Indian Airlines Accident Report - APPENDIX I

FINDINGS - Findings of the Court of Inquiry convened by the Government of India Director General of Civil Aviation to investigate and report on Indian Airlines Airbus A-320 aircraft accident on 14th February, 1990 at Bangalore.

COMMENTS - Government of India, Ministry of Civil Aviation, decisions on the Findings from the Report of the Court of Inquiry on the accident to Indian Airlines Airbus A-320 aircraft on 14th February, 1990 at Bangalore.

1. The aircraft had a valid certificate of Airworthiness and was maintained in accordance with the approved maintenance schedules.
Gov't Comment - Agreed.

2. There was no defect reported on the airframe, engines and their systems prior to the ill-fated flight nor any defect, abnormality or emergency reported during flight by the pilots, till it crashed.

Gov't Comment - Agreed.

3. There was no apparent indication of any abnormality of flying controls.
Gov't Comment - Agreed.

4. Investigation of the engines revealed that the engines were developing power and were at or near-full power when they sheared off from the wings after hitting the embankment.
Gov't Comment - As per DFDR data and engine examinations, the engines had accelerated to high power and not full power at the time of impact with embankment.

5. DFDR data reveals that there was no failure of aircraft electrical, hydraulic, yaw damper and cabin pressurisation **and communications** systems. There was no smoke or fire warning. The GPWS activated 'Sink Rate' warning four times from DFDR seconds 324 onwards.
Gov't Comment - Agreed.

6. The wreckage examination revealed that the slats were extended, flaps were in full down position, spoiler lever armed and landing gears were down thereby indicating landing configuration of the aircraft.
Gov't Comment - Agreed.

7. Weather conditions were clear.
Gov't Comment - Agreed.

8. All security procedures prior to commencement of the flight were carried out and there is no evidence of sabotage.
Gov't Comment - Agreed.

9. The pilots were appropriately licensed to undertake the flight.
Gov't Comment - Agreed.

10. Capt. C.A. Fernandez was flying the aircraft from the L.H. seat as CM.l and it was his first route check for command endorsement under supervision of Capt. Gopujkar, Check pilot of A-320 aircraft.
Gov't Comment - Agreed.

11. Although VOR-DME approach was discussed between the pilots, it is not clear whether VOR-DME let down procedure as per Jeppessen Manual was followed. From 42 NM to 7 NM the aircraft was under surveillance of Bangalore Air Route Surveillance Radar and from 7 NM onwards indications are that visual approach or a mixture of visual with Non-precession approach was being followed.
Gov't Comment - Agreed.

12. The aircraft reported R/W in sight when it was 7 NM west on left base of R/W 09 and was cleared to land by Bangalore Tower at 13:02:17 hrs. which was acknowledged by the flight crew.
Gov't Comment - Agreed.

13. Landing checks were completed but go around altitude was not set. Similarly, Flight Directors were not put off at the time of landing checks.
Gov't Comment - Agreed.

14. The aircraft was slightly higher and also having higher speed when landing clearance was given but thereafter it came to proper profile for approach to land.
Gov't Comment - Agreed.

15. At 13:02:42 (295 DFDR Time Frame - i.e., about 35 seconds before the time of first impact with the ground). the aircraft was at a height of 512 ft. AGL. Since then it started coming down below the profile and aircraft speed was falling below the target approach speed. There is no specific indication that the crew monitored the speed and height since then.
Gov't Comment - Agreed.

16. The relationship between the pilots was quite cordial.
Gov't Comment - Agreed.

17. When Capt. Fernandez (CM.1) was pulling the side stick control off to pitch up the nose and arrest the sink rate, the aircraft entered the Alpha protection zone (high incidence protection) at 318 seconds and finally at 323.1 seconds Alpha floor (thrust protection to increase thrust to take off power) was triggered and in all probability at 323.9 seconds (or at 324.3 seconds), Alpha floor was activated by Capt. Fernandez taking the side stick movement to full back position.
Gov't Comment - Not acceptable as Alpha floor is a self activating system when certain conditions are met and is not triggered intentionally by the pilot. This finding needs to be re-worded as follows:
"When Capt. Fernandez (CM1) was pulling the sidestick control to pitch up the aircraft and arrest the sink rate, the aircraft entered the Alpha protection zone at 318 seconds and finally at 323.1 seconds Alpha floor got triggered and in all probability at 323.9 seconds (or at 324.3 seconds) Alpha floor got activated".

18. Airbus Industrie was not aware of the exact delay between Alpha floor triggering and its activation due to signal transmission through a number of computers and the delay seems to have been investigated only after the accident. Even now there is no definite knowledge of the exact delay which may vary from 0.8 to 1.2 seconds. None was aware of this delay factor so far.
Gov't Comment - Agreed.

19. Basically Alpha floor functioning is built as a protection against wind shear, but the pilots seem to be under the impression that the protection from this system will be available to increase power of the engines in any emergency without any time delay and a false sense of faith has been reposed on this system.

Gov't Comment - Not acceptable as the features of Alpha floor protection are clearly explained during the training of pilots. Comments against finding No. 17 may also be seen.

20. This crash would not have happened:

(a) if the vertical speed of 700 ft. as asked for by Capt. Fernandez at about DFDR 294 seconds had been selected and aircraft had continued in speed/vertical speed mode;
(b) if both the flight directors had been switched off between DFDR seconds 312 to 317 seconds; or
(c) by taking over manual control of thrust i.e., disconnecting auto thrust system and manually pushing the thrust levers to TOGA (take off - go around) position at or before DFDR 320 seconds (9 second~ to first impact on golf course).

Gov't Comment - Agreed. This finding could be amplified further by adding that had the pilot set the go round altitude of 6000 feet on the FCU, it would have prevented the aircraft from going into idle open descent mode as it is not possible for the aircraft to go into idle open descent mode below FCU selected altitude.

21. In all probability one of the pilots acted to put off FD.2 by about TF.313 seconds, but FD.2 failed to go off resulting in confusion in the mind of Capt. Gopujkar.
Gov't Comment - Agreed.

22. There is nothing to show that the pilots realised the gravity of the situation even after the Radio Altimeter synthetic call-outs of 400 feet, 300 feet and 200 feet.
Gov't Comment - Agreed.

23. Whatever be "the exact timing of the throttle movement, it was too late an action to prevent the crash.
Gov't Comment - Agreed.

24. Alpha floor protection was triggered at 323.1 seconds and got activated at 323.9 seconds (or 324.3 seconds) which again was too late to develop sufficient power in the engines to prevent the crash.
Gov't Comment - Agreed.

25. At DFDR seconds 329.8 the aircraft first impacted the golf course. At what point of time 6.125 'G' was experienced and whether its recording by the DFDR was correct, are not decided. No expert witness was examined by anyone to explain the nature of 'G' force and the manner in which DFDR records the said force.
Gov't Comment - The timings of first impact is agreed. However, the force of first impact is not relevant to the accident.
.

26. Soil testing report indicated that the first touch down area was harder as compared to the second touch down point.
Gov't Comment - Agreed.

27. The aircraft bounced for nearly 1.194 seconds after first impact of about 0.42 seconds**.**
Gov't Comment - Agreed.

28. The impact against the embankment caused the detachment of both engines, landing gears and crushing of lower front fuselage.
Gov't Comment - Agreed.

29. Thereafter the aircraft hopped over the 'nullah' and parallel road and landed on a marshy land about 320 feet from RW 09 boundary wall and came to rest about 150 feet short of the boundary wall after dragging on the ground.
Gov't Comment - Agreed.

30. Forward portion of the aircraft was engulfed in a huge fire in the beginning. The fire propagated later towards the rear.
Gov't Comment - Agreed.

31. The rear left door was opened by an airhostess and most of the surviving passengers escaped through this door. A few passengers escaped by opening emergency exit windows.
Gov't Comment - Agreed.

32. The percentage of survivors in the front, middle and rear zones of the aircraft were around 16%, 27% and 73% respectively of the passengers occupying the seats in these zones.
Gov't Comment - Agreed.

33. RA emitted auto call-outs of 400, 300, 200, 100 and 50 (or 30) till the first touch down.
Gov't Comment - Agreed.

34. CVR-DFDR correlation reveals that at about 38 to 40 seconds prior to the first touch down the aircraft was in proper auto thrust speed mode and was descending in vertical speed mode. At DFDR seconds
292 altitude capture mode was activated indicating that a selection on the FCU panel close to MDA of 3300 ft. had been made at an earlier stage of the flight.
Gov't Comment - Agreed.

35. Prior to 305 seconds, the aircraft went into idle open descent mode. A conclusive finding as to what pilots did at this point of time is not possible.
Gov't Comment - Agreed to the extent that "Prior to 305 seconds the aircraft went into idle open descent mode". As regards the cause for engagement of Idle/Open descent mode, the Court itself' at page No. 310, para 14 has noted. "It is also probable that he wanted to select go around altitude first and therefore selected the altitude knob, but while dialing it, the words just delivered to him by CM-l regarding vertical speed influenced his action and thus he selected the altitude of 700 feet without even realising that he has selected wrong altitude". It was this action of the pilot (CM~2) which most probably put the aircraft in idle open descent mode.

36. DFDR recording shows that auto thrust -speed select discrete changed status from '1' to '0' at 295 seconds. There is no doubt that plane was in idle open descent mode by 305 seconds, by which time the plane was at an altitude lower than 400 feet Radio altitude.
Gov't Comment - Agreed.

37. The aircraft could not sustain the height and speed in the approach profile because of fixed idle thrust in idle open descent mode.
Gov't Comment - Agreed.

38. The aircraft never went to speed mode thereafter, though it was the most proper mode for landing.
Gov't Comment - Agreed.

39. In all probability, for some reason the pilots did not realise the gravity of the situation of idle/open descent mode and being at a Radio altitude below 300 ft. at DFDR TF. 305 seconds.
Gov't Comment - Agreed.

40. The ATC tape at Bangalore Airport was found recording the tower and approach frequencies only and time was not recorded.
Gov't Comment - Agreed.

41. The crash fire tenders of HAL Airport must have reached the boundary wall of the airport at the earliest point of time, but, subsequently there was delay in opening the gate and reaching the fallen aircraft.
Gov't Comment - Agreed.

42. Capt. Fernandez had occupied L.R. seat after more than 2 months of operating as CM.2 from RH seat without any simulator or aircraft training prior to change over.
Gov't Comment - Agreed. It should however, be clarified that there is no stipulation of imparting any training for change over to left hand seat after operating from right hand seat.

43. The aircraft touched on its main wheels for the first time in the Golf Course of Karnataka Golf Association approximately 2300 feet short of the beginning of R/W 09.
Gov't Comment - Agreed.

44. During the short flight between first and second touch downs, four trees, in line with the two main gears and the two engines, were broken by the aircraft at heights from 10 feet to 7 feet 2 inches and the aircraft hit the ground on its landing gear in a slightly right wing low altitude.
Gov't Comment - Agreed.

45. There was an explosion when fire commenced and there was also a major fire, forward and aft of the right wing.
Gov't Comment - Agreed.

46. RH rear door had been opened from outside by airport fire services personnel when they reached the aircraft.
Gov't Comment - Agreed.

47. Few passengers escaped through overwing exits and through fuselage openings created by crash/explosion.
Gov't Comment - Agreed.

48. 86 passengers and 4 crew lost their lives at the time of the accident. Two more died later in hospitals. 21 passengers and one crew suffered serious injuries.
Gov't Comment - Agreed.

49. 81 of 90 passengers who died at the time of the accident have died due to shock as a result of burns sustained.
Gov't Comment - Agreed.

50. 32 victims had injuries to lower limbs, 20 to the head and 7 had thoracic injuries causing possible physical inability to escape the fire in time.

Gov't Comment - Agreed.

51. Cause of death of Capt. Gopujkar and Capt. Fernandez was due to shock as a result of burns sustained. Autopsy reports indicated no frac**tures.**
Gov't Comment - Agreed.

52. Tail section behind rear galley housing CVR and DFDR and APU showed no signs of damage.
Gov't Comment - Agreed.

53. Though major part of fuselage was destroyed by fire the RH portion of cockpit structure which had the front wind shield, No.2 sliding window (Direct Vision window) and NO.3 window survived the fire though partially burnt.
Gov't Comment - Agreed.

54. The RH NO.2 sliding window was in an openable condition at the time of the crash.
Gov't Comment - Agreed.

55. A witness had seen a person hitting against the cockpit RH side window before fire engulfed the plane.
Gov't Comment - Agreed.

56. All computer units had suffered extensive damage.
Gov't Comment - Agreed.

57. Speed drop from 132 kts to 106 kts has taken 26 seconds from DFDR times 297 and 323 seconds.
Gov't Comment - Agreed.

58. Computers have not held the actual angle of attack at design limit of 15 degree or at speeds of Alpha max as indicated in FCOM. Actual angle of attack has gone beyond and speed has dropped below the appropriate values.
Gov't Comment - Will be referred to Airbus Industrie.

59. Movement of left and right elevator towards maximum allowable up position as indicated against DFDR time frame 330 is according to design and condition of flight (without expressing anything about the reliability of DFDR recording at this point of time).
Gov't Comment - Agreed.

60. The times of change of FMGC used FD mode and GFC 1 bus (18) discrete status do not correspond to the time of CVR conversation of FDs to be put off and putting them off.
Gov't Comment - The finding is not based on material evidence; hence not acceptable.

61. Idle/open descent mode of auto thrust system has engaged some time after DFDR time 295 seconds. The exact reason for this mode engagement cannot be explained or proved because of non-availability of FCU selected altitude data or FCU controls selection data on DFDR.
Gov't Comment - Acceptable to the extent that FCU selected altitude or FCU control selection data are not recorded on DFDR. As regards engagement of idle open descent mode, the most probable cause has been explained in comments on finding No. 35.

62. Right bank has been induced when CM.1 pulled side stick fully aft and Rudder has been used to lift wing at DFDR times 323 and 327. Loss of about 7 feet has been attributed to this cause by Airbus Industrie.
Gov't Comment - Technically it *is* difficult to establish such a corelation.

63. CVR has shown no sign of panic or anxiety about speed loss till CM.l spoke - "Hey we are going down". There were no calls of speed deviation though speed was 106 kts at DFDR time 323 seconds.
Gov't Comment - Agreed.

64. Low speed display on PFD on A-320 is excellent and they are computer generated. If correct they cannot be mistaken and speed trend display is compelling. There is no digital read out of value of current speed. PFD Air Speed display data is not recorded on DFDR.
Gov't Comment - Agreed.

65. Power awareness may be deficient in A-320 pilots when auto thrust is active, as even an Airbus Industrie test pilot was not aware of power required during final approach at 1000 FPM rate of descent.
Gov't Comment - In regard to this finding, it must be pointed out that in aircraft of this class, auto thrust system is meant to reduce the workload of the pilot on the final approach by maintaining the required speed. It is the speed which is of paramount importance and when flying with manual thrust on this aircraft, it is easy to maintain speed even without referring to engine power indications. *This* is because of the facility of the speed trend arrow.

66. There is no warning if auto thrust brings thrust to idle for whatever reasons during approach.
Gov't Comment - Agreed.

67. Idle/open descent on short final though corresponding to an aircraft in dangerous configuration leading to limit flight condition, is indicated in 'GREEN' on PFD and not in 'RED'.
Gov't Comment - The finding relates to design features of the aircraft and will be referred to Airbus Industrie.

68. Movement of one side stick control is not reflected on the other.
Gov't Comment - The finding relates to design features of the aircraft and will be referred to Airbus Industrie.

69. Static thrust levers when auto thrust is active removed the feel of thrust lever movement and visual indication of position corresponding to actual thrust or thrust change trend. Only way to know the thrust is to read the value on ECAM.
Gov't Comment - The finding relates to design features of the aircraft and will be referred to Airbus Industrie. An A-320 operators conference held in Cairo early this year to review the autothrust fixed throttle concept supported the concept of nonmoving throttles incorporated in A-320 aircraft.

70. Use of VOR/OME during visual approach is in conformity with Indian Airlines and Aeroformation procedures. Use of FD during visual approach is not prohibited by Airbus Industrie. The pilots in the instant case, followed a visual or a mixture of VOR/DME with visual procedure in all probability.
Gov't Comment - Agreed.

71. CM.l pulling side stick backed up by moving thrust levers to TOGA is in conformity with training imparted to pilots by Aeroformation.
Gov't Comment - Agreed.

72. Information in documentation provided by Airbus Industrie to pilots during training and to Indian Airlines has not been very clear and sometimes not appropriate to Indian Airlines aircraft.
Gov't Comment - The finding is not specific. It should be pointed out that the documents are continuously updated.

73. The very grave consequences of IDLE/OPEN DESCENT mode engagement either inadvertently by the pilots or automatically due to a system malfunction is not part of the simulator profile training. This indicates that no one may have visualised such an occurrence to ever take place.
Gov't Comment - Not acceptable. All aircraft while descending from cruise level, descend normally on idle open descent until the aircraft reaches approach profile. At this stage speed has to be carefully monitored. This is a part of training programme of the pilots and there is nothing special as far as A-320 is concerned.
However, the Airbus Industrie has carried out modifications to ensure that the aircraft reverts to speed mode during final approach, if aircraft gets into a low speed situation.

74. The flight control computers seem to have permitted the aircraft to maintain the minimum speed of 106 kts which had been reached at DFDR time 323 seconds. The speed increase to 113 kts before the first touch down and conversion of this kinetic energy into potential energy was prevented. Was this prevention due to the computers is a matter to be considered.
Gov't Comment - Finding is not clear. Due to inertia of motion an aircraft in descent would take some time to arrest the descent and start climbing. There can be no sudden reversal of descent into climb. The angle of attack can also not be excessive. The computers have an angle of attack protection system of the aircraft designed to prevent stalling of the aircraft.

75. Landing mode of the flight controls may have contributed during the last 3 seconds in the prevention of conversion of kinetic energy into potential energy.
Gov't Comment - As in finding No. 74.

76. It seems that Aeroformation simulator training on simulator fitted with CFM 56 engines has been accepted by the concerned department of the DGCA without obtaining full data on the simulator capability even though this had been thought of and concern had been expressed earlier during 1986-87 regarding use of an incompatible simulator even for recurrent training and proficiency checks. No additional stipulations had been prescribed after this acceptance.
Gov't Comment - Not acceptable. European certification authorities have certified the A-320 simulator with CFM-56 engines for training pilots on A-320 aircraft with V-2500 engines.

77. Part of the CA.40.B (J) check in case of both these pilots was carried out on a simulator with CFM.56 engine data.
Gov't Comment - Agreed.

78. Recommendation for approving Airbus Industrie / Aeroformation instructors has been made and approval granted without receiving confirmation of A320 PIC rating and A320 PIC experience in the case of two pilots.

Gov't Comment - Agreed. It may be stated that the two pilot instructors were approved instructors of Airbus Industrie and Aeroformation and were already imparting training to A-320 pilots.

79. The subject of Bangalore HAL Airport holding a licence or not was not relevant and would have in no way affected this crash.
Gov't Comment - Agreed.

80. All primary and secondary flight controls appeared to have operated normally.
Gov't Comment - Agreed.

81. Increase of N2 RPM on slats extension on VT-EPN was less than those recorded on Airbus Industrie aircraft and two other Indian Airlines aircraft.
Gov't Comment - Agreed.

82. The engines have operated normally throughout and have not contributed towards the cause of this accident.
Gov't Comment - Agreed.

83. Under conditions prevailing and based on the DFDR data CVR transcript, the accident commenced at approximately DFDR time 321 seconds. The aircraft had no chance of survival thereafter.
Gov't Comment - Agreed.

84. If ILS was available at Bangalore for R/W 09 most probably, this accident would not have occurred.
Gov't Comment - Not acceptable. This finding of the Court is based on the presumption that if ILS had been available, the pilots would have chosen to make ILS approach and moreover a correct ILS procedure would have been followed. This cannot be said with certainty. The pilot in this case have not chosen to follow a full VOR-DME approach even though such facility was available at Bangalore airport. This accident has occurred primarily due to non-adherence of procedures, particularly non-monitoring of the speed in the final approach. Furthermore, the accident occurred on a clear day with excellent visibility condition and without much traffic.

85. But for the severe fire, the loss of lives would have been considerably less.
Gov't Comment - Agreed.