With comments by
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Refer to the cover letter for full comments.

MARTINAIR FLIGHT 495
AMSTERDAM SCHIPOL to FARO – 21 DECEMBER 1992
MCDONNEL DOUGLAS DC10-30 – REGISTRATION PH-MBN
ACCIDENT ON LANDING AT FARO

STATEMENT BY:
JONATHAN GILLESPIE FRAeS

The following statement consists of the Author's observations and analysis of specific sections of the 'Final Report on the Accident Occurring at Faro Airport – Portugal on 21 December 1992' published by the Director General of Civil Aviation for Portugal, the document entitled 'Analysis of Accident Involving Martinair DC-10-30F, MP495, Faro, 21 December 1992, Limited additional analysis', by H Horlings, dated 17 December 2012, and a draft of the expert's report by Terry Heaslip of Accident Investigation & Research (AIR) Incorporated.

1. Access to Meteorological Information

The Statement of Claim 4.4.1 to 4.4.8 discusses the attendance of the Captain of Martinair 495 at the 'Meteo desk' prior to the flight. 4.4.1 states that 'In 1992, it was standard for the crew to visit a professional meteorologist before the flight commenced'.

1.1 ANALYSIS

In the experience of the Author, before during and after 1992, it was not uncommon practice for pilots to 'self-brief' the meteorological conditions prior to the flight, without physical attendance upon a meteorologist. Weather and other flight information was frequently conveyed to pilots either by computer systems or by hard paper copies. All commercial pilots have always been required to demonstrate an in depth knowledge and understanding of meteorology at the time of issue of their licence. The practice continues to the present and in fact very few pilots will have any contact with a meteorologist.

The statements by crew and meteo did not match.

I.a.w. Martinair BIM, "the captain should have received a meteorological briefing before each flight" (Invest. report § 1.17.1.3). A briefing is not a self-brief.

The point here is that the crew did not follow the company rules.

1.2 CONCLUSION

Any implication that a visit to a professional meteorologist prior to a flight was a pre-requisite to the safe conduct of that flight is erroneous, as evidenced by the multitude of flights completed safely without such a visit.

This flight was not completed safely, but ended in a tragedy because the pilots under-estimated the weather. The crew did not follow the company rules; this can hardly be called erroneous.

2. Unserviceable Thrust Reverser Engine Number 2

The Number (No) 2 engine thrust reverser was reported as unserviceable prior to departure from Schiphol in a Technical Trouble Delay Report, which further reported that the platform vehicle required to access the No 2 engine high up on the tail fin was also unserviceable.

The KLM Aircraft Operating Manual (AOM) Dispatch Deficiency Guide (DDG) 3.1.17 page A, a temporary instruction, stated that 'One fan thrust reverser may be unserviceable provided: Aircraft shall not depart a station where repair or replacement can be made.' The DDG entry was marked with a star (*) and AOM

In 1992, a Martinair AOM applied, not a KLM manual. In the Portuguese accident in-vestigation report (ref. B) no reference was made to any KLM manual, only to Martinair manuals.

3.1.0 page 1 sub-para 02 showed that this meant the engineer should 'consult' with the cockpit crew regarding the unserviceability and that following the consultation dispatch 'may or may not be acceptable'

AOM 3.1.0 page 1 sub-para 03 stated 'Dispatch with an unserviceable item… should not be considered if repair or replacement can be made within the available time'. It continued 'If this is not possible, refer to subpara 02 above'.

On page 2, sub-para 04 stated that '…the final decision to dispatch or not rests with the captain'.

The DC-10 Master Minimum Equipment List (MMEL) page 78-1 showed that 1 fan reverser may be inoperative for dispatch.

A Martinair amendment to the KLM AOM on 3.3.6 page 2 stated 'Landing at Schiphol the use of reverse on all engines is compulsory' but also stated 'The use of reverse thrust on engine no 2 is always SCD' or subject to captain's discretion.

Also in Martinair AOM?

Invest. report § 1.17.1.4 lists AOM provisions on unserviceable thrust reversers: "Aircraft shall not depart a station where repair or replacement can be made".

Again, the crew did not follow company rules.

2.1 ANALYSIS

From the early days of DC-10 operations it became apparent that the No 2 engine was a particular vulnerability because of the specialist equipment required to access it for maintenance and repair. Generally this would be adequately addressed at an operator's base airport but many destinations, especially smaller airfields, did not have the requisite equipment and therefore maintenance would be at best very time consuming and at worst even impossible.

Thrust reverser unserviceabilities were not uncommon but when isolated to a single engine the impact upon performance was such that regulatory authorities and operators considered it acceptable to dispatch, except from an airport at which a repair could be made within a reasonable timescale. In the case of Martinair 495 the mobile platform normally used to access the No 2 engine at Schiphol was also unserviceable, and therefore a repair would probably have taken a long time and potentially put maintenance staff at risk from working at height with less than optimal equipment. The AOM and MMEL required that any unserviceable reverser should be deactivated, in part to prevent uncommanded deployment in flight, and in this case the No 2 reverser was deactivated using an alternative means of access. Martinair documentation required a 'consultation' between the engineer and the cockpit crew in such circumstances and subsequently stated that the final decision to dispatch rested with the captain.

To manage the risk of No 2 engine reverser problems at airfields without adequate maintenance equipment, and the consequent delays, operators sought to modify their procedures with respect to use of the reverser for landing. It was not unusual for landings at destinations away from base to be conducted without use of No 2 reverser. Conversely, in order to regularly test the serviceability of the No 2 reverser or to reveal any existing system defects, it was normal to require pilots to deploy the No 2 reverser on landing at base, where if necessary a repair could be made in a timely fashion. The 'compulsory' use of No 2 reverser for landing in Schiphol (see above) was a reflection of this operational desire rather than any actual need for the No 2 reverser to be serviceable and deployed for such landings. Furthermore the use of No 2 reverser was always at the discretion of the captain.

When windshear is expected, the flap position should be 35°, as recommended by company procedures (Portuguese Accident Investigation Report, ref. B, § 2.2.3). It is obvious that the pilots did not expect or experienced any windshear. In 1992, and still in 2015, there was never ever any windshear measured at the European Airport of Faro. Faro is not on the list maintained by Eurocontrol on the SKYbrary website.

Not i.a.w. AOM, as presented in the Portuguese investigation report.

2.2 CONCLUSION

The decision to depart from Schiphol with the No 2 engine reverser unserviceable and locked in the stowed position was acceptable within the governing rules and guidance. The fact that the access platform vehicle required to rectify the No 2 engine reverser was also unserviceable meant that a lengthy delay would have been incurred for no tangible safety benefit.

There must have been a safety reason for the limitations in the Martinair AOM.

3. Selection of Flap 50 for Landing

The KLM AOM 3.3.5 page 2 sub-para 02 indicated that the 'standard' flap/slat setting for landing was 35/LAND. However, this was overridden by a Martinair amendment on page 3.3.6 page 2 'Additional Information', which stated 'Standard flap setting for landing is 50°, alternate is 35°. This is due to the specific Martinair operation…'

KLM AOM relevant? Martinair FCOM Vol II on page 03-50-08: "Final flap selection is normally 35°. Use 50° flaps on short or contaminated runways (wet or covered by snow, ice or slush, or in the opinion of the Captain landing distance will be adversely affected".

3.1 ANALYSIS

50/LAND was the standard flap setting for landings for the Martinair DC-10. Unlike KLM, much of Martinair's operational network included shorter runways at regional airports rather than capital cities. The lower approach and landing speeds associated with higher flap settings (50 rather than 35 in this case) reduced the required landing distances for the DC-10. As a charter operator Martinair sought to achieve shorter turnaround times at destinations and the reduced braking associated with lower landing speeds allowed for more rapid brake cooling prior to the subsequent departure.

No, not true. 35° was the standard flap setting i.a.w. the Martinair FCOM Vol II on page 03-50-08. However, the use of 50° for landing on the short and wet runway of Faro airport was not against the Martinair procedures.

3.2 CONCLUSION

Flap 50/LAND was the correct landing configuration for Martinair 495 and in accordance with the applicable guidance.

4. Approach Speed

The H Horlings Analysis made several references to the airspeed of Martinair 495 during the final approach, in most cases stating that the speed was too slow, for example in 4.3.1 and 4.3.2.

4.3.2 stated that the speed '…varied from 138 to 150 kt from 54 seconds prior to touchdown', and 4.3.5 that '…the speed of flight decreased to 141 kt and, once the CWS was off, linearly to a level that was too low, namely 134 knots'.

The approach speed has to be at least 5 kt higher than V_{TH}.

The threshold speed for the selected landing configuration equated to 1.3 times the aerodynamic stall speed (V_S) for that configuration (AOM 3.3.5 page 1).

4.1 ANALYSIS

The primary function of the universal requirement to fly at or above a specific speed on approach is to maintain an adequate margin above V_S, allowing for fluctuations in the environmental conditions and for the response time of the pilots or automatic systems to correct any changes as they occur.

and compensate for gusts, deteriorated wing lift due to precipitation, etc.

Are you questioning the 1.3 safety factor? It is there for a reason – for instance to compensate for a wet or dirty wing. For a LW 161,400 kg, power off and flaps 50: V_S = 105 kt (AOM). The minimum threshold speed is to be 1.3 V_S and was 139 kt (out of a table). Additives are required to provide an additional margin for a safe approach under different meteorological circumstances (winds and gusts). In this case, the additive was only 5 kt; the approach speed had to be at least 5 kt higher than the threshold speed (139 + 5 = 144 kt).
Fact is that the airspeed overhead the threshold was 134 kt (DFDR data), 5 kt too low. The touchdown speed was 126 kt.

Although 138 knots or even 134 knots were below the calculated threshold speed for the configuration and weight, a significant margin was still maintained above V_S and the aircraft continued in controlled flight. The calculated threshold speed of 139 knots was by definition 1.3 times V_S and therefore V_S was approximately 107 knots (139 ÷ 1.3 = 106.92).

4.2 CONCLUSION

Throughout the approach the airspeed of Martinair 495 was well above the aerodynamic stall speed and therefore the assertion that the speed on approach was 'too slow' was incorrect.

5. Source of Surface Wind Data

The crew of Martinair 495 received wind information from a number of sources both before and during the flight. These included the forecast winds at Faro and elsewhere, the reported surface wind from Faro air traffic control (ATC) and the inertial navigation systems (INS) on board the aircraft.

With reference to the INS wind information the DC-10 AOM 2.15.4 page 2 sub-para 06 stated 'Wind is calculated as the difference between the TAS and the GS vector', in which TAS refers to the true airspeed of the aircraft, the actual velocity at which it is passing through the air, and GS to groundspeed, the velocity at which the aircraft is passing over the ground beneath. The difference between these two vectors represents the physical effect that horizontal movements of the surrounding air, (the local wind), is having on the aircraft's speed and direction of travel.

Isn't this valid only if the sideslip angle is zero, i.e. during coordinated flight. The sideslip angle was not zero during the final approach.

The same sub-para drew attention to the magnitude of several potential errors, or discrepancies between the INS indicated wind and the actual local wind. In particular it stated during the landing phase the indicated tailwind component could be up to 10 knots in error and the crosswind component up to 5 knots in error. It concluded with a note stating 'Calculations of maximum allowable wind components for landing should be based upon the Tower reported wind.'

5.1 ANALYSIS

If it is available the most reliable and accurate source of surface wind data for pilots for landing is generally that reported to them by ATC. Although the sensors from which the data are generated are not actually on the runway, for obvious reasons, they are normally sited close to the touch down area and provide a reasonable indication of wind over the runway.

If selected on the control and display unit (CDU), the INS wind observed during an approach could at best only give an indication of the instantaneous local wind at the aircraft's position and was subject to significant errors. The same was true for the INS indications of drift. This is because the INS does not specifically detect wind, instead it makes a mathematical calculation of the difference between the aircraft's progress across the surface of the earth (detected by the inertial systems) and the aircraft's progress through the air (detected by the air data systems). This difference is an approximation of the instantaneous wind the aircraft is encountering at the time.

Being well above the stall speed is not the point. A threshold speed, published in formal and approved manuals, exists for pilots to be used, period. Pilots are not to argue the magnitude of the speed. The actual, not the published, stall speed is affected by many factors, for instance by precipitation/ wet wings. 1.3 is the safety factor for this.
The pilots simply did not cross the runway threshold at the Martinair FCOM required airspeed, which was 139 kt. The Martinair FCOM Vol. II on page 03-50-03 states: "Maintain threshold speed (V_{TH}) plus additive until initiation of flare". Hence, the Martinair FCOM required 144 kt, not 1.3 V_S. The threshold speed was 134 kt (NTSB), definitely 10 kt too low.
Again a bust of the rules. An attitude as presented here by Mr. Gillespie leads to accidents, sooner or later.

Why?

Martinair procedure called for checking the INS calculated wind. This is what the captain did. Why? Not for fun or nice to know, but to be used. If INS wind increases above the limits, pilots are alerted that they are very close to, or exceeding aircraft limits, which requires action.

Except in the one or two seconds immediately prior to touchdown the wind encountered by the aircraft, reflected by the INS indicated wind, may differ significantly from the actual surface wind due to a number of factors, including gusts, down drafts, orographic and Coriolis effects and surface friction. In those last few seconds a pilot's attention will be focused on completing an accurate landing and not on the INS displays.

5.2 CONCLUSION

The pilots would have had no reason to doubt the accuracy of the ATC reported surface wind for the touchdown point, any more than they would on any other flight, and there were no potentially more accurate sources available to them. The INS readings were not an adequate substitute or a reliable indication of surface wind.

Conclusion should be that the ATC reported surface wind (150°, 15 max. 20 kt) exceeded the limits of the airplane both for a wet runway (15 kt) as well as for a flooded runway (5 kt).

The INS reading had to be used according to company rules.

Refer to cover letter for more.

6. Calculation of Surface Crosswind Component

the product

The crosswind component of a runway surface wind, that part of the total surface air velocity that is perpendicular to the runway axis, is ~~a function~~ of the sine of the angle between the wind vector and the runway axis, and the speed of the wind. The complexity of such a calculation was alleviated by the provision of a graph on AOM 3.2.3 page 8 (replicated on page 7 of the quick reference handbook or QRH), from which pilots could deduce headwind, tailwind ~~and~~ crosswind components.

or

The H Horlings analysis 2.3.8 stated that the captain's remark at 07:30.47, more than 2 minutes prior to landing, "wind is coming from the right thirty knots, drift twelve degrees so you make it 123 or so", (information probably derived from the CDU INS wind data) should have alerted the pilots to a surface crosswind component in excess of the limit for landing. This assertion was repeated with reference to the captain's remark 10 seconds before touchdown that the wind (again probably derived from the CDU) was "190 degrees with 20 knots".

A little over one minute before touchdown ATC notified Martinair 495 that the surface wind was '150 degrees at 15 knots, gusting to 20 knots', at the same time as issuing landing clearance. Seven minutes earlier ATC had reported the surface wind to Martinair 461 as 150° at 20 knots and 5 minutes before that to TAP 120 as 150° at 24 knots.

6.1 ANALYSIS

It is not easy to make a quick and accurate mental calculation of crosswind component from a wind direction and speed and the QRH provided a graph to facilitate this. However, reference to the QRH by the pilots or the flight engineer in the last 60 seconds of an approach would not be conducive to safe flight. Even if the crew of Martinair 495 had received further wind reports after the one issued with the landing clearance, it is unlikely that they could have made an accurate determination of the crosswind component, other than perhaps that it had increased or decreased from the previous value.

As discussed in 'Source of Surface Wind Data' above, there are many reasons why the INS wind displayed on the CDU may differ significantly from the actual surface wind at the touchdown point on the runway. The INS itself is prone to errors and is only capable of giving an indication of the local wind at the aircraft's current position.

Lots of words. Once again: The Martinair procedure called for checking the INS calculated wind, whether this data is accurate or not. The data had to be read from the display by the crew, which they did, but they did not use the data; they did not initiate a go-around de-spite the fact that the actual wind was exceeding the DC-10 limitations

The crosswind component at 100 feet above the surface ~~and several hundred metres from the touchdown point~~ will frequently be far greater due to local wind variations, surface friction and Coriolis effect.

During a non-precision approach it is necessary to adjust the aircraft's heading so as to achieve and maintain the published inbound approach course. The drift angle announced by the Captain ("…twelve degrees…") during the approach equated to the angular difference between the approach course of 111° and the aircraft heading required to be flown in order to maintain that course over the ground in the prevailing wind conditions at that moment. This would simplify the task of tracking the approach course accurately and had no relevance to the surface wind at the touchdown point.

It is entirely reasonable for a pilot to expect the most accurate surface wind information available to be that provided by ATC and to use it as the basis of a surface crosswind calculation. In the case of the last surface wind report from ATC to Martinair 495 (150/15 gusting 20 knots) the surface crosswind component could have been deduced to be approximately 10 knots up to a maximum of 14 knots. Furthermore, ATC had in the preceding 12 minutes transmitted surface wind information twice, on both occasions with a direction of 150°, first with a speed of 24 knots and later with a speed of 20 knots. From these transmissions it would have been reasonable for the crew of Martinair 495 to deduce that the surface wind was steady in direction and reducing in speed over a sustained period, and that the crosswind component was therefore diminishing.

6.2 CONCLUSION

It is irrelevant to this case to establish the accuracy of a wind source. The Martinair rule maker determined that the INS wind had to be used anyway; the company required the pilot to observe the INS wind, and of course use it.

Having established that the only accurate source of runway surface wind information available to the pilots of Martinair 495 was that reported by Faro ATC, it follows that the only reliable calculation of surface crosswind component would be that based upon the ATC reported wind. The last ATC reported wind indicated a crosswind component that was within the limit of 15 knots specified for a 'wet' runway.

A steady wind of 15 kt is within limits, ATC reported gusts to 20 kt are not. Again, the company required the pilot to observe the INS wind, of course to be used.

Even if they would only have used ATC reported winds, the airplane limits were exceeded by the pilots of MP495 for landing on both a wet and flooded runway.

7. Runway Condition

The DGAC Final Report stated that Faro ATC informed Martinair 495 that the runway was 'flooded', along with an instruction to report at 'minimums' or 'runway in sight', and that this message was acknowledged 9 seconds later. ICAO guidance described the term 'flooded' as meaning 'extensive standing water is visible' on the runway surface.

In subsequent statements the Captain of Martinair 495 indicated that he was not familiar with use of the term 'flooded' as a runway condition, and the First Officer stated that he had not heard the term before in that context.

In his first statement, the captain confirmed to know what flooded means. The term 'flooded' was already standard ICAO phraseology for at least 20 years prior to the accident. Martinair pilots should have been made aware during training, etc. Manuals should have been amended.

7.1 ANALYSIS

It is apparent that the pilots of Martinair 495 did not understand the meaning of the term 'flooded', when transmitted by ATC, as that described in ICAO guidance. This absence of understanding accords with the experience of the author who, during 30 years of flying, never encountered use of the term in the context of runway condition. The descriptive term of 'standing water' within the ICAO definition would

The term was introduced by ICAO 20 years before the accident. Your manuals, like those of Martinair, were obviously not up to date either.
The controller on the Faro tower was better informed.

The pilots never re-calculated the landing distance required using the most recently re-ceived wind data, but continued to use the data received from Faro ATIS, that were at least 30 min. old. Not very accurate.

more accurately describe the runway condition and in the experience of the author would have been more commonly used by ATC to alert pilots to significant water contamination.

Do you really mean that MP495 was lucky to crash, so that the runway condition was irrelevant?

The crosswind gusts exceeded the airplane limit, and so did the runway condition. The crew should have already initiated a missed approach at 9 nm and wait, or divert. Refer to cover letter.

Runway condition was and is reported by ATC to allow pilots more accurately to calculate the landing distance required in the prevailing conditions and if necessary to consider the relevant crosswind limitations, as modified by the effects of the reported conditions upon friction between the aircraft tyres and the runway surface. Martinair 495 did not skid off the side of the runway, nor did it overrun the length of the runway, prior to the accident and therefore the condition of the runway was irrelevant to the outcome.

7.2 CONCLUSION

??? Again, do you mean the airplane was lucky to crash?

Somebody (Martinair) did not make sure that the already 20 years old ICAO terminology was made known and understood by the pilots. If the pilots had understood (actually the captain did), the accident would not have happened.

The pilots of Martinair 495 did not understand the ATC report of 'flooded' to mean that there was standing water on the runway, and therefore comprehend the implications for required landing distance calculations and for crosswind limitations. However, the runway condition had no bearing on the outcome of the accident.

8. Approach Pattern

Chart in Accident Investigation report does'n show Jeppesen as the chart maker.

ranging

window on the HSI

from IP 9 nm

The Jeppesen chart 13-1 for the VOR (VHF omni-directional range) DME (distance measuring equipment) approach to runway 11 at Faro showed that the final approach descent from 2,000 feet was to be commenced from the final approach fix (FAF) 7 nautical miles out as indicated by the ~~VFA~~ VOR DME ~~beacon located on the airfield,~~ following the 291° radial (111° inbound course) from the ~~same~~ beacon. The primary route to arrive at the point 7 miles out on the 291° radial was indicated as establishing the aircraft in a racetrack pattern based upon the initial approach fix (IAF) 6 miles (DME) on the 291° radial, making right hand turns with the outbound leg ending at 10 miles (DME), prior to establishing back on the 291° radial back to 6 miles, to be flown at a minimum altitude of 3,000 feet. When cleared for the approach by ATC the aircraft was to descend in the racetrack pattern via the intermediate fix (IF) at 9 miles (DME) on the 291° radial to arrive at the FAF at 2,000 feet to commence the final approach descent.

Is not an alternative procedure, but for small, slow airplanes.

No, at 10 nm for fast and heavy Cat C/D airplanes, in accordance with the procedure that applied Dec. 1992.

An 'alternative procedure' was also shown on the chart whereby the aircraft would overfly the VFA beacon at a minimum of 4,000 feet and establish outbound on the 269° radial (for approach category C & D aircraft), descending to 2,000 feet. At 8 miles (DME) the aircraft was to turn right to establish on the 291° radial (111° inbound) in order to commence the approach from the FAF.

The DGAC Final report page 102 indicated that as Martinair 495 approached the VFA beacon from the north east, ATC issued a clearance 'outbound radial two six nine'.

You forgot to mention the short cut from 8 nm!

This chart was not in the investigation report. Did it exist in 1992?

Really? Was not in the report either.

Whichever of these routes was flown by an aircraft, the approach from the FAF to the minimum descent altitude (MDA) of 400 feet was the same, maintaining the 291° radial. The chart also provided guidance for crossing altitudes corresponding to each 1 mile (DME) from 6 to 2 miles, which would equate to a constant rate of descent between the FAF and the touchdown point. It also included guidance on rates of descent that would correspond to a 5% descent gradient for a variety of aircraft groundspeeds.

Mr. Gillespie 'forgets' to mention that the DC-10 crew did not follow the correct ap-proach path for a Category C/D airplane to which a DC-10 belongs, to the Final Ap-proach Fix (FAF); the turn to the 291 approach radial (= 111° TO) should have begun at 10 nm, not at 8 nm. From 10 nm, the airplane was not on the correct track to cross the FAF (at 7 nm) on the inbound radial of 111°. The approach was still not stable at 500 ft, not within one dot, not even with a stable N1. A go-around should have been initiated. Refer to the cover letter.

So, because ATC "probably expected"..., the turn at 8 nm was correct? Nothing in the transcript.
The procedure for a fast and heavy jet like the DC-10 requires a turn at 10 nm for stabilizing on the approach in time. That is why a Cat C/D procedure exists. ATC did not approve an early turn towards downwind, but the Captain did. Don't blame the ATC controller.

•Procedures in aviation are never based on "probably expected". Professional aviators do not (and are not qualified to) fool around with documented procedures that are designed to prevent accidents, even under worst conditions. The early turn was definitely not in accordance with the procedure.

This 'alternative procedure' is the procedure for Cat A/B airplanes, slow small propeller airplanes.
The ATC controller asked "confirm in VOR/DME procedure runway 11". MP495 didn't confirm.

8.1 ANALYSIS

Transcripts of the radio transmissions in the DGAC Final Report indicate that Faro ATC probably expected Martinair 495 to fly the 'alternative procedure' published on Jeppesen chart 13-1 and described above, although that specific clearance was not issued. Therefore commencement of the inbound turn from the 269° radial at 8 miles (DME) was correct and in accordance with the procedure.

8.2 CONCLUSION

No, MP 495 should have started the inbound turn at 10 nm (Cat C/D).
According to the ground radar data, MP 495 never crossed the FAF. The Autopilot did not compensate for the strong crosswind, because the wrong heading (080) was selected.

The pilots of Martinair 495 flew the correct initial approach track to the final approach fix (FAF).

Refer to the cover letter for more and a drawing.

9. Tracking the Lateral Approach Course

It is not a suggestion, it is evidence. Not only the position data originating from a long range radar, as included in the formal Portuguese accident investigation report, was used to verify the approach path, but also the CVR and DFDR data, and the settings of the autopilot. It all fits; no doubts whatsoever. Refer to the paragraph and the figure in the cover letter.

Section 4.2 of the H Horlings Analysis suggested that Martinair 495 did not correctly intercept the VOR DME runway 11 approach course of 111° and subsequently did not track the approach course correctly. This was based upon data derived from an ATC surveillance radar located a long distance from Faro, data that were diagrammatically presented in the DGAC Final Report and replicated in the H Horlings Analysis.

Aircraft position and track data presented in the draft expert report by Terry Heaslip refined the surveillance radar data using data recorded by systems aboard the aircraft, working back from the known touchdown point of Martinair 495 on the runway at Faro. These data indicated that the aircraft flew the approach track within the normal tolerances of accuracy required for a non-precision approach.

Actual data are more reliable than analysed data. Was the Heaslip method approved? Show me, explain the method to me.

I do, for instance, not believe that the Heaslip methods accounts for uncoordinated flight.
Refert to he cover letter.

Data from the cockpit voice recorder (CVR) indicated that the pilot flying Martinair 495 intended to fly a heading of 080° to intercept the approach course. The recording also indicated that the captain suggested flying a heading of 123° to allow for a drift angle 12° once the aircraft had commenced the final approach.

The final approach course was 111° inbound to the VOR beacon south of the Faro runway, whereas the runway centreline was 106° and in common with all 'offset' non-precision approaches this required the pilots to manoeuvre on to the runway centreline in the latter stages of the approach, primarily using visual references.

But they never did.

9.1 ANALYSIS

Refer to the cover letter for more comments on this paragraph.

The azimuth accuracy of surveillance radar in identifying the location of a target, in this case an aircraft, is dependent upon a number of factors. Most significant of these factors are the beam width of the radar signal, (the angular arc occupied by each single pulse of energy emitted from the antenna) and the distance between the antenna and the target.

The other way around: number of pulses reflected from a single distant target are a measure of the beam width.

~~The beam width determines the first and last pulse transmitted from the rotating antenna~~ that will be ~~partly~~ reflected by the target to the receiver – all pulses in between will also be reflected. The wider the beam is, the larger the effective radar signature of a target will appear; an extreme example would be a 360° beam width, which would detect the target all of the time, regardless of the antenna's rotation. It is impossible to achieve an infinitely narrow radar beam and the narrower a beam

There is a reason why the antennae of long range radars are so wide: they have a narrow beam width.

With a wide beam, an ATC radar would be useless; many airplanes would result in a single return/blip. At max. radar range, a single "target" is painted at least 3 times by the pulsing radar beam on one pass. A flight path of several miles perpendicular to the radar beam will provide enough data and will be accurate enough to record the flight path.

the lower the energy contained within it and consequently the shorter useful range of the radar. Surveillance radar does not require a high degree of accuracy but benefits from a long range and therefore tends to have a wide beam width.

The distance between the target and the radar antenna is directly proportional to the horizontal distance described by the target detection arc of the radar. A combination of the beam width of a surveillance radar and the significant distance between the radar antenna and Martinair 495 leads to the conclusion that the horizontal location data presented by the DGAC Final Report and replicated in the H Horlings analysis was of low accuracy and unreliable in terms of determining the precise position of Martinair 495 in relation to the approach course. H Horlings acknowledges these weaknesses of accuracy in 4.1.3; '…unclear is whether the radar's range resolution… is sufficient for accurately reflecting the path followed in the horizontal plane…' The data presented by Terry Heaslip refined the surveillance radar data using data from on board recordings and working back from the known touchdown position. Hence these data could be considered to possess a significantly greater degree of accuracy than the raw radar data. These data show that Martinair 495 followed the published approach tracks.

The accuracy of displaying the distance of an airplane to a radar does not change at increasing distances (speed of light, of radar energy, is constant). The radar data was accurate enough to confirm that MP 495 did not cross overhead the FAF. Did you check the range resolution of the radar?

Which recordings? Working back from the touchdown position? Please explain thoroughly.

The control inputs recorded by on-board systems do not agree with this conclusion.

In most regulatory jurisdictions the azimuth tracking accuracy for a VOR radial in flight examinations for the issue and renewal of a professional instrument rating is ± 5°. Whilst Martinair 495 may have been slightly displaced from the 291° radial for some of the approach, the data presented by the DGAC and replicated by H Horlings were not adequate to conclude that the aircraft deviated more than the normal 5° tolerance from the radial. The data presented by Terry Heaslip indicated that Martinair 495 was well within this tolerance. The evidence is entirely conclusive that the aircraft arrived at approximately the correct location on the runway so if it had at any time been significantly off track, that deviation was clearly corrected by the actions of the crew.

Irrelevant; FCOM required ±2,5° for a stable approach.

Radar data in DGAC report shows a larger angle. In addition, the heading required was larger too than would be required for airspeed and wind.

fabricated - not formal

Same remark. Evidence? No crosswind corrections were observed (DFDR data) for yaw and roll.

The choice of 080° as an intercept heading for the final approach course of 111° was entirely consistent with the standard instrument flying practice of adopting a 30° offset. This was an effective balance between achieving intercept within the distance available and ensuring that the angle was sufficiently small as to allow an accurate intercept.

Flying a heading of 123° with an apparent drift angle of 12° would be normal practice to ensure a ground track of 111°, in this case the approach course. The fact that the aircraft arrived at the threshold of runway 11 indicates that this strategy was largely successful. Had the aircraft been significantly north of the approach course as indicated in the DGAC Final Report (and replicated in the H Horlings Analysis), a ground track of 111° would have resulted in the aircraft paralleling the approach course and arriving at a point an equivalent distance to the north of the runway, which it did not.

Yes, is normal. But overshooting the approach radial is not normal. Not effective; the airplane never intercepted the radial thereafter. Which is not required when using the autopilot, as the Captain knew (CVR).

The pilots correctly manoeuvred the aircraft through an 'S' turn on short final approach in order to transition from the 'instrument' approach course of 111° to the landing course of 106°.

FDR data does not show an 'S' turn on short final, only inadequate line-up rudder and aileron control inputs.

9.2 CONCLUSION

Normal practice?
A wind 150/20 kt results in a drift angle of 5°; the approach heading had to be 111+ 5°=116°. For the last mile, the heading would have to be 106+6=112°. The airplane heading was around 125° (while rudder input zero). With the INS wind of 190/20, the wind correction angle would have to be +9°, a heading of 106+9=115°.
Why this difference? Because the airplane was north of the approach radial, as radar data shows, and had to use a larger heading to get to the airport on this visual approach.

> Not true, refer to the DFDR data and also to the NTSB letter on mishandling the CWS.
> The airplane never lined up with the runway heading; it touched down with a crab angle of 11° (DFDR data).

The pilots of Martinair 495 flew the published approach course ~~within the normal tolerances of accuracy. The 'S' turn to line up with the runway was correctly executed.~~

10. Instrument versus Visual Flight Rules

In order to complete the flight from Schiphol to Faro Martinair 495 had to operate in controlled airspace under instrument flight rules (IFR). To obtain approval to do so the operating authority filed an IFR flight plan for the entire flight.

> Vertical guidance was provided by a PAPI.
> Faro did not offer "instrument guidance". Just a VOR and a PAPI for visual approaches.

The VOR DME approach to runway 11 at Faro was a 'non-precision approach' (NPA) in that it provided guidance in azimuth (lateral guidance) but not in elevation (vertical guidance), allowing an aircraft to be navigated with reasonable accuracy to a point from which it may be manoeuvred visually to the landing threshold. The approach guidance was limited by the MDA (see above), below which the instrument guidance was no longer valid.

> ?? Not limited, but valid until reaching...

The approach lateral guidance required the aircraft to follow the 291° radial from VFA, which intersected the extended runway axis of 106° ~~only a short distance~~ to the west of the runway 11 threshold.

> one nm

10.1 ANALYSIS

> Faro does not offer an IFR/ instrument approach; only visual approaches.
> This is published on the approach charts and does not specifically have to be included in a new clearance.

Martinair 495 was operated in accordance with IFR throughout the flight, including the final approach.

Some part of all NPAs must be conducted by use of visual references by the pilots and continuation of the approach below the MDA without the required visual references is not permitted. A statement by one crew member to another, or to ATC that they are 'visual' or 'have visual contact' with the runway is merely informative and makes no change to the flight rules under which the aircraft is operating. Unless ATC issues a specific new clearance for a 'visual approach' the constraints and provisions of IFR remain.

The VOR DME approach to runway 11 would always require the aircraft to be manoeuvred laterally and visually on final approach because the 291° radial from VFA was not precisely aligned with the runway axis.

> During the last 1 nm which is on the approach chart as well. You cannot position a VOR on the runway.

10.2 CONCLUSION

Martinair 495 was operated for the entire flight, including the approach to land in Faro, ~~under instrument flight rules (IFR)~~ and was entitled ~~to expect a full air traffic control (ATC) service throughout.~~

> A VOR approach is not an IFR approach. The pilots were responsible for the approach, not ATC.

11. Use of the Automatic Pilot Systems

The DGAC Final Report found that the automatic pilot (autopilot) systems were operated in command (CMD) mode until approximately 500 feet altitude on final approach. Thereafter control wheel steering (CWS) mode was active down to approximately 100 feet, after which the autopilot was off.

11.1 ANALYSIS

> is an autopilot mode

> CMD is automated, but the pilot has to enter the instructions manually, for instance the heading.
> Speed is mainly controlled by the throttles, which were operated by a separate Auto Throttle System (ATS).

> pilot-selectable input systems

CMD was a highly automated mode by which the aircraft responded to pilot instructions, not via the control column as in manual flight, but via a number of remote interfaces. These allowed the pilots to command aircraft behaviour in terms of its attitude, and hence speed, altitude and heading, while the necessary deflections of the flight controls were commanded by the autopilot.

> and vertical speed

> forces

CWS was a less automated mode than CMD in that aircraft attitude in roll was commanded by pilot inputs to the control column in the normal way but the autopilot systems subsequently commanded additional flight control surface deflections to maintain the existing bank angle if that angle was greater than 3°, or the existing magnetic heading if the bank angle was less than 3°, (AOM 2.3.1 page 1 sub-para 03 refers). At entry into service of the DC-10 this type of automation was unique but more recently similar control philosophies have been adopted for complete aircraft flight control on all Airbus fly-by-wire (FBW) aircraft amongst others.

> or pitch angle

> irrelevant

Transition from CWS mode to autopilot OFF would not necessarily be immediately apparent to the pilots, especially in a dynamic flight environment requiring regular and frequent pilot inputs to maintain or achieve the desired flight path. In a statement from the pilot flying subsequent to the accident he stated that he was not aware of the mode change from CWS to OFF until the recorded flight data were described to him.

AOM 2.3.1 page 1 sub-para 02 showed that any of the following would lead to a mode change from CWS to OFF:

'Either AP release button is pressed.
AP lever manually moved to off.
Any sensor valid input is lost.
The platform selector switch is operated.
The pitch monitor is activated…
The roll monitor is activated…
An excessive CWS signal…
In TURB mode when manual stabilizer trim is used.'

> The most important one is missing here:
> Opposite/ conflicting control inputs from the left and right control columns.

There was also evidence produced that indicated opposing control inputs from both pilots would cause a reversion from CWS to OFF. However, there was no evidence which if any of these conditions caused the mode change to OFF on the final approach of Martinair 495.

> Check the schematic

> Not very relevant either.

The AOM 2.3.4 page 7 sub-para 09 stated that the 'autopilot must be switched to OFF: Not lower than 150 ft (except when already in CWS), when executing a non-precision approach.' AOM 3.3.5 page 9 sub-para 08 gave guidance on minimum altitudes from changing from CMD of OFF and from CMD to CWS on approach but provided no guidance on minimum altitude for selecting CWS to OFF. The aircraft handling 'feel' to the pilot was significantly different between CWS mode and autopilot off (manual flying) and this was one reason why pilots were not to make that mode change late on the approach. However, apart from this change in feel the aircraft remained eminently flyable in manual mode using similar control inputs. Some airlines at the time had forbidden their pilots from using CWS at all, probably because this early 'fly-by-wire' technology was not universally well understood.

11.2 CONCLUSION

So why did you write this paragraph?
NTSB concluded also that "the CWS and ATS functions were inappropriately used by the flight crew".

The CWS mode of the autopilot system was an early automated technology that was intended to reduce the dynamic inputs required by the pilot. CWS was disengaged ~~late~~ on approach but the cause of disengagement was not apparent and the pilots were probably unaware it was disengaged. However, the aircraft remained entirely flyable in conventional manual flight and therefore the disengagement of CWS mode was not relevant.

as required

CWS is programmed to disengage when conflicting inputs from pilot and copilot are measured, which actually happened.

12. Required Landing Distance

H Horlings' Analysis sub-para 3.3.4 implied that the landing distance available on runway 11 at Faro was marginal for Martinair 495 for a 'wet' runway condition and insufficient for a 'flooded' runway condition. The same sub-para listed the landing distance available as 2445 metres.

The crew of Martinair 495 recorded their calculated required landing distances as 1905 metres for 'good' braking action, equivalent to that expected on a dry runway, and 2400 metres for 'medium' braking action, equivalent to a wet runway. Also recorded was the required landing distance of 3055 metres for 'poor' braking action, equivalent to standing water. Martinair procedures required the addition of 200 metres to the calculated landing distance as a safety margin.

The Landing Data Card showed the actual landing distance. This includes the 200 m Martinair safety margin.

The numbers, by the way, do not match with the used KLM AOM Landing performance data.

12.1 ANALYSIS

Certified required landing distances include a 'safety factor', or distance increment, typically equal to 67% of the 'actual' landing distance in dry runway conditions, as demonstrated during ~~the~~ aircraft certification programme. This increment is to allow for unknown variables in environmental conditions and pilot performance. In this case the safety factor would have been 1705 (1905 metres minus 200 metres Martinair margin) ÷ 167 x 67 metres, or 684 metres. Therefore in addition to the margin of 45 metres landing distance available in excess of the calculated required landing distance for a wet runway (2400 metres), a further safety margin of 684 metres was also built into the calculation.

???

45 m is not a safety margin. That 45 m was not available for aircraft to operate on.

684 m for a wet runway? And for a flooded runway? A pilot has to use the numbers and not argue the applied margins.

The application of a required landing distance calculation is primarily to reduce the risk of an aircraft departing the end of the runway due to insufficient distance in which to disperse the kinetic energy at touchdown through braking, reverse thrust, lift dumping and drag devices and friction with the air and runway surface. Martinair 495 did not depart the end of the runway prior to the accident and therefore required landing distance was not relevant to the outcome.

12.2 CONCLUSION

The pilots applied the correct landing distance calculation for landing on a 'wet' runway and the runway length available was sufficient. However, the landing distance required and the runway length available had no influence on the outcome of the accident.

But the pilots did not apply the data for a flooded runway.
No influence?
If the touchdown would have been successful, the aircraft would have overrun the flooded runway, resulting in an accident.
Only if the landing would have been aborted, then an accident would not have happened.

13. Landing with Main Wheel Brakes Applied

This is not the point. The crew should not argue the numbers on the Landing Data Card, but only use them appropriately. Fact is that the wind data on listed on the Landing Data Card, as used for landing performance calculation, was not valid anymore and that landing on a flooded runway would not have been in accordance with the requirements in the Martinair manuals as approved by the aviation authorities, whatever the safety margins might have been.

Why Mr. Gillespie, do you continue to question safety requirements? You are not authorized to do so. If you do, you are not a cognizant and responsible pilot.

Sub-para 4.6.20 of the H Horlings Analysis stated, '…some wheels of the right main landing gear were braking forcibly at the moment that the aircraft touched the ground…' and 'may have cause the fatal fracture in the landing gear'.

13.1 ANALYSIS

AOM 1.14 page 6 sub-para 'The anti-skid system' stated 'A touchdown protection releases all brake pressure (free-wheeling) when ground-sensing mechanism is in flight mode… until spin-up of the aft wheels'. It was therefore not possible for the brakes to have been active at touchdown, whether or not the brake pedal was depressed by the pilot because all brake pressure was automatically released until the aft main wheels began to rotate. Thereafter the normal antiskid protection would have functioned to prevent wheel 'lock-up' skid and excessive mechanical loads.

> Was this AOM applicable to the Martinair DC-10? Did you check whether the front bogie brakes were also 'protected'? Ref. FCOM page 14-10-04 (Horlings' § 4.6.12): "The system incorporates locked wheel touchdown protection, to the rear bogie wheels only, to prevent inadvertent landing with the brakes applied".

> Look at the facts: Page 67of the GGAC report lists: Brake assemblies: Wheel 3 - Locked Wheel 4 - Locked Wheel 7 - Locked Wheel 8 - Unlocked

Furthermore, it is not unusual in aircraft certification trials for the flight test pilots to land with brake pedals fully depressed to demonstrate the minimum landing distance requirement, and whilst this may result in burst tyres and/or hot brakes there is no evidence that it has caused main gear fracture or separation.

> On all airplanes, Mr Gillespie? You are not a test pilot, are you? Pilots during normal operations never have their feet on the brake pedals.

13.2 CONCLUSION

The wheels of Martinair 495 were not 'locked' at touchdown.

> Not a smart conclusion

14. Effect of Reducing Airspeed on Final Approach

H Horling's analysis 4.3.5 stated that 'As from 10 seconds prior to touchdown, the speed of flight decreased… to a level that was too low, namely 134 kt'.

> The threshold speed was 134 kt as determined by the NTSB and copied by me. Thereafter the speed further reduced; touchdown speed was 126.0 kt, again according to the NTSB in the cover letter of the DFDR data read-out.

Data presented in the draft expert report by Terry Heaslip indicated that in those final few seconds the airspeed reduced to 125 knots.

14.1 ANALYSIS

> Refer to the cover letter for comments and figures.

Whilst these two documents disagree on specific values, both agree that that the airspeed reduced.

In normal, steady 1G flight, as on a stable descending approach to land, the lift generated by the wings of an aircraft must equal the weight of the aircraft otherwise it will ~~begin to~~ climb or descend. The basic formula for determining the amount of lift generated by the wings is C_L ½ρ V^2 S, where C_L is the coefficient of lift relative to the angle of attack of the wing, ρ or Rho is the density of the air, V is the airspeed and S is the area of the wing itself. The only significant variables at play over a short period, such as a few seconds, are the coefficient of lift and the airspeed and because the airspeed has an ~~exponential~~ influence on the equation, changes in airspeed have the most substantial short term effect on lift.

> quadratic/ squared

The reducing airspeed on final approach ~~would have~~ led to a reduction in the ~~exponential~~ V^2 (airspeed squared) component of the lift equation and consequent reduction in lift itself, such that the downward force of the aircraft weight exceeded the upward force of lift, thereby inducing an increased rate of descent.

14.2 CONCLUSION

The airspeed decreased during the last 7.5 sec of flight (DFDR data). But the pitch an-gle increased, therewith increasing the angle of attack. The vertical g data of the DFDR show that the rate descent decreases, which shows the effect of the increasing pitch angle. By pulling the control column during the last 5 sec. of flight, the pilots increased the pitch angle which led to a decrease of the rate of descent. Regrettably the pitch angle increase (to 8° - DFDR data) was not large enough for the wings to develop a high enough lift force to enable the captain-initiated go-around 3 sec. before touchdown.

The airspeed of Martinair 495 reduced in the last few seconds of the approach (see 15. below for the cause of the reduction), thereby reducing the lift generated by the wings and potentially increasing the rate of descent immediately prior to touchdown.

134 kt was the threshold speed. The touchdown speed is listed in § 4.6.16, Touchdown and go-around.

15. Cause of the Reduction in Airspeed on Final Approach

The DGAC Final Report, H Horling's Analysis and the draft report by Terry Heaslip all agree that the airspeed of Martinair 495 reduced significantly in the final few seconds. H Horling's Analysis 4.3.5 states that the airspeed at 10 seconds prior to touchdown was 141 knots and that it was later 134 knots but does not indicate the speed at touchdown. The Statement of Claim 6.7.5 states that the airspeed 10 seconds prior to touchdown was 140 knots and that the airspeed at touchdown was 126 knots. The draft report by Terry Heaslip showed the airspeed at 10 seconds prior to touchdown as 146 knots and the airspeed at touchdown as 127 knots.

The reduction in the last 2 seconds could also be caused by the increased pitch angle.

The Statement of Claim 6.7.4 implied that the reduction in airspeed was solely due to closure of the aircraft throttles.

15.1 ANALYSIS

The data from Terry Heaslip indicated that in the period of 10 seconds prior to touchdown the airspeed decreased by 19 knots, an average of 1.9 knots every second. Converted to metres per second per second (m/s^2) this deceleration equates to 0.97744 m/s^2. Using simple ~~Newtonian~~ equations it can be calculated that, if this rate of deceleration was maintained from the touchdown airspeed of 127 knots the aircraft would have come to rest after 2183.5 metres, less than the runway length at Faro, without allowing for any additional retardation due to friction, braking, lift dumping or engine reverse.

Are you serious about this calculation? I recommend not to use this any further. You are not an engineer, isn't it?

It is simply not possible that aerodynamic drag upon an aircraft in flight can equate to the combined decelerating forces acting on an aircraft during a normal landing, which also include the component of aerodynamic drag.

Both drag and the other mentioned forces are to the aft.
There is more, ask an engineer.

An alternative cause for the reduction in airspeed would be a strongly increasing tailwind component. In such cases the air through which the aircraft is flying is effectively catching it up, reducing the relative speed at which the aircraft is passing through the air mass. The inertia of the aircraft would for some time maintain the speed of passage over the ground until, in the absence of other influences, the aircraft's airspeed would increase due to the reduced drag from its flight through the air at a lower airspeed.

Does anybody understand this paragraph?

The data in the draft report by Terry Heaslip indicated that during the last 10 seconds prior to touchdown, as the airspeed reduced by 19 knots, the ground speed remained approximately constant at 143 knots. This confirms that the aircraft was not decelerating in its passage through space relative to the ground but rather the air mass in which it was flying was accelerating from behind it, effectively reducing the airspeed. Had the airspeed been decreasing in a static or constant air mass then the ground speed would have decreased accordingly over the same time.

Where is this data from? The data carrier did not survive the crash.

15.2 CONCLUSION

You cannot prove this, using objective data. Look at the DFDR data traces of pitch and airspeed, if you understand these.

The Martinair FCOM definition of windshear (Vol II page 05-60-04) is: "Severe windshear may be defined as a rapid change in wind direction and/or velocity that results in airspeed changes greater than 15 knots or vertical speed changes greater than 500 feet per minute".

This never happened to MP495.

The reduction in airspeed in the last 10 seconds of the approach was predominantly due to a windshear encounter manifested by an increasing tailwind component, not the aerodynamic drag of the aircraft following closure of the throttles.

16. Failure of the Landing Gear at Touchdown

The Statement of Claim 6.9.2 stated that '… the landing gear broke off, not until 80 metres further along' the runway after initial touchdown. 6.9.3 concluded that 'This means that the landing gear did not break off due to high speed descent…' The 80 metres were evidenced by a skid mark on the runway surface from the right main gear wheel.

The Statement of Claim 7.6.1 quotes the DGAC Report as stating '… the right main landing gear caused a slide mark of 30 meters…' The Statement goes on to conclude that 'The landing gear cannot have broken off as a result of too high a speed of descent… After all a 30 meter slide mark on the runway was observed'.

Were you not aware that the replacement of the right main landing gear was delayed at least two times, because the airplane was already sold?

16.1 ANALYSIS

The touchdown ground speed indicated by the draft report by Terry Heaslip was 143 knots. 143 knots (nautical miles per hour) equates to 73.5 metres per second (143 x 1852 ÷ 3600). The 80 metres referred to in the Statement of Claim represented a fraction over 1 second of travel along the runway surface. The tyre of the right main gear wheel would very likely have remained in contact with the runway surface for at least a second, even during a main gear leg collapse. If the second reference in the Statement of Claim to a 30 metre skid mark, as opposed to an 80 metre skid mark, was correct then it represented less than half a second.

16.2 CONCLUSION

The skid mark from the right main landing gear wheel tyre was not conclusive evidence that the main gear leg collapsed due to forces other than rate of descent.

Have you looked at a possible shear pin failure of the landing gear? And, as mentioned before, at blocked (front bogie) wheels due to applied brakes during touchdown?

I.a.w. the

Signed:

Name: **Jonathan Gillespie**

Date: **23 July 2013**