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FLIGHT RECORDER DIGITAL
AND AUDIO DATA ANALYSIS

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COMMENTS ON THE EVIDENCE RELATING TO THE ACCIDENT TO AIR FRANCE A320 AIRBUS F-GFKC AT HABSHEIM 26 JUN 88

1. The Final Report issued by the French Investigation Commission contains several statements and conclusions which are not supported by the evidence and in some cases are in direct conflict with the evidence contained in the report. Some of the statements made are completely erroneous.

   An analysis of other available evidence raises a number of questions which are not commented on within the body of the report.

2. The Digital Flight Data Recorder (DFDR).

   a) The initial read-out of the recorder produced some anomalous data in the seconds leading up to the accident. It was concluded by the commission (see page 18 of the report) that this was due to "a fold in the tape and/or by dust". They claim that "after cleaning and smoothing out of the tape", correct reproduction of all the data was obtained.

      Comment:

      Four seconds of data had been flagged as out of synchronisation on the first replay. The second replay recovered this data and inserted an additional 4 seconds of data into the time history. A fold in the tape is an unknown occurrence, in my experience, in this type of tape transport. It could only be caused by mis-handling on removal of the tape from the recorder. A fold, if it did exist, would be very difficult to eliminate. If the tape were creased, it would not cause the loss of 8 seconds of data. The tape travels at about 9mm/sec and a maximum of 1 second of data would be lost through this cause. This particular loss of data cannot be attributed to dust either.
      The report on the recovery of the data by the Centre D'Essais en Vol, Bretigny, states that the recorder was undamaged. This poses the question of the necessity to remove the tape in the first place. Most accident investigation authorities would have replayed the recorder itself, thus avoiding possible damage to the tape and maximising the tape to head track alignment. The report also states that the replay was carried out at 8 times the recording speed. On this model of DFDR, the Fairchild F800, the best speed has been found to be twice the recording speed. Replaying at times 8 from an outside track - the

report states that the accident data was on track 1 - was just asking for trouble.

b) It is claimed (still on page 18 of the report) that the errors in sign made on the first replay were corrected on the second replay. On page 22 it is claimed that the aircraft touched the trees "as shown by a decrease in longitudinal acceleration".

Comment:

The longitudinal acceleration was not corrected for sign error from the first replay. (The take-off at Basle is shown with increasing negative longitudinal acceleration). The data, corrected for sign, has to be further corrected for the pitch attitude of the aircraft. When this is done, the recorder shows that the rate of increase in deceleration is actually arrested during the last few seconds of valid data, just the reverse of what would happen on impact with the trees.

It is also stated that all the parameters were correctly recorded and that the operation of the recorder was perfectly correct throughout the flight.

If this was the case why were no comments made regarding:

i. Mach number, which recorded garbage throughout.
ii. The loss of synchronisation at time TGEN 73.
iii. Engagement of ALT HOLD at TGEN 162 (ALT CAP had been engaged at TGEN 99) which is recorded as remaining engaged until TGEN 330, 4 seconds from the end of the recording.
iv. The change from "WHEEL" page to "ENGINE" page on the CRT display at TGEN 330.
v. The engagement of autothrottle N1 mode for take-off, changing to SPEED mode at TGEN 99, and reverting to N1 mode at TGEN 330.
vi. The HP valve FC for engines 1 and 2 bit status change from ones to zeros prior to take-off, followed by a change to ones again at TGEN 250, followed by a change to zeros again for the last two seconds of the recording prior to the crash at TGEN 333.
vii. An indication of the operation of the No.1 Engine START valve at TGEN 334, the last sub-frame with valid data recorded.

c) On page 19 of the report it states that after the first impact with the trees, the DFDR continued to operate for "around one second" and then gave incoherent data for "around two seconds" followed by data from a previous flight. On page 22 this statement is amplified to "followed by the data relevant to the flight preceding the one in which the accident occurred (closed loop operation of the flight data recorder)".

Comment:

i. There is no evidence at all on the recorded flight data to indicate the point of impact with the trees. No indication by changes in the recorded normal, lateral or longitudinal accelerations are present. The radio altimeter does not record passage into the trees by suddenly reducing to zero as it should have done (this parameter had been faithfully recording the passage over trees in the minutes leading up to the accident). All the DFDR shows is that normal recording ceased instantaneously at the end of TGEN 334. The next sub-frame is flagged as being out of synchronisation and contains some obviously invalid data, particularly from just under half way into the second. However, the very first sample is Engine No.1 N1 which has recorded a drop in RPM from 83% to 56%. One eighth into the second Engine No.2 N1 has recorded a drop in RPM from 84% to 65%.

ii. The data from the previous flight does not follow the accident flight as stated, it precedes it on the tape. The DFDR has a 25 hour duration. This aircraft had only flown 22 hours so any data following the accident flight originates from a different aircraft. However, this data is not valid in-flight data as the last 4 seconds show the aircraft doing Mach 2.05 at 4000 feet for two seconds followed by 2000 feet at Mach .52 and .78 during the next two seconds, with a tailwind component of 148 knots. It should be noted that the four sub-frames (seconds) following TGEN 334 are flagged as out of synchronisation. The final sub-frame, not flagged, also contains the rubbish quoted above.

Reference to the listing from the first read-out shows that following TGEN 1522, which it can be demonstrated equates to TGEN 334 on the final report listing, 17 seconds of data were output. The GMT printed for the first second is 1245, for the next 4 seconds 1046, for the following 4 seconds 0848 and for the final 8 seconds, undecoded hours and 46 minutes. The first 3 seconds are flagged as out of synchronisation, the next 5 as in synch, and the final 9 seconds as out of synch.

There is no evidence to confirm that the last valid data is at the point in time when the aircraft entered the trees. It will be remembered that the commission recovered 8 seconds of data from 4 out of synch frames just prior to the accident. No consideration appears to have been given to the possibility of losing seconds in the unrecovered out of synch data at the end of these listings.

It is difficult to equate the report from CEV that the tape was cut just to one side of the left roller on the tape transport with the 17 seconds of data following the alleged point of

impact with the trees. At the nominal recording speed of 9.144 mm/sec this represents 155 mm of tape from the recording head to the cut.
The evidence suggests that some data is missing prior to the actual accident. This is in conflict with the commission's report where it is suggested that the recorder was stopped by a break in the power supply cabling located in a landing gear wheel-well. If this had been the case we would have some seconds of valid data as the aircraft was passing through the trees.

d) On page 21 of the report it states that there was "perfect agreement between the readings of the radio altimeter and those of the barometric altimeter".

Comment:

There was not and there should not have been perfect agreement between these two altimeters. The report quotes some figures based on calculations of QNH altitudes but the comparison with the radio altimeter readings over the airfield should be by correcting to QFE pressure, providing height above airfield elevation. This comparison shows that there was good agreement, not perfect.

e) The explanation of the operation of the flight controls given on pages 34 to 36 and the statement on page 22 that the aircraft response to the commands given by the crew showed no anomalies poses the question:
Why did the elevators move from a 5 to 7 degrees nose up demand towards a nose down demand over the last 3 seconds of valid data when the pilot had increased his nose up demand on the side-stick from 8 degrees to 16 to 17 degrees in the same time period? i.e. the aircraft controls were responding in the opposite sense to the pilot's demands.

f) On page 24 there is a statement that the horizontal stabiliser was set to approximately 4.5 degrees "which is consistent with the DFDR indications, last recorded value was 4.4 degrees)".

Comment:

The listings described as the first to be produced and those shown in the final report only provide data to whole degrees, the final values being 4 degrees. This suggests that the available data differs from that used by the commission during their investigation. Why?
A further point is that some parameters, such as pitch and roll attitude, are sampled more frequently than shown in the data listings thus losing valuable evidence. Did the commission not use all the data that was recorded, for the important parameters at least, and if not why not?

The F800 records a sequential frame number every 4 seconds. Was this data decoded?

g) Page 43 contains a statement that an accompanying graph shows that the engines bettered the minimum certification spool-up times. A graph comparing normally achieved times rather than the minimum required would make the point better.
The following page states that the engine acceleration was "normal up to the moment when, after impact with the trees, they started to absorb the vegetation debris during the final falling of the aircraft into the forest".

Comment:

But there is no recorded data of the passage of the aircraft into the trees. The video evidence suggests that several seconds elapsed before the engines would have ingested any debris.

h) Integration of the corrected longitudinal acceleration produces a curve which is totally dis-similar in shape to the recorded airspeed and groundspeed traces. The shape of this curve is consistent with the changes in the recorded pitch attitude but the the airspeed and groundspeed traces are not. Was this anomaly considered by the commission?
Did the commission compare the recorded pitch attitude with the video recordings?

i) Appendix 1 to the report shows the track of the aircraft derived from the radar recording. No comment is made in the report that this track, which shows the aircraft turning right and then left to line up with the runway, differs in sense from the evidence of both the DFDR and the video recordings. The DFDR shows the aircraft initially turning left and then right to line up; the videos also show the turn to the right.

3. The Cockpit Voice Recorder (CVR).

a) Page 17 of the report claims that recordings of the radio transmissions on the CVR were correlated with those on the air traffic control tape recordings which have a time-base recorded on one track.
This page also contains a description of the spectral analysis which was carried out on the CVR recording and claims that this enabled "a very accurate chronology of the end of the flight to be obtained with an error of less than 0.1 of a second, in using events with precise time and frequency signatures (synthetic voice of the radio altimeter, characteristic noises, voices, etc.)".

Comment:

i. The report contains a number of differences between the times of radio transmissions shown in the ATC transcripts in appendix 5 and the equivalent times shown in the CVR transcript in appendix 6. These differences do not equate with

the claim of very accurate time correlation having been established.

ii. Accurate timing of the CVR cannot be achieved by reference to audio warnings because these all have a tolerance and the exact frequencies are not known. It is impossible to derive precise timing from analysis of voice frequencies.

iii. No reference is made to the fact that the DFDR has a very accurate elapsed time-base and the commission does not mention having utilised this for time correlation.
Examination of the DFDR recorded press-to-transmit events, (using the 1 second elapsed time increment of each DFDR sub-frame) starting at 12:40:44, shows that there is good correlation with the times quoted in the ATC transcript and reasonable correlation with the CVR transcript. However, the very last radio transmission by the crew was the word "Roger" in response to ATC passing the QFE. The ATC transcript gives the time of their transmission as 12:44:25 but does not give the time of the response. The CVR transcript gives the time of the ATC transmission as 12:44:27 and the response as 12:44:31.
The DFDR timebase gives the time of the response as 12:44:27 - a 4 second difference in the time quoted in the CVR transcript. Correlating DFDR events with the CVR transcript shows that this sudden 4 second discrepancy is maintained to the end of the recording. The effect is to make the DFDR events appear to occur 4 seconds later than they really do. This makes an absolute nonsense of the claim to have a timing accuracy of 0.1 seconds between the various sources of evidence.

b) Page 19 of the report states that the CVR continued to operate for "around" 1.5 seconds after impact with the trees, and then stopped.
The last descriptions of sounds in the CVR transcript are "increase in engine speed" followed by "noises of impact in the trees".

Comment:

i. This differs from the transcript from a preliminary report which follows the reference to engine speed with "boom! boom!" and "noises of impact in the trees (2 louder bangs)".
Why was the reference to the boom noises deleted? I understand some witness evidence has suggested the sound of compressor stalls was heard. Was the sound described as noise of impact with the trees positively identified as not having originated from the engines?
The initial contact with the trees would not have produced the sound of two bangs. Have we lost the end portion of the CVR recording as well as the DFDR?

c) Pages 41 and 42 refer to the determination of engine speed by spectral analysis of the sounds recorded on the CVR and a video recording. The statement is made that "these analyses are perfectly in agreement and show that the engines increased in power as soon as go-around was initiated".
A further statement is made that the video film enabled the reproduction of several additional seconds after impact with the trees and that the last maximum N1 engine speed was 91%.

Comment:

i. Why were the spectral plots not published? It would seem impossible for the two analyses to be perfectly in agreement since the video recording is from a source external to the aircraft and subject to errors in frequency measurement due to Doppler effect. No mention is made in the report about the methods adopted, if any, in correcting for this effect. This throws into doubt the accuracy of the claimed maximum engine speed derived from this source.

4. CONCLUSIONS

1. The evidence of the DFDR and the CVR does not justify the claimed known point in time when the aircraft entered the trees.

2. The timebase used by the commission is suspect.

3. A number of claims made in the report need justification and further proof and a number of questions need answering.

4. In the interest of aviation safety, an independent replay and analysis of the DFDR and CVR tapes should be undertaken.

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