Comments of the Kingdom of the Netherlands, by the Aviation Safety Board, on the Final Report of the Portuguese Government, concerning the Aircraft Accident with Martinair Flight MP495, a DC-10-30CF, on December 21th, 1992 at Faro Airport, Portugal.

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General

The Aviation Safety Board is of the opinion that the Portuguese report, in general, correctly reflects the course of events leading to the accident.
The Board agrees with the factual information and generally agrees with the analysis and the conclusions drawn from it.

The Board is of the opinion that the analysis of several aspects in the course of events should be expanded, in order to be able to accurately determine the probable causes of the accident and the contributing factors, for the purpose of learning the lessons and taking accident prevention measures.

In the following paragraphs the Board offers its views on the Analysis in the Portuguese report, concerning the Weather Aspects, the execution of the Approach and Landing, the Autothrottle System, the phraseology "Flooded", the Conclusions and Causes, and the Recommendations.

The Amended Conclusions, Causes and Recommendations with the changes, made by the Board are attached.

Weather aspects

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.
Prior to the flight the Captain and First Officer (F.O.) were informed at the Schiphol Meteorological Office, about the weather enroute and at Faro. They were shown a satellite picture indicating a depression South-West of Portugal and isolated thunderstorms in the Faro region.
Enroute they received weather information from Bordeaux and Lisbon and during the Approach, Faro ATC informed them on the actual weather at Faro Airport.
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 crew was aware of the presence of isolated thunderstorms and while in the initial approach phase they verified the position of the thunderstorms on their weather radar. According to their statements the closest echo was to the West of the airport, between 7 and 12 n.m. and some further activity far to the South, at least 50 n.m away.
The presence of the thunderstorm West of the field at about 8 n.m DME was also evident from the increased turbulence encountered at that position, as recorded on the DFDR, and the crew's report of rainintensity and turbulence.
During their arrival overhead Faro the crew's impression of the weather was not changed by the appearance of the weather. When flying overhead Faro at 4000 ft. they were flying in the clear and could see the runway and some time later, the approaching Martinair MP461.

From the prevailing weather neither the Meteorological Office (SIO), nor the crew of MP495, did anticipate the possibility of the existence of windshear phenomena. In this context it should be remarked that the Portuguese AIP does not contain any warning for specific weather phenomena at Faro Airport.
Consequently, according to AOM procedures, the crew briefing incorporated a standard 50° flap landing, anticipating a wet runway. The Actual Landing Distance as calculated by the crew according to company regulations, was within the Available Landing Distance. With the reported wind: 150°, 15-20 knots, the crosswind component was within the limit of 30 knots for braking action "Good" and also within the limit of 15

knots for braking action "Medium".
The Captain, knowing the runway was wet, instructed the F.O. to make a positive touchdown, which is standard operating procedure to avoid aquaplaning.

The reported visibility in the approach was above 2000 m which is the minimum required visibility for a VOR approach.
The Captain stated that he had the runway in sight from about 1200 ft, which equals about 3-4 n.m. distance to the runway. Notwithstanding the varying rainintensity during final approach he could constantly see the runway lights and the Papi.
At around 250 ft the F.O. lost view on the runway lights due to the rain on his windshield. The Flight Engineer switched the windshield wipers to high, telling the F.O.: "You are at fast". This action obviously restored visibility as, according to the CVR, there was no further comment by either pilot.

During the final approach the Captain monitored windreadings of the Area NAV.
This action is not required in the AOM procedures.
Furthermore, the AOM states that due to the inaccuracy of the Area NAV windreadings, the calculations of maximum allowable windcomponents for landing should be based on the tower reported surface wind.

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.

They did discuss the missed-approach procedure, which is standard operating procedure. The Captain decided that in that case they would proceed directly to Lisbon. This decision was based on the better means of transport for the passengers available at Lisbon, in relation to Seville, which was the first nominated alternate.

The change of the weather occurred rather abrupt, at the moment that the aircraft was on short final at about 150 ft. With the - unexpected - arrival of a spearhead of an active frontal system from the South, winddirection and speed changed from the reported 150° -

15 knots, max. 20 knots, to a wind of 220° knots, with 35-40 knots. The aircraft entered a heavy rainshower, as observed by a crew at the holding position.

The calculations of the NLR showed three area's of downburst/microburst activity along the aircraft approach path.
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.

The Phraseology "Flooded"

During the final approach of MP461 and of 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". 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.
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".

The AOM states that braking action is "Medium" with "Moderate to heavy rain on a clear runway" and "Poor" with "standing water".

If the crew had understood the meaning of the word "Flooded", they would have considered the braking action as "Poor".
However, in view of the prevailing weather, with heavy rain at times, they applied the AOM tables for braking action "Medium".

Approach and Landing

As has been discussed before, the crew, in view of the prevailing weather conditions, prepared for a 50° flap landing, on a wet runway. According to AOM procedures, the approach was flown with one autopilot and two autothrottle systems engaged.
In the crewbriefing the F.O. had indicated a "Manual Crew Coordination Procedure", in which the F.O. would fly the aircraft and the Captain would monitor and look outside for visual cues.

During the crew briefing the F.E. had mentioned the various airspeeds to be maintained in the approach.
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.

During the approach increasing oscillations took place in pitch, airspeed and engine power.
The Board agrees with the view in the Portuguese report concerning the initiation of the oscillations, which was most probably due to the effects of the first downdraft which the aircraft passed through.
The oscillations may have increased due to the influence of the second and third micro-burst along the aircraft approach path, as well as to the interaction of Autothrottle response and pilot control input.
These oscillations became quite large, but at no time did the values exceed the parameters

mentioned in the AOM regarding speed, bank and position relative to the runway.
Only when the preset 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.

It should be considered that the registrations of the DFDR concerning the Altitude Rate (Rate of descent) are not dampened. The registrations show the calculated rate of descent per minute at any moment, while actually the aircraft, due to its inertia, does not follow these excursions.
The flightpath of the aircraft is more related to the indications of the IVSI (Instantaneous Vertical Speed Indicator) which indications are not registered in the DFDR or AIDS.

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.

The problems started at around 150 ft where the ATS increased thrust to 102%, the aircraft temporarily levelled off and the speed increased.
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.
The Board agrees with the Portuguese report that this thrust reduction was to all probability initiated by the ATS, with a follow-through by the F.O.
Engine thrust remained at flight idle. Although a malfunction of the ATS can not be sustained, the influence of the ATS computer logic is insufficiently known to determine whether the ATS should have reacted or not.
The Board agrees that to all probability an action of the F.O. resulted in the sustained flight idle thrust.
From approx. 150 ft to touchdown several occurrences took place.

- A bank to the left developed when the F.O. applied left rudder to decrab the aircraft. Both pilots took opposite corrective control wheel action simultaneously most probably causing the autopilot CWS mode to disengage;

- Airspeed dropped fast to below reference speed, as a consequence of the thrust reduction and the developing tailwind;
- A high rate of descent started, at approx. 80 ft radio altitude.

With the wings level again the aircraft was displaced rapidly to the left side of the runway, obviously by the abrupt change in winddirection and speed.

The Captain, startled by the sinking feeling, reacted by opening the throttles. Due to the rapidly developing situation his corrective actions (Opening the throttles and increasing pitch) were commenced when the aircraft had passed through 50 ft altitude, and consequently were too late to prevent a hard landing.

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 centerline.
The aircraft touched down on the right hand main gear first, with a rolling motion to the right, a crabangle of about 11°, and a high rate of descent.
Touchdown was on the far left side of the runway.

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 crabangle, a high rate of descent and touchdown on the aft right hand wheel first.

It should be mentioned that the registrations of the DFDR after touchdown are to be treated with caution, as their accuracy could be impaired. However, the Board fully agrees with the description of the movements of the aircraft after the impact.

THE FOLLOWING PARAGRAPHS ARE A REPRINT FROM THE PORTUGUESE REPORT, WITH THE CHANGES OF THE AVIATION SAFETY BOARD ADDED IN SHADED TEXT. TEXT TO BE DELETED IS CROSSED-OUT.

3. CONCLUSIONS

3.1. ESTABLISHED FACTS

- The aircraft was in a airworthy condition and was correctly certified for the flight.
- The weight and balance was within the approved limits.
- 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.
- The inoperative items at departure from Amsterdam, did not affect the aircraft operation.
- The crew was correctly licensed, qualified and certified for the operation of the aircraft.
- The crew and the airtraffic controllers were working within the limits of the prescribed working and resttime regulations.
- The meteo conditions at Faro airport area were influenced by a depression centred at the accident time ~~at about 250 n.m. E.S.E. of Faro airport~~ South-West of Portugal with a pressure of 1006 hPa in the center. The depression extended at altitude with an axis practically vertical, bringing into circulation a mass of very humid and unstable maritime air, with an instability which extended practically until the troposphere. In the South-East border of the depression were developping organized lanes of convergence with bank of clouds in which Cb were embedded, with great vertical development that gradually reached the Faro region.

- The forward part of one of these lanes arrived at the Faro airport about

07.30 UTC and at 12.00 UTC still affected the region.
As a consequence strong thunderstorms and heavy rainshowers developed with very significant local wind variations, with gusts developping that in the airport region reached a velocity of 40 kts.
The average wind came from South-East and S.S.E. with an average force of 10-17 knots, that, occasionally, with the passing Cb could surpass 20 to 25 knots.
The surface visibility was 6 to 9 km, being reduced to
2 - 4 km during the periods of intense rainfall.

- The forecast for Faro airport for the period 04.00 - 13.00 UTC gave a surface wind of 150°, 15 knots, visibility more than 10 km, 3/8 stratus at 500 ft, 4/8 cumulus, 1200 ft, 5/8 stratocumulus 2500 ft, temporary visibility 6000 m, some moderate showers and some lightning, small or moderate small hail, intermittent vis more than 10 km, moderate thunderstorm and 2/8 Cb at 1800 ft.

- At 04.45 UTC the meteo center of Lisbon airport sent a sigmet valid between 06.00 - 12.00 UTC in which was warned for clear air turbulence, moderate and locally severe, above FL 340 and thunderstorms and ice formation in Lisbon FIR.

- At 07.09:58 UTC Faro Approach Control gave the following meteo information to flight MP495: Wind 150° 18 kt, vis. 2500 m, present time thunderstorms, clouds 3/8 at 500 ft, 7/8 at 2300 ft, 1/8 Cb at 2500 ft, Temp. 16°, QNH 1013.

- 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.

- ~~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.~~

- 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. ~~for braking conditions POOR.~~

- ~~The windinformation by the Area Nav System was not correct owing to the system not taking into account the side slip of the aircraft.~~

- At 07.32:15 UTC Approach Control transmitted the last wind information. Wind 150° - 15 kts, max. 20 kts.

- Approach Control transmitted to the aircraft the instantaneous wind from runway 29 instead of runway 11.

- AT 07.33.20 UTC the Accident Occurred.

- At 07.35:30 UTC. The SIO registration gave a warning for windshear.

- 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.

- About 08.00 UTC farmworkers gave indications that in the airport zone a very strong wind developed along a narrow lane that passed the beginning of runway 11 from South to North, that destroyed some plastic greenhouses South and North of runway 11, and destroyed part of the airport fence, near the sensors of runway 11, which locally is named Manga de Vento (wind sleeve) and was of sufficient intensity to affect the operations of landing and take-off at Faro airport.

- ~~The crew did not integrate.~~ The instability and the momentary visibility degradation in the final approach ~~and the runway service conditions wich were transmitted to them, in order to take~~ were not of such a magnitude that the crew should have made the decision to discontinue the approach.

- 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. Also the sustained flight idle thrust condition was most probably a result of action of the F.O.;

- The ~~function~~ autopilot CWS mode disengaged ~~was switched off~~ at R.A. 80 ft, apparently non-intentional. ~~When the crew had done it intentionally it should have been done above 150 ft.~~ The crew did not notice the resulting "autopilot red light" flashing signal.

- ~~The power was reduced at 150 ft instead of at 50 ft by autothrottle action.~~

- The ~~premature power reduction and the~~ sudden windvariation in direction and intensity during the last phase of the final approach created a cross-wind component which exceeded the aircraft limits in the AOM. ~~aggravating the rate of descent.~~

- Due to the premature large and sustained power reduction and the tailwind component ~~The aircraft~~, in the final approach phase the aircraft attained a rate of descent of about 1000 ft/min. ~~that exceeded the operational limit of 600 ft/min, for max. landing weight conditions as mentioned in the AOM.~~

- The crew intervention for power increase of the engines was too late to stop the high rate of descent.

- The fracture of the right landing gear was caused by the combination of the touchdown on the right hand aft wheel, the crabangle and the high rate of

descent. ~~and the significant sideslip to the right.~~

- The wind sensors from runway 11 are installed 17 m above runway level, near a hole 7 m deep, located between the sensor and the runway.
  The meteo clock of SIO showed a lag of one minute and 30 sec relative to the reference ATC clock.

- There were no written procedures for time synchronization.

- SIO registration did not include all meteo information displayed in the tower control positions.

- There are no written agreements between INMG and ANA about the way of working of the SIO.

- There are no defined responsibilities about the calibration of the meteo sensors.

- On the tower there are no individual displays for each separate sensor.

- The visual displays do not have a clear indication of the zone of runway they represent.

- There are no written procedures concerning the checks to be carried out by ATC personnel prior to start of their work.

- There are no published Air Traffic Service procedures to decrease the possibility of human error.

- It was not evident that DGAC had inspected the ATC Service at Faro airport.

- The action of the fire fighting personnel was hampered by the difficult terrain at the place of the accident.

- The fire was started by the rupture of the integral tanks of the right wing, after the impact with the runway.

- The survivability was conditioned by the fire which broke out and propagated after the impact.

- The accident was generally survivable.

- The action of the fire fighting personnel had a significant contribution to the survivability of the aft section, keeping open the escape routes.

- The emergency plan was activated correctly but development of the plan was affected by insufficient coordinating instructions.

- The medical equipment at Faro airport was in certain areas insufficient.

3.2. CAUSES

~~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.~~
- ~~The crosswind which occurred in the final phase of the approach, not known to the crew, which exceeded the aircraft limits.~~

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

- a sudden and unexpected windvariation 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 righthand maingear, which in combination with a

considerable crabangle exceeded the aircraft structural limitations.

Contributing factors to the accident were:

- From the prevailing weather neither the meteorological office (SIO) nor the crew of MP 495 did anticipate the possibility of the existence of windshear phenomena.
- The premature large power reduction and sustained flight idle thrust, most probable due to crew action.
- CWS mode being ~~switched off below the prescribed altitude~~, disengaged at 80 ft RA causing the aircraft to be in manual control ~~with as a consequence an abrupt flare and a hard landing~~ at a critical stage in the landing phase.
- The incorrect wind information delivered by Approach Control.
- ~~The incorrect wind information delivered by the Area 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 condition.~~
- ~~The delayed action of the crew in increasing power.~~
- ~~The degradation of the lift coëfficient due to the heavy rain.~~
- ~~The fracture of the landinggear, caused by the high rate of descent, combined with the significant side slip of the aircraft on impact with the runway.~~

4. RECOMMENDATIONS

The commission recommends:

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

4.2. Martinair to review the BIM in order to:

4.2.1. ~~Regulate~~ Review the procedures concerning landings and /or take-offs in order that

when the meteo conditions are ~~worse~~ bad or the operational parameters are marginal, whether the manoeuvres should be performed by the Captain. or not.

4.2.2. Review the operational procedures concerning the use of no. 2 engine thrust-reverser.

~~Avoid in the dispatch deficiency guide procedures which are contradictionary, leaving the responsibility to the Captain.~~

4.3. That ANA installs in Faro airport an approach light system in order to improve pilot perception under conditions of reduced visibility, of the deviation relative to the runway center line, as a contribution to the PAPI's.

4.4. That ANA publishes procedures for SIO operation.

4.5. That all meteo information, displayed in the control tower, is registered for accident and incident investigation.

4.6. That ANA publishes Air Traffic Control Service operational procedures.

4.7. To install in the control tower, wind displays according to international recommendations.

4.8. That the wind sensors of runway 11 are installed correctly according to international regulations.

4.9. That the average wind available at SIO be changed to vectorial average.

4.10. 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.

4.11. That written agreements are made between Meteo authority and the ATC authority, defining the tasks and responsibility of each authority in the area of

aeronautical meteorology.

4.12. That ANA:

4.12.1 Improves the emergency accesspath from the fire brigade building to the runway. Develops alternate accesspath and improve the drainage of the terrain along the runway.

4.12.2 Improves the water refill system of the fire fighting vehicles.

4.12.3 Reviews and corrects the emergency plans of national airports according to ICAO recommendations.

4.13. That conditions be created in order to realise inspections of the Air Traffic Control Services by ANA.

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