Avio*Consult*
Vlaskamp 14
2353 HT LEIDERDORP
Tel: 071 - 541 0851
GSM: 06 - 5532 4494
E-mail: info@avioconsult.com
Web: www.avioconsult.com
KvK: 28091749
Attachments: 2

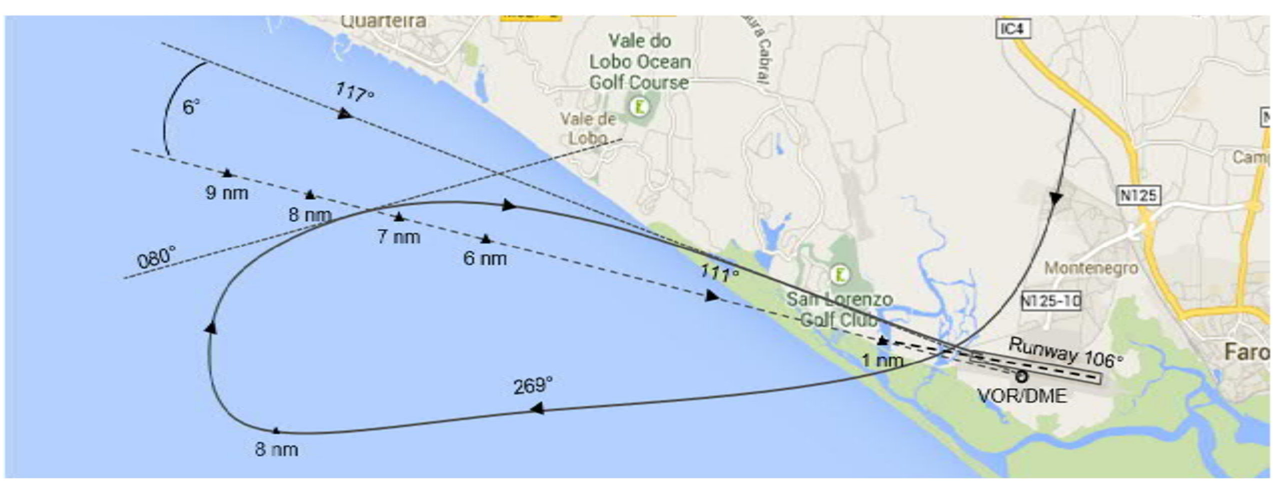
Critical Review of NLR Reports CR 93080 C and CR 94238 C, both on the Analysis of the DC-10 crash at Faro Airport, 21 Dec. 1992

Reference:
Report: *The last 80 seconds of flight MP495*, Avio*Consult*, https://www.avioconsult.com. Direct link: https://www.avioconsult.com/downloads/The last 80 seconds of flight MP495.pdf. Also in Dutch.

1. Introduction. The two NLR reports CR 93080 C and CR 94238 C were reviewed at the request of lawyers who subpoenaed both the State and Martinair for not telling the truth about the accident to victims and their next of kin, and for pilot errors respectively. The first NLR report CR 93080 C was already issued on 19 Feb. 1993, one week after the NTSB mailed the DFDR Factual Report (DCA-93-RA-011 dated 12 Feb 1993) from Washington, D.C. to the Portuguese Commission. Comments and remarks are included in text boxes in both attached NLR reports. Below, a summary and conclusions are presented. First, a brief summary is presented of airplane systems and a VOR/DME approach that was the only option to approach Faro airport.

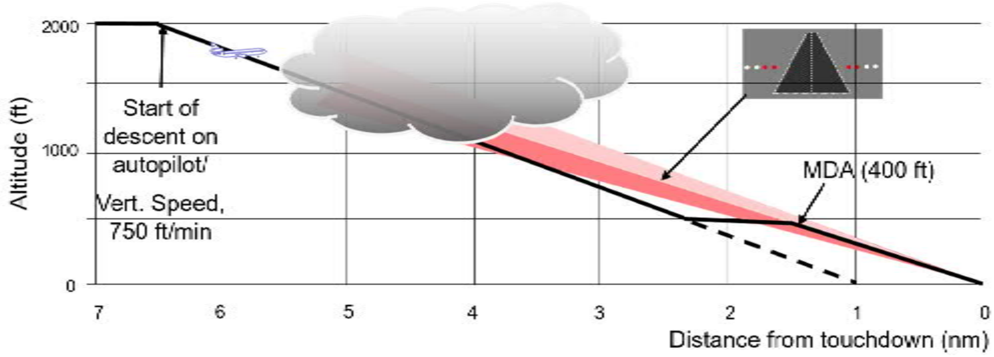
2. Summary approach analysis. The approach aids at Faro airport, in 1992, were limited to a VOR/DME navigation beacon for lateral approach guidance, positioned midfield at ≈1000m from the runway threshold and ≈200 m south of the runway and Precise Approach Path Indicators (PAPI} for vertical guidance, positioned left and right of the runway ≈450 m from the threshold, to indicate the 5.2% (≈3°) glidepath using red and white lights. The proper use of VOR/DME and PAPI as approach aids by pilots is specified in the Martinair/ KLM DC-10 Airplane Operating Manual (AOM).

3. In accordance with the Approach Chart issued by the Portuguese authorities, the final approach begins at 2000 ft altitude at 6.5 nm distance from and on a radial of 111° to the VOR/DME in the Command (CMD) mode of the autopilot that is set at a constant vertical speed, usually 750 ft/min. The 5° lateral offset from



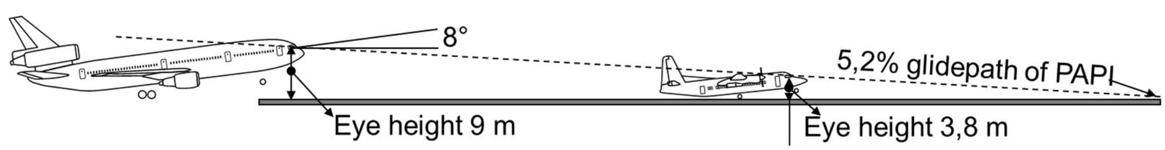
the runway bearing 106° is due to the location of the VOR/DME south of the runway. At 1 nm in front of the runway threshold, the 111 radial intersects with the extended runway centerline, at which point the airplane has to turn 5° left from the offset 111° VOR/DME approach radial to the runway bearing of 106°.

4. Below 500 ft, the vertical speed mode is to be disengaged, and the descent continues in manual control using the Control Wheel Steering (CWS) mode of the autopilot, using the lateral guidance of the then visible runway lights and the vertical guidance of the red and white PAPI lights. If the vertical speed during the initial final descent from 2000 ft was set a little too high, because the head wind component might have been larger than anticipated, the airplane reaches 500 ft earlier, below the PAPI glidepath, requiring straight and level flight until the PAPI indicated glide path (5.2%) can be intercepted. This is what happened to MP495, but is normal to this procedure and is shown in the adjacent figure.



5. NLR however, explained the 10 s level flight of MP495 at 500 ft for intercepting the PAPI indicated glidepath as "*the updraft of the downburst*" (CR 94238 C pages 21 and 26), but it was just part of the normal approach procedure to intercept the PAPI indicated glidepath from below before reaching the Minimum Decision Altitude of 400 ft. NLR engineers concluded up- and downdrafts during the approach, but were obviously not (made) aware of glide path discontinuities that are not uncommon during non-precision approach procedures.

6. In addition, since the DC-10 is a large airplane and uses the same PAPI as smaller airplanes, AOM 3.3.5 – 14 requires the pilot to *"bring the airplane gradually above the on glide-slope indication"* when the altitude is below 200 ft, to "*provide a 30 – 40 ft clearance at the threshold"*. This is what the copilot did, after the captain reminded him by saying "*too low*" three times (recorded on CVR).



This maneuver cannot be called an updraft either, because it simply was not; the pilots operated in accordance with the prescribed AOM procedure for a non-precision PAPI approach. The NLR engineers should have reviewed Airplane Operating Manuals or asked knowledgeable pilots to assist and/or to review the report.

7. NLR, during the analysis, used a (software) model of an Autothrottle System (ATS) that was definitely not of the DC-10 ATS. The DC-10 ATS receives, besides others, feedback of the position of an elevator and has a built-in gust filter. This feedback and the filter serve the following purposes.
When the pilot (or the autopilot) changes the position of the elevator by pulling or pushing the control column for adjusting the pitch angle, the feedback of the left inboard elevator position to the ATS causes the engaged ATS to increase or decrease the engine RPM at once by moving the throttles, to avoid changes in airspeed that might result from the long spool-up or -down time in the response of the big turbofan engines. This indeed occurred not only at 500 ft, when the pilot increased the pitch angle to maintain 500 ft until intercepting the PAPI lights, as shown in the figure above, but also just below 200 ft for maintaining the landing gear clearance above the threshold and earlier also at several other instances during the last 80 s of flight, following both proper and improper pilot control inputs. DFDR data show these engine RPM in- and decreases concurrent with the pitch changes, see attachments in Reference.

8. The airplane descended into light turbulence (1.0 ± 0.5 g) below 800 ft for the remainder of the flight, as DFDR vertical g data proves. When the built-in gust filter in the ATS, by monitoring the vertical g, measures gusts above a certain threshold, it increases the engine thrust for increasing the airspeed of the airplane with 5 kt above the selected approach speed, to achieve a larger safety margin. This happened several times during the last 70 s of flight and was a consequence of the normal operation of the ATS, as explained in AOM 3.3.5 – 03.
DFDR data not only show the in- and decreases of the airspeed due to gusts, but also due to pitch changes. The variations of engine RPM and airspeed were either pilot or turbulence induced and may not be justified as the effects of windshear, up- or downdrafts or microbursts. Knowledge of the DC-10 airplane systems and the non-precision approach procedure would have prevented these conclusions from having been drawn.

9. NLR did not include the pilot control and force inputs in the three (body) axes in the calculations and analyses. NLR was aware of the missing inputs, but still all variations in the flight path and 'measured data' were attributed to wind and weather, while the DFDR and AIDS data, that must have been available to the NLR prior to the release of the report, objectively prove that the copilot near continuously interfered with the proper operation of the autopilot, in both the Vertical Speed and CWS modes, by pushing and pulling the elevator and aileron controls inappropriately, and from 40 s before touchdown also the rudder. The co-pilot caused the variations that the NLR inappropriately brought to conclude windshear, up- or downdrafts or microbursts. The NTSB confirmed that the crew "*used the functions of the autopilot inappropriately*".

10. There was no windshear at Faro airport on 21 Dec. 1992; there never has been, as reported by Euro-Control in its SKYbrary knowledge bank. The Dutch Transportation Safety Board (DTSB) regrettably approved the inappropriate windshear analysis of the NLR. Below, a few details out of the two NLR reports are included. Both reports, provided with many more remarks in annotations, are either attached or separately available from Avio*Consult*.

11. CR 93080 C. Data is clarified from only an engineering standpoint, not with piloting experience. The engineer wonders about variations (inappropriately called oscillations), but was obviously not aware of the discontinuities that usually occur while conducting a non-precision VOR/DME approach, as was explained above. ACMS data was obviously used, but the AOM does not specify an ACMS in the DC-10, only an Aircraft Integrated Data System (AIDS). It is uncertain whether a separate ACMS existed and its data qualified for use as accurate flight data. The engineer states that he doesn't have pilot control force data, so he cannot distinguish between the influence of in- and outside disturbances, nevertheless he continues with his analysis, calculating wind, sideslip, etc. that therefore cannot be accurate. The accuracy of the 'ACMS data' and the consequence thereof in the results of the calculations, estimations and analyses are not discussed by the engineer. The autothrottle model used by NLR in this analysis (appendix B) was definitely not the model of a DC-10 autothrottle, because the feedback of the elevator and the gust filter were not included.

12. It is also believed that the engineer was not aware of the difference between sideslip and drift angles. Sideslip was used to calculate the wind, while pilots and the inertial navigation system only use the drift angle. The sideslip (angle) is usually zero by design (required directional stability provided for by the large vertical tail) and, following outside perturbations, is kept near zero by the yaw damper to avoid the passengers from getting sick. Except when the rudder is being operated for aligning the airplane with the runway during a crosswind landing, the pilot keeps his feet on the floor, not on the rudder pedals.
The presented, sometimes large sideslip data in the report cannot be right. The presented sideslip variations are that big that the passengers should have been very uncomfortable, but this was not reported. The engineer should have known about the yaw damper, and should have asked how a non-precision approach and crosswind landing has to be flown, but he continued using the wrong assumptions and estimates.

13. The word 'estimate' is used way too many times for a scientific report. Accelerations and calculated winds were used to determine the flight path, but this 'estimated' path does not agree with the analysis of both heading and airspeed using objectively measured DFDR data. What NLR calls windshear, microburst, updraft or downdraft are in fact the motions that were either common during a non-precision approach in

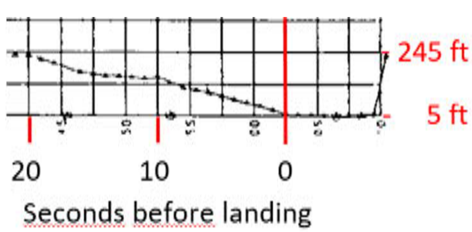
turbulence or induced by the inappropriate, near continuous control force inputs by the copilot while the vertical speed command or the CWS modes of the autopilot engaged (AIDS data). These force control input data might not timely have been made available by DTSB but still, NLR continued the analysis, obviously assuming an ideal continuously descending flight path, a perfect pilot, and flawless computer models. None of these happened. Blind faith in numbers and equations, that were obviously never verified with data of an airplane that really encountered a windshear, led to a report that is definitely incorrect and cannot be used to prove the occurrence of windshear during the approach to Faro, as its title suggests.

14. This report concluded windshear and that conclusion was used by DTSB in their comments to the draft Portuguese Report and even thereafter during the meeting with victims and their next of kin on 1 Dec 1994 in the Congresgebouw. Even the lawyers of the victims used it while the Portuguese Report did not conclude windshear. Report CR 93080 C should be publicly withdrawn.

15. CR 94238 C. This additional report was written after updated 'aerodynamic' data and new parameters such as control forces and control deflections became available. Regrettably the writer still did not familiarize himself with operational procedures, and did not review the operation of the DC-10 ATS prior to writing this report.

16. NLR engineers did not realize that a near constant heading of 125° during the last 80 seconds of the approach, as proven by the DFDR data, was very large if the airplane would have approached on the 111° radial; a large drift (wind correction) angle of 14°! This would be caused by a crosswind component of 34 kt at an airspeed of 139 kt, much too high for a flooded as well as for a wet, even a dry runway; the DC-10 limit on the latter was 30 kt. Since such a strong crosswind is inconceivable, the approach radial must have been larger than 111°, as aeronautical engineers should have concluded. The crosswind component was 20 kt during the last 80 s of flight, as proven by the constant heading and as shown by the AINS and reported by ATC, too large for landing on a wet of flooded runway. NLR writes about the large rudder pedal input 15 seconds prior to touchdown and concludes that the line-up was unsuccessful, but not why. Obviously, the rudder authority (at 95% deflection, 10 seconds before touchdown) was not adequate to align the airplane with the runway. The rudder is designed to indeed align the airplane in a crosswind of at least 30 kt, at the lowest approach speed and lowest landing weight. Not being able to align the airplane in a 20 kt crosswind in fact also means that the airplane did not approach on the extended runway center-line. In addition, NLR did not question the rudder reduction from 7 seconds before to around zero just prior to touchdown (page 10). A pilot would never do this in a crosswind approach. If the crosswind had increased, he would need more rudder. Hence, the approach can neither have been flown on the 111° radial nor on the extended runway center-line. The crosswind did not increase either. NLR did not discuss the inappropriate early rudder input from 07:32:05 (40 s before landing).

17. The 'sink rate' (usually called rate of descent - ROD) during final approach changed from 760 ft/min in the draft of this report (CR 94xxx), to an 'inertial' 966 ft/min in the final version. Fig. 17 shows a change of vertical speed in 2 s from +625 to -2625 ft/min just prior to touchdown. This is not realistic for a 161.400 kg body on a 5.2% glide slope at a low altitude. Objective DFDR Radio altitude data does not confirm this either, see adjacent figure. DFDR data should have been used, rather than such unreliable calculated data.



18. In the report, NLR used words like divergent and oscillations, while none of these can be proven to have occurred using objective DFDR and AIDS data. Windshear, updrafts, downdrafts, microbursts? No, none of these happened. These were concluded and presented by NLR because of unfamiliarity with the standard non-precision approach procedure that applied during the approach to Faro (§ 2 and 3 above).

19. NLR did obviously not review DFDR data (engine rpm, pitch angle) to conclude that the captain initiated a go-around at 3 seconds prior to touchdown. The go-around failed, but the causes of this failure, like a too low and decreasing airspeed, too low an engine rpm and deploying spoilers after touchdown while the thrust levers were forward, were not discussed. The question in § 2.3 on "*what went wrong during the*

very final segment of flight" was not answered. Instead, the airplane motions after touchdown seemed to be of more interest to the engineers (page 12).

20. NLR calculates wind speed but does not tell how, does not use the drift angle, being the difference between the air and ground velocity (vectors). NLR mentions that the wind is recorded on the ACMS, therefore there are doubts about the validity of the data (page 20). The crosswind component can also be verified and reconstructed from the objective DFDR data of heading, airspeed and approach radial (ground course), which was not done.

21. NLR writes about sideslip angle which seems to be considered the same as drift angle: Fig. 16 shows a large sideslip already from 110 seconds before touchdown, while there was no rudder pedal activity and the yaw damper operated normally. A sideslip angle is definitely not the same as a drift angle.

22. NLR labeled the time in text and figures with UTC, while in fact they used radar time. Radar time + 30 seconds = UTC. NLR might have been unaware of the (time) errors made by the commission of investigation, though.

23. NLR accepted several changes by DTSB lead investigator Frans Erhart to delete or change any remark that might not point towards windshear, because windshear obviously had to be the cause of the accident to conceal catastrophic pilot errors, affecting the scientific reliability and independence of the report.

24. This report was not written by a flight operations-knowledgeable engineer, and was obviously not reviewed and approved by flight operations-familiar managers and pilots. This report should have been rejected by DTSB. The occurrence of windshear, up- or downdrafts or microbursts cannot be confirmed with this report. There was no windshear, only light turbulence and a co-pilot who inappropriately used and operated both the vertical speed and control wheel steering modes of the autopilot, and the autothrottle system, as DFDR and AIDS data prove. These conclusions were confirmed by the NTSB in their letter of 26 Oct. 1994 (Appendix in the Portuguese investigation report). In addition, the flight crew did not adhere to the prescribed Martinair approach procedures.

25. Main conclusion. The lack of knowledge of DC-10 airplane systems, of flight operations and of the non-precision approach procedure for approaching Faro airport, as well as the blind application of improperly developed and evaluated computer models led to many errors in these reports and to the conclusion that these reports are not suitable as scientific publications for determining whether windshear, up- and downdrafts or microbursts occurred and contributed as cause of the accident with the Martinair DC-10. There was no windshear and were no downdrafts or updrafts encountered by flight MP495 during the approach to airport Faro on 21 Dec. 1992.

26. During the accident, 57 people lost their lives, many more were badly injured. The victims and the next of kin of the deceased have the right to learn what exactly happened. These NLR reports do not contribute to the search for the truth, on the contrary, they are deficient and misleading. They were used by an incompetent DTSB and by lawyers to avoid Martinair to have to pay too much financial compensation.

27. Recommendation. It is strongly recommended to publicly withdraw both reports, and to require NLR engineers to read the referenced report *The last 80 seconds of flight MP495*, the attached, annotated NLR reports and never ever again write a flight-operations related report without consulting a knowledgeable pilot or Flight Test Engineer.

Harry Horlings
Lt-Col ret. RNLAF
Graduate FTE USAF Test Pilot School
AvioConsult

Attachments: (Can also be downloaded: https://www.avioconsult.com/downloads/NLR-Faro.zip)
- NLR CR 93080 C with annotations
- NLR CR 94238 C with annotations