults on the aircraft or its systems that could have contributed to the degradation of safety nor could have increased the workload on the crew during the final phase of the flight*" (Experts § 8.4.1- indent 3, page 49).

5.11.4.6. The metallurgic analysis defined that the collapse of the gear is due to excessive static forces, meaning that the main reason is the rate of descent (V17 page 61).

5.11.4.7. "*The Experts validate this OvV assertion and developed the respective analysis. Landing with braked wheels (aft wheels of the two wing gears) is not possible as soon as the anti-skid system is operative*".

5.11.4.8. The Experts validate this OvV assertion on landing with blocked wheels (V17 page 62) and "*Landing with brake pedals depressed: This assertion is wrong*" (V17 page 67).

5.11.5. Conclusion Experts

There is no doubt whatsoever in regards to this element; the Portuguese experts conducted analyses that are irrefutable:

- *The material did not have any defect that could have weakened the gear's resistance;*
- *The maintenance of the system conformed with the constructor's instructions;*
- *The fracture occurred after a mechanical pressure on the landing gear that was beyond the metal's resistance capacity.*

5.11.5.1.1 Question. Why do Experts state "there is no doubt whatsoever in regards to this element"?

5.11.5.1.2 Question. How do Experts know that "the material did not have any defect that could have weakened the gear's resistance" and "the maintenance confirmed with the constructor's instructions"? Were the maintenance records reviewed? How and when did Experts receive those? Facts please.

5.11.5.2. The Experts' conclusion should be that the crab angle could be a contributing factor to the collapse of the gear (V17 page 27).

5.11.5.2.1 *Question.* Agree, but why not firmly concluded?

5.11.5.3. But, the load factor (1,95~~55~~33 G) and the high vertical speed at touchdown are, without any doubt, not only contributing factors but causes of the collapse of the gear.

5.11.6. Remarks and Questions Claimants

5.11.6.1. The reason for postponement of the right main landing gear exchange must have been recorded in the aircraft maintenance logbook. The NL accredited representative must have reviewed the logbook with due care, but obviously (intentionally?) did not report this important issue to the Commission. Did Experts review the log? Since there are no records, the Experts cannot have concluded that *the maintenance of the system conformed with the constructor's instructions*. The Experts should have been alerted by the 143 families questions and conclude that the landing manoeuvre was not in agreement with the landing technique prescribed in the AOM for landing on a wet or otherwise contaminated runway (AOM 3.3.5-15), which will also have contributed to the fracture of the landing gear.

5.11.6.2. Unless the logbook is found, it will remain unsure whether the replacement was required because of the presence of small cracks of because of a routine replacement based on exceeding the number of landings.

5.11.6.3. A (high) rate of descent never is the only cause of a collapse and/or damage. For instance, a feather of a bird dropping to the ground at 760 ft/min will not damage anything at all. For damage to occur, both the kinetic and potential energy dissipation count in the equation in which not only the rate of descent is a factor, but also the landing weight. A quite readable paragraph for non-engineering experts out of a landing gear accident analysis is included in an NTSB report (Appendix 35), out of which a paragraph was already presented in the facts above. After reading (and hopefully understanding) this analysis, the Experts will have increased expertise on the subject and will definitely not say again: "*But, the load factor (1,9533~~55~~G) and the high vertical speed at touchdown are, without any doubt, not only contributing factors but causes of the collapse of the gear*" (V17 § 5.2.2.4 page 27). The experts of the Claimants have, after reading the Expert conclusions and without any doubt, no confidence in the expertise of the Experts that is required to analyse an aircraft accident.

5.11.6.4. Experts quote out of FAR § 25.473, "*Ground Load Conditions and Assumptions*" (Appendix 35, page 3) that describes the descent velocities that must be assumed during certification for certain landing conditions (for example, level landing, tail-down landing, one-wheel landing, and side load conditions). However, as also stated in § 5.11.4.1 above, Experts forgot to include the first line of this regulation: "*The selected limit vertical inertia load factors at the c.g. of the aircraft may not be less than the values that would be obtained …*"

5.11.6.4.1 *Question*. Did Experts verify what limit vertical load factors McDonnell Douglas did select? Without these limit load factors, this statement does not make sense, as made clear with the feather example in the previous paragraph. The answer is in Appendix 35.

5.11.6.4.2 *Question*. The title of FAR 25.473 changed after 1997 as the quote of this paragraph in Appendix 35 suggests. Can Experts clarify whether their analysis and comments agree with the context of the version of the mentioned FAR that applied in 1992?

5.11.6.5. DASB tried to convince the Commission to delete "*and the significant sideslip to the right*". The commission then changed this to "*the crab angle*". "*Touchdown on the right hand aft wheel*" does not belong in the remark of the DASB, because this is required during all crosswind landings as prescribed in the AOM procedures 3.3.5-15 (Appendix 2).

5.11.6.6. The actual weight of MP495 at landing was 161400 kg, 31000 kg less than the maximum approved landing weight of 192300 kg (AOM 3.7.1 – 01). The AOM published a landing load acceleration limit: "*The maximum load factor for ground contact is comparable to at maximum structural landing weight, a descent rate of 600 ft/min*" (AOM 3.7.1 – 09, Appendix 32). The limits in a user manual are always on the safe side. As presented in the facts in § 5.11.2.5 above, McDonnell Douglas designed landing gears that can absorb much more energy than occurs at a rate of descent of 600 ft/min. In addition, the rate of descent at a lower landing weight can be higher for the same dissipated kinetic energy. Experts will be able to calculate the difference.

5.11.6.7. The antiskid system "*incorporates locked wheel touchdown protection, to the rear bogey wheels only, to prevent inadvertent landing with the brakes applied"* (DC-10 FCOM 14-10-04, Feb 1/87, Appendix 38). This means that the front bogey wheels were not protected and that attaining and maintaining brake pressure by the co-pilot could have caused additional forces and moments on the landing gear, leading to its failure. The RvO did not present data on the anti-skid system of MP495, but even if all wheels are equipped with anti-skid, the wheel braking is enabled as soon as the aft wheels are spinning-up and either pilot applies the brake pedals. The co-pilot indeed applied the brake pedals already at least 80 sec. before touchdown (DFDR and AIDS data in RvO Annex 9); hence brake pressure did energize the brakes at, or almost immediately after touchdown, while the normal prescribed procedure is to start braking only after the nose gear touched down on the runway (AOM 3.3.5 – 13; Appendix 30) and the aircraft, including the wheels of each landing gear, is aligned with the direction of the runway to avoid excessive forces and moments on the landing gears and shock struts. It took 2.5 sec after touchdown for the pitch angle of the aircraft to reach zero degrees, during which time the aircraft travelled approximately 150 m.
Experts, with their statement "*This assertion is wrong*" (§ 5.11.4.8 above and V17 page 67), obviously did not review AIDS data in RvO Annex 9.

5.11.6.8. The normal procedure for deceleration on a wet or otherwise contaminated runway is to not commence brake application until the ground spoilers are extended (automatically or manually) and the nose gear is firmly on the ground. The co-pilot violated the formal procedures and made a grave mistake. In AOM 3.3.5 – 15, guidance on deceleration is presented, refer to Appendix 2.

5.11.6.9. Landing with brakes applied, and/or braking as soon as the wheels are spinning-up, in combination with the 11° crab angle, imposed forces and moments on the landing gear that it was not designed for, or could handle. The experts did not address the additional forces and moments that occurred due to the 11° traversing landing, which landing technique is not approved for a DC-10 (AOM 3.3.5 – 15, Appendix 2).

5.11.6.10. It is physically impossible for a pilot to move his feet up or down on the pedals, to or from the brake pedals, which are integrated on top of and with the rudder pedals, while also rudder pedal inputs are applied. DFDR and AIDS data prove that the pilot was applying rudder inputs, as well as brake pedal inputs. He had not positioned his feet as he should have done for landing, therewith causing the brakes to engage at or immediately after touchdown, which is in violation with the AOM procedure listed in the AOM paragraph listed above.

5.11.6.11. The factual data sources DFDR and AIDS show neither an abnormal vertical (normal) acceleration, nor a Rate of Descent that suddenly and unusually increased. The descent during the last 10 seconds of flight was linear, the Rate of Descent was constant (DFDR data RvO Annex 15; Appendix 7). On the contrary, during the last 2 sec, the vertical acceleration even increased to 1.2, meaning that the aircraft landing weight was not fully transmitted into the landing gear on top of the loads required to decelerate the aircraft vertically from the aircraft's sink rate. The reduced vertical acceleration at touchdown should have been taken into account during the hard landing evaluation by the Experts before stating that the aircraft was not designed for hard touchdown.

5.11.6.12. The NTSB accident investigation report (DCA97MA055) of a crash during landing with an MD-11 in Newark, 31 July 1997, included a paragraph on Landing Gear Energy and Load Limit Certification. A few quotes out of this report, paragraph 1.16.1 (included as Appendix 35):

- *"Boeing indicated that the MD-11 landing gear certification was based on drop tests conducted on DC-10 landing gear, which are nearly identical to MD-11 landing gear".*
- *"For vertical loads above 2.0 g's, the [MLG] is not designed to separate from the wing. Instead, the landing gear and its back-up structure are designed to be very robust, i.e. they are designed to withstand significantly greater descent rates than the 12 fps (ultimate) required per Part 25.723 (b). Analysis has indicated that for a maximum landing weight, typical-landing-configuration landing, the MD-11 [MLG] can withstand up to a 16.9 fps [1014 ft/min] descent rate without bottoming the shock struts or failing its backup structure including the wing spar. Similarly, for a rolled landing (8 degrees one-wing-low attitude, with lift equal to aircraft weight), the landing gear can withstand up to 15 fps [900 ft/min] descent rate without bottoming the shock strut or failing its back-up structure including the wing rear spar."*

5.11.6.13. Hence, a DC-10 landing gear will not fail with a ROD of 850 ft/min at 161 ton, with a landing bank angle of 5.62° to the right. More importantly, the comments by the Experts do not take into account the increase in pitch angle prior to touchdown to 8.79°, reducing the vertical speed, which is confirmed by the normal g graph. Experts did obviously not analyse the DFDR data.

5.11.6.14. The landing gear did not fail at touchdown as the scratches on the runway prove. The right engine nacelle caused scratches from 80 m further than the beginning of the normal rubber trace of the right landing gear on the runway surface (RvO Annex 11, Appendix 36). In addition, the investigation did not discuss the fuse pin in the vertical plane that is included in the landing gears to avoid the gear from punctioning the wing-fuel tanks due to a large load. This pin might also have failed, as it was designed for, causing damage to the landing gear.

5.11.6.15. The Experts did not address the additional forces and moments on the right main landing gear that occurred due to the 11° traversing landing, which landing technique is not approved for a DC-10 (AOM 3.3.5-15, Appendix 2).

5.11.6.16. The Experts suggest to have reviewed the metallurgic analysis, which is in the RvO Annex 10 in the Portuguese language. If indeed the gear collapsed due to excessive static forces, as the Experts state, then this means that the collapse did not happen at touchdown because the forces during touchdown are dynamic forces. Static forces occur when the lift of the wings reduce after touchdown, the aircraft weight is added to the forces on the landing gear and due to non-alignment with the runway direction. The metallurgic analysis, if correct, in fact confirms that the collapse of the landing gear was caused by the excessive static forces and moments due to the increased friction of the landing gear that touched down with an 11° crab angle, which is not approved for a DC-10 (AOM 3.3.5 – 15, Appendix 2). Boeing aircraft though, are allowed to touchdown with a crab angle. The question remains whether the collapse occurred because of the postponed landing gear replacement.

5.11.6.17. *Question 129 of 143 questions:* Was the statement on 2 July 1993 by Mr. Schotgerrits a reason for the commission of inquiry to minutely examine the right-hand landing gear on any defects which may have been present before the crash? The DASB answer was: "*The fracture of the right landing gear is, according to the Portuguese investigating committee, caused by overload during the hard crabbing landing. There were no existing defects whatsoever*".

5.11.6.18. *Question 130 of 143 questions:* If not, does the commission of inquiry see any reason for that now? The DASB answer was: "*same as question 129*".

5.11.6.18.1 *Question:* The DASB, following the review of the maintenance logs of the aircraft, must have noticed the triple postponements of the right landing gear exchange, but failed to report this to the Commission. Don't Experts agree that the DASB answer was wrong?

5.11.6.19. *Question 131 of 143 questions:* Or was it found in an earlier stage of the investigation what the cause was of the collapse of the right-hand landing gear? The DASB answer was: "*same as question 129*".

5.11.6.19.1 *Question:* The AIB did not report on the three maintenance postponements of the right landing gear, while those data must have been available. Don't Experts agree that the DASB answer was wrong?

5.11.6.20. *Question 132 of 143 questions:* Was the collapse of the right-hand landing gear the result of a defect which existed earlier, or of an incorrect landing manoeuvre? DASB answered: "*According to the investigation by the Portuguese commission of inquiry the failure of the right-hand landing gear was due to overloading during the hard, sliding landing. There were no defects which existed earlier*".

5.11.6.20.1 *Question:* There must have been a reason for replacing the landing gear as discussed above. The DC-10 landed with an 11° crab angle, while the landing should have been conducted with a zero crab angle, the normal landing technique for a DC-10 as prescribed in AOM 3.3.5 – 15, Appendix 2. The landing manoeuvre was definitely incorrect. Don't Experts agree that the DASB answer was wrong?

5.11.6.21. *Question 133 of 143 questions:* Could the collapse of the right-hand landing gear be identified as the cause of the inability to control the aircraft during the landing and therefore as one of the main causes of the crash? The DASB answer was: "*same as question 129*".

5.11.6.21.1 *Question*: Yes, but wrong answer by DASB; not the same as answer Q129. RvO page 21: "After the collapse of the right landing gear, the right engine nacelle and the right wing tip contacted the runway. The right wing suffered total rupture between the fuselage and the right engine". The aircraft [thereafter] became uncontrollable on the ground. This was indeed one of the main causes of the crash. Don't Experts agree?

6. Cause of the accident by Experts

Experts V17 § 4. "*The Experts have found it necessary to conduct this analysis for a better understanding of this accident and consequently, of the behaviour of all entities involved in the investigation*" (V17 § 4 and § 8.6).

The Experts formulated their own cause of the accident while such was specifically not asked by the Court. But since they did, Claimants feel obligated to respond.

6.1. Conclusions and Recommendations Draft Report Changed by DASB

6.1.1. Facts

6.1.1.1. In the ***draft*** *report* of 21 July 1994, which was sent by the Portuguese Commission of Investigation (DGAC) to participating organisations, including DASB, for review, the following causes were presented:
"*The Commission determined that the probable causes for the accident were:*

- *The high rate of descent in the final phase of the approach.*
- *The crosswind which occurred in the final phase of the approach, not known to the crew, which exceeded the aircraft limits."*

6.1.1.2. In the ***final*** *report* (§ 3.2), the published causes were:
"*The Commission of inquiry determined that the probable causes for the accident were:*

- *The high rate of descent in the final phase of the approach and the landing made on the right landing gear, which exceeded the structural limitations of the aircraft.*
- *The crosswind, which exceeded the aircraft limits and which occurred in the final phase of the approach and during landing.*

The combination of both factors determined stresses which exceeded the structural limitations of the aircraft."

- *The contributing factors to the accident as presented in the final report were:*
- *The instability of the approach.*
- *The premature power reduction, and the sustaining of this condition, probably due to crew action.*
- *The incorrect wind information delivered by Approach Control.*
- *The absence of an approach light system.*
- *The incorrect evaluation by the crew of the runway conditions.*
- *CWS mode being switched off at approx. 80 ft RA, causing the aircraft to be in manual control in a critical phase of the landing.*
- *The delayed action of the crew in increasing power.*
- *The degradation of the lift coefficient due to the heavy showers.*

6.1.2. Comments DASB.

6.1.2.1. DASB tried to persuade the Commission during a visit and with deletions and additions in the Report RVDL3 (lijst 4 tab 23) to change the causes to:

"*The commission of inquiry determined that the accident was initiated by:*

- *a sudden and unexpected wind variation in direction and speed (windshear) in the final stage of the approach.*

Subsequently a high rate of descent and an extreme lateral displacement developed, causing a hard landing on the right-hand landing gear, which in combination with a considerable crab angle exceeded the aircraft structural limitations."

6.1.2.2. DASB tried to add to the contributing factor to the accident:

- *"From the prevailing weather neither the meteorological office (SIO) nor the crew of MP495 did anticipate the possibility of the existence of wind-shear phenomena."*

6.1.2.3. DASB tried to change:

- *"CWS mode being switched off below the prescribed altitude, causing the aircraft to be in manual control with as consequence an abrupt flare and a hard landing",*
  into*:*
  "CWS mode being disengaged at 80 ft radar altitude, causing the aircraft to be in manual control at a critical stage in the landing phase"; and
- *"The premature large power reduction due to crew action",*
  into*:*
  "The premature large power reduction and sustained flight idle thrust, most probable due to crew action".

6.1.2.4. DASB tried to delete all other contributing factors in the draft report:

- *"The incorrect wind information delivered by the R-Nav on board.*
- *The crew's decision to continue the approach for a runway without approach lights, after having lost visual reference at about 250 ft altitude.*
- *The incorrect evaluation by the crew of the runway conditions.*
- *The delayed action of the crew in increasing power.*
- *The degradation of the lift coefficient due to the heavy rain,*
- *The fracture of the landing gear, caused by the high rate of descent, combined with the significant side slip of the aircraft on impact with the runway".*

6.1.2.5. DASB also tried to change the recommendations:

- *"That the engine manufacturer institutes an investigation concerning the interaction between man/machine in situations of manual flight in combination with CWS and ATS",*
  into*:*
  "Airworthiness Authorities to review current procedures regarding the use of ATS and CWS during approach and landing especially in extreme weather conditions".

"*Martinair to review the BIM in order to:"*

- *"Regulate the procedures concerning landings and take-offs in order that when the meteo conditions are worse or the operational parameters are marginal, the manoeuvres be performed by the captain",*
  into*:*
  "Review the procedures concerning landings and/or take-offs in order that when the meteo conditions are bad or the operational parameters are marginal, whether the manoeuvres should be performed by the captain or not".

- *"Avoid in the dispatch deficiency guide procedures which are contradictionary, leaving the responsibility to the captain",*
  into*:*
  "Review the operational procedures concerning the use of no. 2 engine thrust reverser".
- *"That the former INMG, now ING, establishes a study about the phenomena Manga de Vento (wind sleeve)",*
  into*:*
  "That the former INMG, now ING, establishes a study about the phenomena Manga de Vento (wind sleeve) and when applicable, amend the relevant AIP information".

6.1.3. Comments Experts

6.1.3.1. The Experts seemed to find the final conclusion "*a problem of wording*", and formulated a new cause in V17 § 5.2.1.2 (page 16), though "*considering that both the analysis and the conclusion of the Commission of Investigation are true*":
"*The accident is a sum of conditions leading to a hard touchdown for which the aircraft was not designed, and therefore "not certified" (i.e. outside the certification limits). As a result, the right landing gear collapses and the right wing broke*."

6.1.3.2. The contributing factors were also amended by Experts, into:

- *"An approach becoming unstable on short final, just before the landing, apparently due to a change of the meteorological conditions and a high rate of descent;*
- *A premature reduction of thrust which aggravated the previous contributing factor;*
- *On very short final, a lack of decision to initiate a missed approach procedure;*
- *An incorrect meteorological information;*
- *A change in the flight management mode on very short final that might have disturbed the pilots' sensations in regards to the aircraft".*

6.1.4. Remarks and Questions Claimants

6.1.4.1. The Portuguese Commission presented "*probable causes*" in the final report; they obviously were not 100% sure. The causes were indeed not correct as discussed in the AvioConsult report. There was no high rate of descent that exceeded the capabilities of the aircraft (§ 5.11), and a crosswind from the right always requires landing on the right gear first, because de-crabbing is required for a DC-10 and a bank angle is required to "*not allow the aircraft to drift during the flare*" (AOM 3.3.5 – 15, Appendix 2).

6.1.4.2. The Experts were not asked to formulate their own cause and contributing factors. However, since they did, these should be the result of a thorough, impartial and objective scientific-level analysis of all the available evidence and objective data. Experts state in their cause "*the accident is sum of condition*s", but do not provide the well-researched and analysed conditions.
This Interim Report V17 did not establish in detail what happened, how it happened and why it happened (i.a.w. ICAO Doc 9756 Part IV), but only contains Experts' inadequate and unscientific unsubstantiated opinion(s), a real investigator and 'expert' unworthy.

6.1.4.3. There was no "*hard touchdown for which the aircraft was not designed and therefore not certified*". Refer to § 5.11 above and Appendix 35 for guidance on how to analyse the energy dissipation on touchdown.

6.1.4.3.1 *Question*. How did the Experts determine that the touchdown was hard for which the aircraft was not designed and therefore not certified? Motivate please, if not already done in answers in § 5.11.

6.1.4.4. The DFDR data does not show the aircraft becoming unstable on short final. Flight path stability in the approach configuration is subject of experimental flight testing for certifying an aircraft airworthy, which test the DC-10 must have passed. There were some variations because of the wind and the turbulence, but these were controllable; the radar altitude graph of the last 20 seconds of flight is a straight line, apart from a small flight path correction to prevent descent below the PAPI glide path and prevent the landing gear of the large DC-10 from touching down too early (AOM 3.3.5 – 14; Appendix 23). The turbulence was only light, to the applicable ICAO definition; the pitch angle changed, but as result of a pitch-up command by the pilot. The airspeed decreased because the throttles were kept close, and the heading changed because of maximum rudder inputs, first maximal to the left, then back to the other side and again to the left just prior to touchdown. These pilot-induced motions, which were not at all normal for a crosswind landing, may not be called unstable, neither in engineering terms, nor in flying qualities terms. The inconsistent control inputs show that the pilot did not succeed in manoeuvring the aircraft to the extended runway centreline; the aircraft approached the runway from the left and never made it to the centreline. The control inputs and the aircraft heading and attitude were definitely not as they should have been during a crosswind landing. Refer also to § 4.4.5.6.

6.1.4.5. The change of the meteorological conditions cannot be confirmed by objective DFDR data either. Any argument on the aircraft behaviour or change of flight path because of changing meteorological conditions is not based on the factual data of aircraft motions as recorded by DFDR and AIDS.

6.1.4.5.1 *Questions.* Do Experts indeed agree with the Portuguese Commission that the aircraft followed a non-standard trajectory (i.e. lateral trajectory rather than glide path)? And that a variation of meteorological conditions existed? Do the DFDR data support this? Which limitations? Please motivate your answers by referring to DFDR data and seconds to touchdown.

6.1.4.5.2 Questions. V17 § 5.2.1.3. How can Experts say that "In general, the main cause of the Faro accident was that the aircraft touched-down in a way and with a trajectory that did not follow, in very short final, the vertical standard flight path established by the applicable procedures" when the radar altitude graph (Appendix 7, bottom page 2) is a straight line? In addition, Experts didn't discuss the lateral flight path. Did Experts notice the touchdown point on the left side of the runway? The centre gear near the left runway border, the left main gear even left of the runway? And the groove that a centre gear rim made in the asphalt of the runway in a near straight line in the direction of the runway? Doesn't this imply that the aircraft was not in a sideward motion?

6.1.4.5.3 *Question.* V17 § 5.2.1.3. As for Experts recommendation "*to teach the pilots to initiate a missed approach in case of an un-stabilized approach and under a fixed height*", do Experts then agree that the pilots should have initiated the go-around much earlier in the approach, like at 500 ft when the approach needs to meet the requirements for a stable approach and where is this case a go-around should have been executed at MDA (400 ft) because the call "*Landing*" was not given? Why don't Experts say that the pilots violated the go-around requirements in BIM 3.4.4 – 02 (Appendix 29) and – 06 (Appendix 11) and in AOM 3.3.5 – 08 (Appendix 14)?

6.1.4.5.4 *Questions*. V17 § 5.2.1.3. "After the issuance of the draft report of the Commission of Investigation, the Dutch Aviation Safety Board proposed modifications to the content of this report to adjust the wording, but accepted the conclusions of the final report". This was not the case, as the Report RVDL3 (lijst 4 tab 23) proves. The Dutch Safety Board didn't accept the cause in the draft report and wanted their own cause, including a sudden and unexpected wind variation (windshear) and an extreme lateral displacement, to replace the Portuguese cause in the final report, which the Portuguese Commission did not accept. DASB wanted windshear as the cause of the accident, but there was none as the Portuguese Commission and the NTSB also determined. Did Experts review the DFDR data for any occurrences of windshear, for instance speed changes up to ± 15 kt, ROD changes of up to ± 500 ft/min, pitch attitude changes of ± 5° (AOM 3.3.8 – 02, Appendix 22) or unexplained heading changes. There were none recorded on the DFDR, don't the Experts agree? What do Experts now think about the functioning of the DASB?

6.1.4.5.5 *Question*. V17 § 5.2.1.3. "The Expert's mission is not to scrutinize the causes as indicated in the official report published by the Portuguese Commission of Investigation". The Experts are to establish facts, to provide a substantiated answer to the question whether the DASB handled the information they had with due care. The DASB had all of the objective data, including CVR transcript and DFDR graphs, but still they wanted windshear as cause of the accident. So, did the DASB handle the available information with due care?

6.1.4.5.6 Question. V17 § 5.2.1.3. "During the analysis of the documents provided, the Experts have forced themselves to stay away from the notions of "technical cause" and "responsibility" in the judicial sense. This is also how the Experts evaluated the Dutch Aviation Safety Board's actions as well as answered the questions asked by the court". Did Experts accomplish an in-depth analysis of initiating a go-around and the accident to support their cause? There are no references to DFDR data, and there are not too many comments on the DASB's actions. Don't you agree?

6.1.4.5.7 *Questions.* After reading the cause and contributing factors drafted by the Experts, the following questions remain. Did the Experts review the landing really from a purely engineering point of view? Did the experts review and analyse the applicable, objective DFDR data? Did the experts review and analyse other DC-10 accident data? Did the Experts contact Boeing to confirm the (energy) limits to which the DC-10 landing gear was designed? Were the conclusions of the Commission of Investigation correct for stating this cause?

6.2. Conclusion Experts

6.2.1. Experts, in V17 § 7 on page 40 wrote the following conclusions:

Let's remember that the question asked to the Experts was to define if whether or not the action of the Dutch Aviation Safety Board during the investigation that followed the accident of the December 21st 1992 was in accordance with national and international regulations of the time, and beyond mere regulation, if the investigation was well conducted, "with due care".

The Experts' mission is not to determine what or who was/were responsible or liable for the accident.

As demonstrated in several documents provided to the Experts, the Dutch Aviation Safety Board's behavior could have been improved, but was in accordance with standard investigation regulations.

In accordance with ICAO, the Dutch Aviation Safety Board did not lead the investigation but participated in the investigation under the authority of the appointed Portuguese Chief of the Commission of Investigation.

This is a crucial point:

- *Any remark, any request for additional investigation, any analysis has to be approved by the official Commission of Investigation;*
- *Any other conclusion would be illegitimate if we take into consideration the aim of an investigation as defined by international treaties and conventions.*

Another important and interesting factor not to forget is that the Dutch Aviation Safety Board and its accredited representatives are subject to the same limitations and constraints as the Commission itself.

These limitations are established by the ICAO Annex 13.

It absolutely does not authorize to establish legal liability.

It only allows to establish causal chains or contributing factors as to anticipate other future potential issues and therefore improve the global flight safety.

The Dutch Aviation Safety Board proposed the involvement of third parties in order to bring a best-in-class professional expertise and answer questions raised by the Commission of Investigation; the Dutch Aviation Safety Board's behaviour in accordance with international norms, recommended practices and conventions.

In short, using the expertise of a Dutch laboratory like NLR or the expertise of the involved airline is in line with international recommendations.

There is no reason to objectively doubt the conclusions of these laboratories or organizations.

Nothing forced the Commission of Investigation to take into account these conclusions or even ask for different opinions if they started doubting the correctness of the answers given.

The proposals of modifications of the final official report were evaluated in detail by the Experts.

Some appeared to be adequate, and some other not.

But only the official Commission of Investigation had the power to accept such proposals of modifications or reject them.

To conclude, the Experts consider that the Dutch Aviation Safety Board — through its actions, comments, and involvement into the investigation as an accredited representative of the Commission of Investigation — did not deviate from its responsibilities and fulfilled its obligations in due care as defined at the time of the accident in the ICAO Annex 13.

6.2.1.1.1 *Question*. Following reading all of the remarks in this review, can Experts still maintain these conclusions?

6.3. More Conclusions Experts

6.3.1. V17, § 6.8. "The crew's interpretation – or lack thereof – of the term *flooded*"

6.3.1.1. "*As explained before, the Experts estimate that analyzing the understanding of this word can be done solely in a large sense and cannot be dissociated from the "human factor", which ought to be considered as a cause or a contributing factor of the accident".*

6.3.1.2. "*This type of "human factor" analysis was at its early stage at the time of the accident, and no specific publication defined it clearly even though some airlines started to consider it in the flight safety policies".*

6.3.1.3. *"The "flooded" information was transmitted to the crew around 5 minutes before expected landing"*.

6.3.1.4. *Question*. According CVR transcript the experts should have seen that around 4 minutes before that time "*flooded*" was clearly transmitted to MP461.

6.3.1.5. "*It came at a moment when the pilots' workload was high:*

- *In the middle of the final turn;*
- *Crossing of a storm west of the airport;*
- *With important variations of the flight parameters;*
- *And with important thrust variations and the flickering of fuel tank pumps lights indicating that the aircraft took at this precise moment, a substantial pitch attitude but within the AFM limits.*

6.3.1.5.1 *Question* about the workload. To minimize cockpit workload and thus to increase the safety level, optimum use of the autopilot and its sub modes and autothrottle as far as permitted per Aircraft Operations Manual, is strongly recommended during the whole flight regime (RvO page 92: AOM 3.4.3 – 01, Appendix 33). During the final turn, both the autopilot and the autothrottle were engaged; workload was not high, was it? If Experts don't agree, please explain.

6.3.1.5.2 *Question*. DFDR data during the final turn only show one peak in normal g to 1.4 g for 2 seconds, less than light turbulence. The pitch only showed an increase of 0.4° at that time. Thrust variations other than would be required in light turbulence were not recorded either, except that the rpm of engine #3 showed 20% for two minutes, which is explained nowhere. Can Experts clarify the "*important variations of flight parameters", "thrust variation"* and *"substantial pitch attitude"* they mention using objective data?

6.3.1.6. "*The Experts note the delay, quite long (9 seconds), between the transmission of the "flooded" information by the ATCO and the answer from the crew, showing also that the crew was highly busy at this time"*.

6.3.1.6.1 *Question*. Can experts define why the crew was highly busy. It was a normal turn to intercept the inbound radial. It would have been busy if they followed the AOM procedure in order to be in landing configuration and start the descent 0,5 nm prior 7 DME. Don't Experts agree?

6.3.1.7. *"From a "human factor" standpoint, it is then conceivable that the information "flooded" was not fully perceived and understood, or actually even heard".*

6.3.1.8. *"It is credible that the captain's answer was more of a reflex, which means that the information was not well understood".*

6.3.1.8.1 *Question*. Experts to explain: did he hear it or did he understand it. We agree if he didn't understand, then he should have asked for details, shouldn't he?

6.3.1.9. "*On the other hand, one could suppose that the information was well heard and understood*".

6.3.1.10. *"The Experts estimate that this information alone might not be sufficient to cancel the approach at this moment"*.

6.3.1.11. "*The final decision is what is called "a captain's decision*".

6.3.1.11.1 *Question*. Do experts conclude or "*estimate*"? Was the "*captain's decision*" to continue the approach, given all of the arguments on all of the subjects discussed in this review, a correct "*captain's decision"*?

6.3.2. Comments Experts

6.3.2.1. "*On this chapter regarding the meaning of "flooded", the Experts remind that the fact that the runway was or not flooded is neither a direct cause nor a direct contributing factor of this accident"* (V17 § 6.8 page 37).

6.3.3. Remark and Question Claimants

6.3.3.1.1 *Question*. If the pilots would have applied the runway condition data then, knowing the aircraft limits, they would have waited or diverted and the accident would not have happened. Don't Experts agree?

6.3.3.2. The Court did not ask for an investigation by the Experts to the cause of the accident, but only to answer 11 questions on the themes and in general, answer the question, based on their expertise, whether the DASB in its role at the time of the accident investigation, did process the known and available data adequately.

7. Other Aspects

7.1. Documents used by Experts

7.1.1. Irrelevant info

7.1.1.1. Experts included much irrelevant data and information that does not apply to this case, for instance autoland on V17 page 127 and 128. And "*the crosswind is out of the limit for an automatic landing*" (V17 page 128). At Faro, an automatic landing was not possible due to the lack of an appropriate ILS.

7.1.1.1.1 *Question*. Why did Experts mention this when an automatic landing is not possible?

7.2. Time references, § 0.4 and § 8.1

7.2.1. Standards, norms

7.2.1.1. UTC is the norm to be used as formal time reference in aviation.

7.2.2. Facts

7.2.2.1. In the RvO at least five different clocks/times were used. The clocks used in the report were not synchronized to enable accurate data comparisons in the RvO. The CVR clock was 2 minutes 19 seconds lagging the standard UTC (called Padrão UTC in the RvO) at the beginning of the (40 min.) CVR recording and 31 seconds at landing time.
"*The meteo clock of SIO showed a lag of one minute and 30 secs relative to the reference ATC clock*" (RvO § 3.1 Established Facts, page 127), meaning that when SIO measured an increase in wind at 7:32:00, the aircraft had already landed (at 07:33:20 standard UTC).

7.2.3. Comments DASB

7.2.3.1. DASB avoided criticizing the different time references in the RvO; on page 12 of the Report RVDL3 (lijst 4 tab 23) only with one sentence: "*There were no written procedures for time synchronization*". The times used in the paragraph "*3.1 Established facts*", were indeed (standard) UTC times, though.

7.2.4. Comments Experts

7.2.4.1. The experts do not consider the time references an important issue because these were not considered a contributing factor to the accident. In § 0.4 the Experts wrote: “*But the real question is, whatever time reference is being used, whether this reference should be considered as a contributing factor to this accident*”. In § 8.1 the Experts state that "*the use of multiple time references used in the report had no consequences on the work of analysis done by the Commission of Investigation*". On page 51, the Experts wrote as comment: "*The DASB did not issue any comment on this sentence: that ATC did not transmit a wind of 220° with 35 kt to the aircraft. This is the exact feeling of the Experts: 220° at 35 kts is the crosswind limit of the DC-10*."

7.2.5. Remarks and questions Claimants

7.2.5.1. The assignment to the Experts is not to establish the cause of the accident or its contributing factors, but to establish whether the DASB did its job correctly. An important argument by the DASB to support the windshear theory was a dramatic increase in wind strength to 35 – 40 kt and an equally dramatic change in direction to 220° during the last moments of the flight. These values were not measured by the by the SIO measuring systems, in addition there was a time difference of 1.5 minutes between the measurements used and the moment of landing.

7.2.5.2. In § 0.4, the Experts state to "*use the DFDR time as the main time reference, because it is the cockpit reference time and also because it is the end of the DFDR*". However, they used corrected CVR time, not the elapsed time of the DFDR. They also wrote: "*The DFDR time reference is the time provided by the captain’s clock in the cockpit*". This is not correct either, DFDR time is in no way connected to any clock in the aircraft. The DFDR clock is fully autonomous, therefore reported by NTSB as elapsed time in the RvO Annex 15 (Appendix 7). The DFDR stopped recording approximately 7.5 seconds after touchdown.

7.2.5.3. When comparing events in the report, such as the occurrence of increased winds, windshear, etc., it is important to ensure that the times of the events are synchronized to the same standard, which should be the one and only UTC, the Greenwich Mean Time. The Commission provided synchronized data of three times/clocks in RvO Annex 5.

7.2.5.4. The time references were indeed not a contributing factor to the accident, but certainly were to the analysis of the accident, because events cannot be accurately placed on a single time line, making an accurate analysis of events impossible or unrealistic. The Experts used CVR time as UTC rather than the real, the standardized UTC in their analysis; they were not using the corrected time references of RvO Annex 5. The table in § 8.1 is wrong, does not agree with the data in RvO Annex 5. Any analysis by Experts in which a time is used, is therefore unreliable.

7.2.5.4.1 *Question*. Where did the Experts get the data in the time table in § 8.1 from? Did the Experts not notice that in RvO Annex 5 all events were synchronized to appear on one line for different clocks, and that the stretch of the CVR tape was corrected for? This usually is done using audio tones in the cockpit that can be linked to events recorded on the FDR, and to time labels of radio transmissions that are recorded in ground stations. Annex 5 still shows three "*UTC*" times (is an error), of which only standard (padrão) UTC is the real UTC time, which should have been used by the Experts, rather than CVR time. This would have saved them a lot of hours. There are several CVR transcripts of MP495 in which the tape correction has not taken place. AvioConsult also described these deficiencies and the causes in its report. Why was it mandatory to adjust the CVR time (for the Experts)? Or do Experts mean that is was mandatory / required for the Commission to be able to conduct the accident analysis.

7.2.5.5. The question is not whether the time references are an important issue, but to determine whether the DASB handled the available information at that time with due care. During the investigation, wind data out of the SIO was used of which the time of occurrence was not adjusted. The time references should have been synchronized to enable accurate conclusions using the wind and other data from several sources. The accredited representative of the DASB should have insisted on synchronizing all of the times in the report.

7.2.5.6. ATC never had display of a wind of 220° at 35 kt prior to the landing of MP495, and hence, could not pass that data to the aircraft. The aircraft never suffered a strong crosswind like this, because that would be obvious from DFDR data. If this wind was indeed measured, its time of occurrence was not synchronized to the standard UTC time; the aircraft was already on the ground at that time. RvO Annex 5 does list a wind of 220/35, but these data are labelled "*Valores calculados*", meaning calculated, not measured. They might have been added because of incorrect time synchronisation, or under pressure. In any case, the objective DFDR data provide a more reliable source of data to show and prove aircraft behaviour in the air and on the ground. This is what both NTSB and AvioConsult used in their analyses.

7.2.5.7. A wind of 220° at 35 kt is not the crosswind limit of the DC-10; AOM 3.7.1 (Appendix 32) publishes a max. crosswind of 30 kt, which is for a dry runway ≥ 45 m wide and a proficient pilot. For a contaminated runway, other crosswind limits apply: 5 kt for flooded (braking action poor), 15 kt for wet (braking action medium; AOM 3.7.3 – 04; Appendix 9). The co-pilot had only landing experience with crosswinds up to 15 kt (ref. fax Martinair to AIB Appendix 5), which data was not forwarded by DASB or AIB to the Commission. On page 7, the Experts use DFDR time (is an elapsed time) but in the report they use adjusted CVR time. A wind 220° at 35 kt would have resulted in a required wind correction angle of 14° and a crosswind of 32 kt, for landing on runway 11. Neither was the case; this wind never actually happened during the flight.

7.3. Comments Experts on the Portuguese RvO

7.3.1. Causes as concluded by Experts

§ 5.2.1.2: "From a purely technical point of view, and considering that both the analysis and the conclusion of the Commission of Investigation are true, the causes of the accident should have been presented as follow:

The cause:
The accident is a sum of conditions leading to a hard touchdown for which the aircraft was not designed, and therefore "not certified" (i.e. outside the certification limits). As a result, the right landing gear collapses and the right wing broke.

The contributing factors:

An approach becoming unstable on short final [below 200 ft], *just before the landing, apparently due to a change of the meteorological conditions and a high rate of descent;*

A premature reduction of thrust which aggravated the previous contributing factor;

On very short final, a lack of decision to initiate a missed approach procedure;

An incorrect meteorological information [of runway 29 rather than runway 11];

A change in the flight management mode on very short final that might have disturbed the pilots' sensations in regards to the aircraft".

7.3.2. Remarks and Questions Claimants

7.3.2.1. It was specifically not requested by the Court to conduct an analysis or investigation, and report on the results.

7.3.2.2. The PAPI is a visual glide path indicating system, which is not recorded in the aircraft (by a forward-looking camera). Only by analysing control inputs, aircraft motions, and CVR transcript, it can be determined whether the aircraft was on the correct glide path.

7.3.2.2.1 *Question*. How do Experts know the approach becoming unstable?

7.3.2.2.2 *Question*. Isn't a "*stabilized non-precision approach*", in aviation terms, an approach when, at an altitude of 500 ft, the aircraft is within the horizontal (± 2°) and vertical margins (± 0.5°) of the centre of the approach guidance, the airspeed is the required approach speed and engine thrust is stable for maintaining the airspeed and the glide path?

7.3.2.3. An aircraft is stable if well-defined stability requirements are met that are evaluated during flying qualities flight-testing. An atmospheric disturbance will not render the aircraft uncontrollable. The flight-tests the aircraft underwent prior to certification include but are not limited to longitudinal static stability, phugoid stability, flight path stability, short period response, residual oscillations, longitudinal PIO and longitudinal control in sideslips.

7.3.2.3.1 *Questions*. The approach was not becoming unstable at all; the aircraft was fully controllable. There was light turbulence and the pilot mishandling the automated systems that caused motions. Can the Experts explain exactly where the aircraft became unstable and why? Was it a phugoid, or a short period problem? Or just some variations due to the strong wind, the ground effect, the crossing of the sea – land border, etc.

7.3.2.3.2 *Questions*. "*An Incorrect meteorological information*"? Why do you state there were no other data? There were errors in clock synchronization and time references. It was never proven that the ATC Controller made a mistake, only assumptions.
In flight, the pilots must have noticed the large drift angle caused by a considerable crosswind, and the captain collected his own wind data from the R-Nav system; they had light turbulence and knew there were thunderstorms. They crossed a heavy shower seconds before landing. They had actual "*meteorological information"* themselves, didn't they? Should they still rely on the weather information that was at least 5 min old and wind data provided by ATC with the landing clearance, and not take into account their own observations? Who is ultimate responsible? Do you still agree with your cause on "*An incorrect meteorological information*"?

7.3.2.3.3 *Question*. No call "*Go-around*" was given in the cockpit, as Experts mention in footnote 20 out of a statement of the Flight Engineer. No "*my controls*" call either by captain. The pilots will not even have noticed the change following disengagement of the CWS. Refer to AOM 3.3.6 – 02 (Appendix 31).

7.3.2.4. The cause of the accident is that the pilots didn't apply procedures during the whole flight - lack of decision power, crosswind >15 kt, crosswind in-experience, flooded, etc. The aircraft is not certified for a crabbed landing; therefore, a crabbing landing is a pilot error.

7.3.2.5. Experts § 5.2.1.3: "*In general, the main cause of the Faro accident was that the aircraft touched-down in a way and with a trajectory that did not follow, in very short final, the vertical standard flight path established by the applicable procedures. It means, that one of the recommendations to improve the flight safety and issued by the Commission of Investigation as required by the Annex 13, should be to teach the pilots to initiate a missed approach in case of an unstabilized approach and under a fixed height*".

7.3.2.6. Experts do not talk about the standard lateral flight path. The radar data in RvO Annex 12 (Appendix 12) shows a large deviation. Nothing about the traversing landing in the cause and about the resulting additional adverse forces and moments acting on the landing gears. The right landing gear collapsed, at least one of the tyres of the centre main gear blew, after which the rim caused a deep groove in the runway (in the direction of the runway).

7.3.2.6.1 *Question*. A missed approach procedure does not only have to be initiated under a fixed height, but at any time during the approach (BIM 2.3.6) and flare (AOM 3.3.5 – 15, Appendix 2). Why do Experts suggest that it has to be taught, while it already is prescribed in the manuals?

7.3.2.6.2 *Question*. Was the approach stabilised, that is within the lateral and vertical boundaries as required in BIM 3.4.4 – 06 (Appendix 11)? No, isn't it? Should the pilots not have initiated a go-around?

7.3.2.7. Experts rely entirely on statements by the crew; did not analyse the objective data recorded on CVR and DFDR.

7.3.2.8. Experts § 5.2.1.3 page 17. "*After the issuance of the draft report of the Commission of Investigation, the Dutch Safety Board proposed modifications to the content of this report to adjust the wording, but accepted the conclusions of the final report.*"

7.3.2.9. No, the Safety Board did not accept the conclusions and causes at all, please refer to Report RVDL3 (lijst 4 tab 23) to see the many changes that DASB wanted the Commission to incorporate. DASB wanted windshear as cause, but the Portuguese Commission did not, and did not include this in the final report. DASB modified their point of view and issued a new report with their own interpretation that was, i.a.w. Annex 13, included an Appendix to the RvO.

7.3.2.9.1 *Question*. Have Experts compared the Report RVDL3 (lijst 4 tab 23) and the DASB report dated 6 Sept. 1994 in the RvO Appendix?

7.3.2.10. Experts § 5.2.1.3 page 17. "*During the analysis of the documents provided, the Experts have forced themselves to stay away from the notions of "technical cause" and "responsibility" in the judicial sense.*
This is also how the Experts evaluated the Dutch Aviation Safety Board's actions as well as answered the questions asked by the court".

7.3.2.11. But Experts wrote about technical aspects, like landing gear failure, and about professional responsibilities.

7.3.2.12. Experts § 5.2.1.3 page 17. "*The Expert's mission is not to scrutinize the causes as indicated in the official report published by the Portuguese Commission of Investigation. The Experts are specifically requested to consider the action of the Dutch Aviation Safety Board and to verify if "the Civil Aviation Board handle the information it had at the time regarding the aspects stated in 2.5 of this judgment with due care". During the analysis of the documents provided, the Experts have forced themselves to stay away from the notions of "technical cause" and "responsibility" in the judicial sense. This is also how the Experts evaluated the Dutch Aviation Safety Board's actions as well as answered the questions asked by the court*".

7.3.2.12.1 *Question*. Don't Experts agree that the meaning of the word scrutinize is to examine or observe with great care, inspect minutely or critically?

7.3.2.12.2 *Question*. How can Experts answer the questions by the Court with due care?

7.3.2.13. Experts, in § 5.2.2.1, provide general comments on the role of the comments DASB. They repeat that "*the Dutch Aviation Safety Board agrees in general with the description of the events by the Commission of Investigation – based on the factual information – and more important, with the analysis and the conclusions made by this Commission*".

7.3.2.14. But the Experts did not review the Report RVDL3 (lijst 4 tab 23), the comments of DASB on the draft of the Portuguese Report, but only the amended version of 6 September 1994 in the Appendix of the RvO, that was required because the Commission did not accept the required changes to the report that all were aimed at introducing windshear as cause of the accident.

7.3.2.15. DASB contracted NLR to "*investigate the windshear situation*", but when the first version of the report was presented to the DASB, the lead investigator required NLR to delete any data that could lead to the conclusion that there might not have been windshear, or extreme lateral displacement, such as a rate of descent of 'only' 760 ft/min. NLR, in their final report that is included in RvO Annex 4, wrote in § 1: "*it was concluded that windshear (a downburst) was present, however, it was not a hazardous factor itself during the approach of the aircraft. Furthermore, strong crosswinds were determined to be present at the moment of landing, far in excess of the crosswind limits of the aircraft*".

7.3.2.16. Experts § 5.2.2.1 page 18: "*The Dutch Aviation Safety Board agrees with the official conclusions in general, but they request a sharper analysis on the causes and contributing factors of the accident".*
"That being said, within the Portuguese Commission of Investigation they [DASB] are not in charge to build up the analysis and issue the final report".
"Ultimately, the Portuguese Commission of Investigation is the one making the conclusions and it is its choice to accept or refuse the remarks of the Dutch Aviation Safety Board".

7.3.2.17. As already described in §4.4 above, neither the NLR engineer who wrote the report, nor his approving chiefs, and nor the DASB were obviously aware of the way a visual non-precision approach is flown with a DC-10 (i.a.w. AOM). DASB should have filled this gap. The interception of the PAPI glide path from above with the autopilot in the Vertical Speed mode set at a rate of descent of 750 ft/min always results in a few moments of straight and level flight, unless the pilot is experienced enough to execute this manoeuvre smoothly. This short straight flight cannot be explained as windshear; is not very smart to do so. DASB should have noticed and assisted the NLR, but they didn't. They just wanted windshear in the report.

7.3.2.18. DASB might not be in charge to build up the analysis, but they received all of the data and could do a thorough analysis by themselves, but they didn't. They limited their contribution to making sure that windshear was included, while there wasn't any. DASB obviously did not conduct an analyses of the available data with due care.

7.3.2.19. Indeed, the Portuguese Commission had the lead, but offered to include the Comments of the DASB (and the NTSB) in an appendix to the final report. Officially, windshear was not the cause, but DASB persisted that windshear did occur, as well as an extreme lateral displacement. DASB denied the official report and spread his own inappropriate conclusions in the media and during meetings in The Netherlands. There is no evidence whatsoever that windshear occurred and that there was an extreme lateral displacement.

7.4. ICAO Annex 13

7.4.1.1. Experts included information on ICAO Annex 13 in § 3 and § 8.2 and concluded on page 46 that "*Annex 13 stipulates even more distinctly that the aim of the investigation is not to lay blame or to establish legal liability, be it civil or crimina*l".

7.4.1.2. But the DASB tried to use its influence to change the cause of the accident and drag the conclusions away from a possible legal liability issue to an uncontrollable and unforeseeable weather phenomenon. The questions of the Court were not aimed at accident prevention, but to evaluate the performance of the DASB.

7.4.1.3. The questions of the Court were not aimed at accident prevention, but to value the performance of the DASB. This Experts' assignment was not an Annex 13 investigation.

7.4.1.3.1 *Question.* Why did Experts include ICAO Annex 13 quotes in § 3 and § 8.2? This is only of relevance for accident investigations, not for answering the questions of the Court. Please explain.

7.5. Experts comments on meetings

6.10.1. MEETING OF 1993

A first information meeting was organized on August 11th 1993: the result of this meeting was the submission of 143 questions asked by the Anthony Ruys Foundation to Martinair and the Dutch Aviation Safety Board.

All these questions were raised before the issuance of the official report of the Commission of Investigation, and answered in November 18th, 1994 in writing.

Consequently, the Experts consider as normal that the airline and the Dutch Aviation Safety Board, itself linked by an obligation of secret (to protect its independence because of its involvement as accredited representative in the Commission of Investigation), answer the questions after the issuance of the official report.

The Experts underline that the most part of these questions were not appropriate to the investigation itself but are related to liability and/or responsibility of the different actors, which is not the main purpose of such an investigation.

6.10.2. MEETING OF 1994

Another meeting took place on December 1st 1994, after the issuance of the final report of the Commission of Investigation.

The purpose of this new meeting was to explain the content of this report, to provide information about the role of the Dutch Aviation Safety Board and to give opportunity to ask factual questions.

The most important remarks raised by the families and victims were that the witnesses' statement was not taken into account by the Commission of Investigation.

The Experts have been provided with a document Dossier NA 2617 and Dossier NA 2622, merging the visual witnesses' statements.

The answers provided during the meeting to the families and victims were considered as not appropriate by the families and victims.

The Experts note that in some cases, the answers were not enough substantiated, mainly in the way an accident investigation is organized or conducted according to ICAO Annex 13.

They note the existence of contradictions in between the witnesses' statements but also contradictions between the statements and the objective recorded flight data.

7.5.1.1. In V17 § 5.2.2.1, the Experts provide general comments on the role of the DASB. They repeat that "*the Dutch Aviation Safety Board agrees in general with the description of the events by the Commission of Investigation – based on the factual information – and more important, with the analysis and the conclusions made by this Commission*". "*That being said, within the Portuguese Commission of Investigation they* [DASB] *are not in charge to build up the analysis and issue the final report*".

7.5.1.2. "*Ultimately, the Portuguese Commission of Investigation is the one making the conclusions and it is its choice to accept or refuse the remarks of the Dutch Aviation Safety Board*".

7.5.1.2.1 *Remark*. Throughout this review, comments are presented on the answered questions and the issues raised during the two meetings.

7.6. Cross reference list of inappropriately answered questions on 1 dec. 1994

Question 17: § 4.6.3.4	Question 88: § 4.4.5.7	Question 130: § 5.11.6.18
Question 18: § 4.6.3.5	Question 89: § 4.4.5.8	Question 131: § 5.11.6.19
Question 19: § 4.6.5.4	Question 102: § 2.2.4.1	Question 132: § 5.11.6.20

Question 26: § 4.6.5.5	Question 107: § 2.2.4.2	Question 133: § 5.11.6.21
Question 27: § 4.6.5.6	Question 112: § 2.3.4.3	Question 137: § 2.3.4.5
Question 28: § 4.6.5.7	Question 113: § 5.9.5.5	Question 140: § 5.10.5.6
Question 29: § 4.6.5.8	Question 114: § 5.9.5.6	Question 141: § 5.10.5.7
Question 31: § 4.7.3.12	Question 115: § 5.9.5.7	Question 142: § 5.10.5.8
Question 58: § 5.10.5.3	Question 126: § 5.10.5.5	
Question 59: § 5.10.5.4	Question 129: § 5.11.6.17	

List of Abbreviations

AFM	Aircraft Flight Manual
AIB	Accident Investigation Bureau
AIDS	Airborne Integrated Data System
AOM	Aircraft Operations Manual
ATS	Auto Throttle System
BIM	Basic Instructions Manual
BVO	EN: Accident Investigation Bureau; NL: Bureau VoorOnderzoek
CVR	Cockpit Voice Recorder
CWS	Control Wheel Steering (autopilot mode)
DASB	Dutch Aviation Safety Board (DASB)
DDG	Dispatch deficiency Guide
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
FAR	Federal Aviation Regulations (USA)
FCOM	Flight Crew Operating Manual
FO	First Officer (co-pilot)
ft	foot, feet
ft/min	foot per minute (ft/min)
GARTEUR	Group for Aeronautical Research and Technology in EURope
ICAO	International Civil Aviation Organization
KLM	EN: Royal Dutch Airlines
kt	knot or knots (nm/hour)
LDC	Landing Data Card
MDA	Minimum Decision Altitude
MLG	Main Landing Gear
(M)MEL	(Master) Minimum Equipment List
NLR	EN: National Aerospace Laboratories
nm	nautical mile (1852 m)
NTSB	National Transportation Safety Board (USA)
OvV	EN: Dutch Aviation Safety Board ('16); NL: Onderzoeksraad voor Veiligheid
PANS-RAC	Procedures for Air Navigation Services - Rules of the Air and Air Traffic Control
PAPI	Precision Approach Path Indicator
PF	Pilot-flying
PNF	Pilot-not-flying
R/T	Radiotelephony
RVDL	Dutch Aviation Safety Board; NL: Raad voor de Luchtvaart
R-Nav	Area Navigation (Inertial, supplemented by radio navigation, whenever available)
RvO	EN: Accident Investigation Report; NL: Rapport van Ongeval
UTC	Universal Time Coordinated (Greenwich Mean Time)
V17	Interim Report Experts version V17
VOR	VHF Omnidirectional Ranging (radio navigation ground beacon)

List of Appendices

Appendix 1. Meteo information know to the crew.

During the flight, the weather at Faro airport deteriorated. The CVR transcript (RvO Annex 5) provides the facts about the weather from 40 minutes before landing, the maximum recording time of the CVR.

1) During the arrival (approach) briefing at 06:54:56 (UTC – padrão, meaning standard), the co-pilot acknowledges a "*wet runway*".
2) At 06:57:50, the captain said "*you have to make it a positive touchdown*". At 07:04:09, the captain said: "*I'm listening out what we …*" (most probably the ATIS info on the VOR frequency, which includes weather info).
3) At 07:04:27, ATC transmits to Martinair flight MP461, which is 6.5 minutes ahead of MP495: "*wind 150/15kt, present weather* ***thunderstorm****, 1/8 cumulonimbus at 2500 ft*".
4) At 07:05:17, the captain informs the cockpit crew of what he heard from ATIS amongst other data: "***thunderstorms***".
5) At 07:05:30, MP461 asked the controller "*could you say again the wind please*", the answer was "*presently from 150/16 max 18 kt*".
6) At 07:09:58, ATC reported to MP495 "*wind 150/18, present weather* ***thunderstorm***". The confirmation of this message by the captain came 41 sec later.
7) At 7:14:01 UTC, the co-pilot said, "*it's raining cats and dogs over there*", and the captain: "*we should have arrived half an hour earlier*", which did both pilots confirm.
8) At 07:14:36, MP461 requests ATC "to proceed approximately 5 miles over left to avoid build-up".
9) At 07:16:24 a cabin attendant asked "*how is the weather*", and the captain responded "*it's lousy weather over there*".
10) At 07:19:51 a wind of 150/24 kt (crosswind 17 kt) was included in the take-off clearance of departing flight TP120 from Faro. The flight engineer responded, "*What*" and "*yeah, I'll check them*", which might have been to check the approach data because of the increased wind.
11) At 07:23:26 the departing flight TP120 reported, "*We are in the middle of a* ***thunderstorm***" after a right turn out from near overhead the airport.
12) At 07:24:22, MP461 reports being "*fully IMC*", i.e. in clouds, on the approach just below 2000 ft.
13) At 07:24:58, MP461 is "*cleared to land, the runway surface condition* ***flooded****, wind 150/20 kt*", a crosswind of 14 kt (9 kt too high for a flooded runway, 1 kt from the limit for a wet runway).

Overhead Faro at 07:25:57, 4000 ft down to 2000 ft.

14) At 07:26:20, the controller again reported to MP461: "*cleared to land, now 130/18, 21 maximum*".

At 07:28:40 over right, to heading 080.

15) At 07:28:56, ATC reported to MP495 "*runway surface conditions are* ***flooded***", upon which the captain responded "*roger*", meaning he understood the message, otherwise he would have asked immediately the meaning of the word, but he didn't; he knew.

7 nm from DME at 07:29:32; Gear down at 07:29:37; Flaps down 50 at 07:30:18 UTC.

16) At 07:29:53, the captain says "*wind is from the right*" and at 07:30:47 "*wind is coming from the right, 30 kt, drift 12°, so you make it 123 or so*".
17) At 07:31:33 The flight engineer mentions "*The runway is …*". The transcript in folder 2624 in the National Archives does not show "…", but the word "***flooded***". Someone changed the transcript.
18) At 07:32:15, MP495 is "*cleared to land runway 11, the wind 150/ 15 max 20*", of which the crosswind component was 14 kt.
19) At 07:32:24 the captain says "*ok hé, the runway is* ***…***".
20) At 07:32:30, the flight engineer said, "*you missed the 500*": the 500 ft call coincided with the call approaching minimums, after which the decision is made to land or go-around. This decision was not communicated in the cockpit as required.
21) At 07:33:00, the co-pilot said "*windshield anti ice,* ***I don't see anything***".
    At 07:33:10, 10 seconds before the touchdown, the captain said "*wind is uh 190 with 20*", a crosswind of 20 kt (15 kt too high for a flooded runway, 5 kt too high for a wet runway).

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15 LANDING ON A WET OR OTHERWISE CONTAMINATED RUNWAY

The landing and deceleration on a runway where reduced braking action or risk of hydroplaning exists must always be considered critical. A heavy weight (high V_{th}) landing on a wet runway in combination with no headwind or tailwind greatly increases the risk of hydroplaning.

- Under zero wind conditions, most runways have adequate cross fall to provide drainage under quite high rates of precipitation.
- Under crosswind conditions above 10 kt, drainage can be seriously affected, but a 15-20 minute waiting period after a downpour is usually sufficient to drain the water.

Runway Selection

Calculate Actual Landing Distance for the appropriate runways and select the most favourable one.
The most critical wind condition for runway length requirement is with zero headwind component. The effect of wind on the landing distance is factored by using 50% of the headwind component and 150% of the tailwind component.
This factor disappears in light winds.

Flare and Touch Down

- An automatic landing is recommended.
- If a manual landing must be performed:
  . Apply normal crosswind techniques (if applicable).
  . Do not allow the aircraft to drift during the flare, land on the centreline and aim for a positive touchdown.
  . Avoid a long float.
  . Be prepared to go-around at any time during the flare.

Deceleration

- Ground spoilers may not extend immediately.
- As the wheels must spin up before effective braking can commence, do not commence brake application until:
  . Ground spoilers are extended (automatically or manually).
  . The nose gear is firmly on the ground.
- Apply maximum available reverse thrust.
- Apply full brake pedal deflection, do not modulate brake pressure.
- Apply forward column pressure as soon as the nosewheel is on the runway to increase weight on the nosewheel for improved steering effectiveness.
  CAUTION: Do not apply excessive forward column pressure because this will unload (to some extent) the main wheels and decrease braking.

When the aircraft is in a skid:

- Disconnect AP.
- Release the brakes to maximize cornering capability.
- Select idle reverse thrust.
- Align the aircraft longitudinal axis with the runway centreline.
- Regain runway centreline.
- If recovery measures fail, select forward idle thrust to eliminate reverse thrust component side forces.
- When the aircraft is under control again, resume maximum braking and reverse thrust.

-oOo-

Appendix 2

★ - Thrust Reversers	One fan thrust reverser may be unserviceable provided: . Aircraft shall not depart a station where repair or replacement can be made. . The unserviceable fan thrust reverser is secured and stowed according to MAI 78-00-01. . When dispatching from a wet or contaminated runway, the thrust used for take-off shall not be less than full A rating. . Asymmetric thrust reverser configuration does not seriously affect directional control due to the runway conditions at destination and/or alternate airports. . Anti-skid system is in <u>Phase IV</u> configuration.
- REV IN TRANS Light	Must be serviceable on serviceable thrust reversers.
- Reverser Valve Open Light	May be unserviceable provided: . The affected reverser is secured in the stowed position.
- REV Light	All may be unserviceable provided: . Interlock system to prevent application of thrust until fan reverser translating cowl is deployed, is serviceable. . The REV IN TRANS light is serviceable. . Thrust reverser is functionally operated through the full cycle and checked for proper operation and stow position.
- Oil Quantity Indications	One may be unserviceable provided that: . The oil tank is filled to the maximum recommended capacity before departure. . There is no evidence of above normal consumption, leakage or fuel contamination. . Oil pressure and oil temperature indications and oil pressure low light are serviceable.
- Oil Temperature Indications	Must be serviceable.
- ENG OIL PRESS LO Lights	One may be unserviceable provided the associated oil pressure, oil temperature and oil quantity indications are serviceable.
★ - ENG FAIL Lights	May be unserviceable provided: . Thrust settings are closely monitored during take-off. . Runway/obstacle limited T/O weight (TL chart) or if no TL chart available, runway length limited T/O weight (T/O runway length chart) is decreased with 7000 kg.
- Engine Vibration Indicating System	Must be serviceable for departure from stations where repair or replacement can be made.

-oOo-

Definitions

The definitions of specific words and phrases used in this manual are found at Appendix A.

The Master Minimum Equipment List

A Master Minimum Equipment List (MMEL) is an approved document created specifically to regulate the dispatch of an aircraft type with inoperative equipment. It establishes the aircraft equipment allowed to be inoperative under certain conditions for a specific type of aircraft and still provide an acceptable level of safety. The MMEL contains the conditions, limitations and procedures required for operating the aircraft with these items inoperative. The MMEL forms the basis for development and review of an individual operator's Minimum Equipment List (MEL).

A (**Insert country**) operator will frame its MEL based on the MMEL duly approved by the authority of the country of manufacture of the aircraft.

Dispatch with Inoperative Equipment

The MEL is an alleviating document. Its purpose is not, however, to encourage the operation of aircraft with inoperative equipment. It is never desirable that aircraft be dispatched with inoperative equipment and such operations are permitted only as a result of careful analysis of each item to ensure that the required level of safety is maintained. A fundamental consideration in permitting the dispatch of aircraft with inoperative equipment is that the continued operation of an aircraft in this condition should be minimized. The limitations governing repair intervals are discussed later in this document.

Legal Basis

(**Insert country**) Civil Aviation Rules (CARs) provide that the operation of an aircraft with equipment and/or instruments inoperative may be approved through the use of a Minimum Equipment List.

Where a Master Minimum Equipment List has been approved for a particular type of aircraft by the authority of the country of manufacture of the aircraft, a Minimum Equipment List shall not be approved for that type of aircraft unless it complies with the minimum standards set out in that MMEL.

Installed Equipment

Most large transport aircraft are designed and certified with a significant amount of redundancy in their systems, such that the minimum standards of airworthiness are satisfied by a substantial margin.

Martinair Holland

Martinair Building, P.O. Box 7507
1118 ZG Schiphol Airport
The Netherlands
Phone: (31) 20-6011222
Telefax: (31) 20-6011303
Telex: 11678, Cable: Macair
VAT nr. NL002804466B01
Martinair Holland NV, reg.nr. 29.668
Chamber of Commerce Haarlem

FAX TO : RIJKSLUCHTVAARTDIENST
Attn. Mr. F.A. van Reijsen,
Accident Investigation Bureau

02503-23040

FROM : MARTINAIR HOLLAND
H. Frijns
Head Flight Department

DATE : April 19th 1993

Page(s) : 1

In answer to your request we herewith provide a summary of hours as PF, manual landings, autolands, hours, destinations of F/O R.J.H. Clemenkowff.

June 21st till and incl June 30	6.50	manual landings	1
July	17.25	manual landings	6
August	06.55	manual landings	1
September	11.35	manual landings	2
October	27.05	manual landings	4
		auto lands	1
November	22.10	manual landings	3
		auto lands	1
December	26.20	manual landings	2
		auto lands	1

Total June 21st till December 21st 1992 :

hours as PF	118.20
stretches as PF	32
manual landings	19
auto lands	3

cross wind till approx 15 kts

Destinations EUR : AMS, MIR, PIK
NAT : YMX, ANC, SEA
FE / ME : AUH, DXB, MCT, TPE, MNL, HKG

Kind regards.

END

Appendix 5

3.1.7 WIND SHEAR ENVIRONMENT

With reference to the basic information in KLM FRG 5.1.2 and the aspects covered in the relevant Aircraft Operations Manual, the following rules and recommendations should be adhered to.

- Take-off

  If a wind shear in the take-off flight path is expected or known to exist, consideration should be given to the following:
  - delay the take-off until conditions are more favourable
  - selection of a more favourable runway and/or climb out direction
  - use of full rated take-off thrust
  - use of a higher climb out speed (max V_2 + 30)
  - delay of heading changes and/or restrictions of bank angle to 15° in the shear area.

  A take-off should not be made in the direction of a reported shear if the take-off is performance limited.
  A take-off should not be made when severe thunderstorms are present in the initial flight path area, for reasons of uncertain wind/gust patterns normally associated with these phenomena.

  Cases of expected or known pronounced temperature inversion should also be reason for consideration of some of the above factors.

- Approach

  If a wind shear in the approach area is expected or known to exist:
  - use speed increment as indicated in the AOM
  - consider the use of a reduced landing flap setting, runway length permitting
  - use autopilot and autothrottle, if possible
  - monitor Inertial/Omega data, IAS, rate of descent, pitch and power, closely for early shear recognition.

  Do not make large power reductions until beginning of the flare.

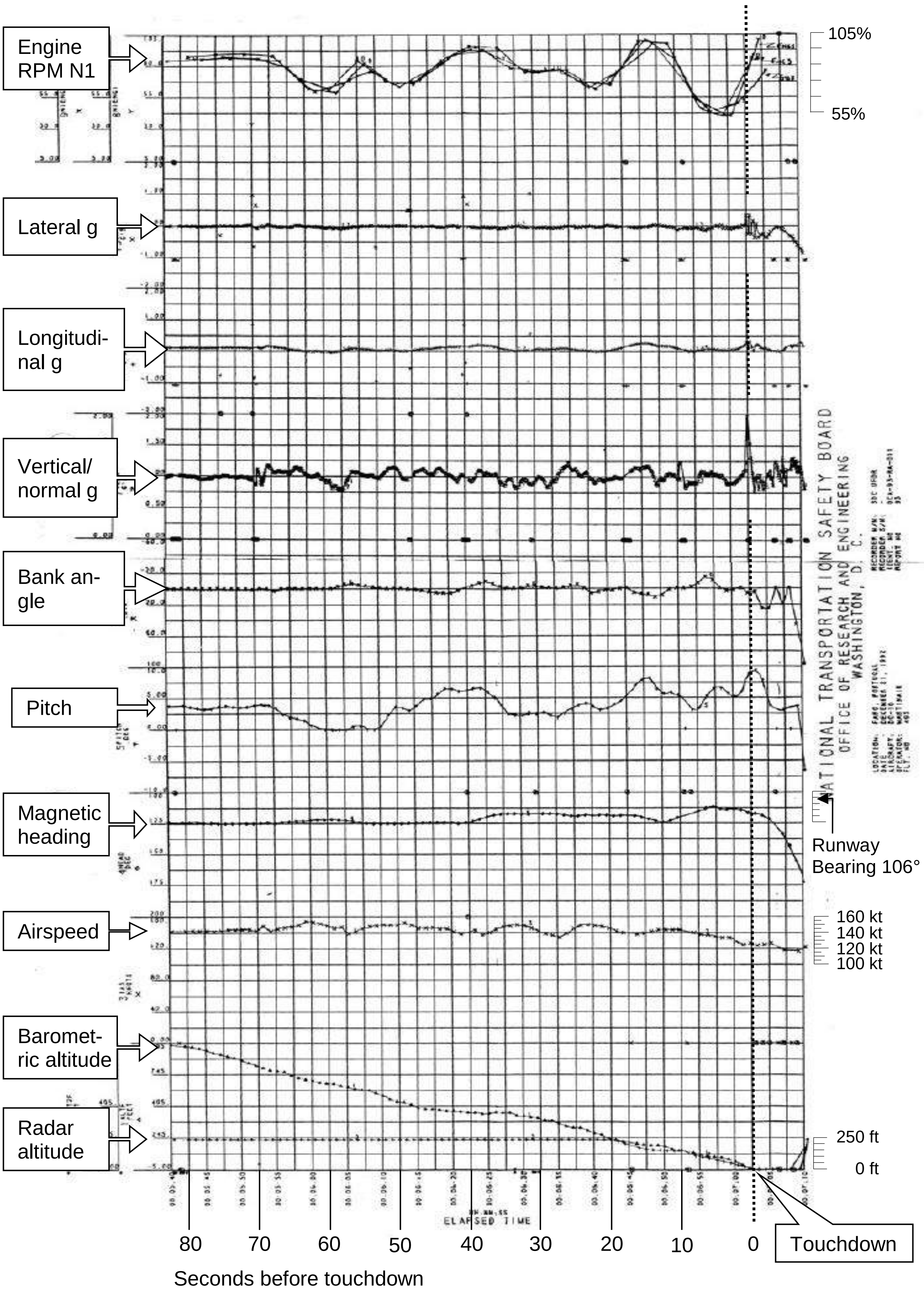
  Delay approach or divert if severe thunderstorms are present in the approach area.

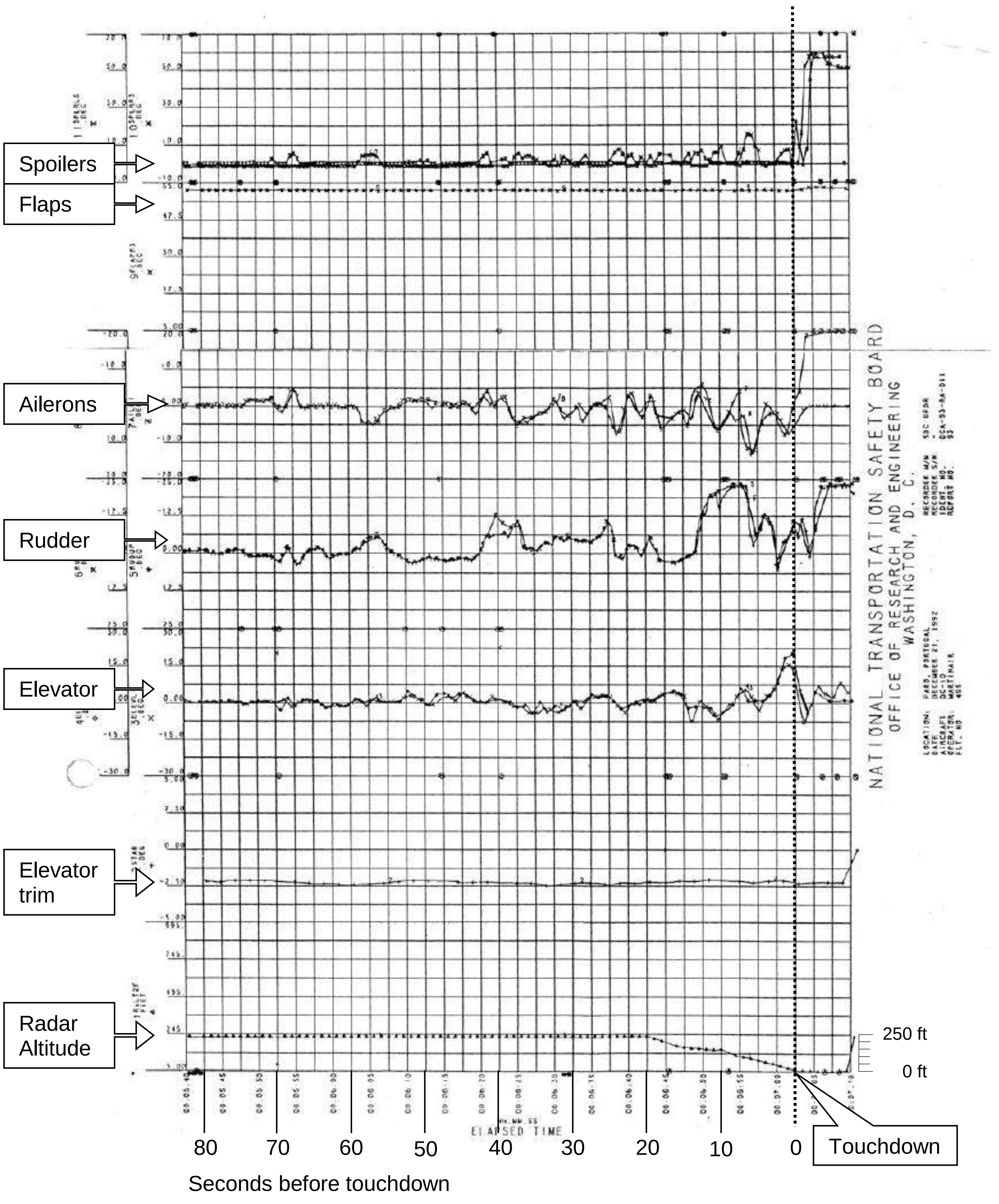
- Reporting

  If wind shear has been encountered, this should be reported immediately to ATC.
  Reports should include altitude and amount of shear.

-oOo-

Appendix 6


Engine RPM N1
105%
55%
Lateral g
Longitudinal g
Vertical/ normal g
Bank angle
Pitch
Magnetic heading
Runway Bearing 106°
Airspeed
160 kt
140 kt
120 kt
100 kt
Barometric altitude
Radar altitude
250 ft
0 ft
NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF RESEARCH AND ENGINEERING
WASHINGTON, D.C.
ELAPSED TIME
80
70
60
50
40
30
20
10
0
Touchdown
Seconds before touchdown


Spoilers
Flaps
Ailerons
Rudder
Elevator
Elevator trim
Radar Altitude
250 ft
0 ft
NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF RESEARCH AND ENGINEERING
WASHINGTON, D. C.
ELAPSED TIME
80
70
60
50
40
30
20
10
0
Touchdown
Seconds before touchdown

16712

04 CREW CO-ORDINATION AND MONITORING

Use of Auto Flight System

The primary method of executing an approach, regardless of weather conditions, is by means of the autopilot(s) and autothrottles. To avoid inadvertent autopilot disconnection by overpowering, hold the controls lightly.

Division of duties

During every approach and landing, monitoring of instruments is essential. At the same time, in a see to land operation, looking out is necessary. None of the following instructions relieves the crew of the duty to scan for conflicting traffic, weather conditions permitting.

Regarding the division of duties, there is a further refinement to the general definitions of the AUTOMATIC- and MANUAL Flight Mode of Operation as described in AOM 3.3.1 - Crew Co-ordination and Monitoring. Conventions for the operation of the Auto Flight System remain unchanged, but the crew co-ordination is governed by the following conventions:

- AUTOMATIC CREW CO-ORDINATION PROCEDURE (ACCP)
  The Auto Flight System is in the AUTOMATIC Flight Mode of Operation AND is coupled to an ILS Localizer and Glide Slope when reaching the Descent Limit.

- MANUAL CREW CO-ORDINATION PROCEDURE (MCCP)
  One or more of the above mentioned criteria is not met.

NOTE: For the standard call-outs and the division of duties refer to the description of the applicable approaches in this chapter.

05 ARRIVAL CREW BRIEFING

The PF shall give the arrival crew briefing preferably before starting the descent. It shall be completed or confirmed in response to the applicable item on the approach checklist.
The crew briefing shall at least cover the following items:
- Any deviation from the standard AOM procedures.
- Applicable minimum altitudes.
- Type of approach/landing and landing flapsetting to be used.
- Approach profile, descent limit and, for non-precision approaches, rate of descent and MAPt.
- Missed Approach Procedure.
- Runway condition and landing distance (if marginal).
- Taxi-in route.
- Set-up of NAV-equipment.
- Operational impact of local situation, weather and aircraft deficiencies, if not yet covered.

Appendix 8

16759

04 RESTRICTIONS TO MAXIMUM WIND COMPONENTS

- Runway Conditions (Take-off and Landing)

Braking Action	Motne Code	Friction Coeff. (μ)	Typical Runway Condition	Maximum Cross Wind Comp.(kt) RWY Width 45 m or more	Maximum Cross Wind Comp.(kt) RWY Width 40 - 45 m	Maximum Tail Wind Comp.(kt)
GOOD	5	0.40 and above	. Dry Runway . Wet Runway with good surface condition	30	15	10
MEDIUM to GOOD	4	0.39 to 0.36		20	*	*
MEDIUM	3	0.35 to 0.30	. Moderate to heavy Rain On clear Runway . Snow/Ice covered but sanded Runway	15	10	5
MEDIUM to POOR	2	0.29 to 0.26		*	*	*
POOR	1	0.25 and below	. Slush or Ice covered Runway . Ice covered Runway . Freezing Rain . Drizzle on dusty Runway . Standing Water	5	0	0

NOTE: * Use of intermediate wind limits permitted.
For JBI information refer to AOM 3.5.2.
For deviation from minimum runway width requirement refer to AOM 3.7.1.

- Landing Weather Minima

Cross- and Tailwind limits for landing are affected by Landing Weather Minima as follows:

Minima less than 250 ft/ 1200 m	Max. crosswind comp.: 15 kt
CAT II and III	Max. crosswind comp.: 10 kt Max. tailwind comp.: 5 kt

- Emergency/Abnormal Configuration

Emergency/Abnormal procedures may further restrict crosswind component as per procedure.

- Autoland

Maximum Headwind Component: 25 kt.
Maximum Crosswind Component: 15 kt.
Maximum Tailwind Component: 10 kt.

-oOo-

Appendix 9

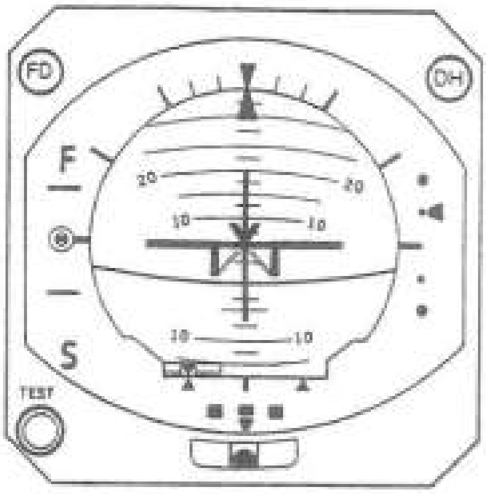
KLM 0554

11 ILS DEVIATION LIMITS

ILS deviation limits are:

■ 200 ft RA or above

. Localizer : one dot as indicated by the Rising Runway symbol.
. Glide slope: one dot.

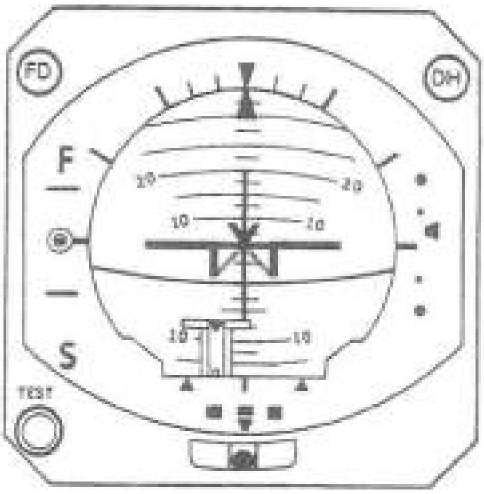


Deviation: one dot

■ Below 200 ft RA (including roll-out)

. Localizer : 1/2 dot as indicated by the Rising Runway symbol.
. Glide slope: 1/2 dot.

NOTE: Disregard glide slope indication below 50 ft RA.



Deviation: 1/2 dot

Actions in case of ILS deviation

If the above mentioned deviation limits are exceeded or the rate of deviation is such that an exceedance must be expected, the PNF shall call "LOCALIZER" and/or "GLIDE SLOPE".
Continue the approach down to CAT I/II DA/DH or 100 ft in case of CAT IIIA.
Execute a go-around when:
. Upon arriving at the DA/DH/100 ft the ILS deviation limits are still exceeded.
. Below DA/DH/100 ft the ILS deviation limits are exceeded.

05 500 ft call

A 500 ft call shall be included in the final part of each approach to protect against subtle incapacitation and to serve as an awareness call for the landing clearance.

On aircraft with a basic crew including a flight engineer, the latter shall give this call and on aircraft with a basic crew of two pilots only the PNF shall give this call.
In both crew compositions the PF will respond "CLEARED/NOT CLEARED", followed by a "CHECKED" call from the PNF, which means that he agrees with the response from the PF.

All basic crew members should be convinced that the landing clearance has been received and acknowledged before landing.

Considering the purposes of the call, it will be clear that is not meant to be a precision call.
The call will in principle be made with reference to the radio altimeter or, if this is impractical due to underlying terrain, with reference to the pressure altimeter. When the latter is the case, the subject shall be discussed during the crew briefing.

For details refer to the AOM concerned.

06 Approach stability

Early stabilization on the final approach path with respect to glide path and centre line is considered essential. At not less than 500 ft above threshold elevation this flight path stabilization must also be accompanied by a basic stability of speed and thrust, thus ensuring that any disturbing influences or deviations in the latter stage of the approach can be readily recognized and rapidly corrected.

Should circumstances prevent such stability being achieved before reaching 500 ft, then it must be realized that safe continuation of the approach to landing becomes questionable. Vital factors such as speed, descent rate, threshold height and point of touch down, can all be adversely influenced. On short or wet runways such factors become of paramount importance. It is therefore strongly recommended that no landing be attempted if the desired stabilization has not been achieved when passing 500 ft above threshold elevation.

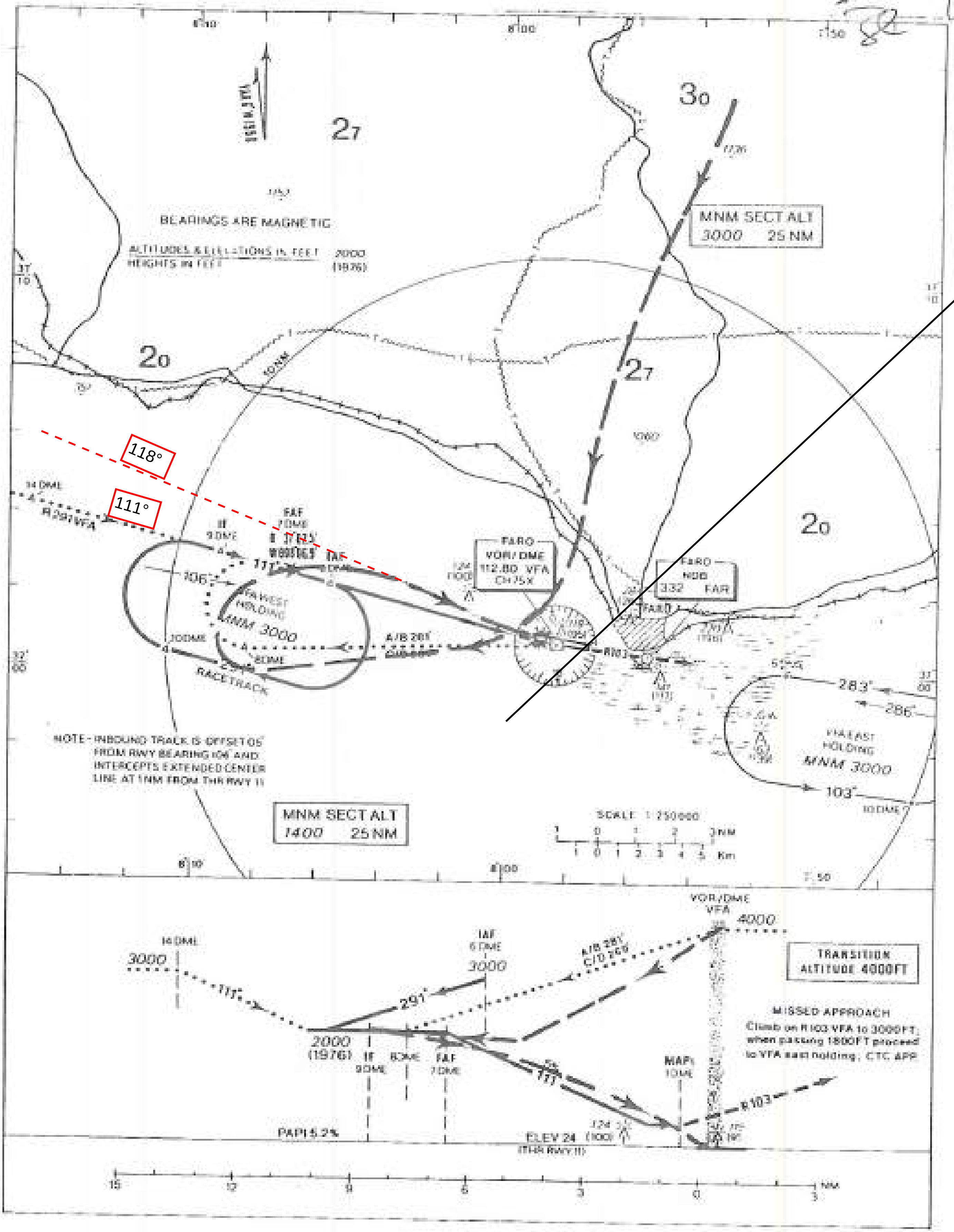
It will be self evident that the basic principles outlined in the preceding paragraph pre-suppose the availability of accurate glideslope and localizer guidance. However, should such guidance not be available and a non-precision type approach executed, the basic principles remain unchanged. Their achievement merely demands a higher order of pre-approach planning and calculation (e.g. drift angles, rate of descent, etc.) so that basic data are available to the pilot when judging the degree of approach stability being achieved.

07 Height at threshold

Dispatch landing distance requirements are based on an assumed wheel height over the threshold of 50 ft.
In the published actual landing distances, average wheel height over the threshold for a particular aircraft type has been accounted for.

- Precision approaches.
  On an ILS approach, the wheel clearance over the threshold depends on the height of the downward extended straight portion of the glide path over the threshold (TCH), the location of the aircraft glide path antenna relative to the landing gear and the aircraft pitch attitude.

Appendix 11



AEROPORTO DE FARO

TRAJECTÓRIA RADAR DO VOO MP 495

Appendix 12

2.3.6 OPERATION BELOW THE DESCENT LIMIT

Operation below the descent limit is authorized if the captain is convinced that a safe landing and roll-out can be made on the intended runway. For this it is a requirement that at least:

i) The required visual reference has been obtained
Flight visibility must at least equal the prescribed operating minimum in order to provide for an adequate visual ground segment. The length of the visual segment must enable the pilot to see the visual cues needed to assess the aircraft's position, bank angle and cross track velocity relative to the approach lights or the runway. The threshold should be in sight if optimum pitch reference is required. This will normally be the case for non-precision approaches.
For roll reference, sight of one or more elements providing horizontal information is required (crossbars, red side barrettes, threshold, TDZ). This ground segment must be continuously in view from the moment the descent limit is reached up to and including touchdown. Since for a manual landing the overriding requirement is for visual cues to be available, sufficient runway surface information must be visible to manually control flare and touchdown.

ii) Stabilized aircraft conditions are obtained
Such conditions include that the aircraft is in a position from which a descent to landing on the intended runway can be made at a normal rate of descent, using normal manoeuvres and where that rate of descent will allow touchdown to occur within the touchdown zone of the runway of intended landing.

A go-around shall be made:
. at any time after descending below the descent limit, when the captain is no longer convinced that a safe landing and roll-out can be made,
. according to AOM directives,
. at any time when the required visual reference is no longer available.

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08 NON-PRECISION APPROACHES

General

Non-Precision Instrument Approaches are approaches without electronic glide slope guidance. When an ILS facility is used for a non-precision approach, set the G.SLOPE switch to OVRD before entering the warning envelope to avoid nuisance warnings. For approach stabilization apply only slight variations on the target rate of descent.

- It is strongly recommended to use the AP in CMD until the runway/approach lights can be used as reference for line-up and glide path.
  The minimum height to change from CMD to CWS is 500 ft HAT.
  The minimum height to change from CMD to OFF is 150 ft HAT.
- Start descent 0.5 NM before, and timing at point "D".
- The PNF occasionally goes head up, and goes fully head up after his call "APPROACHING MINIMUMS".

Crew Co-ordination procedure (MCCP)

FLIGHT PHASE or EVENT	STANDARD COMMANDS, ACTIONS and CALLS	
Passing OM (if applicable)	PNF PF ALL PNF	"OUTER MARKER" "CHECKED" Check crossing altitude. Switch off marker audio.
At approx. 500 ft RA	PNF PF PNF+F/E	"FIVE HUNDRED" "CLEARED" -or- "NOT CLEARED" "CHECKED"
At MDA + 100 ft	PNF PF PNF	"APPROACHING MINIMUMS" "CHECKED" Head up and report: "CONTACT", "APPROACH LIGHTS", "RUNWAY"
Not later than MDA	PF PNF	"LANDING" -or- "GO-AROUND" Resume monitoring task.
At 50 ft RA	F/E	"FIFTY"

NOTE: As the 500 ft call is not ment to be a precision call, amend the above procedure if the 500 ft call conflicts with the call Approaching Minimums.

ILS Localizer Approach

In absence of glide slope reception, the localizer can be coupled to the AP and the descent performed by means of the VERT SPEED wheel.

ILS Back Beam Approach

ILS back beam approaches shall only be flown if the procedure is published.
Use the following setup:
- Set the front beam MAG course on the ILS panel.
- Select ILS on the Radio Nav Panels.
  . The Course Deviation Bar will indicate aircraft deviation from the back beam in the correct sense.
  . The ADI expanded localizer will indicate in the reverse sense.
- Operate in HDG SEL and ALT HOLD/VERT SPEED modes.

VOR/DME and ADF Approach

Bear in mind that, while tracking VOR radials or QDM/QDR's, small heading changes cause shallow banked turns, thus a slow response must be expected.

17422

The Actual Landing Distances on this page are based on the following **Reference Conditions:**

- Flaps 35.
- Landing Weight: 160.000 kg
- Standard flight techniques as per AOM 3.3.
- Touchdown point at: 620 m for Flaps 35.
  560 m for Flaps 50.
- Braking technique: Full brakes at nose gear touchdown *.
- Standard temperature.
- Zero slope.

[shaded box] Landing not allowed

* For the purpose of calculating Actual Landing Distances only 50% of the maximum available retardation force of the brakes has been taken into account. This is based on studies on the braking effectivity in airline operation.

REFERENCE ACTUAL LANDING DISTANCES (m)

Braking Action		GOOD	MEDIUM	POOR
Tailwind	10 kt	1910	2460	3160
Component	5 kt	1840	2360	3040
Zero wind		1760	2250	2890
Headwind	10 kt	1630	2070	2630
	20 kt	1500	1890	2370
Component	30 kt	1370	1710	2110

Corrections (m) for deviating conditions:

WEIGHT	Per 10.000 kg ABOVE / BELOW 160.000 kg	+70 -60	+110 -100	+160 -150
FAS	Per 1 kt ABOVE V_{TH} + 5 kt	+20	+30	+40
CROSSWIND	Per 1 kt	+10	+10	+10
TEMPERATURE	Per 1°C ABOVE / BELOW Std	+6 -6	+8 -8	+10 -10
FIELD ELEVATION	Per 1000 ft ABOVE Sea Level	+60	+80	+100
SLOPE	Per 0.1% DOWN / UP Slope	+20 -15	+25 -20	+40 -30
REVERSE THRUST	No reverse eng 1 or eng 3	+30	+360	+770
	No reverse eng 2	+30	+100	+190
	No reverse	+110	+360	+770
FLAPS	Flaps 50	-100	-150	-200

Maintain a margin of 200 m over the Actual Landing Distance.

-oOo-

Appendix 15

04 ISS RUN DOWN TIME

After selecting the MSU Mode Selector from NAV or ATT to OFF:
- Wait at least 5 min before moving the aircraft.
- Wait less than 3 seconds or more than 5 min before reselecting NAV or ATT.

05 COMPLAINT CRITERIA

- ISS Fault light illuminates if error exceeds 2 + 4T NM. (T is time in NAV in hours).
- Complaint should be filed if any of the following position and/or ground-speed errors are observed.

  - For flights of greater than one hour duration, the radial position error in nautical miles (NM) for a single flight exceeds five times the time (T) in Navigate mode in hours: (> 5T NM).
  - For flights of greater than one hour duration, the radial position error in nautical miles (NM) for two consecutive flights exceeds three times the time (T) in Navigate mode in hours: (> 3T NM).
  - The ground-speed error in knots for a single flight or prior to departure, exceeds 15 knots: (> 15 knots).
  - The ground-speed error in knots for two consecutive flights exceeds 4 plus the time (T) in Navigate mode in hours: ((4+T) knots).

06 ACCURACY OF AMBIENT WIND CALCULATIONS

Wind is calculated as the difference between the TAS and the GS vector. Accuracy of these vectors is dependent upon the accuracy of TAS, GS, True Heading and True Track.
- The combined position and computer error for the TAS during the approach varies between -2 and +6 kt.
- True Heading is comparatively accurate.
- GS and True Track may show an error (refer to AOM 2.15.4-05).

If RNAV derived winds are utilized for landing, it should be realized that:
- Wind direction shown is in degrees True.
- The tailwind component may be up to 10 kt in error.
- The crosswind component may be up to 5 kt in error and is strongly influenced by slide-slip manoeuvres, such as de-crabbing.

NOTE: Calculations of maximum allowable windcomponents for landing should be based upon the Tower reported surface wind.

-oOo-

4.3.2.3.7 Altimeter setting(s)

The QNH altimeter setting shall be given and, either on a regular basis in accordance with local arrangements or if so requested by the pilot, the QFE altimeter setting. Altimeter settings shall be given in hectopascals (millibars) and shall be rounded down to the nearest lower whole hectopascal (millibar).

4.3.2.3.8 Other significant information

This shall include any available information on meteorological conditions in the approach, missed approach or climb-out area relating to the location of cumulonimbus or thunderstorm, moderate or severe turbulence, wind shear, hail, severe line squall, moderate or severe icing, freezing rain, marked mountain waves, sand storm, dust storm, blowing snow, tornado or waterspout, as well as any information on fog dispersal operations in progress.

4.3.3 Messages concerning the operation of aeronautical facilities

Note.— General provisions concerning this subject are set forth in Annex 11, 4.2.

4.3.3.1 Messages concerning the operation of aeronautical facilities shall be transmitted to aircraft from whose flight plan it is apparent that the operation of the flight may be affected by the operating status of the operating facility concerned. They shall contain appropriate data on the service status of the facility in question, and, if the facility is out of operation, an indication when the normal operating status will be restored.

4.3.4 Messages containing information on aerodrome conditions

Note.— Provisions regarding the issuance of information on aerodrome conditions are contained in Part V, 8.

4.3.4.1 Whenever information is provided on aerodrome conditions, this shall be done in a clear and concise manner so as to facilitate appreciation by the pilot of the situation described. It shall be issued whenever deemed necessary by the controller on duty in the interest of safety, or when requested by an aircraft. If the information is provided on the initiative of the controller, it shall be transmitted to each aircraft concerned in sufficient time to enable the pilot to make proper use of the information.

4.3.4.2 Information that water is present on a runway shall be transmitted to each aircraft concerned, on the initiative of the controller, using the following terms:

DAMP – the surface shows a change of colour due to moisture.

WET – the surface is soaked but there is no standing water.

WATER PATCHES – patches of standing water are visible.

FLOODED – extensive standing water is visible.

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01 NORMAL CONFIGURATION

NORMAL CONFIGURATION		NORMAL CONFIGURATION 2 and 3 Engines												
LDG WT tons	Vs	130	135	140	145	150	155	160	165	170	175	180	185	LDG WT tons
UP/RET min. manoeuvre	1.5	204	208	211	215	218	222	226	229	233	236	239	242	UP/RET min. manoeuvre
0°/T.O. min. manoeuvre	1.5	175	178	182	185	188	191	194	197	200	203	206	209	0°/T.O. min. manoeuvre
22°/T.O. min. manoeuvre	1.4	144	146	149	152	155	157	160	162	165	167	170	172	22°/T.O. min. manoeuvre
50°/LAND alt. threshold	1.3	124	126	129	131	133	136	138	140	142	144	145	147	50°/LAND alt. threshold
35°/LAND threshold	1.3	128	130	133	135	137	140	142	144	146	148	150	152	35°/LAND threshold

NORMAL CONFIGURATION		NORMAL CONFIGURATION 2 and 3 Engines												
LDG WT tons	Vs	190	195	200	205	210	215	220	225	230	235	240	245	LDG WT tons
UP/RET min. manoeuvre	1.5	246	249	252	255	258	261	264	267	270	273	276	279	UP/RET min. manoeuvre
0°/T.O. min. manoeuvre	1.5	212	215	218	221	223	226	228	231	233	236	238	240	0°/T.O. min. manoeuvre
22°/T.O. min. manoeuvre	1.4	175	177	179	182	184	186	188	190	192	195	197	199	22°/T.O. min. manoeuvre
50°/LAND alt. threshold	1.3	149	151	154	156	158	160	161	163	165	167	168	170	50°/LAND alt. threshold
35°/LAND threshold	1.3	154	156	159	161	163	165	167	169	170	172	174	176	35°LAND threshold

NOTE: If 15°/T.O. is used for manoeuvring: Minimum speed is 22°/T.O. + 10 kt.

Appendix 18

06 APPROACH INITIATION

Assuming an initial approach altitude of 2000 ft HAA, use the following procedure for an ILS intercept:

- Initial approach configuration: 15/TO.
- Prior to GS CAP select 22/TO.
- At GS CAP select gear down.
- Perform LANDING checklist up to item "Flaps/Slats".
- At minimum 1500 ft HAA select 35/50/LAND, set speed FAS and complete checklist.

NOTE: If the initial approach altitude is higher than 2000 ft HAA adjust the ILS procedure to be established in the Final Approach configuration not below 1500 ft HAA.

Several conditions may require early stabilization, such as:

. tailwind
. high weight
. CAT II/IIIA weather conditions
. N-1 approaches
. Non-precision approaches

In these cases use the following procedure for intercept:

- Initial approach configuration: 22/TO.
- Approaching GS (2 dots ILS GS) -or- 2 NM prior point "D": select gear down.
- Prior GS CAP (1 dot) -or- 1 NM prior point "D": select 35/50/LAND.
- Set speed FAS and perform LANDING Checklist.

05 IN FLIGHT

During flight turn wing and engines (nacelle) anti-ice on whenever icing conditions are anticipated or encountered. Both systems are intended for anti-icing rather than de-icing.

06 LANDING ON WET/SLIPPERY RUNWAY OR WITH RUNWAY CONTAMINATION

- When planning a landing from the dispatch phase or during flight:
  - A landing on or dispatch to a runway with POOR braking action is undesirable. This operation should not be planned unless other factors make it imperative.
  - The Required Landing Runway Length chart of Dispatch is included in AOM 6.4. In all cases use the WET scale.
    The Actual Landing Distance tables are also included in AOM 6.4.
  - Observe crosswind and tailwind limits. Refer to AOM 3.7.3.

- Decide which braking action has to be taken into account.
  If with adverse conditions the braking action is not known, request same.
  When braking action and/or friction coefficient are/is still not known, refer to AOM 3.7.3 to determine braking action by reference to runway condition.

- Blowing or drifting in a cross wind condition may create a false impression of the aircraft's movement over the ground. It is thus possible to have an impression of no drift when in fact a considerable drift exists. When landing under these conditions runway markers or runway lights can supply the necessary visual reference.

- Reverse thrust when continued below 60 kt on DRY snow can result in loss of forward visibility. Take action as appropriate to the braking action and runway length available.

07 TAXI IN

If the approach was made through icing conditions or if the runway was covered by slush or snow, retract flaps initially to 22. Damage could occur if ice is present.

Inspection after parking will show whether the necessity to de-ice the flaps exists.

08 PARKING

The aircraft should be headed into the wind if practicable. This is particularly desirable in driving snow conditions. The parking area must be clear or well sanded to prevent the tires from freezing to the ground.

In addition to the After Parking Checklist perform the next items:
- Flaps/Slats .... UP/RETRACTED

In addition to the Long Term Parking Check perform the next items:
- Horizontal Stabilizer .... FULL AND
- Parking Brakes .... OFF
- Wheels .... DOUBLE BLOCKED
- Water Systems .... DRAINED
- Anti-Icing Treatment .... AS REQUIRED
  - Refer to BOM 2.1.7 - Cold Weather Operation.

02 FLAP SETTINGS

■ Standard setting 35/LAND
- Optimum performance in windshear.
- Optimum fuel consumption.
- Low noise generation.

■ Alternate setting 50/LAND

❑ 50/LAND is mandatory when
- CAT II/IIIA DH is applicable (including practice approaches).
- Limited runway length is available.

❑ Consider 50/LAND in case of
- Braking action less than "good".
- Bad runway surface conditions.
- Tailwind.
- Limited approach and/or landing aids.
- Short turnaround (brake cooling).

NOTE: The minimum manoeuvring speed for 22/TO at weights above 180 tons exceeds the 50 flap placard speed, so establish 35/LAND, before selecting 50/LAND.

03 WIND CORRECTION FACTOR (WCF)

WIND	AUTOLAND	MANUAL LANDING ATS ON			MANUAL LANDING ATS OFF		
			min	max		min	max
STEADY STATE	5 kt	1/2 of the wind above 20 kt	5 kt	20 kt	1/2 of the wind above 20 kt	5 kt	20 kt
GUST	5 kt	all of the gust above 5 kt	0 kt	15 kt	all of the gust	0 kt	20 kt

NOTE: - If both steady state and gust require a WCF, the greater will prevail.
- During gusty wind conditions, the ATS will add up to a maximum of 5 kt to the ATS reference speed. Without ATS the additive is not available.

SIGNIFICANT PERFORMANCE DECREASING WINDSHEAR	ATS ON or OFF	min 15 kt	max 20 kt

The maximum amount of the WCF may be governed by:
- Landing distance available.
- Flap Placard Speed in case of 50/LAND.
Keep in mind the additive of maximum 5 knots during gusty wind conditions.

02 WINDSHEAR RECOVERY TECHNIQUE

Basic information can be found in the FRG and BOM. The following actions are recommended whenever flight path control becomes marginal below 1000 ft AGL on Take-off or Approach. As guidelines, marginal flight path control may be indicated by deviations from target conditions in excess of:

- ± 15 KIAS.
- ± 500 ft/min. vertical speed.
- ± 5° pitch attitude.
- ± 1 dot displacement from the glideslope.
- Unusual throttle position for a significant period of time.

If flight path control becomes marginal at low altitudes, initiate the recommended Windshear Recovery Technique without delay. Accomplish the first two steps simultaneously.

THRUST
Disengage the autothrottles and aggressively apply necessary thrust to ensure adequate aircraft performance. Avoid engine overboost unless necessary to avoid ground contact. When aircraft safety has been assured, adjust thrust to maintain engine parameters within specific limits.

PITCH
For a windshear encounter after lift-off or on approach disconnect Autopilot, increase or decrease pitch attitude as necessary (at a normal pitch rate) toward an initial target attitude of 15°. On Take-off where a normal all engine pitch attitude has been established before a windshear is encountered, it is not necessary to decrease pitch to 15°. The all engine pitch attitude may be maintained until either the shear has been exited or stick shaker is encountered. Always respect stick shaker. Use intermittent stick shaker as the upper limit for pitch. Rapidly changing vertical winds can also cause momentary stick shaker at any attitude. If attitude has been limited to less than 15° to stop stick shaker, increase attitude toward 15° as soon as stick shaker stops.

If vertical flight path or altitude loss is still unacceptable after reaching 15°, further increase pitch attitude smoothly in small increments.

Rapidly changing winds may cause rapid excursions in pitch and roll with little or no pilot input. Control pitch in a smooth, steady manner (in approximately 2° increments) to avoid excessive overshoot/undershoot of the desired attitude. Once the aircraft is climbing and ground contact is no longer an immediate concern, airspeed should be increased by cautious reductions in pitch attitude.

If windshear is encountered on the runway during Take-off and abort is not practical, rotate toward 15° at normal rate of rotation but no later than 600 m usable runway remaining. After becoming airborne, continue with "Actions when Airborne".

CONFIGURATION
Do not change flap, gear or trim position until terrain is no longer a factor. However, stabilizer trim may be used to trim out stick force due to thrust application.

NOTE: It is recognized that a change in flap position may improve windshear recovery. However, this procedure is not recommended since the risk of moving the flaps in the wrong direction or amount is considered to be greater than the risk of encountering a shear so great that a flap change is needed for recovery.

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Actions during Take-Off on the runway

After the dicision has been made to continue the Take-Off:
- Apply maximum available thrust.
- At V_R not later than 600 m runway remaining.
  . Rotate initially to 15° pitch.
  . Rotate further in 2° steps to lift off within the remaining distance (this may result in a tail strike).
- Once airborne continue with Actions after Airborne.

Actions when Airborne (T/O after Lift-off, Approach and GA)

- Simultaneously:
  . Disconnect Autopilot and Autothrottle(s).
  . Rotate to 15° pitch (increase/decrease except when a stable pitch was obtained after lift-off). Ignore the FD pitchbar.
  . Reduce bank unless absolutely required for obstacle avoidance.
  . Do not change configuration.
  . Apply maximum available thrust.
  GA thrust up to 14.000 ft, MCT above 14.000 ft.
- When resulting flight path is still unacceptable:
  . Increase pitch in 2° steps until speed is just above the stickshaker actuation.
  . **ALWAYS RESPECT THE STICKSHAKER.**
- When ground contact is imminent:
  . Move throttles to forward mechanical stop.
- When out of shear:
  . Reduce thrust to required level.
  . Accelerate to apropriate speed and adjust configuration.
  . Restore Set-up of Autoflight Systems.

03 RECOVERY FROM APPROACH TO STALL

General

Indication of approach to stall may be one or more of the following:
- Rapid decrease of airspeed below the bug setting.
- Rapid decrease of climb rate during take-off or go-around.
- Rapid increase in sink rate during approach.
- Stick shaker or initial LOW SPEED stall buffet.
  WARNING: Do not apply this procedure for HIGH SPEED STALL BUFFET.

At the first indication of approach to stall, simultaneously apply maximum available thrust (GA thrust up to 14.000 ft, MCT when above 14.000 ft), level wings and adjust pitch as required to minimize altitude loss. With the autopilot in CMD or CWS, immediately disconnect the autopilot and initiate stall recovery.

In an emergency situation (i.e. encountering a downdraft of a decreasing performance windshear), positive climb performance and limited manoeuvre margin still exists at or near stick shaker actuation speed. High pitch attitudes are then to be expected, however pitch attitude should not be increased so rapidly that airspeed decreases below stick shaker actuation speed (refer to "Windshear Recovery").

Be alert to counteract excessive nose-up trim condition.

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14 THRESHOLD CROSSING HEIGHT

Use of Visual Approach Aids

When using VASIS/PAPI, the general limitations such as large tolerances, large vertical dimension for on glide path indication, atmospheric distortions, should be kept in mind. These systems are not calibrated nor flight checked.

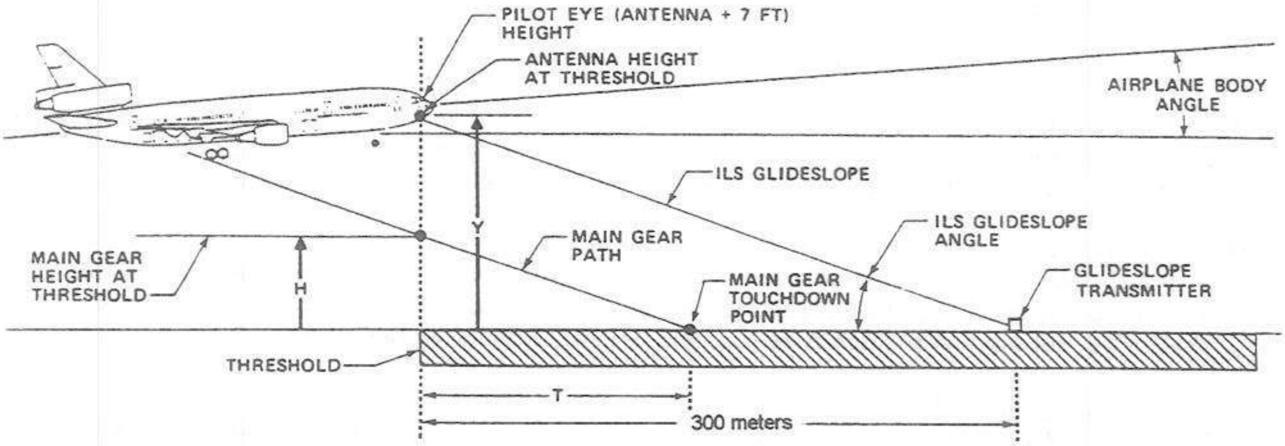
- 3-BAR VASIS
  A 3-Bar VASIS is suitable for DC-10 approach guidance when the upper two bars are used. A glide path angle of 3° and a visual aiming point of approx. 500 m down the runway will produce adequate threshold clearance.

- 2-BAR VASIS and PAPI
  If 2-Bar VASIS or PAPI is the only vertical guidance available, it may be followed down to 200 ft above the runway threshold. Thereafter the aircraft must be brought gradually above the "on glide slope" indication to provide a 30 to 40 ft wheel clearance at the threshold.

  NOTE: A 2-Bar VASIS or PAPI can cause insufficient threshold clearance. These systems establish a visual aiming point that is only about 300 meters down the runway instead of the required 500 m. Also the on glide slope indication is not sharply defined, but is an area with considerable vertical dimension. The aircraft is as likely to be in the bottom area as in any other part of it.

- T-VASIS
  The T-VASIS is suitable for the DC-10 when the approach is flown with the T-VASIS showing one dot high.

ILS Glide Slope TCH



FLAPS	GLIDE PATH ANGLE	ESTIMATED BODY ANGLE	ANTENNA HEIGHT AT THRESHOLD Y	MAIN GEAR HEIGHT AT THRESHOLD H	MAIN GEAR TOUCH DOWN POINT T
35	2.5° 2.75° 3.0°	4.5° 4.2° 4.0°	44 ft 48 ft 52 ft	16 ft 20 ft 24 ft	115 m 130 m 145 m
50	2.5° 2.75° 3.0°	3.8° 3.5° 3.3°	44 ft 48 ft 52 ft	18 ft 22 ft 26 ft	120 m 135 m 150 m

The illustration shows the variation of main gear height at the runway threshold, associated with the given condition. Due to tolerances, with a nominal glide slope height of 50 ft, the actual main gear height at the threshold may be even lower than indicated.

When the KLM approach charts shows either:
- no autoland TCH or,
- no autoland DC-10 TCH,

the ILS glide slope is too low at the runway threshold. At 100 ft HAT change the visual aiming point to 500 m down the runway and gently bring the aircraft above the ILS glide slope to provide a 30 to 40 ft wheel clearance at the threshold. The lowest minima under these conditions are 200 ft HAT/1000 m.

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09 CIRCLING APPROACH AND VISUAL CIRCUIT

Circling Approach

- Refer to BOM 3.4.4 for a general description of the Circling Approach. For the DC-10 (group D aircraft) the circling area is 5.3 NM from the thresholds, and the obstacle clearance is 400 ft. The timing of 45 sec + 1/2 sec/kt wind ensures manoeuvring within the circling area and the possibility to see the beginning of the 900 metres approach lighting system (or other objects identifiable with the runway), on base leg turning final.
- In case of a go-around, the Missed Approach procedure for the instrument part of the Circling Approach must be used. Decide on a definite flightpath to be followed to join this procedure from any point in the Circling Approach.
- Configuration for the instrument part of the approach: 22/TO and GEAR UP.
  . Consider gear down selection to increase drag if required.
- At or above MDA (clear of clouds) select ALTITUDE HOLD.
- Manoeuvre the aircraft in such a way as to join down wind/base leg at a proper distance. When an ILS facility was used for the instrument part of the circling switch the ILS off.
- Proceed with Visual Continuation.

Visual Circuit

- Established on down wind in configuration 22/TO at 1500 ft HAA.
- Proceed with Visual Continuation.

Visual Continuation

- When an ILS facility is used to assist in a visual approach, set the G.SLOPE switch to OVRD before entering the warning envelope to avoid nuisance warnings.

- It is strongly recommended to use the AP in CMD until the runway/approach lights can be used as reference for line-up and glide path.
  The minimum height to change from CMD to CWS is 500 ft HAT.
  The minimum height to change from CMD to OFF is 150 ft HAT.

- Abeam the threshold:
  . Start timing (45 sec ± 1/2 sec/kt wind).
  . Gear down.

- Approaching end of down wind:
  . Select 35/LAND.
  . Set speed V_{th} 35/LAND + 15 kt or FAS whichever is higher.
  NOTE: V_{th} 35/LAND + 15 kt provides for safe manoeuvring with 25° bank.
  . Perform LANDING checklist (up to item "Flaps/Slats" if landing with 50/LAND).

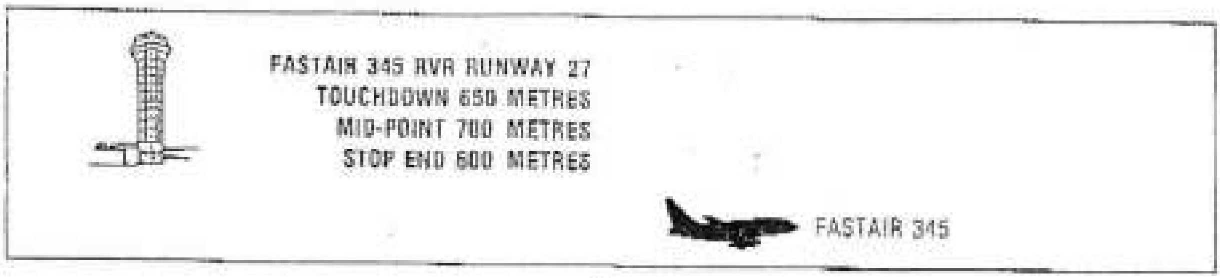
- Intercepting a 3° visual glide path:
  . Rate of descent ± 750 ft/min.

- Rolling out on final (bank 15° or less):
  . Reduce speed to FAS (35/LAND).
  . Optional: select 50/LAND, set speed FAS (50/LAND) and complete the LANDING checklist.
  . Adjust rate of descent to maintain/attain a 3° glide path with an aiming point of 500 metres beyond the landing threshold.

NOTE: Various circumstances may require adaptation of the standard circuit (e.g. noise sensitive areas, descent direction, ATC instructions).

Appendix 24

10.2.2 Where multiple RVR observations are available, they are always transmitted commencing with the reading for the touchdown zone.



10.3 RUNWAY SURFACE CONDITIONS

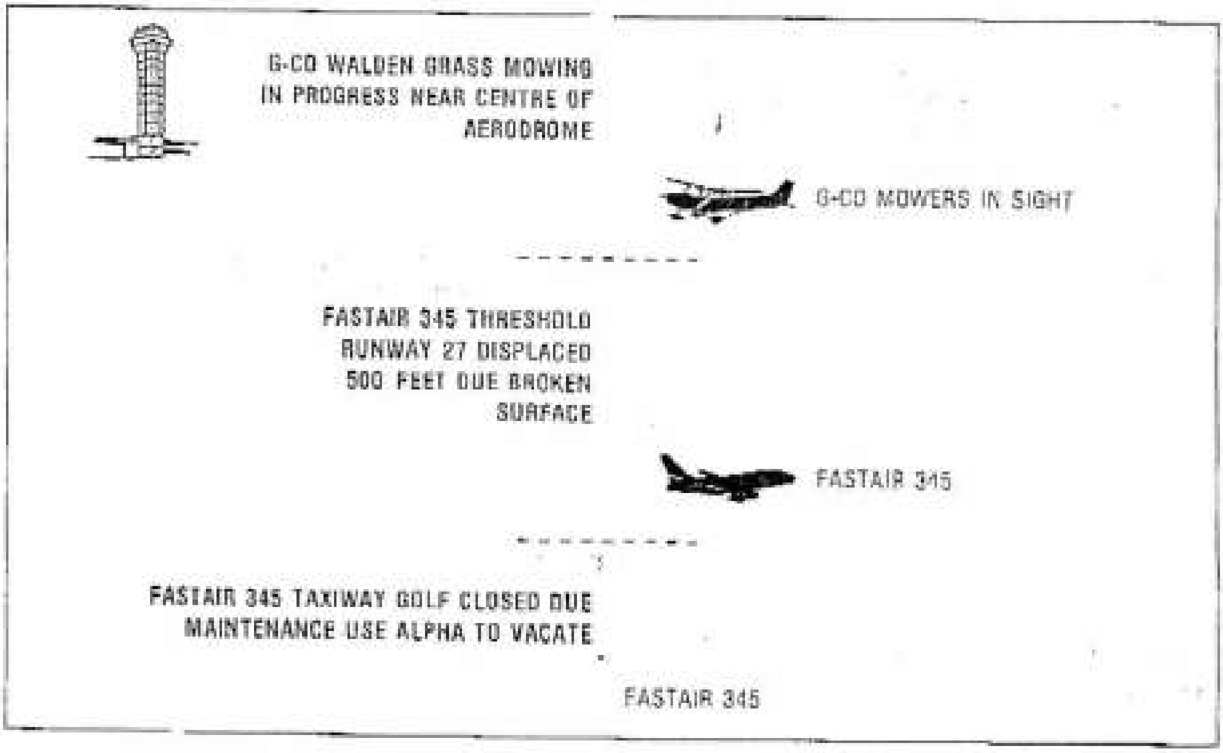
10.3.1 Procedures for the measurement and reporting of runway surface conditions are detailed in Annex 14.

10.3.2 Reports from pilots may be re-transmitted by a controller when it is felt that the information may prove useful to other aircraft:

"BRAKING ACTION REPORTED BY (aircraft type) AT (time) (assessment of braking action)".

10.3.3 Whenever a controller deems it necessary, information that water is on a runway shall be passed to aircraft using the terms "DAMP", "WET", "WATER PATCHES" or "FLOODED" according to the amount of water present.

10.3.4 Other runway surface conditions which may be of concern to a pilot shall be transmitted at an appropriate time.



Appendix 25

Word/Phrase	*Meaning*
CLEARED	"Authorized to proceed under the conditions specified."
CONFIRM	"I request verification of: (*clearance, instruction, action, information*)."
CONTACT	"Establish communications with . . ."
CORRECT	"True" or "Accurate".
CORRECTION	"An error has been made in this transmission (or message indicated). The correct version is . . ."
DISREGARD	"Ignore."
HOW DO YOU READ	"What is the readability of my transmission?"
I SAY AGAIN	"I repeat for clarity or emphasis."
MAINTAIN	Continue in accordance with the condition(s) specified or in its literal sense, e.g. "maintain VFR".
MONITOR	"Listen out on (frequency)."
NEGATIVE	"No" or "Permission not granted" or "That is not correct" or "not capable".
OUT	"This exchange of transmissions is ended and no response is expected." *Note.— Not normally used in VHF communications.*
OVER	"My transmission is ended and I expect a response from you." *Note.— Not normally used in VHF communications.*
READ BACK	"Repeat all, or the specified part, of this message back to me exactly as received."
RECLEARED	"A change has been made to your last clearance and this new clearance supersedes your previous clearance or part thereof."
REPORT	"Pass me the following information . . ."
REQUEST	"I should like to know . . ." or "I wish to obtain . . ."
ROGER	"I have received all of your last transmission." *Note.— Under no circumstances to be used in reply to a question requiring "READ BACK" or a direct answer in the affirmative (AFFIRM) or negative (NEGATIVE).*
SAY AGAIN	"Repeat all, or the following part, of your last transmission."
SPEAK SLOWER	"Reduce your rate of speech."
STANDBY	"Wait and I will call you." *Note.— The caller would normally re-establish contact if the delay is lengthy. STANDBY is not an approval or denial.*

Appendix 26

PREAMBLE

JAR–OPS 1

Issued **22.05.95**

JAR–OPS 1 consists of 19 Subparts. However, the second published version does not contain Subpart Q (Flight and Duty Time Limitations and Rest Requirements) and where all Subpart Q material should be located is shown as 'Reserved'. Until, or unless, Subpart Q is adopted, the existing national regulations governing Flight and Duty Time Limitations and Rest Requirements will apply.

Where reference is made in JAR–OPS 1 to other JAR codes which have not yet been implemented (e.g. JAR–FCL) the equivalent existing national regulations will apply until such time as the referenced code has been implemented.

Change 1 **01.03.98**

The second Issue of JAR-OPS 1 contains a large number of amendments which reflect the results of NPA-OPS-7 and NPA-OPS-9. It should be noted that, unless otherwise indicated, where amendments in this Issue are more demanding that the requirements in the initial Issue of JAR-OPS 1 (dated 22.5.95), the intended effective date for such requirements is no later than 1 October 1998. For those requirements where this is not the case, and no extra burden is demanded of operators, it is intended that the effective date should be 1 April 1998.

In addition to Subpart Q, it should be noted that JAR-OPS 1.245(a)(2) is also ' Reserved'. The reason for this is that, following the comments received on this sub-paragraph during NPA-OPS 7, and the resulting changes that it was felt should be made to the text proposed in the NPA, JAR-OPS 1.245(a)(2) will have to be the subject of a further NPA. In addition, a supporting Acceptable Means of Compliance (AMC OPS 1.245(a)(2)) is being developed and will be included in the same NPA. The effect of this sub-paragraph being 'Reserved' is that, for those aeroplanes to which it will apply (those having a Maximum Approved Passenger Seating Configuration of 19 or less and a Maximum Take-off Mass less than 45360kg), the existing national rules for this type of operation will continue to be applicable, pending the results of the NPA.

SECTION 1

Subpart A

(a) Delayed implementation date in JAR-OPS 1(b)(2) arising from NPA-OPS-9.

Subpart B

(a) Amendment to Section 2 references in JAR-OPS 1.035 and sub-paragraph (a), and addition of sub-paragraph (e), arising from NPA-OPS-7.

(b) Introduction of JAR-OPS 1.037 arising from NPA-OPS-7.

(c) Amendment of JAR-OPS 1.050 arising from NPA-OPS-7.

(d) Introduction of reference to IEM OPS 1.065 arising from NPA-OPS-7.

(e) Introduction of reference to IEM OPS 1.070 arising from NPA-OPS-7.

(f) Amendment of JAR-OPS 1.075(a) arising from NPA-OPS-7.

(g) Amendment of JAR-OPS 1.080 arising from NPA-OPS-7.

(h) Introduction of new sub-paragraphs (a) and (b) to JAR-OPS 1.085 and amendment of sub-paragraph (f) arising from NPA-OPS-7.

Appendix 27

06 Crew co-operation and monitoring

In case of abnormalities or emergencies during any portion of a flight, one pilot shall be solely occupied with the control of the aircraft. This pilot shall not be distracted by conversation or actions with respect to a problem being encountered. When certain actions will effect the control of the aircraft, he shall be informed before the action is taken.
Constant monitoring by one pilot is also required when the autopilot/ autothrottle is engaged for early detection of possible system errors.

Only the captain is authorized to declare an emergency situation and it is up to him to decide if and when such emergency is declared.
Generally stated: whenever the safety of the aircraft and/or its occupants is, or is likely to become endangered, the captain shall consider the declaration of an emergency in order to mobilize all possible outside assistance.

If a captain is not satisfied with the manner in which a pilot under his command handles the flight, verbal instructions will normally be sufficient to remedy the situation.
During critical phases of the flight, however, there may not be time to wait for response and the only alternative will be to take immediate control of the aircraft. If this action is considered necessary, the captain shall fully take-over control while calling out "My Controls".
Changes in e.g. power settings, flight instrument set-up, configuration, shall not be made without informing the PF, as this may lead to unco-ordinated actions.

07 Look-out

Although it is the responsibility of ATC to maintain separation between IFR traffic, it is nevertheless essential to maintain a good look out during IFR flights, especially during climb or descent in areas of heavy traffic.
In VMC, it is the direct responsibility of a pilot on an IFR flight to avoid other aircraft (that may be on VFR), even though this flight is in a control area on an IFR ATC clearance.
Due to the above requirement and other obvious reasons, reading of literature other than that essential for the safe and efficient execution of the flight is not permitted whilst on duty in the cockpit.

During the hours of darkness the use of white light in the cockpit shall be kept to a minimum in order not to impair night vision.
Proper adjustment of the cockpit lights in comparison with the expected amount of outside lighting shall be completed well before a night take-off or approach and landing, for adaption of the eyes.
A certain amount of white lighting shall, however, be maintained to provide illumination of the instrument panel, should a DC power failure occur.

08 Clearing of cockpit

A clear cockpit is an important factor in safety. Therefore any superfluous paper or equipment shall be removed or stowed in its proper place before every take-off and descent. After completion of a duty period the crew shall clear the cockpit.
The captain is responsible for restowing of the navigation equipment after the flight.
When stowing crew articles in the cockpit (e.g. coats, bags, books, pencils):

- all aircraft equipment shall remain attainable
- seats shall not be restricted in their movements
- blocking of control cables by fallen objects shall be impossible.

3.4.4 FINAL APPROACH AND LANDING

01 Potential hazards

A common source of potential hazard in the final approach and landing phase is flying in heavy rain; in addition to the poor visibility outside and the reduced windshield transparency, there is also a refraction error in vision which causes the eye to indicate a false horizon that lies below the true one. In this way objects appear to be lower than they actually are, which in turn may deceive the pilot to descend below glide path.
The error can be as much as 5^{o} which at a distance of 0.5 NM means 200 ft.
The danger is greatest when making visual contact after breaking out below clouds. It is therefore of vital importance to continue monitoring altimeters and whatever glide slope or distance information is available.

Drifting snow or the combination of rain or snow and cross wind, especially at night, may cause a wrong impression of yaw-rate during the de-crabbing phase.

02 Visual approach

A visual approach is an approach by an IFR flight when all or part of an instrument approach procedure is not completed and the approach is executed by visual reference to terrain.

The captain may request to make a "Visual Approach" when:

. he has the aerodrome in sight and visual reference to terrain can be maintained during the entire approach, and
. the flight visibility is such that he can assume the responsibility for obstacle clearance and traffic separation, and
. he has reasonable assurance that a normal visual glide path can be established.

The captain shall not cancel his IFR flight plan to make a visual approach.

Normally ATC will provide separation with other traffic during a visual approach. An exception to this rule is making a visual approach in the USA where separation is not provided by ATC.

The visual approach procedure may save some flying time but also introduces the risk of an undershoot or landing at a wrong aerodrome or wrong runway.
Moreover it may create terrain clearance hazards if continuous good visibility is not assured.
Therefore, if a choice of runways is available, preference should be given to a runway equipped with glide slope guidance, with due regard to other operational factors.

Experience has shown that full use of available aids is the most effective means to prevent an undershoot or a landing on the wrong runway or airport.

When a visual approach is made, and particularly when over dark terrain at night, special emphasis must be placed on the familiarity with terrain, elevation and obstruction data from the approach charts.
A descent below minimum sector altitude shall not be made, until both pilots are certain of the aircraft's position and the safety of this descent.
Moreover, ample terrain and obstacle clearance must be maintained until final descent is started.

The captain must be prepared for a go-around from any point of the visual approach.

03 Circling approach

For the definition of a circling approach refer to BIM 2.3.1.

Before commencing the let down for a circling approach, both pilots must study the approach chart and memorize terrain features, elevations, spot heights and obstructions as well as the pattern to be flown.

13 MANUAL LANDING

FLIGHT PHASE or EVENT	STANDARD COMMANDS, ACTIONS and CALLS	
At 50 ft	PF	Monitor throttle lever retardation. If both autothrottles are disengaged, or fail to retard, retard throttles manually.
At 30 - 40 ft	PF	Initiate flare. A slight flare (2° à 3°) is required. Touch down attitude is approx. 7°. Do not float and do not trim during the flare. Ensure touch down before passing the visual aiming point by a slight forward pressure on the control column. See CAUTION.
At main gear touch down	PF	Place the reverse levers in the idle reverse position and at the same time lower the nosewheel on the runway to counteract the pitch up tendency resulting from ground spoiler extension.
	F/E	Check ground spoiler extension. If spoilers are not extending, call "NO SPOILERS". On command of the PF to "EXTEND SPOILERS", extend the spoilers. Check reverse operation. Call "GREEN LIGHTS". 1)
After nose gear touchdown	PF	Apply reverse thrust. Apply brakes as required.
Roll out	F/E	Monitor N_1, EGT.
	PNF	Call speeds at 10 kt intervals until safe taxi speed is attained. 2)
At 80 kt	PF	Smoothly return reverse levers to idle reverse position to achieve idle at 60 kt.
	PNF	If movement of reverse levers towards idle is not initiated at 70 kt, call "CHECK REVERSE".
End of landing roll	PF	Select forward idle.

1): In case of reverser failure the F/E calls "REVERSE NUMBER ....(AND ...) ONLY".
2): Above 70 kt use IAS, below 70 kt use HSI GND SPD.

NOTE: - For further information on the use of reverse thrust refer to AOM 2.17 - Power Plant.
- As judging of the ground speed is difficult, especially shortly after landing, check the ground speed on the HSI before turning off the runway.

CAUTION: The floating tendency is pronounced with CWS engaged. The nose-up attitude continues to increase at a slight pull force. Releasing the column to the neutral position will only stop the attitude change. Forward pressure is a must to stop excessive floating.

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01 GENERAL

- The pitch bar is referenced to V_2 + 10 kt for the existing weight.
- As the pitch attitude is limited to approx. 15° ANU a speed overrun may occur.
- If clean-up is not necessary, the AFTER TAKE-OFF checklist and the DESCENT checklist may be omitted.
- If the nose gear touches the ground during a touch and go, disconnect the autopilot.

02 GO-AROUND CREW CO-ORDINATION PROCEDURE

- Check, but do not call, the following initial FMA changes:
  . N_1
  . HDG HOLD
  . GA
- The F/E does not repeat the call "CHECK THRUST" and does not call "THRUST SET".

NOTE: In the next presentation, the standard response "CHECKED" is not reproduced. No distinction is made between MANUAL and AUTOMATIC Crew Co-ordination.

FLIGHT PHASE or EVENT	STANDARD COMMANDS, ACTIONS and CALLS	
GA initiation	PF	"GO-AROUND" and press TOGA button to initiate thrust application. "FLAPS 22"
	PNF	Comply.
	PF	"CHECK THRUST"
	F/E	Comply (silent).
Positive rate of climb	PF	"GEAR UP"
	PNF	Comply.
Initial climb	PF/PNF	Monitor speed, minimum V_{th} 35 or V_{th} 50 + 5
Gear selected up	PF	"SET HEADING SELECT"
	PNF	"HEADING SELECT"
	PF	"SET ALTITUDE"
	PNF	"ALTITUDE .... ARMED"
	PF	"SET SPEED ...." (22/TO)
	PNF	"SPEED ... SET"
When AP is OFF	PF	"SET COMMAND 1/2"
	PNF	"COMMAND 1/2 SET"

NOTE: A go-around from sealevel to 2000 ft followed by 6 minutes level flight (160 kg/min) in 22/TO Gear-up configuration at 22/TO speed, followed by an approach requires 1750 kg fuel.

06 MAXIMUM WIND COMPONENTS (incl. gusts)

- Take-off and Landing: . Crosswind .... 30 kt
  . Tailwind .... 10 kt

- Autoland : . Headwind .... 25 kt
  . Crosswind .... 15 kt
  . Tailwind .... 10 kt

For restrictions due to runway conditions and weather minima refer to AOM 3.7.3-Weather Limitations. These restrictions are always overriding.

07 WIND LIMIT FOR CARGO COMPARTMENT DOOR OPERATION

Cargo doors may be fully opened in winds up to 40 kt.

08 FLIGHT MANOEUVRING LOAD ACCELERATION LIMITS

- Flaps UP/Slats Retracted: .... plus 2.5 g to minus 1.0 g
- Flaps and/or Slats Extended: .... plus 2.0 g to 0.0 g.

The positive manoeuvring limit load factors limit the angle of bank in turns and limit the severity of pull up manoeuvers.

09 LANDING LOAD ACCELERATION LIMITS

Maximum load factor for ground contact is comparable to:
. At maximum structural landing weight : A rate of descent of 10 ft/sec or 600 ft/min.
. At maximum structural take-off weight: A rate of descent of 6 ft/sec or 360 ft/min.

10 INSTRUMENT LIMIT MARKS

- Maximum and minimum limits: .... Red radial line
- Precautionary ranges: .... Yellow arc

11 ALTITUDE-TEMPERATURE LIMITS

En Route

- Maximum altitude .... 42.000 ft

Take-off and Landing

- Maximum altitude (except Martinair aircraft) .... 10.000 ft
- Maximum altitude (Martinair aircraft only) .... 8500 ft
- Maximum temperatures:
  . 1000 ft below SL to 2500 ft above SL .... + 50°C
  . 2500 ft to 10.000 ft above SL .... Standard + 40°C
- Minimum temperatures:
  . 1000 ft below SL to 10.000 ft above SL .... - 54°C

Appendix 32

3.4.3 AUTOMATIC FLIGHT

01 General

To minimize cockpit workload and thus to increase the safety level, optimum use of the autopilot and its submodes and autothrottle as far as permitted per Aircraft Operations Manual, is strongly recommended during the whole flight regime.

The following general regulations apply:

- The autopilot shall be regarded as the primary means of aircraft control during turbulence.
- Below 2500 ft above terrain the PF shall have his thumb near the disconnect button in order to be able to disconnect immediately when necessary.
- At least one pilot shall always be in a position to take over manually at any time and without delay in case of a malfunction, therefore at least one pilot shall be seated with his seat belts fastened at all times during flight.
- The aircraft shall be properly trimmed for the intended configuration and speed before the autopilot is switched on; it shall remain trimmed during the next operation, for which purpose the trim indicators shall be checked regularly.
- Apart from standard crew co-ordination procedures, the pilot (PF) will ask the co-pilot (PNF) for settings and selections of instruments and systems during manual flying. When the autopilot is engaged the pilot (PF) may make settings and selections of the Flight Guidance and Control System himself, while keeping the co-pilot (PNF) informed about these actions or mode changes.
- During approach, all control actions shall be followed with hands and feet on the controls by the PF, in order to resume manual control immediately after a disconnect.
- When conducting an automatic approach/landing the vital function of both pilots is to monitor instruments and annunciators, and to be alert to take over immediately when circumstances dictate so.

02 Use of autopilot and autothrottle

- Compared with the manual approach/landing technique, use of the autopilot/autothrottle has the following advantages:
  - . speeds and ILS beams can be flown with a higher accuracy
  - . lower cockpit workload, permitting better monitoring
  - . in marginal weather conditions a better decision making process is obtained.
- Maximum use of autopilot and autothrottle is required for ILS approaches provided that:
  - . the performance of the relevant airborne and ground systems is satisfactory
  - . the localizer can be intercepted at an adequate distance from the runway
  - . no restrictions to autopilot use are indicated on the approach chart.
- It should be realized that in weather conditions of CAT I or better a number of factors such as:
  - . protection area not assured to be clear
  - . close sequencing of aircraft
  - . switch over time of ground aids
  - . quality of ILS signals

  may influence performance of aircraft autoland systems in a negative way. Therefore it is essential that the pilot flying is prepared to take immediate action in case of a significant deviation from the desired flight path and, if necessary, make a (Auto) Go-around.

1. GENERAL

The Sperry integrated autothrottle/speed control (AT/SC) system provides automatic throttle positioning, speed control indications and stall protection and warning from take-off to landing.

There are 2 AT/SC systems. Each system can be engaged separately or together.

Manual override of the autothrottle is possible at all time.

2. MAIN COMPONENTS AND SUBSYSTEMS

2.1. AT/SC computer (2)

- Autothrottle control, speed control guidance and stall warning utilize common sensors and computations and are therefore packaged in this single computer which provides following outputs:
  - Drive signal for autothrottle.
  - Speed error to fast/slow indicator.
  - FD pitch command (in TO and GA only).
  - Stall warning.

  For FD pitch command in TO and GA and for stall warning, the measured alpha (angle of attack sensor) is used. For all other functions the computed alpha is utilized.

2.2. Duplex servo drive unit (1)

- Contains 2 motors, one for each AT/SC system. They drive a summing differential which connects the motors to the single output shaft to move the throttle levers.

2.3. Autothrottle system (ATS)

- Speed mode:
  - Basic ATS mode is selected automatically by engaging ATS.
  - Low speed limit is alpha speed.
  - Speed selected on ATS panel is reference speed for computer.
  - High speed limit is flap placard speed.
  - N_1 limit as selected on TC cannot be exceeded.
- N_1 mode:
  - Take-off mode (FD mode)
    - Aircraft on ground.
    - FD switches on.
    - TOGA button pushed.

    Engage by switching either or both ATS engage lever (s) to ON.

    If TO MAX or TO FLX selected on TC, the computation of N_1 limit freezes at 30 kt. Throttles keep adjusting power and will be clamped when 80 kt are reached and stay clamped until N_1 mode selector is pushed.
  - Go-around mode (FD and AP mode)

    Engage by pressing TOGA button if FD and ATS engaged, aircraft not on ground and flaps extended. GA N_1 limit on the thrust computer will be selected automatically.
  - Selected N_1 mode

    Engage by pressing N_1 mode selector switch. ATS controls to N_1 limit as selected on thrust computer.
- Retard mode
  - Engages when aircraft descends below 50 ft radio height (if slats in landing position or AP preland test completed).
  - Throttles retard at a programmed rate.
  - Fast/Slow indicators removed from view.
  - After main gear spin-up, fast retard to idle stop.

2.4. Speed control system (SCS)

- Speed control:
  - Basic mode, if flight director and autopilot are disengaged.
  - Fast/Slow indicator displays speed error between actual speed and selected speed (or flap placard, respectively alpha speed).
- Speed guidance:
  - A flight director mode, for take-off and go-around only.
  - Engage by pressing TOGA button if FD is on.
  - Provides attitude command to maintain respective target speed. (N)
  - Engine failure is sensed by fan sensor.
  - Fast/Slow indicator displays speed error between actual speed and computed speed.
  - During take-off prior rotation, FD pitch command and fast/slow indication are invalid.

Appendix 34

(cont'd)

PB2000-910402
NTSB/AAR-00/02
DCA97MA055

NATIONAL TRANSPORTATION SAFETY BOARD

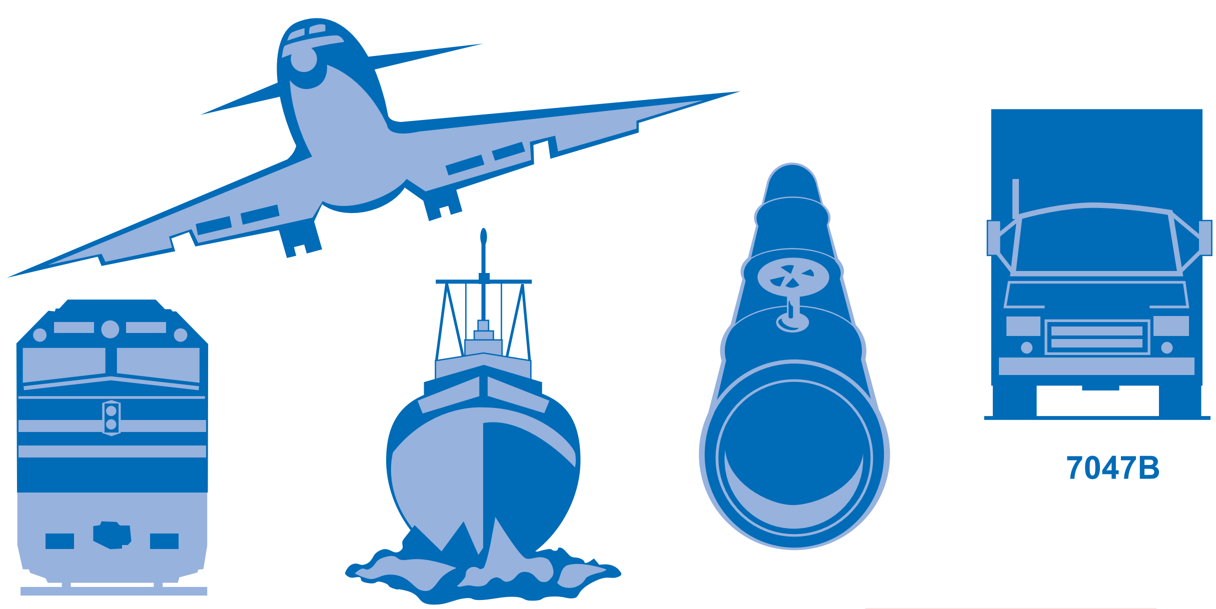
WASHINGTON, D.C. 20594

This file limited to
§ 1.16 Test & Research,
Landing Gear Energy and Load
Limit Certification.

URL Full Report:
http://www.ntsb.gov/investigations/AccidentReports/Reports/AAR0002.pdf

AIRCRAFT ACCIDENT REPORT

CRASH DURING LANDING
FEDERAL EXPRESS, INC.
MCDONNELL DOUGLAS MD-11, N611FE
NEWARK INTERNATIONAL AIRPORT
NEWARK, NEW JERSERY
JULY 31, 1997



7047B

1.16 Tests and Research

1.16.1 Landing Gear Energy and Load Limit Certification

Landing gear certification requirements for transport category airplanes that were applicable to the certification of the MD-11 are primarily contained in 14 CFR 25.721 through 25.737.

Subsection 25.721(a) states:[53]

> The [MLG] system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads to act in the upward and aft directions), the failure mode is not likely to cause—
>
> (1) For airplanes that have passenger seating configuration, excluding pilots seats, of nine seats or less, the spillage of enough fuel from any fuel system in the fuselage to constitute a fire hazard; and
>
> (2) For airplanes that have a passenger seating configuration, excluding pilots seats, of 10 seats or more, the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.

Subsection 25.721(b) states further that "each airplane that has a passenger seating configuration…of 10 seats or more must be designed so that with the airplane under

[51] According to FedEx shipping documents, declared items of hazardous materials were loaded in the forward 1L and 2L cargo container positions. Thirteen packages of hazardous materials were in container 1L, including 10 packages of (flammable gas) aerosols and 3 packages of a flammable solid. The 2L container carried 1 package of perfumery, classified as a flammable liquid, a package of gallium (a corrosive), and methyl methacrylate, another flammable liquid.

[52] Subsequent examination of the package determined that it contained sterilized blood and that it was not a dangerous goods shipment.

control it can be landed on a paved runway with any one or more landing gear not extended without sustaining a structural component failure that is likely to cause the spillage of enough fuel to constitute a fire hazard."[54]

Section 25.473, "Ground Load Conditions and Assumptions," describes the descent velocities that must be assumed for certain landing conditions (for example, level landing, tail-down landing, one-wheel landing, and side load conditions).

Section 25.723, "Shock Absorption Tests"; Section 25.725, "Limit Drop Tests"; and Section 25.727, "Reserve Energy Absorption Drop Tests," describe landing gear energy and load limits. Subsection 25.723(a) states that "it must be shown that the limit load factors selected for design in accordance with [Section 25.473] for takeoff and landing weights, respectively, will not be exceeded." Sections 25.725 and 25.727 describe the values and parameters to be used in conducting the landing gear limit and reserve energy absorption drop tests described in Subsections 25.723(a) and (b). Subsection 25.723(b) also states that the "landing gear may not fail in a test, demonstrating its reserve energy absorption capacity, simulating a descent velocity of 12 fps at design landing weight, assuming airplane lift not greater than the airplane weight acting during the landing impact."

Subsection 25.473 (1) states:

> The selected limit vertical inertia load factors at the center of gravity [c.g.] of the airplane may not be less than the values that would be obtained—
>
> (i) In the attitude and subject to the drag loads associated with the particular landing condition;
>
> (ii) With a limit descent velocity of 10 fps at the design landing weight (the maximum weight for landing conditions at the maximum descent velocity); and
>
> (iii) With a limit descent velocity of 6 fps at the design takeoff weight (the maximum weight for landing conditions at a reduced descent velocity).

---

[53] This requirement was added as a result of a notice of proposed rulemaking (NPRM) issued by the FAA on August 12, 1969. In this NPRM, the FAA stated that the existing Section 25.721 "was designed to [e]nsure that if the landing gear fails, no part of the fuel system in the fuselage of the airplane will be punctured. It is proposed to extend this protection to the entire fuel system of the airplane. However, since not all punctures of the fuel system would result in a fire hazard, the proposal would protect against those punctures only that would result in the spillage of enough fuel to cause a fire." The NPRM proposed amending 25.721 to require that "[t]he [MLG] system…be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads are in the vertical plane parallel to the longitudinal axis of the airplane), the failure mode is not likely to cause the spillage of enough fuel from any part of the fuel system to constitute a fire hazard."

In its final rule, which adopted the language that currently appears in Subsection 25.721(a), the FAA stated on February 24, 1972, that this paragraph had been "substantially amended" since the NPRM and that "in response to a comment, the parenthetical expression in the proposed amendment has been changed to make it clear that the regulation is based on the assumption that the overloads act in the upward and aft directions."

[54] The cargo version of the MD-11 was designed to passenger aircraft certification standards.

Subsection 25.473 (2) states that "airplane lift, not exceeding the airplane weight, may be assumed to exist throughout the landing impact and to act through the [c.g.] of the airplane."

According to Boeing, the MD-11 was designed to allow "sacrificial shedding" (by use of fuse pins) of the MLG assemblies under aft (drag) overload conditions to prevent catastrophic loads being transmitted to the wing box.[55] Boeing indicated that the MD-11 landing gear certification was based on drop tests conducted on DC-10 landing gear, which are nearly identical to MD-11 landing gear.

Boeing, in a submission[56] to the Safety Board, stated that a review of "historical data indicated that [MLG] failure due to overload was most likely to occur as a result of striking an obstruction." The Boeing submission, which described Douglas' landing gear design philosophy for the DC-10 and MD-11, added the following:

> The [Boeing Long Beach Division] believed that the most probable condition would be a 1.0 g vertical load at maximum ramp weight (i.e., the weight of the aircraft would be distributed between the two [right and left] [MLG], the center [MLG] and the nose landing gear with no aerodynamic lift), static gear extension, with a drag load applied to the axles until the failure of the gear. For this condition it was shown by analysis that the [MLG] would separate from the wing without any failures to the fuel tanks. This was validated by tests done on full scale DC-10 landing gear and wing test structure. By analysis this was shown to be true for vertical loads up to 2.0 g's (i.e., twice the weight of the aircraft is distributed between the two [right and left] [MLG], the center [MLG] and the nose landing gear with no aerodynamic lift) at the aircraft ramp weight.
>
> Because a fuse [pin] in the vertical plane may not prevent substantial loads from entering the wing structure once the fuse has released, and because the review of historical data indicated that failure due to overload was most likely to occur as a result of high drag loads, a different approach was taken to assure fuel tank integrity for the high vertical load (above 2.0 g's) condition. For vertical loads above 2.0 g's, the [MLG] is not designed to separate from the wing. Instead, the landing gear and its back-up structure are designed to be very robust, i.e., they are designed to withstand significantly greater descent rates than the 12 fps (ultimate) required per Part 25.723 (b). Analysis has indicated that for a maximum landing weight, typical-landing-configuration landing, the MD-11 [MLG] can withstand up to a 16.9 fps descent rate without bottoming the shock struts or failing its backup structure including the wing rear spar. Similarly, for a rolled landing (8 degrees one-wing-low attitude, with lift equal to aircraft weight), the landing gear can withstand up to 15 fps descent rate without bottoming the shock strut or failing its back-up structure including the wing rear spar.[57]

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[55] The wing box, often the heaviest single piece of an airplane's airframe, is the strong, primary structure of a modern, stressed-skin wing. Loads are taken by cantilever beams comprising upper and lower skins joined to front and rear spars.

[56] Boeing's Long Beach Douglas Products Division. Undated. Submission of Proposed Findings for *FedEx Flight 14, MD-11-F, N611FE, Newark, New Jersey, 31 July 1997.*

The Boeing submission added that "creating a reliable vertical fuse can only be accomplished by adding weight and complexity" to the airplane, and increasing landing gear energy absorption capability "could have a cascading effect in that the total aircraft structure would have to be strengthened to absorb the additional energy." For "extreme roll angles," the Boeing submission noted that "the landing gear design criteria and philosophy do not come into play. Striking the wingtip may fail the wing directly or may cause the aircraft to 'cartwheel.'" The Boeing submission stated that "for lesser roll angles the single gear on the 'wing low' side may fail (or fuse if so designed) if the combination of sink rate and roll rate (and amount of wing lift) impart loads that exceed the design thresholds." Boeing's submission added the following:

> For 'fused' aircraft the (remaining) energy of vertical descent would then be absorbed by flexing the low-side wing, or by some combination of exercising the high-side landing gear, and flexing the low-side wing. For some combinations of sink and roll rates the low-side gear may fuse (followed by the wing engine/nacelle) and the aircraft may 'settle in' on the remaining gear and the low-side wing without compromising fuel tank integrity. For higher sink and roll rates (or lower amounts of wing lift) the low-side wing may fail nonetheless, as a result of exceeding its flexure (bending) limits.

The Boeing submission further noted that because "kinetic energy is a form of energy associated with the motion of an object, the kinetic energy dissipated into the landing gear during landing touchdown is derived from both the rate of descent and the aircraft's rolling rate at touchdown…During a normal landing, the kinetic energy from descent and roll rates is absorbed by shock strut stroking at touchdown, which can be called 'Phase 1' energy absorption." Boeing's submission added that during "Phase 2" energy absorption, which also occurs via shock strut stroking, "potential energy related to aircraft weight[58] eventually gets absorbed by the main and nose landing gears as wing lift is reduced due to the reduction of both angle of attack and forward velocity and deployment of ground spoilers. This energy is normally absorbed some time after the total kinetic energy related to the descent rate is completely absorbed at initial touchdown." The Boeing submission added the following:

> In a stabilized approach, assuming calm atmospheric conditions and ignoring ground effect, once the aircraft's rate of descent is stabilized, vertical acceleration is equal to 1.0 g and lift is equal to the aircraft weight. … If the aircraft's vertical acceleration at touchdown is a value less than 1.0 g, then the energy that results from the positive acceleration towards the ground due to the reduced lift becomes additive to the kinetic energy from the rate of descent. The effect is that the landing gear has to absorb not only the Phase 1 energy at touchdown, but a portion of the Phase 2 energy at the same time. The end result is a higher load into the landing gear and attaching structure during touchdown.

---

[57] Boeing further stated in its submission that it had "begun an evaluation into the net safety benefit of installing a fuse for vertical overload in the DC-10 and the MD-11 [MLG]…that could take a year or more to complete." Boeing also stated that it would include the Newark accident scenario in its study of the potential safety benefits of vertical fusing.

[58] Potential energy is a function of gravitational acceleration and vertical distance above a reference level, or the relative position of an object.

> The accident aircraft's recorded vertical acceleration at the start of the second touchdown impact was approximately 0.5 g, that is, wing lift was equal to approximately half the aircraft weight, which imparted huge additional potential energy into the landing gear and attaching structure above and beyond those associated with the 11 fps [c.g.] descent rate and the 7 [degree per second] roll rate [which combined resulted in the 13.5 fps sink rate]. In addition, these energies were imparted primarily into the [right] MLG only, due to the right wing down roll angle…at touchdown. At the accident aircraft's landing weight of 452,000 [pounds]…potential energy of 678,000 ft-lbs was added to the approximately 896,000 ft-lbs. [Right] MLG kinetic energy from the combined aircraft descent and roll rates, for a total energy into the [right] MLG of nearly 1,574,000 ft-lbs. Comparing the loads into the [right] MLG from the accident landing at Newark to the [right] MLG energy absorption requirements for certification shows that the energy developed during the accident landing was over 3 times the reserve energy (ultimate) certification requirements for a single [MLG].

Figure 9 shows Boeing's calculations of the energy imparted to the right MLG in the Newark accident.

RMLG Energy - Newark MD-11 Accident

- RMLG Energy During Accident:
  - Potential Energy Due to Reduced Lift = 678,000 ft.-lb. = (452000)(0.5)(3)
  - Kinetic Energy = 895,754 ft. lb.
  - Total Energy = *1,574,000 ft.-lb.*
    - 452,000 lb. Landing Weight
    - 11 fps Sink Rate @ c.g. and 7°/sec roll rate
    - Lift = 0.5 X Weight
    - MLG Strut Stroke = 23 in.
    - MLG Tire Deflection = 13 in.
- RMLG Energy for Certification = 494,500 ft.-lb. = $(0.5)[(491500)(.45)\div 32.2](12)^2$
  - 491,500 lb. Max. Certified Landing Weight (45% of this is the effective weight on one wing-mounted MLG); symmetrical landing
  - 12 fps Sink Rate (FAR 25.723 Reserve Energy Condition)
  - Lift = Weight (FAR 25.473)
- RMLG Energy During Accident Relative to Energy for Certification: (1,574,000/494500)x100 % = *318 %*

Figure 9. Boeing calculations of right MLG energy in the Newark accident.

The Boeing submission concluded that a "sink rate of approximately 13.5 fps (11 fps at the [c.g.] plus the [right-wing-down] roll rate) at touchdown impact is, by itself, outside the design envelope; a 13.5 fps sink rate landing on a single [MLG] is even further outside the design envelope; [and] a 13.5 fps sink rate landing on a single [MLG] with a net 0.5 g downward acceleration is yet further outside the design envelope."[59]

In addition, the Boeing submission noted that it was revising the MD-11 maintenance manual to expand hard landing definition and inspection criteria. Boeing stated that the criteria should include "information on the effects of reduced lift and adverse aircraft attitude on loads into the landing gear." The Boeing submission added the following:

> Data developed during this investigation show that the absolute recorded vertical acceleration value during landing should not be the only criteria for determining if a hard landing has taken place. The recorded vertical acceleration at the beginning of the touchdown can also be very important. Specifically, if the recorded vertical acceleration at the beginning of the landing is less than 1.0 g, then aircraft weight that is normally accommodated by the 1.0 g wing lift is instead transmitted into the landing gear on top of the loads required to decelerate the airplane vertically from the aircraft's sink rate. The effects of non-routine aircraft pitch and roll attitudes on energy introduced into singular landing gear should also be part of the hard landing evaluation.[60]

1.16.2 Dynamic Failure Simulation of MD-11 Right Wing Structure and Right Main Landing Gear Assembly

Initial simulation conducted by Boeing did not show loads great enough to cause the failure of the right-wing rear spar, MLG, or associated structure. Subsequently, Boeing contracted with Mechanical Dynamics, Inc., (MDI), a Michigan-based company specializing in dynamic simulation, for assistance. Boeing and MDI developed a computer model of the airplane structure to simulate its flightpath based on the FDR data and determine the resulting dynamic loading imparted to the aircraft structure during the accident.[61]

MDI and Boeing personnel developed a computer model of an MD-11's structural elements and validated its static and dynamic characteristics via comparison with certification test data. Two structural failure sequence theories were then explored. The first scenario (beginning at the second touchdown impact) proposed the following failure sequence:

- the right MLG strut and tires bottomed but did not fail immediately, the right inboard flap separated, and the outboard bolt of the side brace fitting failed because of inboard load on the lower right MLG;
- the subsequent gear failure transferred the load to the No. 3 engine and pylon and outboard wing and flap; and

[59] Certification for landing on one wheel is governed by 14 CFR 25.483, "One-wheel Landing Operations." Based on conditions and assumptions contained in Section 25.473, Section 25.483 requires that an airplane be certified to withstand a 10 fps vertical landing at its maximum landing weight (471,500 pounds) with zero roll angle.

[60] Boeing incorporated these findings into a revised maintenance manual that was released in November 1999.

[61] The simulation is based on a mechanical system simulation software package, known as ADAMS software, developed by MDI. According to MDI, ADAMS software is also widely used in the automotive, marine, and construction vehicle industries. The Board's Airplane Performance Group reviewed this simulation effort and verified the methodology.

- the wing failed inboard of the landing gear fitting.

According to the Boeing submission, simulations of Scenario 1 did not generate loads great enough to fail the side brace fitting. Scenario 1 also failed to match runway evidence.

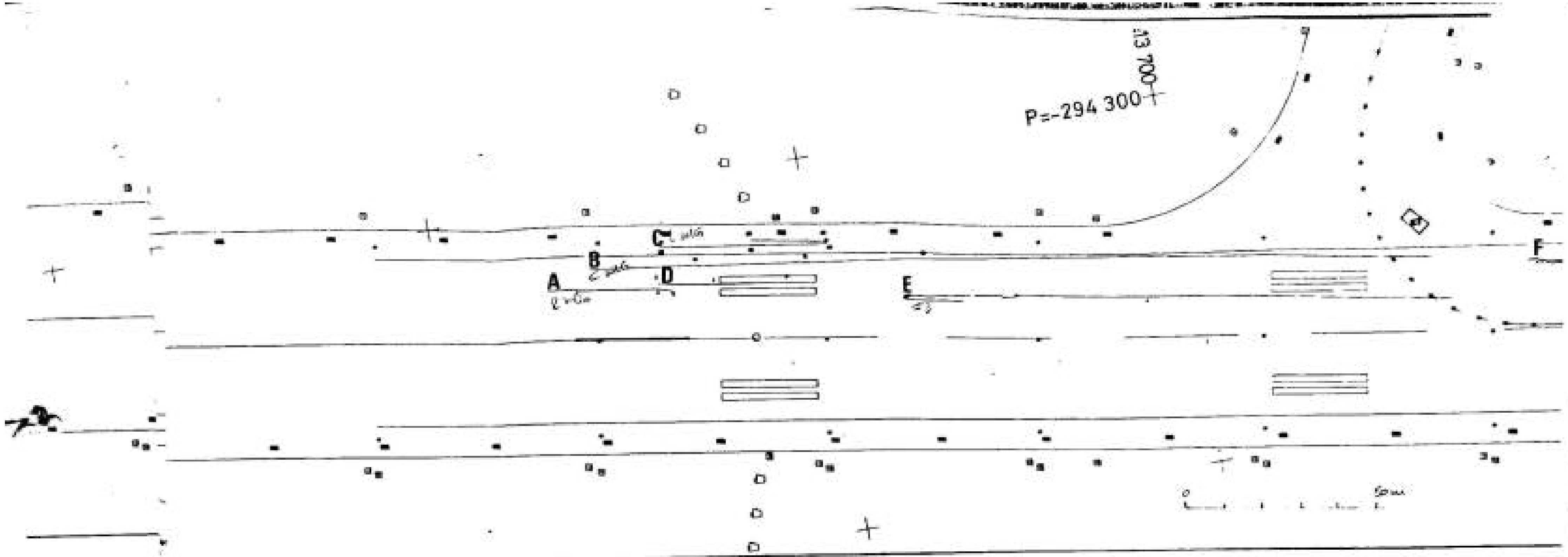
The simulations for Scenario 2 indicated the following failure sequence:

- right MLG strut and outboard tires bottomed and vertical strut "spiked";
- right rear spar web and spar caps fractured inboard of the gear fitting;
- inboard upper wing (skin and stringer) panel began to collapse from back to front;
- outboard right wing twisted leading-edge down, right MLG wing fitting moved up, and right MLG tires moved aft and outboard;
- right inboard flap track came off rollers at the side of the fuselage;
- right inboard flap twisted off its outboard hinge support fitting and separated from the aircraft;
- excessive movement of the right MLG and its wing attach fitting imparted large prying loads on the side-brace-fitting-to-trapezoidal-panel joint, inboard half of the inboard trap panel fractured, and outboard bolt fractured;
- right [engine] nacelle contacted runway;
- fuel spilled from the right wing and ignited;
- aircraft began to roll clockwise, "dragging" the right wing underneath; and
- other failures were consequent.

The Boeing submission concluded that its dynamic simulation model of the Scenario 2 accident sequence correlated "substantially with evidence from the crash site" and FDR data.[62] Elaborating on this point, Boeing concluded that

> it is most probable that, as a result of loads applied to the right [MLG] that were substantially beyond design limits, the right wing structure failed. The failure most probably initiated at the rear spar/bulkhead (trunnion) rib interface and progressed through the primary wing box structure. As a result of this failure, the right main gear trunnion moved substantially upward and aft with respect to the trap [trapezoidal] panel fitting. This motion was sufficient to cause the fixed side brace to bind against the pillow block footing, tearing the pillow block loose from the trap panel.[63]

[62] The Boeing submission stated that the "failure of the rear spar web and the wing torque box [was] modeled as perfectly elastic/perfectly brittle. In the real structure, the failure would be elastic/plastic. Consequently, the results from the point of failure of the rear spar on become less quantitative than prior to this point in the event. Nevertheless, the model behavior subsequent to the structural failure appears to be in reasonably good qualitative agreement with the evidence from the crash site."



ÍNDICE DE LOCALIZAÇÃO DOS DESTROÇOS, RASTOS E IMPACTOS — *LOCATION OF WRECKAGE, I*

LADO DIREITO DA PISTA 11
RIGHT SIDE OF RUNWAY 11

9. Slat da asa # 1 — *Left wing slat # 1*
10. Painel interior da cabine — *Pax cabin panel*
10. Revestimento do estabilizador horizontal — *Horizontal stabilizer skin*
11. Revestimento do estabilizador vertical — *Vertical stabilizer skin*
12. Revestimento da fuselagem — *Fuselage skin*
13. Painel de abastecimento da asa # 2 — *Wing # 2 fuel panel*
14. Anteparo do caixão central — *centre wing box bulkhead*
15. Caixa de drenos do motor # 2 — *Engine # 2 drain box*
16. Bordo de ataque da asa esquerda — *Left wing L. edge*
17. Fragmento do estabilizador vertical — *Vertical stabilizer fragment*
18. Revestimento do extradorso da asa esquerda — *Left wing upper skin*
19. Fragmento do estabilizador vertical — *Vertical stabilizer fragment*
20. Bordo de ataque do estabilizador vertical — *Vertical stabilizer L. edge*
21. Fragmento do revestimento do estabilizador horizontal direito — *RH horizontal stabilizer skin fragment*
22. Fragmento do leme de profundidade direito — *RH elevator fragment*
23. Fragmento do revestimento do extradorso da asa esquerda — *Part of upper left wing skin*
24. Fragmento da capotagem do motor # 1 — *Engine # 1 cowling fragment*
25. Revestimento do extradorso da asa esquerda — *Left wing upper skin*
26. Fragmento do revestimento do intradorso da asa esquerda — *Left wing lower skin fragment*
27. Fragmento do revestimento do intradorso da asa esquerda — *Left wing lower skin fragment*
28. Fragmento do revestimento do estabilizador horizontal direito — *RH horizontal stabilizer skin fragment*
29. Fragmento do estabilizador horizontal direito — *RH horizontal stabilizer fragment*
30. Leme de profundidade direito — *RH elevator*
31. Macaco do actuador do flap — *Flap elevator*
32. Fragmento da capotagem do motor # 3 — *Engine # 3 cowling fragment*
33. Fragmento do estabilizador horizontal direito — *RH horizontal stabilizer fragment*
34. Bordo de ataque do estabilizador horizontal direito — *RH horizontal stabilizer L. edge*
35. Fragmento do estabilizador vertical — *Vertical stabilizer fragment*
36. Slat da asa esquerda — *Left wing L. E. slat*
37. Revestimento do interior da cabine — *Pax cabin panel*
38. Fragmento do estabilizador vertical — *Vertical stabilizer fragment*
39. Fragmento do revestimento do intradorso da asa esquerda (transfer fuel tank) — *Part of lower left wing skin, tank no. 1 (Transfer fuel pump)*
40. Fragmento do estabilizador vertical — *Vertical stabilizer fragment*
41. Parte inferior do leme de profundidade direito — *RH elevator lower skin*
42. Braço fixo do trem principal direito — *RH main landing gear fixed side brace*
43. Fragmento da capotagem do motor # 3 — *Engine # 3 cowling fragment*
44. Revestimento do extradorso da asa esquerda — *Left wing upper skin*
45. Fragmento do revestimento da capotagem do motor # 3 — *Engine # 3 cowling fragment*
46. Porta do trem direito — *RH main landing gear door*
47. Fragmento do revestimento da capotagem do motor # 3 — *Engine # 3 cowling fragment*
48. Fragmento do revestimento da fuselagem — *Fuselage skin fragment*
49. Fragmento da estrutura do caixão central — *Central wing box structure fragment*
50. Fragmento do tanque do caixão central — *Fragment of central fuel tank box*
51. Ferragem do estabilizador horizontal — *Horizontal stabilizer support*
52. Fragmento da capotagem do motor # 1

A — Rasto dos pneus do trem principal direito — *Track of M.L.G. RH side tires*

B — Rasto dos pneus do trem principal do centro — *Track of M.L.G. center side tires*

C — Rasto dos pneus do trem principal esquerdo — *Track of M.L.G. LH side tires*

D — Ziguezague do trem principal direito — *Zigzag of M.L.G. RH side*

E — Impacto e arrastamento do motor # 3 — *Impact and trailing of engine # 3*

F — Sulco provocado pela falange da jante da roda # 2 do trem principal do centro — *Furrow made by flange of drop wheel # 2 of M.L.G. center side*

G — Linhas provocadas pelo arrastamento da aeronave — *Path of draw trailing of aircraft*

16755

For system limitations refer to AOM 2.1. to 2.18.

01 MAXIMUM WEIGHTS

Registration	DTA-DTD/DTL 134C-138C 9G-ANA	GIA-GIF	MBN/MBP/MBT	ALL AIRCRAFT CENTER GEAR RETRACTED
Taxi	257.600 kg	253.100 kg	257.600 kg	200.900 kg
Take-off	256.300 kg	251.700 kg	256.300 kg	199.600 kg
Landing *	186.400 kg	186.400 kg	192.300 kg	164.900 kg
Zero Fuel	167.200 kg	167.200 kg	182.200 kg	158.800 kg
In Flight: Landing Flaps	192.300 kg	192.300 kg	193.700 kg	192.300 kg

*In case of an unplanned landing the following maximum landing weights apply:

Landing	190.900 kg	190.900 kg	192.300 kg	181.000 kg

These weights may be reduced by the following limitations:
. Operating limitations.
. Centre of gravity envelope.
. Fuel loading
. Fuel management.

If max. landing weight is exceeded make an entry in the AML. Inspection limits are published in the Maintenance Manual Chapter 5 and AOM 1A.20.

02 LOADING

Loading limitations are contained in AOM Chapter 5. Compliance is required with loading limitations relative to:
. Maximum number of passengers.
. Floor and compartment strength.
. Centre of gravity limits.
. Fuel load distribution (AOM 1A.).

03 MINIMUM CREW

- Cockpit: Two pilots and a flight engineer.
- Cabin : Refer to BOM 1.2.3 Minimum Crew Requirements and AOM 4.2.1 Number and Seating of Cabin Crew.

04 RUNWAY SLOPE LIMITS

- Take-off and landing : 2% up or 2% down.
- Take-off with runway clutter: 1% up or 1% down.

05 RUNWAY CONTAMINATION

For operational consequences refer to AOM 3.5.2 and AOM 6.1.2.

Appendix 37

The ABS landing mode is activated when spoilers are deployed (either automatically or manually) with throttle levers retarded and brake pedals released. Automatic braking is delayed after spoiler deployment for approximately 1 second in maximum mode and approximately 3 seconds in mimimum or medium modes to allow for normal nose wheel touchdown. Pilot takeover can be initiated at any time and ABS system will disarm if brake pedal is depressed beyond approximately 40 percent of travel, if throttle lever 1 or 3 is advanced beyond 15 degrees, deceleration selector is moved to OFF position. The arm-disarm switch will move to DISARM and ABS lights will come on for the above conditions. (Moving AUTO BRAKE deceleration selector to OFF will not turn on ABS lights). Stowing ground spoilers will release brake pressure without disarming the ABS landing mode. The ABS lights will remain off and automatic braking will again be available if spoilers are re-deployed.

An ABS malfunction will cause the system to automatically disarm. The arm-disarm switch will move to DISARM, and indicating lights will come on. To rearm the ABS system after it has automatically disarmed, the deceleration selector must be moved to OFF and then back to the deceleration setting and the arm-disarm switch moved to ARM. If the fault has cleared, the system will rearm. In flight the ABS is disarmed when the gear handle interlock relay senses the gear handle up.

ANTI-SKID SYSTEM

A fully automatic, pressure modulating anti-skid control system is installed in each of the two hydraulic power brake systems. the system is controlled by individual wheel speed transducers, anti-skid control box, and individual anti-skid control valves for each main and center wheel brake. Pilot induced manual brake valve pressure (as a result of toe-brake pedal deflection) is metered as necessary to provide efficient braking and prevent tire skidding. The anti-skid system responds most efficiently with full pedal application (pedals bottomed) or at least steady partial pedal application. The system incorporates locked wheel touchdown protection, to the rear bogie wheels only, to prevent inadvertent landing with the brakes applied. A shift from ground mode to fllight mode, while on the ground, will release the rear bogie wheels at low speed leaving normal braking on forward bogie wheels. The system automatically reverts to a manual power brake system, below 10 knots for the main gear and on some aircraft 3 to 4 knots for the centerline gear, but the anti-skid lights remain off. An arming switch, test button, and indicating lights are provided to control and monitor the system.

CONTROLS AND INDICATORS

Controls, indicators, and annunciator lights are on the pilots'instrument panels, Pedestal, Overhead Panel, and Flight Engineer's Upper Instrument Panel No. 3. The main and nose gear alternate gear extension lever is to the right of the pedestal on the floor and the center gear alternate extension handle is on the floor forward of the main circuit breaker panels. Illustrations of these major panels are in Chapter 1. Individual controls and indicators are illustrated and described in another section of this chapter.