REPORT

ON

ACCIDENT TO ALLIANCE AIR BOEING 737-200 AIRCRAFT VT-EGD ON 17TH JULY, 2000 AT PATNA

BY

THE COURT OF INQUIRY

AIR MARSHAL P. RAJ KUMAR, PVSM, AVSM, VM

PROGRAMME DIRECTOR (FLIGHT TEST)

AERONAUTICAL DEVELOPMENT AGENCY, BANGLORE

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D.G.C.A.

NEW DELHI
31ST MARCH, 2001

CONTENTS

LIST OF ANNEXURES

EXECUTIVE SUMMARY

On 17th July, 2000, Alliance Air flight CD-7412, a Boeing 737-200 ADV aircraft VT-EGD crashed at 0734 hrs. (IST) while on approach to Patna airport. The flight had taken off from Kolkata at 0650 hrs. and was on a scheduled flight to Delhi via Patna and Lucknow. Two Pilots, four Air-hostesses and 52 passengers were on board. Patna weather was clear with a visibility of four kilometers. Approximately, 30 seconds prior to the crash, the crew requested a 360º turn due to being high on approach and were cleared by the Air Traffic Controller on duty. The aircraft stalled shortly after commencing the 360º turn and crashed in the Gardani Bagh residential area. All the crew and 49 passengers were killed as a result of the crash. The aircraft was completely destroyed by the crash and post crash fire. Five persons on the ground lost their lives.

The Court of Inquiry determined that the cause of the accident was loss of control of the aircraft due to human error (air crew). The crew had not followed the correct approach procedure which resulted in the aircraft being high on approach. They had kept the engines at idle thrust and allowed the air speed to reduce to a lower than normally permissible value on approach. They then maneuvered the aircraft with high pitch attitude and executed rapid roll reversals. This resulted in actuation of the stick shaker stall warning indicating an approaching stall. At this stage, the crew initiated a Go Around procedure instead of Approach to Stall Recovery procedure resulting in an actual stall of the aircraft, loss of control and subsequent impact with the ground.

The Court of Inquiry also determined that the aircraft was fully airworthy and was properly maintained. No in-flight failure of any system had occurred. In the course of the investigations, the Court observed that Patna airport had several operational constraints resulting in erosion of safety margins for operation of Airbus 320/Boeing 737 type of aircraft. In addition, Patna airport had no further scope for expansion.

The Court has recommended the following :-

(a) Improvements in crew training procedures and re-organisation of the quality control set up of Alliance Air.

(b) Removal of constraints for operation of A-320/B-737 aircraft at Patna airport.

(c) Development of Air Force station Bihta as an alternative to the existing Patna airport.

(d) The Airports Authority of India (AAI) should maintain landing and navigational aids and airport equipment at all airports in the country to the required standards.

GLOSSARY OF TERMS

ACTUATOR :- A device that transforms hydraulic fluid pressure into mechanical force, which is then used to operate control surfaces of the a/c or other components such as landing gears.

AILERON : - A control surface mounted on the rear (Trailing edge) of each wing, moving in opposite directions controls the lateral axis of the a/c.

KINEMATICS: - A process that involves fitting curves through available Flight Data Recorder (FDR) data (Heading, Pitch, Roll), obtaining flight control time history rates from these curves and obtaining accelerations from these rates. Forces, Moments and Aerodynamic Coefficients are then obtained from those accelerations using Newton's Laws.

LANDING REFERENCE SPEED, V_{REF}: - The minimum speed at the 50-feet height in a normal landing. This speed must be at least 1.23 times the 1g stall speed in the landing configuration.

OAT : - Outside Air Temperature – the free air static (ambient) temperature.

REPORT ON THE ACCIDENT INVOLVING

ALLIANCE AIR BOEING 737-200 AIRCRAFT

VT-EGD AT PATNA ON 17TH JULY, 2000

(a)	**Aircraft**		**Engines**	
	Type	: Boeing 737	Maker :	Pratt & Whitney
	Model	: 200	Type :	JT8D-17A
	Nationality	: Indian	Left	: S/N ESN-P-674152B
	Registration	: VT-EGD	Right	: S/N ESN-P-709360B
(b)	**Owner**	:	Indian Airlines Ltd. Airlines House, New Delhi	
(c)	**Operator**	:	Airlines Allied Services Ltd. (Alliance Air), IGI Airport, New Delhi	
(d)	**Pilot-In-Command**	:	Capt. M.S. Sohanpal	
	Extent of Injuries	:	Fatal	
(e)	**Co-Pilot**	:	Capt. A.S. Bagga	
	Extent of Injuries	:	Fatal	
(f)	**No. of Cabin Crew**	:	Four	
	Extent of Injuries	:	Fatal	
(g)	**No. of Passengers**	:	52	
	Extent of Injuries	:	Fatal - 45	
			Injured - 6	
			Unhurt - 1	
			(Four of the injured passengers	

			succumbed later)
(h)	Place of Accident:		**Gardani Bagh Near Patna Airport** 1 Km Left of Approach Path to R/W 25 and 1 km short of the runway threshold Latitude - 17°35'24" North Longitude - 085°06'18" North
(I)	Date And Time of Accident	:	17TH July, 2000 at 0734 hrs.

(All timings in the report are in IST)

SUMMARY

Alliance Air Flight No. CD-7412 departed Netaji Subhash Chandra Bose International Airport, Kolkata at 0651 hrs. on 17th July, 2000 bound for Patna-Lucknow-Delhi. After normal departure from Runway 01R, the aircraft climbed to FL 260 on track to Patna via route W52. The aircraft was under the control of Kolkata Radar from 0652 hrs. to 0659 hrs. It changed over to Kolkata Area Control Centre. The aircraft reported position SAREK at FL 260 at 0712 hrs. and changed over to Patna Control with information that there was no reported traffic for descent. The aircraft contacted Patna ATC at 0713 hrs. and gave it's ETA at Patna as 0736 hrs.

Patna ATC cleared the aircraft to PPT VOR ILS/DME ARC Approach for R/W 25. The ATC Officer communicated that Patna METAR originated at 0650 hrs. stated **"Wind calm, Visibility 4000 metres, Weather Haze, Clouds Broken 25000 feet, temp 29°C, Dew Point 27°, QNH 996 hPa, No Sig"**. The aircraft was cleared to descend to 7500' and report 25 DME from PPT VOR. The aircraft reported 25 DME at 0726 hrs. The aircraft then descended to 4000' on QNH 996 hPa and was asked to report 13 DME for ILS/DME ARC Approach R/W 25. The aircraft reported commencing the ARC at 0728 hrs. The aircraft reported crossing lead radial 080 at 0731 hrs. and coming on to the Localizer. The aircraft was then asked to descend to 1700' on QNH 997 hPa with instructions to call established on Localizer. The aircraft informed Patna ATC at 0732 hrs. that it would like to do a 360° turn due to being high on approach. Patna ATC sought confirmation from the aircraft whether it had the airfield in sight and on receiving an affirmative reply, asked the aircraft to report on finals for R/W 25 after carrying out a 360° turn. This was acknowledged by the aircraft at 0732 hrs. This was the last communication from the aircraft. Immediately thereafter, the aircraft was spotted by the Air Traffic Controller in normal descent aligned with the R/W 25. It, however, appeared to be high on approach. The aircraft then turned steeply to the left losing height all of a sudden and disappeared from sight behind a row of trees. The Air Traffic Controller observed a huge column of smoke rising from the

Gardani Bagh area outside the airfield perimeter and initiated crash action.

INITIATION OF INVESTIGATION :

On receiving information about the accident, Shri H.S. Khola, Director General of Civil Aviation along with S/Shri K. Gohain, Dy. Director General of Civil Aviation, N. Ramesh, Dy. Director General of Civil Aviation, S.S. Nat, Director of Airworthiness, Delhi Region, V.K. Chandna, Director of Air Safety proceeded to the accident site on 17th July, 2000. Investigation was started immediately in coordination with officials of Airports Authority of India, police, Indian Airlines and Alliance Air. Chairman & Managing Director, Indian Airlines, Secretary, Ministry of Civil Aviation along with Honorable Minister of Civil Aviation also visited the accident site on the same day. Shri P. Shaw, Regional Controller of Air Safety, Kolkata also visited the accident site on 17th July, 2000 and started the accident investigation. Shri P. Shaw, Regional Controller of Air Safety, Kolkata was appointed as Inspector of Accidents, under Rule 71 of Aircraft Rules, 1937 to investigate the accident by the Director General of Civil Aviation on 17th July, 2000.

Subsequently, the Govt. of India, Ministry of Civil Aviation appointed a Court of Inquiry under Rule 75 of the Aircraft Rules, 1937 vide Notification No. AV.15013/2/2000-SS dated 8th

August, 2000 to investigate the accident. The Court of Inquiry was headed by Air Marshal P. Rajkumar, Programme Director (Flight Test), Aeronautical Development Agency, Bangalore. Shri Shailesh A. Deshmukh, General Manager-Engineering (QC&TS), Air-India and Captain N.S. Mehta, Director-Air Safety (Retd.) & Senior Boeing 747-400 Commander, Air-India were appointed as Assessors to the Court. Shri S.N. Dwivedi, Dy. Director of Airworthiness, DGCA was appointed as Secretary to the Court. The Headquarters of the Court of Inquiry was Delhi.

The Court of Inquiry, soon after its appointment, held an initial sitting at Delhi on 10th August, 2000 to decide the course of action in order to carry out the investigation of the accident. Thereafter, the Court of Inquiry along with the Assessors and the Secretary visited the accident site at Patna on 11th and 12th August, 2000. During this visit, the Court of Inquiry visited the accident site to assess the circumstances of the accident and ascertain the damage caused to civilian property. The Court of Inquiry carried out examination of the wreckage at the accident site and examined key witnesses. The Court of Inquiry met important Bihar State Government functionaries like the Chief Secretary, Director General of Police, District Magistrate, Patna and the Chief Justice of the Patna High Court.

The Chief Justice of the Patna High Court Mr. Justice Ravi Dhawan informed the Court that he had not acceded to the request made by the Ministry of Civil Aviation, Govt. of India

to provide a sitting Judge of the Patna High Court to carry out the inquiry. He said that he was convinced that it was a matter to be investigated by a technically competent person. All efforts made by the Ministry of Civil Aviation to convince the Chief Justice to provide a sitting Judge were in vain and resulted in the constitution of the Court of Inquiry only on 8th August, 2000, three weeks after the accident.

Notification regarding constitution of the Court of Inquiry was published in leading daily newspapers at Delhi, Lucknow, Patna and Kolkata between 18th and 21st August, 2000. The general public was invited to come forward to provide details of the accident, which may be of material use to the conduct of the inquiry.

The Court of Inquiry visited Kolkata Airport on 24th August, 2000 to examine Engineering and Flight Dispatch personnel of Indian Airlines Ltd., since, they had dispatched the aircraft and were the last to see the passengers and crew on the morning of 17th July, 2000. The maintenance facilities of Indian Airlines Ltd. at Kolkata were inspected. The Air Traffic Controllers of AAI who performed the duties of Air Traffic Control at Kolkata on 17th July, 2000, were also examined.

The Court of Inquiry held public hearings at Patna from 4th to 6th September, 2000. A total of 41 witnesses were examined during the public hearings. The witnesses who gave their

testimony at the public hearing included members of the public, who had witnessed the last few moments of the flight before its crash and those who had participated in the rescue operation. Patna Airport Fire Service personnel, the City Fire Brigade officials, Police officials and Doctors of the Patna Medical College Hospital also gave their testimony during the hearing.

On 11th September, 2000, the Court assembled at Delhi and released the information regarding material facts relating to accident on a web site with the address "http://civilaviation.nic.in/coi"

Thereafter, the court reconvened at Mumbai on 15th September, 2000 to examine the Pratt & Whitney JT8D-17A engines of B737-200 aircraft VT-EGD, which were recovered from the wreckage at the crash site at Patna and transported to the Engine Overhaul Facility of, Air-India, Mumbai.

The Court of Inquiry held public hearings at Delhi from 18th to 21st September, 2000. It examined a total of 30 witnesses belonging to various organisations e.g. Indian Airlines, Alliance Air, Airports Authority of India, DGCA and Air-India.

The Court of Inquiry along with its members visited Patna Medical College Hospital (PMCH) on 27th September, 2000 to examine the facilities available there. Since, all the injured

passengers as well as passengers and crew members with fatal injuries were moved to PMCH on 17th July, 2000 after the accident, the Court decided to obtain a first hand knowledge about the availability of various facilities at PMCH.

The Court along with its members also visited Air Force Station, Bihta, Patna on 28th September, 2000 to assess the suitability of that airfield for the operation of scheduled civil flights.

1. FACTUAL INFORMATION

1.1 History Of The Flight

On 17th July 2000, the operating crew reported for flight briefing at the Alliance Air Operations, Kolkata at 0545 hrs. The scheduled Time of Departure (STD) Kolkata of CD-7412 was 0630 hrs.

All six crew members, two pilots and four cabin crew underwent pre-flight medical examination including breath analyser test and were found fit.

The pilots were briefed about the weather at destination, alternate and at Kolkata. The pilots were also briefed about Patna ILS Glide Slope being restricted to 300 feet as per the communication NOTAM. The flight

plan fuel was 7.4 tonnes. The pilot in command, however, requested for 600kgs. extra fuel. Hence the total fuel on board was 8 tonnes (8000kgs.) at Kolkata. The trip fuel for the Kolkata-Patna leg was estimated at 2.5 tonnes.

The load and trim sheet data indicated aircraft take-off weight of 42714kgs., estimated landing weight of 40130kgs. and balance index of 21 & 20 respectively.

The aircraft VT-EGD had arrived at Kolkata on 15th July 2000, at 2200 hrs. There were no reported defects on this flight. The aircraft underwent a 'Layover Check'. There were no observed defects except for one windshield wiper, which was replaced. 16th July was a Sunday and Alliance Air schedule reportedly did not need this aircraft. The aircraft remained on ground at Kolkata throughout the Sunday.

On 17th July, the aircraft was prepared for flight CD-7412, Kolkata – Patna – Lucknow – Delhi. The aircraft was positioned on Bay No. 33 and the pilots had reported a total of 58 persons on board through security. Recorded VHF R/T conversation between Kolkata ATC and the aircraft records that the flight was cleared for pushback and start up at 0640 hrs. Kolkata ATC cleared the flight to Patna via route W52 FL 260 (Flight Level 26000 ft) with instructions that after departure from R/W 01R the aircraft

had to climb straight ahead to 4000 ft., turn left and then climb on track. The aircraft was airborne at 06.51 hrs. and thereafter it changed over to Kolkata Radar.

The aircraft was with Kolkata Radar from 0652 hrs. till 0659 hrs. and then changed over to Kolkata Area Control. At 0712 hrs., the aircraft reported position SAREK FL 260 and it changed over to Patna after being informed by Kolkata Area Control that there was no reported traffic for descent. However, the pilot, reported that he could not read the message and it was once again read back by the Area Controller but he still reported that the transmission was unreadable and changed over to Patna ATC.

VHF R/T conversation between the pilots and Patna ATC confirmed that at 07:13:35 hrs., the aircraft had called Patna ATC while maintaining FL 260 and communicated ETA Patna as 0736 hrs. The pilot also informed Patna ATC that the aircraft had crossed SAREK at 07:11 hrs. Patna ATC cleared the aircraft to PPT(VOR) ILS DME ARC approach runway 25, Transition level FL 55. The ATC Officer also communicated Patna Metar of 0120 UTC (0650 IST) – “wind calm, visibility 4000 meters, weather haze, cloud broken 25000 ft., temperature 29, dew point 27, QNH-996, hPa No sig.”

Patna ATC asked the aircraft at 0717 hrs. to report for descent and also to check descent traffic with Kolkata Area Control. The aircraft soon responded that Kolkata had reported negative traffic. The aircraft was then cleared for descent to FL 75 and asked to report 25 NM and the same was reported by the aircraft at 07:26:09 hrs.. The aircraft was cleared to descend to 4000 ft. on QNH 996 hPa and was asked to report 13 DME for ILS-DME ARC approach runway 25. At 07:28:02 hrs., the aircraft reported commencing the arc and at 07:31:26 hrs. reported crossing the lead radial and coming up on the localiser. The aircraft was then asked to descend to 1700 ft. on QNH 997 hPa with instructions to report established on localiser. The aircraft acknowledged the transmission. At 07:32:30 hrs., the aircraft informed Patna ATC that they would like to do a 360 due high on approach. Patna ATC sought confirmation from the aircraft about the aerodrome being in sight, which was confirmed. The aircraft was asked to report finals for R/W 25 after carrying out a 360 and the clearance was acknowledged by the pilot at 07:32:40 hrs. This was the last transmission available on the Patna ATC tape.

As per the ATC officer, Patna after giving permission to carry out a 360o orbit, he started looking out for the aircraft and could see it before Patna

Secretariat Tower, which is approx. 2 Kms. from the threshold of runway 25. At that time, he noticed that the aircraft was on a normal flight path and aligned with the runway center line. It was however high on the approach. Thereafter, he noticed the aircraft turning left after crossing the Secretariat Tower i.e. towards southeast of the aerodrome and losing height all of a sudden. The aircraft went out of sight behind trees. He made several calls to the aircraft but there was no reply from the aircraft. The ATC tape had nine calls to the aircraft made by the ATCO from 07:34:00 to 07:34:48 hrs. As per the ATC tape, there was no emergency call from the aircraft while losing height.

No sign of fire was observed by the ATC Officer as long as the aircraft was in view. The ATC Officer presuming that the aircraft had crashed switched on/off the crash siren and fire bell. At the same time, he observed a huge column of smoke from the Gardanibagh area just to the left of the threshold of runway 25.

1.2 **Injuries to Persons after the crash.**

INJURIES	FATAL	SERIOUS	MINOR
Crew	2+4	-	-
Passengers	49	2	1
Others	5	5	-

1.3 Damage to the Aircraft

The aircraft was totally destroyed on impact with the ground and post impact fire.

1.4 Other Damage

Two Residential quarters No. 6&8 on Gardani Bagh, Road No. 29 were destroyed and another residential quarter No. 9 on the same road sustained damage to its roof.

1.5 Personnel Information

1.5.1 Pilot in Command - Capt. M.S.Sohanpal

Date Of Birth	2nd May, 1965
ALTP No	2089, valid till 17th Nov. 2000
FRTO Number	3581 valid till 14th Sept. 2000
RTR No.	5890 valid till 22nd March, 2002
Date of Last Medical Examination	03.05.2000 (Assessment-FIT)
Instrument Rating & Licence Renewal Check	25-05-2000 Above standard
Date of Last Route Check	01.05.2000 (Proficiency A.S.)
Date of Last Refresher	02.03.2000 (Result Pass)

Date of Endorsement on B-737-200	P1: 06.02.1998 P2: 29.10.1992
Experience on B-737-200 aircraft (as on 15.7.2000)	P1:1778:15 hrs
Total Flying Experience (as on 15.7.2000)	4361:15 hrs
Hrs. flown in the last 365 days	602:00
Hrs. flown in the last 90 days	132:25
Hrs. flown in the last 30 days	68:00
Hrs. flown; in the last 7 days	12:15
Hrs. flown in the last 24 hrs.	05:20
Rest availed prior to the flight	15:20 hrs.

1.5.2 **First Officer - Capt. A.S.Bagga.**

Date Of Birth	11th November, 1968
ALTP No	2057, valid till 26th June, 2001
FRTO Number	3828 valid till 7th May, 2001
RTR No.	6144 valid till 21st Sept., 2002
Date of Last Medical Examination	07.03.2000 (Assessment-FIT)
Instrument Rating & Licence Renewal Check	23.3.2000 Above standard
Date of Last Route Check	23.03.2000 (Proficiency A.S.)
Date of Last Refresher	02.09.1999 (Result Pass)
Date of Endorsement on B737-200 (Not yet released as P1)	P1: 27.06.2000 P2: 01.04.1992

Experience on B-737-200 aircraft (as on 15.7.2000)	P2:3605 hrs
Total Flying Experience (as on 15.7.2000)	4085 hrs
Hrs. flown in the last 365 days	612:00
Hrs. flown in the last 90 days	175:25
Hrs. flown in the last 30 days	77:00
Hrs. flown; in the last 7 days	15:55
Hrs. flown in the last 24 hrs.	02:30
Rest availed prior to the flight	19:40 hrs.

1.5.3 **Cabin Crew**

Ms. Sapna Anand, Ms. Pushpa Inder, Ms. Priyanky Newar and Ms. Shweta Khurana.

1.6 **Aircraft Information**

Boeing 737-200 is a twin engine jet transport airplane manufactured by Boeing Commercial Airplane Company, USA. It is designed to operate over short to medium ranges at cruise speeds of approximately 950 Kilometers/hour (Kmph). Two P&W JT8D/17A engines power the aircraft, each developing approximately 16,000 Pounds (lbs) of thrust at sea level.

Typical seating capacity of this aircraft is 125 passenger (FAA exit limit is 136) but for Alliance Air fleet it is 119 passenger General dimensions of B-737-200 are 100 ft. 2 inch length, 93 feet wing span, 36 ft. 10 inch height of vertical fin.

B737-200 aircraft is equipped with a conventional tricycle type retractable landing gear system. Wheel-base is 17'2" and the longitudinal dimension between nose and main landing gear is 37'4".

The aircraft is pressurised using engine air bleed and can be alternately pressurised using the auxiliary power unit bleed up to the altitude of 17000 ft. The ceiling altitude is 35000 ft. with a normal operating differential pressure of 7.8 + 0.1 PSI.

The aircraft primary controls operate hydraulically, on the three separate hydraulic systems of the aircraft

1.6.1 **AIRCRAFT PARTICULARS**

Date of Manufacture	June 19, 1980
Serial No.	22280
Date of first landing in India	June 23, 1980
Certificate of Registration No.	2186
Date of Registration in India	June 26, 1980

Owner	Indian Airlines Ltd., New Delhi
Operator	Airlines Allied Services Ltd. (Alliance Air), New Delhi.
Certificate of Airworthiness No.	1718
Date of First issue	June 18, 1980
Valid till	March 25, 2001
Maximum all up weight	52390 Kg.

1.6.2 **MAINTENANCE ARRANGEMENTS**

Alliance Air, subsidiary of Indian Airlines Ltd., is approved by DGCA, to carry out maintenance of Boeing 737-200 aircraft, its systems and the P&W JT8D Engines up to issue of Flight Release Certificate (3A Check). Higher Inspection schedules are carried out by Indian Airlines Ltd. at their facility at Delhi.

1.6.3 **Airframe Particulars**

Airframe Hrs. since New	44087:33 hrs.
Airframe Landings/ Cycles since new	51278 cycles
Hrs. since Last C of A Renewal Inspection	981.08 hrs.
Cycle since Last C of A Renewal Inspection	1177 cycles
Last Periodic “Layover” check completed on	17.07.00 morning

Next Check due at (Hrs.)('B' check)	44265.25 hrs.
Last weighing date of aircraft	23.08.99
Last 7C Check (12,000 Flt. Hrs.) completed on	29.01.2000 at 42782.33 Hrs., 49701 Cycles
Last B Check (750 Flt. Hrs./180 days) completed on	09.05.2000 at 43528:21 Hrs./ 50634 Cycles
Last 3A Check (FRC-375 hrs./75 days) done on	21.6.2000 at 43890:25 Hrs., 51061 Cycles 1305:00 Hrs.
Hrs. since last B check	559.12 Hrs.
Hrs. since last Flight Release Check	197:08 Hrs.
Hrs. since last A Check done on 05.07.2000	81:39 Hrs.

1.6.4 **Significant work undertaken during last <u>7C check completed on 29.01.2000.</u>**

(i) 20 years Ageing Aircraft Modifications.

(ii) All inspections of CPCP (Corrosion Prevention and Control Program) complied with.

(iii) Yaw Damper coupler Modification.

(iv) FIDS (Cargo Compartment Smoke Detection and Fire Extinguishing Installation Modification).

(v) All applicable; Airworthiness Directives and Service Bulletins incorporated on the Rudder Power Control Unit (PCU).

1.6.5 **Engine Particulars: Left Hand (LH) & Right Hand (RH)**

Engine manufacturer	Pratt & Whitney
Engine type	JT8D-17A
Engine Serial No.	LH S/No. P674152B RH S/No. P709360B
Date of Installation on the aircraft	LH 29-01-2000 during 7C Check RH 29-01-2000 during 7C Check
Hrs. since Overhaul	LH-12347:00 RH-8154:12
Cycles Since Overhaul	LH – 13931 RH – 9387
Hrs. since New	LH – 34289:00 RH – 29121:57
Cycles since New	LH – 49679 RH – 34074
Last Heavy Maintenance Inspection (HM) on Port Engine completed on	28.04.1999
Time since HM	2462:27 Hrs./ 2835 Cycles
Last Hot Section Inspection (HIS) on Stbd. Engine completed on	18.06.1998
Time since HIS	4226:07 Hrs./4909 cycles

1.6.6 **APU Particulars**

APU Manufacturer (Allied Signal)	Garrett Turbine Engine Company
APU Type	GTCP85 – 129

APU Serial Number	P334990
Hrs. since New	56291.22
Hrs. since last Overhaul	6792:02

1.6.7 **GROUND PROXIMITY WARNING SYSTEM (GPWS)**

The aircraft was equipped with a Mode 5 GPWS manufactured by Sundstrand Data Control. The system provides the crew with aural and visual warnings of potentially dangerous flight pattern in relation to terrain being flown when one or more of flight thresholds are exceeded.

WARNING

MODE	REASON	AURAL WARNING
Mode 1	Excessive descent rate	“WHOOP WHOOP PULL UP”
Mode 2	Excessive terrain closure rate	“WHOOP WHOOP PULL UP”
Mode 3	Altitude loss after take off or go-around	“WHOOP WHOOP PULL UP”
Mode 4	Unsafe terrain clearance when not in the landing mode	“WHOOP WHOOP PULL UP”
Mode 5	Below glide slope. Deviation alert.	“GLIDE SLOPE”

1.6.8 **HYDRAULIC SYSTEM OF BOEING 737-200 AIRCRAFT**

The 'A' Hydraulic System is powered by Engine Driven Hydraulic Pumps mounted on each engine. Either pump is capable of providing System Operating Pressure of 3000 PSI with a delivery of 22g/minute (even with engine running at idle speed). This flow capacity is more than adequate to meet the simultaneous utilisation of flight controls including flap retraction. The 'B' Hydraulic system is powered by two Electric Motor Driven Hydraulic Pumps.

The Boeing 737-200 aircraft incorporates three functionally independent hydraulic systems, which operate at approximately 3000 Pounds Per Square Inch (PSI) pressure. The systems are designated as System 'A', System 'B' and the 'Standby' System. Each system has it's own independent reservoir and it's own control and delivery System. System 'A' and 'B' normally provide the dual hydraulic power for all Flight Control. Each system alone can take care of all Flight Control requirements. Capacity of each of the four hydraulic pumps of System 'A' and 'B' are such that one pump alone can meet the full flight control authority requirements of it's respective system.

The ‘A’ hydraulic system is powered by two Engine Driven Hydraulic Pumps, one mounted on each engine. This system supplies hydraulic power to Flight Controls, Landing Gear, Nose Gear steering, Alternate Brakes, Inboard Flight Spoilers, Ground Spoilers and Engine Thrust Reversers.

The ‘B’ hydraulic system is powered by two Electric Motor Driven Pumps. This system provides Leading Edge Flaps and slats, outboard flight spoilers and normal brakes.

The ‘Standby’ hydraulic system is powered by one electric motor driven pump. The system has no separate control switch but gets activated by arming ‘Alternate Flaps’ on selecting ‘STANDBY RUDDER ‘A’ or ‘B’ on the overhead panel in the Cockpit. This system provides hydraulic power to Rudder Control System and extension of Leading Edge Flaps & Slats (Retraction is not possible with this system) in the alternate mode and alternate operation of both Engine Thrust Reversers.

In the normal operation, both hydraulic systems ‘A’ and ‘B’ are switched ‘ON’. The ‘ALTERNATE FLAP’ is switched to ‘OFF’. The ailerons and elevators can be operated manually without power.

1.6.9 **FLIGHT CONTROL SYSTEM**

(a) LATERAL CONTROL

Lateral Control of the aircraft was achieved by operation of an Aileron and two Flight Spoilers on each wing. These surfaces were operated by the Pilot and Co-Pilot control wheels in the cockpit. A cable system connected the control wheels to an Aileron control quadrant. The quadrant operated the Aileron Power Control Unit (PCU) through a mechanical link.

In normal operation, both control wheels operated the Aileron PCU through the left Aileron Cable System. In case of jamming of the left Cable System, lateral control was achieved by operating the Flight Spoilers through the right Aileron Cable System. Control Wheel Movement of more than 9 degrees to the Left or Right activated the transfer mechanism. An Aileron spring cartridge provided the mechanical input connection between the Co-Pilot's Aileron input and the Aileron PCU.

The Spoilers were either operated by the Aileron Control System or by the speed brake Lever in the Cockpit. These two inputs were summed

together through a Spoiler Mixer. This allowed Spoilers to be used for augmentation of lateral control even when being used as speed brakes simultaneously. The Spoiler Mixer also acted as a ratio changer which changed the output to the Spoiler Mixer for a given magnitude of input from the Aileron System. With the speed brakes raised the lateral Control Output decreased.

The Ailerons were controlled by two independent hydraulic power control units (PCUs), one connected to System 'A' and the other connected to System 'B'. Either unit was capable of providing the full range of lateral control. Aileron trim was provided by a mechanical actuator operated from the Cockpit Pedestal Aileron Trim Knob. This actuator repositioned the Aileron Centering Mechanism.

Two Flight Spoilers on each wing worked in conjunction with the Ailerons. With the speed brake lever in the 'DOWN' Detent, the Spoilers on the Up-Aileron side would start lifting at 9$\pm$1° equivalent control wheel movement. In the 'FLIGHT' Detent position, the Spoilers became operational at all control wheel movement. Of the two Flight Spoilers, the outboard operated on System 'B' and the

inboard on System ‘A’. All the four operated together as Speed Brakes in flight.

Two Ground Spoilers on each wing operated as drag devices for operation on ground only. These four surfaces were operated by System ‘A’ hydraulic pressure. A mechanical link connected to the Right Main Landing Gear operated a bypass valve to prevent in-flight operation of the Ground Spoilers.

(b) LONGITUDINAL CONTROL

Aircraft control in the longitudinal axis (Fore and aft) was provided by Elevators and the movable horizontal stabilizer. The Elevators were powered by two independent hydraulic PCUs. One PCU operated on System ‘A’ and other on System ‘B’. Either unit could provide full pitch control.

The Pilot’s control was achieved through the Control Column through a dual Cable System and torque tube connected to both Elevators. The Pilot’s Feel was provided by the Elevator Feel System, which provided a hydraulic force proportional to air speed and stabilizer position.

In the absence of hydraulic pressure, the elevators were operated directly by the Control Column. Tabs were provided on the elevators to assist in manual operation. Hydraulic actuators lock the tab to the elevator when hydraulic pressure was available. The absence of hydraulic pressure unlocked the tab.

Movement of the horizontal stabilizer provided longitudinal trim. The stabilizer was operated by a dual load path ball screw. The ball screw could be operated by three means; the main electric trim motor, auto pilot trim motor or the manual trim, which was operated by trim wheels on either side of the cockpit pedestal. The manual trim wheels were connected to the horizontal stabilizer by a Cable System.

(c) DIRECTIONAL CONTROL

Directional Control (YAW) about the vertical axis was provided by operation of a Rudder. The Rudder was a tabless surface operated only through a hydraulic PCU with no possibility of manual reversion. The Rudder PCU operated the Rudder through a dual load path linkage and was powered by both Hydraulic Systems ‘A’ & ‘B’ with

the capability to operate on any one system. Each system operated through it's own Control Module mounted on the PCU.

The Standby Hydraulic System operated the Rudder through a Standby Rudder Actuator, providing a back up source. The Standby Actuator received power only when operation was selected by the Flight Control Switch either 'A' or 'B' to the STANDBY RUDDER position. On selecting the Standby Rudder position, hydraulic pressure from one of the Hydraulic Systems was cut off to the Rudder PCU. This ensured that only two Hydraulic Systems operated the Rudder PCU at any one time.

Yaw Damper System operated the Rudder through Hydraulic System 'B'. Its authority was limited to 2° left & right and did not provide any feed back to the Rudder Pedals. The feel and centering mechanism provided artificial feel for the Pilot. Rudder trim was operated through a mechanical actuator operated by the rudder trim knob on the pedestal.

The Airworthiness Directive (AD) 97-14-03 introduced a Rudder Pressure Reducer. The Pressure Reducer was mounted only on System 'A'

and reduced the Hydraulic Pressure from 3000 PSI to 1400 PSI (B737-100/200) under certain conditions of flight when large rudder movements were not required. The full hydraulic pressure of 3000 PSI was available during take off and climb up to 1000' Above Ground Level (AGL) and below 700' AGL during approach.

(d) LEADING EDGE DEVICES

High Lift Leading Edge (LE) Devices were used in combination with LE Flaps to allow the airplane to operate from short runways. The extension of the LE Devices changed wing camber, which increased lift.

Three LE Slats were installed outboard of each engine and two LE Flaps inboard of each engine. The Slats were operated by hydraulic actuators with three positions, Retracted, Extended and fully extended. The LE Flaps were operated by hydraulic actuators with two positions, Retracted & Extended.

The hydraulic actuators incorporated a Blocking Valve, which would create a hydraulic lock in case of loss of hydraulic pressure or in case of

low pressure (2000 PSI). The surfaces would lock in the position at which the loss of pressure had taken place. This prevented blow back of surfaces in case loss of pressure occurred during Take Off or Landing.

The actuators were normally powered by Hydraulic System 'A'. The Standby hydraulic system provided alternate source of power for extension only. The Slat Actuator had a mechanical locking provision when the actuator was in the retracted position. The Slat Actuator had a provision to monitor movement of the inner piston through a Reed Switch.

The operation of LE Slats and Flaps was dependent on Trailing Edge (TE) Flap position. When the Pilot moved the flap lever in the Cockpit to FLAPS 1 position, the movement operated the Flap Control Valve on the Flap Control Unit through a set of cables. When the TE Flaps moved to FLAPS 1 position, the movement was fed back to Flap Control Unit, which operated the LE Flaps & Slat Control Valve. This allowed Hydraulic System 'A' pressure to unlock all the Slats 1 through 6 and move the inner piston to Extend position and Flaps 1 through 4 to their Fully Extended position.

The next movement of LE Slats occurred when the TE Flaps moved from FLAPS 5 to FLAPS 10 position. The LE Slats went to FULL EXTEND position when the outer piston extended. The LE Flaps, which were already fully extended, did not move. The LE Flaps/Slats did not change extended position after the FLAPS 10 to FLAPS 40 selection.

The retraction cycle was exactly opposite of this operation. The LE Slats moved from fully extended to extended position when the TE Flaps moved from 10 to 5º. The LE Slats & Flaps completely retracted when TE Flaps moved from 1 º to UP position, giving a clean configuration of the aircraft.

(e) LEADING EDGE FLAPS AND SLATS INDICATION

The position of the individual LE Slats & Flaps was displayed by the LE devices Anunciator Panel located on the Forward Overhead Panel. Each Slat position was displayed Amber, indicating transitory position with two green lights indicating Extend and Fully Extend position. Each Flap had one Amber Light for transitory and one green light for Fully Extended position.

The Pilots Central Instrument Panel had two indicator lights just below the gauge for TE Flaps. Amber Lights illuminated when any of the LE Flaps or Slats were in transit. The Green Light illuminated only when each of the LE Flaps & Slats had reached its commanded position i.e. 'Extended or Fully Extended'.

There was no light indication with the LE Flaps retracted.

(f) TRAILING EDGE FLAP SYSTEM

The Trailing Edge (TE) Flaps provided additional lift during take off (T/O) & Landing by increasing the Camber of the wing. They worked in conjunction with the LE Flaps & Slats.

There were a total of four TE Flaps installed on the aft edge of the wings. Each Flap was a triple slotted structure consisting of fore, mid and aft flap. The slots were provided to increase lift by preventing stagnation of airflow on the Flap.

The movement of the Flaps was achieved by two-ball screw mechanism (Transmission Units) on

each Flap. These ball screws were driven by gearboxes and torque tubes running along the length of the wing. The torque tubes were driven normally by a hydraulic motor and alternately by an electric motor.

The Flap Control Lever, when operated by the Pilot, actuated a control valve on the Flap Control Unit through a set of cables. The Control Valve ported hydraulic pressure to the flap power unit, incorporating a reversible hydraulic motor driving the torque tubes through a gearbox.

System ‘A’ pressure was used for normal Flap Operation. In case of loss of pressure, the Flaps could be operated electrically. The forward overhead panel had the alternate flap ARM switch & flap control switch. The ARM switch was guarded and wire-locked in OFF position, the hydraulic system was cut off from the Flap Control Unit by a bypass valve. Operation of TE Flaps in NORMAL mode was not possible once the switch was put to ARM position. The Flaps were then moved in the ‘UP’ or ‘DOWN’ direction by the Flap Control Switch which was held in that position by the Pilot to achieve the desired TE Flap position. The Down movement of this switch also activated the Standby

hydraulic System and moved the LE flaps and Slats to fully Extended position. The 'UP' movement of the switch only operated the TE Flaps to 'UP' position but the LE Flaps and Slats could not be retracted by the Standby System.

The TE Flap position was indicated on the cockpit by a dual pointer (L & R) gauge on the Pilots Center Instrument Panel. The TE Flap System also incorporated flap limit switches providing logic inputs for Landing Gear Warning Horn, Take Off Warning Horn, Mach Trim and 10º Flap logic.

1.7 METEOROLOGICAL INFORMATION

India Meteorological Dept. Aviation Div. At Patna Airport was a Class I centre, recording current weather parameters at half hour intervals and issuing Metar/Speci to ATC services. Relevant Metars issued on July 17TH were as below.

MET Report, Patna Time 0050 UTC (0620 IST), wind calm, Visibility 4000 metres Haze Clouds Broken, 25000 ft. (7500 metres) Temperature 28ºC Dew Point – 27ºC QNH-0996 hPa 29.41 Inches of Mercury QFE-0990 hPa 29.23 Inches of Mercury No significant weather.

Metar Issue Time 0051 UTC (0621 IST)

MET Report, Patna, Time 0120 UTC (0650 IST), wind calm visibility 4000 metres Haze Clouds Broken 25000 ft. (7500 metres), Temperature 29ºC, Dew Point 27ºC QNH-0996 hPa, 29.41 Inches of Mercury, QFE-0990 hPa, 29.23 Inches of Mercury No significant weather.

Metar Issue Time 0121 UTC (0651 IST).

MET Report, Patna, Time 0150 UTC (0720 IST), Wind Calm, Visibility 4000metres Haze, Clouds Scattered 1500 ft. (450metres), Temperature 30ºC, Dew-Point 27ºC, QNH-0997 hPa, 29.44 Inches of Mercury, QFE-0990 hPa, 29.23 Inches of Mercury. No significant weather.

Metar Issue Time 0151 UTC (0721 IST).

1.8 **AIDS TO NAVIGATION**

Patna Airport was equipped with following Navigational Aids for utilisation by arriving, departing and overflying aircraft.

1.8.1 **Non Directional Beacon (NDB)**

One transmitter made by RADIFON commissioned on April 21, 1956.

1.8.2 **Doppler Very High Frequency Omni Range (DVOR)**

Two transmitters made by GCEL commissioned on November 9, 1995. Records indicated that performance of DVOR for radials and orbit including approach radial 252 and 065 were satisfactory with an error spread of 1.6º.

1.8.3 **Distance Measuring Equipment (DME)**

Two transmitters made by GCEL commissioned on November 9, 1995, colocated with DVOR

1.8.4 **Instrument Landing System (ILS)**

(a) Localizer. two transmitters made by NEC, Japan commissioned on December 13, 1988.

(b) Glide Path (GP) two transmitters made by NEC, Japan, commissioned on December 13, 1988.

(c) DME (PAT) co-located with GP – two transmitters made by NEC, Japan, commissioned on December 13, 1988.

As per last reports, localizer was restricted to + 25º due low clearance on 150 Hz side i.e. right side of approaching aircraft. Also, the GP was restricted for use only up to 300 ft. height due to trees making elevation of 1.3º on the approach path.

1.9 COMMUNICATION

Ground to air communications at Patna Airport was available on 118 MHz and 121.1 MHz VHF frequencies. The station was provided with ECIL make transmitters and receivers Qty. 9 each. On 17.7.2000, the station had six transmitters and eight receivers in serviceable condition. The crew of CD-7412 were in contact with Patna ATC on 121.1 MHz frequency. The crew had smooth uninterrupted and normal conversation with the ATC Officer.

1.10 AERODROME INFORMATION

Patna Airport was owned and managed by Airports Authority of India (National Airports Division). Its co-ordinates were latitude 25º 35'36" north and longitude 85º 05'39" east. It had a single runway designated as 07/25 true bearing 069º and 249º Runway surface was tar macadam with PCN of 46/R/B/W/T. Physical runway length was 2286 metres and 46 metres width. Patna Airport was surrounded by thickly populated residential areas, trees, electrical poles etc. Due to these obstructions and non-availability of standard basic strips, the usable length of runway was restricted in both directions as given below.

Runway	Take-off Run Available (TORA)	Take-off Distance Available (TODA)	Associated Stop Distance Available (ASDA)	Landing Distance Available (LDA)
07	1954M	1954M	1954M	1954M
25	1954M	1954M	1954M	1820M

Instrument Landing System installed for R/W 25 was rated as Category I with Localiser and the Glide Slope with an angle of 3.05º with a co-located low power DME. Additionally, the runway was served with PAPI (Precision Approach Path Indicator) lights matching the Glide Slope. R/W 25 had an abridged simple approach lighting system extending up to the distance of 210 metres from the threshold with a cross bar at 150 metres.

Patna Airport had the following local flying restrictions.

1. All aeroplanes to maintain visual flight watch for flying club aeroplanes/gliders.

2. Pilots to exercise caution during landing and take-off due to the presence of birds in the vicinity of Patna Airport.

Patna Airport had Category VI fire protection with two Crash Fire Tenders (CFTs) and one Ambulance.

Each CFT had water capacity of 8000 litres, foam capacity of 800 litres. With a pump discharge of 4000 litres/minute, each CFT could spray foam for approximately two and a half minutes, after which the water tank needed replenishment. The foam needed replenishment after about four deliveries.

1.11 FLIGHT RECORDERS

The aircraft was equipped with two recorders

1.11.1 Solid State Flight Data Recorder (SSFDR)

Part NO. S703-1000-00 manufactured by L-3 Communications (LORAL), USA, Model No. F1000 S/No. 00620.

The accident aircraft recorder had the capability to record following the 11 parameters.

(i) Pneumatic altitude.
(ii) Pneumatic Indicated Air Speed(IAS).
(iii) Heading.
(iv) Engine Pressure Ratio (EPR) Eng.1.
(v) Engine Pressure Ratio (EPR) Eng.2.
(vi) Elevator Position in Inches.
(vii) Elevator Position in Degrees.
(viii) Pitch attitude.
(ix) Roll Attitude.

(x) Vertical Acceleration.

(xi) Longitudinal Acceleration.

In addition to these parameters, there was a provision to record the discrete of Radio Transmission Mike Keying. With these parameters, this SSFDR could store data up to 100 hrs. of aircraft operation. It also had an Event Marker facility.

1.11.2 **COCKPIT VOICE RECORDER (CVR)**

Part No. A100 manufactured by Fairchild, Serial No. 6340, was a conventional tape type recorder. It had capability to store recording of last 30 Minutes with four channels namely, Cockpit observer, First Officer, Commander and Area Mike.

1.12 **WRECKAGE AND IMPACT INFORMATION**

Total wreckage of the aircraft was confined to one location covering residential quarters No. 6 and 8 on Gardani Bagh Road No. 29 and it was primarily spread over an area of 100 feet X 100 feet. The wreckage site was at Latitude 25°35'24" N and Longitude 85°06'18" E, which was at an approximate distance of 2852 feet from the threshold of R/W 25 on an approximate bearing of 117°. The aircraft, prior to impacting the ground, had

passed through six trees and grazed past quarter No. 9. The aircraft trail indicated that during the last phase it was on an approximate track of 210º and it had grazed the roof of quarter No. 9 with its right wing indicating right bank at impact.

Details regarding wreckage examination include landing gears, wings and trailing edge flaps, screw jacks, trimmable horizontal stabilizer and its screw jack etc. These were as follows: -

(a) Observation around the wreckage site indicated that the aircraft had approached from North-Easterly direction and passed through a Neem Tree (T5) as indicated in the wreckage diagram (Annexure 'A').

(b) The aircraft had right bank and its right wing tip grazed the roof of a 12 feet high residential quarter No. 9 on Road No. 29 at Gardani Bagh.

(c) The aircraft, soon thereafter, passed through a group of mango trees marked as T1, T2, T3 and T4. A portion of right wing tip was found lying near the root of Tree T-4.

(d) After passing through the trees, the aircraft turned sharply to its right and struck residential quarters No. 6 and 8 and the ground.

(e) The aircraft wreckage was primarily spread over an area of approximately 100 feet X 100 feet and the available wreckage indicated that the aircraft was structurally intact till it passed through the trees and grazed the roof of residential quarter No. 9.

(f) Cockpit components were towards the North and the tail section was towards the South, at the crash site.

(g) Aircraft tail section, containing both stabilisers viz. horizontal and vertical with attached control surfaces, was found separated from the aircraft. Right horizontal stabiliser had a deep cut on the outboard leading edge, whereas, outboard 2/3 portion of the left horizontal stabiliser along with corresponding elevator surface was found torn and separated.

(h) Both wings were found torn and separated. Both engines were found separated from their installation. All separated and disintegrated parts were found confined to the wreckage site.

(i) On examination, no evidence of in-flight fire was observed. Both wings and fuselage had suffered extensive damage. Post impact fire had consumed a large portion of the wing and fuselage.

(j) Landing Gears were individually examined:-

(i) Landing Gear Selector Lever was in the Off position.

(ii) Left Landing Gear was folded towards retract position and its Up-lock pin was missing.

(iii) Right Landing Gear was in Up and locked position with Up lock pin engaged in the hook.

(iv) Nose Landing Gear was in retracted position with Nose Wheel Assemblies undamaged.

(k) Movable Horizontal Stabiliser screw jack was found torn and separated. Position of its ball-nut on the jack, as established from exposed length of screw on either side, indicated that the THS was approximately at 8.5° Nose Down, and it corresponded to aircraft attitude of 11.5° Nose Up on scale.

(l) Examination of screw jacks operating outboard wing trailing edge flaps and position of ball nuts on

corresponding screw jacks indicated that the outboard flaps were at approximately 15 units.

(m) Position of ball nuts, as noticed on inboard wing trailing edge flap screw jacks, indicated that the inboard flaps were at approximately 15 units.

(n) Rudder control surface trailing edge was towards full right. Main Power Control Unit (MPCU), Standby Actuator and Trim Actuator of the Rudder were found in position and were visually undamaged.

(o) Rudder Trim Knob, on control stand in cockpit, was found jammed approximately 8 and 3/4 units to right, which equated to approximately 10½ of right rudder. The Rudder Trim Actuator was found extended to 0.65 inches and it equated to 14½ of right rudder. This could be due to the Trim Knob getting rotated on a cable pull during breakage/separation of fuselage structure on impact.

(p) Aileron Trim Knob on control stand was found jammed approximately 13-14 units to left. This could be due to Trim Knob getting rotated by a cable pull during breakage/separation of wing/fuselage structure on impact.

(q) Three, out of four, Flight Spoiler Actuators were located -

(i) One was found detached from the aircraft, fully retracted and its data plate indicated Part No. 65-4456-14, S/N 2558.

(ii) Two units were found attached to the right wing in the fully retracted position.

(r) Two, out of four, Ground Spoiler Actuators were located in the wreckage:-

(i) One outboard Ground Spoiler Actuator was fully retracted and attached to the wing structure.

(ii) One inboard Ground Spoiler Actuator was found detached from the aircraft with the actuator extended to 1.8". It was possible that the actuator extended during separation.

(s) Three Leading Edge Actuators and one Leading Edge Flap Actuator were retrieved out of six Leading Edge Slat Actuators and four Leading Edge Flaps Actuators. All retrieved actuators were partially extended.

(t) Aileron and Elevator PCUs of both System 'A' and System 'B' were located in the wreckage.

(u) Core section of port engine from fan to turbine assembly was found detached leaving its outer casing in one piece. Damage observed on the rotating assembly, viz. fan and compressor blades curled opposite to the direction of rotation indicated that the engine was operating at the time of impact. No evidence of internal engine fire was observed.

(v) Similar damage was observed on the rotating assembly of No. 2 engine, viz. curling of compressor blades opposite to the direction of rotation, indicated that the engine was operating at the time of impact. No evidence of internal engine fire was observed.

(w) Thrust Reversers of both engines had separated and were in the stowed position.

1.12.2 **COCKPIT GAUGES AND PANELS**

These were retrieved in extensively damaged condition. Salient observations are stated below: -

(i) **CAPTAIN'S PANEL**

- RADIO MAGNETIC INDICATOR (RMI) – Found smashed with front glass broken and displayed a Heading of 247°, No. 1 and 2 bearing selector

knobs respectively at ADF and VOR position, No. 1 pointer reading 225° and No. 2 Pointer at 355°.

- COURSE DIRECTOR INDICATOR – indicated heading of 240° and course window reading 248°. Course and heading selector knobs were free to rotate.
- RADIO ALTIMETER INDICATOR – needle found stuck at 20 feet and Minimum Decision Height (MDH) indicated 280 feet.
- Mach/Airspeed Gauge, Attitude Director Indicator, Altimeter, Vertical Speed / TCAS Indicator were found smashed and without any display.

(ii) **FIRST OFFICE'S PANEL**

- TOTAL AIR TEMPERATURE (TAT) / ENGINE PRESSURE RATIO LIMIT (EPRL) GAUGES – were found smashed with mode selected in "GA" (Go Around).
- ATTITUDE DIRECTOR INDICATOR – Bank indication was 30° right, runway symbol on right hand side of the scale with attitude indication in blue region. All flags were in view.
- ALTIMETER – Pointer displayed 150 feet, counter reading – 9500 feet, QNH 997 mb and 29,49 inches of mercury.
- RADIO ALTIMETER INDICATOR – read 150 feet with flag in view.

- Radio Magnetic Indicator, Vertical Speed / TCAS Indicator and DME Indicator were found smashed and without any display.

(iii) **CENTER INSTRUMENT PANEL**

- FUEL TOTALIZER GAUGE – reading 5400 kg., Zero Fuel reading 33000 kg., Flap Setting Knob at 40.
- CENTRE TANK FUEL GAUGE – reading zero.
- LEFT TANK FUEL GAUGE – reading 2400 kg.
- RIGHT TANK FUEL GAUGE – reading 2800 kg.
- AUTO BRAKE SELECTOR SWITCH – at “MED” (Medium) selection
- ENGINE NO. 1 & 2 – gauges were found damaged and the readings did not make any sense.
- Standby Artificial Horizon, YAW Damper Position Indicator and YAW Damper Switches were found damaged.

(iv) **AFT ELECTRONIC PANEL**

- FIRE CONTROL MODULE – smashed and Fire handles were found in stowed position.

(v) **FORWARD OVERHEAD PANEL**

- PRESSURISATION CONTROL PANEL – selector found jammed in AUTO position, landing altitude

reading at 160 feet and cruise altitude reading 26100 feet.

- AIR-CONDITIONING CONTROL PANEL – No. 1 & 2 Air Mix Valve Selector Knob found in COLD position.
- ENGINE AND APU BLEED CONTROL PANEL – Engine-1 bleed switch was found in ON position, Engine-2 and APU bleed switches were in OFF position, Gasper Fan in OFF position, Pack-1 switch was found jammed in ON position, Pack-2 switch jammed in OFF position, Isolation Valve Switch in AUTO position.
- EXTERNAL LIGHTS SWITCHING PANEL – Anti-Collision Light, Wheel Well Light and Wing Scan Light switches were found in ON position.

(vi) **AFT OVERHEAD PANEL**

- CVR CONTROL PANEL – intact.
- OXYGEN PANEL – passenger oxygen pressure gauge reading 1190 PSI.
- Observer's Audio Selector, Flight Recorder and Stall Warning panels were found smashed.

(vii) **LIGHT SHIELD PANEL**

- FLIGHT DIRECTOR-1 CONTROL PANEL – Mode Selector found in "GA" (Go Around) position. Altitude Hold Switch found in OFF position.

- FLIGHT DIRECTOR-2 CONTROL PANEL – Mode Selector found in "GA" position. Altitude Hold Switch found jammed in ON position.
- AUTO PILOT CONTROL PANEL – Roll (Aileron) Selection Lever found free and Pitch Selection Lever found jammed in 'disengaged' position. Mode Selector Knob found in 'manual' position.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

On 17th July, 2000, the Flight Crew reported to Alliance Air Operations, Kolkata Airport at 0545 hrs. to operate CD-7412. The scheduled time of departure of the flight was 0630 hrs..

Both Pilots and the four cabin crew subjected themselves to preflight medical examination including breathalyser for alcohol. Each of them had negative test report (No alcohol found). Personnel on duty at Kolkata Airport on that day reported that they had not noticed any abnormal or indifferent behaviour of the crew while interacting with them. The doctor who performed the preflight medical examination stated that both Pilots were temperamentally, clinically and verbally coherent.

After the accident, the bodies of crew were shifted to Patna Medical College Hospital (PMCH). Both the

Pilots were fatally injured. Captain M.S. Sohanpal and Captain A.S. Bagga were identified to the doctors of PMCH, Patna by the officers of Indian Airlines and autopsy was performed on their bodies.

The autopsy of the Pilots was conducted by Dr. R.K.P. Singh and Dr. Arvind Kumar Singh of the Dept. of Forensic Medicine, PMCH in the presence of Wing Cdr. G. Gomez, DDMS (CA). During the proceedings, samples necessary for Histo-Pathological examination were collected by the doctors and packed in necessary preservatives. These samples were taken to the Dept. of Aviation Accident Pathology at the Institute of Aerospace Medicine, Indian Air Force, Bangalore by Wing Cdr. G. Gomez for Histo-Pathological and Toxicological Analysis.

1.14 **FIRE**

There was no evidence of pre-impact fire. Substantial portion of wings, fuselage interior and structure were consumed in the post accident fire. It was estimated that approximately 5.4 tonnes of fuel was remaining in the aircraft fuel tanks at the time of the crash.

The accident site was approximately five to six kilometers by road from the Airport Fire Station. The duty

fire personnel stated that they had monitored the descending aircraft disappearing behind the trees and had seen smoke rising from the vicinity immediately thereafter. They were also alerted by means of the fire bell, airport siren, announcement on PA system and were ordered by ATC on walkie-talkie to proceed to the crash site.

As stated by the fire personnel, they reached the crash site in five to six minutes after making their way through a large crowd of people and numerous vehicles that had gathered on route to the crash site. However, the local residents stated that the fire vehicles had reached the site after about 15 to 20 minutes. The fire crew of the first turn out Crash Fire Tender (CFT) No. 10 positioned the vehicle west of the crash site and fought the fire after laying two lengths of delivery hoses in tandem. Due to being positioned at a distance, it was not possible for the CFT to utilise the overhead monitor. The CFT, however, failed suddenly after three minutes of operation. After failing in their effort to rectify the fault, the CFT crew had to call a mechanic from the airport. The CFT was put back into operation after about an hour. Operation of the CFT after repairs, lasted for a few minutes and was taken back to the airport to refill water. The CFT however broke down twice on the way to the

airport and each time the mechanic who was on board the vehicle repaired it.

The fire crew of the second turn out CFT No. 54 positioned the vehicle to the east of the crash site and fought the fire with the help of the overhead monitor. The operation lasted for a few minutes and the crew returned to the airport to refill water. The CFT returned from the airport after about 40 to 45 minutes and was put back into operation.

City Fire Vehicles arrived at around 08:30 hrs. and joined the fire fighting operations. By this time, the airport's CFT-54 returned after refilling and most of the fire was extinguished. Isolated small patches of fire and smoke were smothered by use of water only. After completing the fire fighting operations, safety services of the airport returned to the Fire Station by about 10:30 hrs.

As per the statement of the Dy. Inspector General of police (DIG), Central Range, Patna, he received a wireless message about the accident at his residence, which was located about two kilometers from the accident site. He immediately instructed fire tenders, ambulances, cranes, policemen in the Police Line and neighbouring Police Stations to rush to the crash site. He, too quickly reached the accident site. He stated that "some local

people had already assembled there, and were helping in dousing the flames, which were rising to about 30 feet. The wreckage of the aircraft was strewn in a radius of about 100 meters and the tops of the trees in line of the approach of the ill-fated plane had been clipped. Two Fire Tenders had already reached there, but one was not being effective as there was no water pressure in it. Surprisingly, I did not see foam being used by the fire extinguishers, though that is the surest and quickest way to put out an electrical or oil fire".

1.15 SURVIVAL ASPECTS

When the aircraft struck the residential quarters and the ground, the impact was severe. The intensity of post impact fire was also severe. Initially, seven passengers were extricated alive. Of them six were seriously injured. Miraculously, one of the passengers walked out of the wreckage without much injury, even though, he had minor concussion and was treated later. Of the six injured passengers, four died subsequently. Two passengers recovered completely after treatment.

The airport ambulance had proceeded to the crash site along with the CFTs. Two injured passengers were transported to the PMCH in the first instance. Subsequently, the second ambulance from the airport

was also pressed into service to transport the remaining injured passengers for medical aid. Shortly after the arrival of the airport ambulance, ambulances from other assisting agencies also arrived and helped in removing all the injured for medical aid.

1.16 TESTS AND RESEARCH

1.16.1 Rudder Power Control Unit (PCU) Investigation

The Main Power Control Unit (MPCU) of the rudder has been a subject of intense debate and discussions and has undergone mandatory modifications as a result of some previous accident investigations. The inputs from the Pilots Rudder Pedals or Rudder Trim Knob in Cockpit and those from the YAW Damper (YD) Computer operate a servo valve on the MPCU. The servo valve consists of two slides, the smaller primary slide moving inside a bigger secondary slide. When the slides are displaced by the input command, hydraulic pressure is ported to move the rudder in the desired direction.

There have been some incidents of anomalous rudder movements such as un-commanded movements, rudder lock up in a particular direction, and reversal of rudder to that of the commanded position. These have been attributed to the secondary slide jamming with the

primary slide due to contamination or adverse build up of tolerances during manufacture.

These issues have been addressed by FAA Airworthiness Directives (FAA AD) 97-14-03 and 97-14-04. These ADs required the following actions to be complied with.

(i) Modification of MPCU using redesigned Servo Valve and the two slides.
(ii) Replacement of MPCU input rod bolts.
(iii) Replacement of YAW Damper coupler with new coupler with dual solid state rate sensor in place of electromechanical rate sensor.
(iv) Introduction of Hydraulic Pressure Reducer in Hydraulic System 'A'

All these modifications were incorporated on the accident aircraft during the 7C check, which was carried out during November, 1999 to January, 2000. Alliance Air and Indian Airlines have not experienced this kind of rudder malfunction in their fleet.

Even though the rudder was not a suspect in this case, Boeing requested for lab analysis of the rudder components.

The Standby Rudder PCU and the Pressure Reducer were tested at the EQA Laboratory of Boeing at Seattle, USA. Representatives of Boeing, National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA) of USA were present along with the Court. Both the units passed all laboratory tests satisfactorily.

The Main Power Control Unit (MPCU) was tested at the Parker Hannifin (Manufacturer) Facility at Irvine, California, USA with all the above agencies represented. This unit also passed all tests satisfactorily.

1.16.3 **Engine Examination**

The accident aircraft DFDR had a provision to record Engine Pressure Ratio (EPR) of each engine. EPR is a ratio of Pt7 (Turbine Discharge Pressure) to Pt2 (Compressor Inlet Pressure) and is indicative of thrust generated by the engine. EPR is used as the primary thrust setting parameter by the Pilots to set the engine throttle.

Scrutiny of the EPR recording at the time of take off (T/O) from Kolkata indicated that both engines were developing adequate and equal thrust. The climb and cruise performance was normal. The EPR recording

indicated that the engines were at Idle (this is the minimum setting of the engine to sustain its operation but provides negligible thrust) from 07:20:00 hrs. till 07:32:45 hrs. i.e. approximately 15 seconds before the crash.

Thrust had been increased in three steps 1.5 EPR, which was low thrust, 1.8 EPR, a high thrust setting and in the last phase, 2.2 EPR, which was a very high EPR setting, with each step taking four to five seconds.

The terminal flight path passed over a residential area. Most of the witnesses had remarked about the high noise level when the aircraft passed overhead at a low height. Post crash examination of the engine showed that the engines were producing thrust at the time of impact.

The engines were recovered from the crash site and taken to the Air-India Engine Overhaul Facility at Mumbai for detailed examination by engine experts. Both the engines had ingested considerable amount of mud in the gas path. All the compressor stages were heavily damaged with the blades curled opposite to the direction of rotation. There was no evidence of internal fire or case penetration. The left engine Low Power Turbine (LPT) case was punctured inward near the stage 3 turbine rotor. This was the probable cause of stage 3 turbine blades breaking away and damaging the 4^{th} stage blades. A

dent was noted on the right engine LPT case but the case was not punctured. This was indicative of the wings transferring impact loads to the engines.

It was, therefore, evident that the FDR recording of the EPR represented the true status of the engines which continued to operate at high thrust right up to impact. The idle thrust setting set by the crew from 0720 hrs. till 16 seconds before the impact was not indicative of any malfunction of the engines. The Court concluded that the engines had operated normally.

1.17 ORGNISATIONAL ASPECTS OF ALLIANCE AIR

Airline Allied Service Ltd. (Alliance Air), under the Companies Act, 1956 was a wholly owned subsidiary of Indian Airlines Ltd. (IA), New Delhi. The company was incorporated and registered on 13th Sept 1993. It was revitalized in Dec 1995 and commenced its airline operations under the brand name of Alliance Air on 15th April 1996 after acquisition of one B-737-200 aircraft from IA. M/s Alliance Air took possession of the second aircraft from M/s Indian Airlines on 25th April 1996. It subsequently took over the third and fourth aircraft w.e.f. 10th July and 19th August, 1996, respectively. The route network of M/s Alliance Air expanded further when the fifth and sixth B737-200 aircraft started operating in the

first week of September 1996. The company started operations with the seventh and eighth aircraft from 26th November, 1996. On 17th July 2000, all twelve (12) Boeing 737-200 airplanes were being operated by M/s Alliance Air.

M/s Alliance Air had appointed IA as its General Sales & Handling Agent, Additionally, the major maintenance of aircraft was being carried out by IA who also supplied spare parts and other stores from their existing inventories. The following activities had been contracted out by M/s Alliance Air to IA:-

(i) Sales
(ii) Passenger check-in and ground handling
(iii) Major maintenance including major snag rectification and maintenance checks above "3A" of all the aircraft and Line Maintenance activities at all out stations excepting Delhi
(iv) Training of Pilots and Engineers.
(v) Security
(vi) Training of Cabin Crew up to 1998.

M/s Alliance Air carried out the following activities on its own:-

(a) Supervision of passenger handling
(b) Catering services at main bases

(c) Line maintenance activities up to Flight Release Certificate for six (6) aircraft (including the crash aircraft VT-EGD) at Delhi

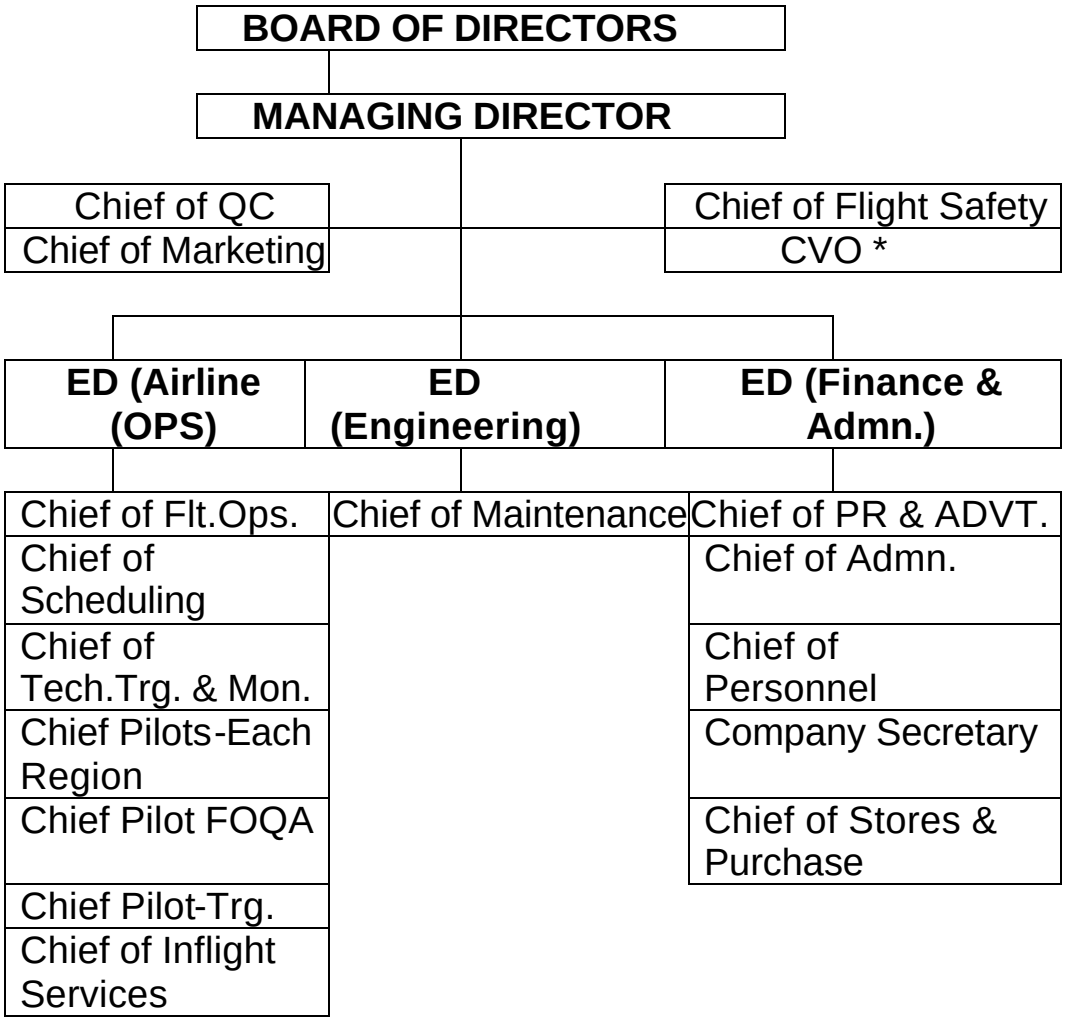
(d) Pilots and Cabin Crew

(e) Flight Dispatch

(f) Personnel and Financial Management

(g) Training of Cabin Crew since 1999.

ORGANISATION CHART OF ALLIANCE AIR



* Being looked after by Chief Vigilance Officer (CVO), Indian Airlines.

1.18 **INITIAL ACTIONS**

Immediately after the accident, the Director General of Civil Aviation, India (DGCA) appointed Shri P Shaw, Controller of Air Safety, Eastern region, Kolkata as the Inspector of Accident.

The DGCA also appointed teams of experts from DGCA and the airline industry to collect data for the Inspector of Accident. Experts from other fields such as Forensic Science, Explosives, Security and Boeing joined the teams.

Detailed examination of the wreckage was carried out to establish the configuration of the aircraft at the time of the crash. The Flight Data Recorder (FDR) and the Cockpit Voice Recorder (CVR) were located and removed for safe custody. The tapes of conversation between ATC and the aircraft at Patna and Kolkata were heard, transcripts prepared and kept in safe custody.

The entire history of the aircraft from the time of its manufacture had been preserved in the form of log books. The data about hours and cycles flown, maintenance checks carried out, Airworthiness Directives, Modifications and Service Bulletins complied etc. was

being continuously recorded and preserved. These records were sealed and kept in safe custory.. Similarly each engine had it's own log book with similar data. These log books and all other documents pertaining to the aircraft were sealed and kept in safe custody.

The records pertaining to training, Pilot's licenses, medical examinations and refreshers of the operating crew members were collected.

The records of the navigational aids at Patna Airport such as ILS, DVOR, DME, etc. with their serviceability and calibration reports were collected. The calibration check of the ILS was carried out using the check aircraft. The records of the AAI fire services were also collected.

The Inspector of Accident scrutinised the documents collected which are mentioned above

2 ANALYSIS

2.1 Airworthiness Aspects

The aircraft had been operating with Indian Airlines since its manufacture in June, 1980 by Boeing. The aircraft records show that the aircraft sustained damage to its Right Wing tip due to contact with the runway surface during a Go Around initiated close to the ground at Trichurapally in Tamilnadu, India on 15th January, 1986. The repair was carried out and after that the aircraft had continued to fly satisfactorily.

7 'C' check, which is the highest category of major check for B737-200 aircraft, was undertaken between November, 1999 to January, 2000. The aircraft underwent a 20-year ageing aircraft modification programme and Corrosion Prevention and Control Programme (CPCP) inspection & repair. These two programmes were part of the industry wide effort to eliminate the effect of fatigue and age on the aircraft structure. These programmes were developed in consultation with the manufacturer, various airline representatives (including Indian Airlines, Air-India), Federal Aviation Administration (FAA) of USA and other industry bodies such as IATA, ATE etc. Accomplishment of these programmes ensured that the aircraft structure

was safe to continue beyond its Design Service Objective (DSO).

Scrutiny of the completed checks indicated that the aircraft was in a satisfactory condition. Its structure was inspected thoroughly and all the inspection findings were attended to.

All the required Airworthiness Directives, modifications and inspections were complied with. The Engineering Department of Indian Airlines, Delhi carried out the 7C check on this aircraft. The engineering organisation had the approval of DGCA to undertake the scope of work of the 7C check of Boeing 737-200 aircraft. The Engineering Department of Indian Airlines was carrying out the maintenance and inspection of Boeing 737-200 aircraft since its induction in the year 1969. Indian Airlines was, therefore, adequately experienced to undertake the maintenance and inspection work of Boeing 737-200 aircraft.

The work on the aircraft had been undertaken as per the manufacturer's guidelines. In addition, extra tasks were performed as per in-house experience. The aircraft undertook its first flight after the major check on 1st February, 2000 and was in continuous service since then. It had accumulated 1305 hrs. of flying at an average of 8

hrs. flying per day in the preceding 5½months from 1st February to 17th July, 2000,. In this period, it also carried out 1577 landings.

All the intervening checks were carried out well ahead of the maintenance schedule and no check was overdue at any time. The defect history of the aircraft indicated that there were no serious defects in the 5½ months of operation since check 7C. In the flight controls chapter, two defects were reported. One defect was reported thrice between 24th February, to 10th March, 2000 pertaining to Flap Lever being stiff between 0 to 1 and 1 to 0 positions. Inspection and lubrication of the cable system was carried out, after which, the defect was not reported again.

The other defect related to LE Flap number two Transit Light remaining 'ON'. Replacement of the proximity sensor resolved the problem on the same day it was reported i.e. 29th June, 2000.

In Hydraulics Chapter (29) one defect related to observation of hydraulic leak on ground from a pinhole on the full extend line of LE Slat NO. 1, inboard of LH engine. There was no loss of pressure or difficulty in Slat extension reported. The defect was rectified by perma-swaging (a Boeing approved repair procedure for

hydraulic lines where external sleeve is swaged on to the line) of the line in two places.

In all, there were 396 write-ups in the last 165 days of operation. None of these defects were considered to be of a serious nature which might have had a bearing on the accident. In general, the rectification action was not delayed or deferred for any period longer than necessary. There was no apparent lack of spares or manpower to support maintenance of the aircraft.

The post crash period saw a number of comments about the safety of aging aircraft. The safety of any aircraft depends on the maintenance standards that are being adopted. A poorly maintained aircraft may not be old but may still be unsafe. The integrity of the structure decides the continued safety of an aircraft.

The structure of the aircraft is affected by fatigue and corrosion. The manufacturer and the regulatory agencies have addressed these issues by incorporating various requirements during the operation of an aircraft.

The structure is subjected to repetitive inspections using different techniques such as detailed visual inspection, Eddy current and ultrasonic inspections, X-ray and radiographic inspections etc. These inspections are

carried out at intervals, which depend on usage of aircraft as well as the calendar. Increased utilisation means more frequent inspection. However, an aircraft with low utilisation is also inspected at fixed intervals of time. Various parts of the structure, which are susceptible to fatigue, undergo mandatory modifications to improve the reliability of the structure.

The systems of an aircraft are subjected to various inspections and operational and functional checks. The components of an aircraft including engines, undergo inspection, overhaul and functional check to ensure continued serviceability.

From the time of its manufacture the aircraft is subjected to continued airworthiness programme to ensure the safety of operation. The honorable Chief Justice of the Mumbai High Court had the following comments to make about the effect of age on the safety of an aircraft, while ruling over a Public Interest litigation on 12th January, 2001 (Writ petition No. 3921 of 2000).

QUOTE

> "We have, therefore, reached the conclusion that the mere fact that an aircraft has crossed its design economic life does not make it unsafe for flying, though it may adversely, affect the profit-earning

capacity of the operator on account of its high cost of flying in view of the heavy cost of maintenance, repairs and replacement of parts. However, if such an aircraft is properly maintained in accordance with the instructions of the manufacturers and the directions issued from time to time by the aviation authorities, such aircraft can be flown for many years after it has crossed its design economic life. " **UNQUOTE**

The Court agrees with these comments. The safety of the aircraft depends on Standards of Maintenance, which in this case, were found satisfactory.

2.2 **Weather**

The visibility at 0720 hrs. was 4000 meters with morning haze. The wind was calm with temperature of 30° C. Hence, weather was not a considered to be contributory factor for any of the actions taken by the crew.

2.3 SABOTAGE ASPECTS

2.3.1 Explosives Examination

The wreckage, the crash site and the surrounding area was subjected to the above examination by the Bomb Disposal & Detection Squad (from Kolkata office) which is a part of the Bureau of Civil Aviation Security. In their report these experts concluded that there was no explosion on board the aircraft prior to the crash. There was also no material evidence to indicate that there was an explosion on the ground after the crash. The report ruled out sabotage as a cause of the crash.

2.3.2 Fire

The crash site was approximately five to six km. by road from the Airport Terminal. The normal practice of taking out one or both Crash Fire Tenders (CFTs) on every arrival and departure of an aircraft was followed on 17th July, 2000. The crash crew were supposed to have been in their respective positions in readiness for any eventuality. However, the crash crew were short by two members on that day.

On 17th July, 2000 both CFTs were waiting for the arrival of flight CD-7412 at Patna. Since, the crew of the

CFTs had a clear view of the approaching aircraft and could see for themselves, the aircraft descending, disappearing behind the trees and the column of smoke indicating a crash. This was followed by the crash siren, crash alarm and announcement over the public address system by the duty Air Traffic Controller.

Both the CFT crews stated that they reached the crash site within five to six minutes of the alarm. This was unlikely as the distance and traffic conditions at Patna would have prevented them from reaching the site in less than 10 to 12 minutes. Many eyewitnesses present at the crash site have supported this. Out of the two CFTs, only one was able to function as the other had a mechanical breakdown after about three minutes of operation. The CFT had the capacity to deliver foam from the monitor for approximately three minutes. Foam delivery was limited by the capacity of the water tank of the CFT

The CFTs had a provision to draw water from tanks or shallow wells and use it for fire fighting. However, no such source of water could be located and one CFT had to return to the Airport for water. The City Fire Brigade joined the fire fighting effort after about 30 to 40 minutes of the crash message being circulated.

Airports are graded as per the capacity of the fire services they can provide. International Civil Aviation Organisation (ICAO), a body of United Nations (UN) has laid down the standards in this regard. The size of the aircraft that can land at any airport is decided, amongst other things, by the category of the fire services. As per the above standards, Patna airport required one CFT, which was category V. This was adequate for Airbus 320/Boeing 737 operation. However, Airports Authority of India (AAI) maintained category VI i.e. two CFTs, which was higher than required.

As per ICAO Annexure 14-Aerodromes, Volume-I, Para 9.2.19, the operational objective of the rescue and fire fighting service, should be to achieve response times of two minutes and not exceeding three minutes, to the end of each runway, as well as to any other part of the movement area, in optimum conditions of visibility and surface conditions.

Since, the crash site was five to six kilometers away from the Fire Station of AAI by road, it was felt that there was no undue delay on part the of the Airport Fire Services to reach the crash site and start rescue operations.

The principle objective of the Airport Fire Services was to control the fire in such a way as to allow rescue of the passengers to commence quickly and save lives. It was supposed to cover the Airport and its immediate vicinity. In this respect, the Patna Airport Fire Services equipment met the requirement. The failure of one CFT was attributed to an airlock in the fuel line, which was rectified by the AAI workshop mechanic in about 1½ hours. By this time, the need for fire fighting had greatly reduced.

There was no doubt that the second CFT would have contributed to the rescue operation since it was the first to reach the site. However, it was possible that someone from the surging crowd might have stepped on the fuel line disturbing its connection. This exposed fuel line has been provided with a protective cover subsequent to this accident. AAI may look into the requirement to provide protective covers to all similar CFTs in their inventory.

2.3.3 **Crowd Control**

The Gardani Bagh area was a densely populated low-lying area with narrow roads and slushy shoulders. The CFTs of Airport Fire Services and even the City Fire Brigade Fire Tenders encountered considerable difficulty

while attempting to reach the crash site due to this topography. (Refer Annexure “A” for Wreckage Diagram).

There was no doubt that the local residents of the surrounding area were the first to start rescue operations to help the passengers and risked their lives in the process. The Civil Lines at Patna where senior functionaries of the Bihar Govt. including the Chief Secretary and Police Officials reside was next to the crash site. This proximity to the crash site enabled them to reach there within minutes. This was extremely fortuitous as they were able to mobilise State Govt. resources for fire fighting and rescue rapidly.

Unfortunately the crowd which had collected within a short time was of unmanageable proportions and definitely hampered the passage of rescue vehicles. According to witnesses, even though there was no outbreak of violence, crowd tempers ran high and there was a general tendency to target anybody in uniform or position of authority with verbal abuse and physical violence. The Airport Fire Service personnel, Indian Airlines staff, police personnel and even the Chief Secretary himself were victims of ire from the crowd. At times, there were hundreds of people trying to climb on to the rescue vehicles to get a better view. This definitely

slowed down rescue efforts. (Refer Annexure 'B-1','B-2' and 'B-3' showing photographs of the crowd)

Arrival of Bihar Military Police Jawans of the Police Training College and the Army contingent finally brought the situation under control. Their arrival helped rescue operations to continue till all the dead bodies were extricated from the wreckage. However, tension prevailed in the area for a few days and the investigating teams had to seek police protection at times.

In general, the rescue operation commenced without any delay. When the crisis occurred, the response of the people at all levels was prompt and praiseworthy. However, this effort was hampered by the unmanageable size of the crowd and resulting mob mentality.

(Please refer to the photographs at Annexure 'B-1', 'B-2' and 'B-3')

2.4 **ANALYSIS OF FLIGHT RECORDERS**

(Refer Annexure B-12, B-13 and B-14 for DFDR & B-15, B-16 and B-17 for CVR photographs.
Also refer Annexure 'C' for CVR transcript and 'D-1', 'D-2' and 'D-3' for FDR plots and 'H' for FDR ground track)

2.4.1 **Flight Data Recorder (FDR) Analysis**

The aircraft had arrived at Kolkata on the night of 15th July, 2000 at 2200 hrs. after operating the Kolata-Ahmedabad-Jaipur-Kolkata sectors.

The aircraft was on ground throughout Sunday, 16th July, 2000, as there was no requirement for its utilisation. It was observed that there were neither Pilot reported defects nor defects under Minimum Equipment List (MEL). All required checks were satisfactorily completed.

Scrutiny of the ATC tapes at Kolkata (CCU) revealed that the departure from Kolkata was normal and routine. Witnesses who had completed the departure formalities confirmed this.

The aircraft took off at 0651 hrs. and was estimated overhead Patna at 0736 hrs., after a flying time of 45 minutes. The Kolkata Area Control tracked the progress of the flight on the MSSR (Monopulse Secondary Surveillance Radar). Scrutiny of these tapes revealed that the aircraft had maintained it's assigned altitude and the W52 track.

This monitoring was possible up to SAREK (an aerial reporting point with coordinates N24 08.0 E086

46.0) and slightly beyond after which the aircraft went out of range of the radar. The aircraft reported crossing SAREK at 07:11 hrs. and was on a heading of 315° at FL 260 (its assigned cruise level). The aircraft reported to Patna ATC two minutes after crossing SAREK and obtained clearance as well as the Meteorological (MET) report. Eight minutes after crossing SAREK at 07:19 hrs., the aircraft was cleared to descend to 7500 feet and told to report 25 NM (Nautical Miles) from Patna DME (Distance Measuring Equipment). The aircraft reported that it was 25 NM from Patna at 07:26 hrs. ATC cleared the aircraft to descend to 4000' and join the ILS-DME ARC approach at 13 NM on DME.

Analysis of the FDR data indicated that the aircraft then deviated right from the W52 track of 315º to a heading of 329°. This happened at approximately 21 NM on the DME. (Refer Annexure 'D-3' for heading plot of last six minutes)

Patna ILS-DME ARC Approach procedure was introduced on 24th March, 2000. The procedure connected the W52 Track coming from Kolkata to a constant radius turn at 11 NM maintaining a height of 2000' up to the Lead Radial at 080°. After crossing the Lead Radial, the aircraft had to turn on to the Localizer Beam at a height of 1700' and then follow the Localizer

and GS commands. With this procedure, the aircraft was established on the runway centre line at 6 to 7 NM and stable approach was achieved for a proper landing. (Refer Annexure 'E-1' and 'E-2' for the above procedure at Patna airport)

At 07:28 hrs., the aircraft informed ATC "Commencing the ARC 7412, call you established Localizer, to which Patna ATC replied "Descend to 2000' QNH 997 hPa. Report crossing Lead Radial 080 PPT".

The FDR data indicated that the aircraft did not commence the ARC but continued on the same heading of 329°. The aircraft would have had to turn right through 60° to 70° to join the ARC and thereafter, execute a slow but continuous left turn to 250° to align with R/W 25. However, no such maneuver was recorded. The aircraft was supposed to descend to 2000' while flying the ARC approach but the FDR data indicated that the height remained at 4000' even two minutes after reporting "Commencing the ARC".

The FDR Heading data further showed that the aircraft then slowly started turning left from 329° to 323° again right to 327° and back to 321°. During these 3½ minutes, the configuration of the aircraft changed from

Flaps UP to Flaps 1, Flaps 5, Gear down, Flaps 15. At 07:26 hrs., the aircraft reported to ATC "7412 crossing Lead Radial and coming up on Localizer". The ATC replied back "Descend to 1700' QNH 997 hPa, report establishing Localizer".

As per the Approach procedure at the crossing of Lead Radial 080, the aircraft should have been at 11NM from Patna DME and at 2000'. In actual fact, it was estimated that the aircraft was at approximately 3.5 NM and at 3000'. It must have crossed the R/W 25 centre line almost immediately while maintaining a heading of 320°. (Refer Annexure 'H' for ground track)

On the Approach Chart, at 3.5 NM, the aircraft should have been well established on the Localizer and tracking the Glide Slope, aligned with the runway centre line. The height should have been about 1400'. After crossing the runway centre line, the heading data indicated that the aircraft started turning left from 320° to 231.5°. During this time, the configuration changed to Flaps 40 from earlier Flaps 15. The heading again started changing to the right from 231.5° to 240°.

At 7:32:26 hrs, the last communication from the aircraft to Patna ATC started in which permission to carry

out a 360 due high on approach was requested. This was the point at which a decision must have been made to discontinue the approach and do a 360º turn and make a fresh approach. The aircraft was estimated to have been at a height of 1280' and at a distance of 1.2 NM from the threshold of R/W 25. As per Approach Charts, at 1.2 NM, the height should have been between 610' to 650'.

At 07:32:45 hrs., the communication with Patna Tower ended. The aircraft which was in a left turn, started a right turn just as the transmission ended which was again reversed to a steep left turn and then a right turn. In approximately 15 seconds, the FDR recorded bank angle changes from Left 21º to Right 14º to Left 47º to Right 30º. After the decision had been made for a 360, the Nose Down pitch attitude of the airplane reversed to airplane Nose UP first to 8º and then to a peak of 16º. The CVR recorded Stick Shaker activation, which was an advance warning of approach to a Stall at 07:32:51 hrs., six seconds after the last transmission was made. The sound of the Stick Shaker was heard continuously till the end of the recording.

Within two seconds of Stick Shaker activation, engine thrust was increased to 1.84 EPR and the Flap Lever was moved to 15º gate as indicated by a click

sound on the CVR. The Pilot called out for gear retraction (*GEAR OOPER LELO*). This was followed by a click sound indicating operation of the Gear Lever.

The Gear Unsafe Warning sounded at 07:32:56 hrs. This was indicative of the Flaps transiting from 40 to 25 (Gear Unsafe Warning sounds when Landing Gear is not locked down and the Flaps are in landing configuration i.e. 25 to 40. This warning cannot be silenced by the horn cancel button.

The Gear Unsafe Warning stopped sounding as soon the Flaps moved from 25 upward towards its commanded position of 15 as found in the wreckage. The Ground Proximity Warning “Whoop Whoop pull up” started sounding at 07:32:58 hrs. and continued. The CVR recorded the sound of crash at 07:33:01 and the recording stopped thereafter.

Scrutiny of parameters recorded in the FDR indicated that from the time the aircraft was cleared to descend from Flight Level (FL) 26000 i.e. at approximately 07:20 hrs., the engines were throttled back to idle and remained at idle till 07:32:45, i.e. 15 seconds before the crash. Even though the aircraft was being maneuvered, the engines remained at idle.

The Indicated Air Speed (IAS) record showed that the speed had continuously reduced to the lowest value of 119 Kts (Nautical Miles/Hr). This air speed was the same as V_{REF} for Flaps 40 landing at an aircraft weight of 40 tonnes (V_{REF} is the speed, which the aircraft is supposed to attain when it is about to touch down).

In this respect, the Boeing 737 Operators Manual stipulates the following procedure for an approach.

QUOTE

> "When the wind is reported calm or light and variable and no wind shear exists V_{REF}+5 Knots is the recommended air speed on final, bleeding off the 5 Knots as the aircraft approaches touchdown. **UNQUOTE.**

In effect what it meant was that the airspeed should have been much higher than 119 Kts, at least 124 Kt, if not more. When the final communication was started with Patna Tower, the speed recorded was 130 Kts. By the time, the transmission was completed 16 seconds later, the speed had dropped to 122 Kts and thereafter to 119 Kts.

This speed reduction did not appear to be intentional. It meant that the Co-Pilot (flying the aircraft

from the left seat) was not concentrating on flying. He was probably looking out for the runway and judging the situation or his attention was diverted to what the Commander (sitting on the right seat) was conveying to Patna Tower, which had caught him unawares. The Commander was probably busy with the conversation. Either way it appeared that both Pilots had failed to notice the drastic reduction in air speed. The turn was probably started without realising that the air speed had reduced to 119 Kts.

The aspect of Engine Thrust Management was examined closely since the engines had remained at idle power throughout the descent. The Boeing 737 Operation Manual did not mention the engine thrust requirement directly but the requirement of air speed was specified at various places. It was for the Pilot to judge and use adequate engine thrust so as to maintain the required air speed. Experienced Boeing 737 Pilots whose views were sought in this respect, were all of the opinion that using at least 1.40 EPR with Flaps down was a safe practice. (Refer Annexure 'B-9' and 'B-10' for photographs of engine)

It was not clear why the engines were kept at idle thrust even after selecting Flaps 40. It was perhaps because the aircraft was higher than normal on approach.

If the intention was to regain the correct glide path then classic flying technique would have required the Pilot to maintain speed by reducing the angle of attack i.e. by pushing the control column forward while allowing the aircraft to regain the correct glide path with an increased rate of descent. The old adage that "the Stick (control column in an airliner) controls airspeed and power controls the glide path" continues to be true even for modern jet airliners. There was little doubt that a higher engine thrust setting would have prevented rapid speed decay and delayed activation of the stick shaker. It would have also aided quick recovery from an approach to stall condition of flight. In this respect, an entry in the Co-Pilot's training records where during a simulator training session his instructor had noticed poor thrust management becomes pertinent. The instructor had given him additional training before clearing him.

2.4.2 **Cockpit Voice Recorder (CVR) Analysis**

The sound quality of the CVR tape was good even though the box itself was totally burned in the fire after the accident. Since, each of the Cockpit Stations was assigned a separate channel, it enabled confirmation of the source of recording. (Refer Annexure 'C' and 'D-1' for CVR transcript and FDR data plot with CVR transcript of last 40 seconds)

The Public Address (PA) System announcement, which was at the beginning of the tape, created a doubt about the seats occupied by Captain Sohanpal and Captain Bagga. Voice recognition by the wives of the deceased Pilots confirmed that Captain Bagga, the Co-Pilot was seated on the left seat and Captain Sohanpal, the Commander was seated on the right seat. Except for the PA announcement at the beginning of the flight, all RT air to ground communications were carried out by Captain Sohanpal.

Much of the CVR conversation was communication with various ATC and Tower personnel. The intra cockpit conversation was mostly in the form of checklists and announcements. There was hardly any conversation between the Commander and the Co-Pilot, except for asking for a Newspaper or commenting about moisture or asking for the Patna frequency.

Considering the fact that it was an early morning flight lasting for only an hour, it was possible that much conversation was not the expected norm.

It was observed that Patna ATC was being given an impression that the aircraft was following a “Standard DME ARC Approach Procedure” as per the manual while

there was no intention to follow the ARC. It was expected that at least the Commander would have briefed his Co-Pilot about the procedure which was to be followed. No such briefing was heard on the CVR.

The second glaring silence was at the time when it was realized that the approach had not stabilized, the aircraft was not at the correct height and was too close to the R/W 25. There was a definite need for the Commander to brief the Co-Pilot about his intended corrective action.

The CVR recording, just prior to the last conversation of the Commander with Patna ATC, had three words from the left seat channel with the rest drowned out by the RT communication.

> The words sound as “Left hand down……or “Left and down…….”

A series of viewpoints were considered. One view was that the Co-Pilot wanted to carry out a missed approach and go left hand downwind of R/W 25. The other was that he was merely pointing out the runway location.

Either way this brings into picture a conflict of views, which the Commander decided to resolve in a completely different manner without any discussion with the Co-Pilot.

The procedure to carry out a 360 was not an authorised procedure as per the Alliance Air Operations Manual and could have caused considerable confusion in the mind of the Co-Pilot. It was clear from the FDR recording that the aircraft was not following the DME ARC ILS procedure but Patna ATC was being given the impression that the aircraft was doing so.

At any busy airport with some more traffic, this would have been unthinkable and would have created a conflict. However, there was no other traffic for miles around Patna and ATC gave the permission, only after confirming that the crew had the airfield in sight.

2.5 **Circumstances Leading to the Crash of the Aircraft.**

Approximately 8 seconds before impact, the stick shaker warning was activated. At initiation of warning, the configuration of the aircraft was, “Flaps 40, engine thrust at 1.5 EPR, Speed at VREF-119 Kts., Pitch Attitude-10° Nose Up, Left bank at 20° (just out of a rapid bank reversal)”.

Under normal circumstances, the stick shaker was expected to be activated at a speed much below 119 kts. However, a rapid roll reversal with higher than normal Nose Up pitch attitude might have activated the stick shaker at higher speeds. Simulation exercises were carried out at the B737-200 Flight Simulator at Central Training Establishment, Indian Airlines Ltd., Hyderabad. Repeated simulations with the same kind of maneuvers that were seen on the FDR always resulted in activation of stick shaker at speeds between 118 Kts. to 122 Kts. However since there was no provision to record flight data, the load factor in all these simulations could not be ascertained.

Boeing carried several studies involving mathematical simulations and analysis of wind tunnel data. They were of the view that a significant loss of lift equivalent to 18 Kts. of speed had occurred. They did not agree with the view that the stick shaker had activated at a higher speed due to maneuver of the aircraft as the FDR had recorded a load factor (vertical acceleration) close to 1g. They said that such a low load factor was not likely to trigger activation of the stick shaker. They carried out studies with various changes in the configuration of the aircraft. These consisted of deployment of Speed Brakes in flight, Single Flight Spoiler extension, High Lift

Devices Trailing Edge Flaps and Leading Edge Flaps out of commanded configuration.

The simulation and studies had eliminated all, but one, configuration about Leading Edge (LE) Devices not being in their commanded position i.e. fully extended. This study in part was dependent on the examination of the Actuators of the LE Devices found in the wreckage. Initially, these were not in the list of parts for which Boeing had asked for laboratory tests to be conducted on. However, on 20th December 2000, five months after the accident, Boeing requested the Court for permission to examine them at the Equipment Quality Assurance (EQA) Laboratory at Seattle, WA, USA.

Out of a total of 10 actuators, seven were sent to Boeing, two were not located and one was examined in-situ, still attached to a portion of broken wing. Of the eight actuators, one was found fully extended, another was fully retracted and locked. The other six were in a partially extended position. The extension was such that both inner and outer pistons had unlocked and extended. As explained earlier, the actuator had a hydraulic blocker valve, which was supposed to keep the Leading Edge Slats and Flaps from blowing back with loss of hydraulic pressure. (Refer Annexure ‘B-11’ for photograph of Slat Actuator No. 5)

Hence, it was expected that the actuators, if they had been fully extended, would have maintained their position even after impact with the ground. In support of this, Boeing produced photographs of actuators from another accident to a Boeing 737-200 aircraft with Registration Mark-N999UA of United Airlines Flight UA-585, which had crashed at Colorado Springs, USA in March, 1991. The aircraft had entered a nearly vertical dive and impacted the ground nose first. Most of the actuators were severely damaged but were found to be in the fully extended position.

The actuators, which were recovered in the wreckage at Patna, were mostly in an undamaged condition, even though they had been subjected to impact loads and burned in the post crash fire. The only actuator, which was severely damaged, was the one with full extension. Its housing was damaged and cracked in several places, which had probably not allowed the pistons to retract post crash. Boeing stated that the actuator had extended due to vapourisation of the hydraulic fluid during post crash fire.

On its final flight path, the outboard portion of the right wing had broken off, when a tree had torn through the wing. This portion of the wing separated and fell near

the trees next to the crash site. A photograph of the wing portion with No. six LE slat clearly indicated that the LE Slat was extended. (Refer Annexure 'B-8' for photograph of No. 6 LE Slat and 'B-6' and 'B-7' for the final flight path of the aircraft).

The rest of the aircraft, with landing gear in retracted position, hit the ground, with the engines contacting the ground first and taking the impact of the wing. The aircraft also brought down two brick houses and the wings were buried under the earth.

It was not possible to estimate the loads and forces the LE slats and flaps had been subjected to at impact. The aircraft wreckage had to be moved around to recover bodies trapped under it. This was done using mechanical shovels and equipment. The Court carried out laboratory tests on the LE Slat Actuator at the Indian Airlines, Engineering Facility at Delhi. The test was aimed at understanding the retraction of actuator pistons from the fully extended position with no hydraulic pressure and external force applied to retract them. It was observed that a sustained force of approximately 150 kgs. was sufficient to start a slow retraction of pistons. This force could have been applied while shifting the wreckage to search for bodies or even with a number of persons

standing on the wreckage. (Refer Annexure ‘B-3’ and ‘B-4’ for photographs of the rescue operation)

It was necessary to make several assumptions to invent a scenario of LE Slats and Flaps remaining out of commanded position. Following was the sequence of assumptions as suggested by Boeing.

(A) The aircraft on its departure from Kolkata (CCU) had to have a fully functional LE Slats and Flaps System. Otherwise, the aircraft would have had to return to the departure gate

(B) When Flaps were selected to FLAPS 1, the LE Flaps and Slats did not extend. The Amber Light “FLAPS IN TRANSIT” came on, but the crew ignored the warning and did not even mention it to each other since nothing was recorded on the CVR. Alternately, the indication system had also malfunctioned. Refer Annexure ‘L’ for indication panel of LE Devices)

(C) When Flaps were selected to Flaps 15, again, the LE Slats did not go to the full extend position and the crew ignored the warning again. Alternatively, the indication system had again malfunctioned. This would amount to a third malfunction in the

Leading Edge Devices Extension and indication system. The crew had not mentioned it to each other since the CVR had not recorded any such conversation.

(D) When the Stick Shaker activated and the crew initiated a Go Around procedure and raised the Flaps to 15 from 40 followed by gear retraction, the aircraft stalled and started loosing height rapidly. The crew then realised that the LE Devices were not in the commanded position. After the Flaps had moved to 15 position, the Co-Pilot looked up at the overhead panel, reached out and selected Alternate Flaps to ARM and Flaps Switch to Down (to extend the LE Devices).

The aircraft crashed three seconds later.

The last assumption (D) became necessary in view of the fact that the LE Slat Actuators had both the pistons extended by a few inches at least. As explained earlier, the LE Slat Actuator follows a sequence of extension with inner piston extending first at Flaps 1 and outer piston thereafter at Flaps 10, when they are extended normally using Hydraulic System 'A'. It is only when the Flaps are selected to ALTERNATE FLAPS ARM and DOWN the inner and outer pistons extend simultaneously using the

Standby Hydraulic System. (Refer Annexure 'J' for Flight Control panel diagram and 'I' for hydraulic diagram of LE Devices))

However, with the Alternate Flaps selected to ARM, the normal operation of the Trailing Edge Flaps with the System 'A' hydraulic motor is stopped. Any further operation had to be carried out electrically by the Pilot on the left seat (in this case the Co-Pilot) selecting the Flaps Control Switch to UP or DOWN. The CVR timing of Flap retraction and Gear unsafe warning indicated that the Trailing Edge Flaps had retracted hydraulically. That meant, the Co-Pilot on the left seat, had to wait till Flaps had moved to 15 and then select the Alternate Flaps to ARM and select Flaps DOWN. By this time, the aircraft was probably very close to hitting the trees. It was highly unlikely that a pilot flying the aircraft would leave the Control Column and reach for the Flaps Switch with the aircraft undergoing post stall gyrations. The autopsy report of the Co-Pilot's body revealed that he had injuries on his hands and feet which indicated that he was gripping the Control Column and had his feet resting on the Rudder Pedals at the time of the crash.

Considering the flight conditions (the aircraft had commenced post stall gyrations at this time) and the time

available to the Co-Pilot to use the alternate system to extend the LE Devices, this scenario is ruled out.

Boeing presented a plot of Lift Coefficient against Angle of Attack. It was argued that the plot from FDR data matched that of wind tunnel test data for an aircraft with LE Slats retracted. However, this data had not been validated by any flight tests.

The Boeing 737 landing with LE Devices not in correct position, required a Flaps 15 landing with speed being maintained at V_{REF}+5 Kts i.e. 134 Kts in this case. The use of Flap 15 in the case of LE Devices not in correct position is to allow a Go Around procedure to be executed, if necessary. A normal Flaps 15 landing is at 129 Kts (for a landing weight of 40 Tonnes). These figures were obtained from Quick Reference Handbook of B737 airplane at CTE, Indian Airlines, Hyderabad.

Boeing argued that even if the LE Devices remained retracted, there was no question of the aircraft going out of control. The aircraft would not have encountered loss of lift if adequate speed was maintained. Even if a loss of lift situation had arisen due to reduction in speed, the aircraft would not have stalled if prompt Approach to Stall recovery procedure had been initiated when the stick

shaker activated. (Refer Annexure ‘M’ for Approach to Stall Recovery procedure)

Considering all the above aspects, it did not seem probable that an aircraft would develop multiple defects and the crew would ignore all warnings and continue the flight without taking timely corrective action. Even Boeing admitted that such a pattern of failure had not been reported to them by any operator in the past. There have been instances of a single Slat or Flap indication failure, always accompanied by warning light, but Boeing could not quote an instance where complete failure of a system along with indication failure, had occurred.

The plot of Lift Coefficient against Angle of Attack submitted by Boeing may be mathematically correct but in the absence of validation by Flight Test, it was difficult to determine the difference in performance of the wing in the two configurations (Slats normal and Slats retracted). The difference between the two configurations as far as landing speed was concerned, was only five Knots. It was probable that the plot represented the actual performance of the wing with Slats fully extended.

Detailed analysis of the graph of kinematically corrected pressure altitude against the time scale revealed that there were three distinct changes in the

slope of the curve which otherwise had a smooth rate of descent. At 16 seconds before the crash, the spooling up of the engine had reduced the rate of descent. However, eight seconds later when the Flap Lever was moved to 15, the rate of descent increased as seen by the steepening of the slope of the curve. This was caused by loss of lift due to the reduction in wing area as the flaps moved up from 40 to 15. (Refer Annexure 'D-1' for FDR plot of last 40 seconds)

Six seconds after the Flap Lever was moved to 15, the rate of descent increased even further indicating that the flaps were close to 15 position and the wing no longer generated enough lift to support the aircraft. This high rate of descent together with the high Nose Up pitch attitude held by the Pilot resulted in the aircraft attaining a very high Angle of Attack of the order of 26º. The aircraft had completely stalled by this time and even though thrust had been increased to the maximum possible on both engines, recovery was not possible

Extrapolation of the curve before the Flap Lever movement indicated that the aircraft would have certainly recovered from the approaching stall if the flaps had not been disturbed. Adequate engine power and reduction of Angle of Attack by reducing the pitch attitude would have allowed the aircraft to fly out of the hazardous situation.

2.6 **Pilot Factor**

It was clear from the CVR tape that the atmosphere in the cockpit was relaxed and tension free till 15 seconds before the crash.

There was no mention of any abnormality or malfunction of any system of the aircraft. The configuration of the aircraft was changed from Clean Cruise Configuration to Landing Configuration of Flaps 40 and Gear Down approximately 2 minutes 20 seconds prior to the crash.

Even when the decision for a 360° turn was conveyed to Patna ATC, there was no sense of anxiety or apprehension in the voice of Captain Sohanpal. However, the element of surprise must have been there having sighted the field so near, with the aircraft much higher than expected.

It was not clear whether the Co-Pilot (Flying from Left Seat) understood the decision of the Commander (Flying from right seat) to make a 360° turn instead of a Missed Approach Procedure which, probably, was in his mind. (Left hand down…).

In all probability, the heading change to the Right seen on the FDR was either for a missed approach or to make an “S” approach to lose height and still try to effect a landing. (“S” approach is resorted to in VFR conditions, when the aircraft is high on approach and cannot lose sufficient height with a straight-in approach. The aircraft is maneuvered in a zigzag manner to lengthen the approach path and enable loss of excess height). However, within two seconds of end of conversation with Patna ATC, the aircraft reversed its bank by rolling to the left and the pitch attitude increased to 12° nose up.

The sound of stick shaker activation was clearly heard on the CVR. However, there was no verbal comment from either pilot. The next sound heard on the CVR was most probably that of the flap lever hitting the gate at 15 position. (Refer Annexure ‘K’ for Flap Lever operation)

The first sign of anxiety became apparent only when the Co-Pilot called out “*Gear Ooper Lelo*” (Raise the Gear up). By this time, the aircraft had probably entered a full aerodynamic stall and the controls were no longer effective (as is to be expected in a stall). There were no more comments from the crew except for a “Noooo-“ exclamation by the Commander.

The actions of the crew i.e. full engine thrust, Flaps to 15 and Landing Gear Up, related to Go Around procedure. This, along with the pitch attitude of 10 to 12° as recorded by the FDR, indicated that the crew had initiated a Go Around to fly out of the situation. However, activation of the Stick Shaker was a warning that the aircraft was approaching a stall and would stall unless an aggressive Approach to Stall recovery action was initiated.

An Approach to Stall recovery action required that the aircraft configuration not to be disturbed, full thrust opened on both engines and the Angle of Attack reduced by lowering the nose (pitch attitude). The FDR had not recorded any of these actions, except for opening up of the throttles of both engines that too in two steps of medium thrust followed by full thrust only in the last stages of flight. (Refer Annexure 'M' for check list of Approach to Stall Recovery procedure).

CVR analysis revealed that during the early part of the approach at time 22:03:4, the call for Flaps 40 by the Co-Pilot was not acknowledged by the Commander. However, a sound was recorded at time 22:04:8, which sounded like that of flap lever movement. In addition after the "*Gear Ooper Lelo*" call at time 22:25:06, Gear Unsafe Warning was recorded which would have activated only

when the landing gear was not locked down and flaps were moving up from 40 to 25. This was irrefutable proof that the flaps were at 40 when the approach was commenced.

The Gear position was acknowledged in checklist earlier with “Down, Three Green”, which indicated all the three gears were Down and Locked. The scenario in the final moments was as below:

(i) The aircraft had not followed the approved Approach procedure, but intersected the Extended Runway Centerline with a lateral separation of about 3 to 3.5NM and tried to align with the centerline at a very short distance from the runway.

(ii) The engines were at idle throughout the descent profile and the speed was continuously reducing.

(iii) When it was realized that the aircraft was too high to effect a landing, a 360° orbit was requested. The speed by this time had dropped to V_{REF} 119Kts., which was actually the landing speed.

(iv) The aircraft was maneuvered sharply and the Stick Shaker activated.

(v) A “Go Around” was initiated by retracting the flaps to15, opening throttles, retracting the landing gear and holding a nose up pitch attitude of 10 - 12°.

(vi) The retraction of flaps to 15 together with high pitch attitude and in- sufficient speed caused further loss of lift and the aircraft entered into a full stall regime, from which it could not recover and impacted the ground.

It was probably possible to recover from the situation if prompt and correct recovery had been initiated when the stick shaker activated.

The histo-pathological and toxicological analysis was carried out on the viscera of both Pilots at the Institute of Aerospace Medicines, Indian Air Force, Bangalore. The report was negative.

Wing Commander Gomez, Dy. Director, Medical Service who deposed before the Court, explained in detail about the injuries sustained by the Pilots. He stated that the pattern of injuries indicated that Captain Sohanpal was occupying the left seat and Captain Bagga, the right seat. The Court however felt that it was difficult to conclude this on the basis of injuries suffered. The small size of the cockpit and the unpredictable dynamics of

disintegration of the front section of the aircraft during its impact with the ground made it difficult to understand the nature of injuries suffered by the Pilots.

Wing Commander Gomez further stated that a Pilot handling the controls during an air crash i.e. hands on control wheel and feet on rudder pedals suffered a particular pattern of fractures of the bones of hands and feet. He found this pattern only on the body of Captain Bagga. This was conclusive proof that Captain Bagga handled the controls till the end.

2.7 **ORGANISATIONAL ASPECTS**

2.7.1 **Quality Control Organisation**

Indian Airlines was the registered owner of Alliance Air. The organisation of Alliance Air was completely different with most of its employees working on contract rather than on a permanent basis. Indian Airlines was the main source of trained personnel as their staff were deputed to Alliance Air. Retired Indian Airlines personnel were employed on contract by Alliance Air

Out of the 11 Boeing 737 aircraft, six were under the control of Alliance Air Quality Control organisation. The remaining five aircraft were under the control of

Indian Airlines. All the 11 aircraft were operated by Alliance Air.

The Engineering set up of Alliance Air was restricted to Delhi with all other stations serviced by Indian airlines. Alliance Air had DGCA approval to carry out checks up to 3A (flight release check) i.e. 375 hrs./75 days elapsed time. These checks were carried out by Alliance Air only on the six aircraft under their control.

Indian Airlines carried out these checks on the remaining five aircraft. Work on all aircraft at stations other than Delhi and major checks above flight release check on all aircraft was the responsibility of Indian Airlines. Repair, overhaul and replacement of all components including engines for all aircraft was the responsibility of the Indian Airlines because they had the maintenance infrastructure at Delhi and Kolkata.

The preparation of work-scope of the six Alliance Air aircraft, was the responsibility of the Quality Control Managers (QCM) of Alliance Air as far as maintenance of the aircraft was concerned. However, actual work was carried out by Indian Airlines who would then carry out the checks under their own QCM without any reference to their counterparts in Alliance Airlines. The QCM of Alliance Air reported directly to the Managing Director of

Alliance Air while the Indian Airlines QCM reported to their management. There was a possibility that the two managements could take entirely different decisions for the same fleet of Boeing 737 aircraft.

The officials of Indian Airlines and Alliance Air including Mr. S.C. Jain, the then Director of Engineering, Indian Airlines supported the present set up. It was probably because the personnel on both sides had spent most of their working life in one organisation i.e. Indian Airlines.

The present system of dual channels of responsibility for the same fleet of aircraft being operated by one airline could lead to confusion and divergent decisions. Even though there was no evidence of safety being compromised, there appears to be a strong case to revamp the quality control system in order to eliminate dual control over the same type of aircraft fleet.

2.7.2 **Operations**

The senior management personnel of Alliance Airlines who deposed before the Court stressed the importance being given to Flight Safety at Alliance Air. Crew Resources Management (CRM)l training, Flight Operations Quality Assurance (FQOA), Voluntary

disclosures by the crew, CVR, monitoring, corrective training were all being practiced proactively by the management of Alliance Air.

In this accident, however, it was observed that there was a general lack of adherence to standard operating procedures on the part of the crew. The decision to carry out a 360º turn instead of a missed approach without any discussion with each other indicated a lack of CRM. Adoption of the “Go around” procedure instead of Approach to Stall Recovery procedure when the stick shaker activated indicated that training lessons had been forgotten.

The management of Alliance Air had also emphasised that the recruitment and induction procedures were designed in such way that trainee Pilots were exposed to the airline philosophy and procedures with enough time to absorb them at each level.

The accident provided grim proof that there was a need to review the training curriculum of Pilots of Alliance Air both in the simulator as well as the classroom. There was a need to encourage Pilots to adhere to Standard Operating Procedure (SOP).

2.7.2 **Patna Medical College Hospital**

The bodies of the fatally injured passengers were taken to the Patna Medical College Hospital (PMCH). Autopsies of the bodies were performed by the doctors of the Dept. of Forensic Medicine. All the bodies were videographed before being handed over to the next-of-kin.

The Court visited the PMCH to gain the first hand knowledge of the facilities available there. The facilities of any hospital would be stretched to the limit when a tragedy of this magnitude occurred without warning. PMCH was no exception to this and some confusion did prevail in the initial hours. A surging crowd had collected at the PMCH premises within minutes of the crash. This caused some difficulties for movement of rescue vehicles, the relatives of the passengers and even the doctors themselves. It was to the credit of the PMCH and the civil administration that they brought the situation under control and completed the necessary formalities quickly.

The Court took the opportunity to visit the mortuary, the Casualty Ward and discussed the availability of facilities with the Superintendent and doctors of the PMCH. It was observed that the mortuary building and the facilities were in need of immediate upgradation. The

refrigeration equipment which was meant for preserving bodies awaiting formalities, was not functioning since its installation in 1988. The casualty ward was in need of routine maintenance and upkeep. The Court also felt that there was a need to clean up the premises in general and keep them that way.

2.8 **Analysis of Infrastructure at Patna Airport**

2.8.1 **Patna Airport**

The airfield at Patna has been in existence for more than 40 years. The airfield had a single runway with an orientation of 07/25. The basic strip had a length of 2074 mts. and a width of 150 mts. The Landing Distance Available (LDA) was 1677 mts. for R/W 07 and 1820 mts. for R/W 25. The Take Off Distance Available (TODA) was 1954 mts. from both ends. This difference in the LDA and TODA was due to obstructions and restrictions at both ends.

An aircraft coming in to land on R/W 25, passed over Patna town and keeping the secretariat tower to the left, the aircraft passed over the zoological garden and the airport road. There were tall trees in the zoological garden, a part of which fell in the Approach Funnel of R/W 25. Vehicular traffic on the airport road which was close

to the threshold of R/W 25 also caused restrictions for runway use. As a result, the threshold of R/W 25, was displaced by 400 feet. Tall trees in the Approach Funnel also affected the stability of the radio beam of the glide path. At present, the reliability of the glide slope was only up to a height of 300 feet. Normally for a Cat I ILS System, the glide slope should be reliable up to a height of 200 feet above the runway.

The main railway line on the Delhi-Kolkata route passed very close to the southern airport perimeter wall near R/W 07 end. Immediately to the north of the airport perimeter wall of R/W 07, there was workshop of Bihar State Transport Corporation. As a result of these two obstructions, there was no basic strip (150 mts.) available at this end of the runway. Consequently, the threshold was displaced by 1500 feet. There was a vast open area between the perimeter wall of the airfield and the railway line to the south. This area was occupied by several habitations which included meat and poultry shops. These shops attracted birds and vultures, which posed a serious hazard to aircraft landing on R/W 07.

Prior to the 70s except for the railway line, the trees in the zoological park and the State Transport Corporation workshop, did not pose any restriction. The surrounding areas of the airfield were relatively free from human

habitation. Only light aircraft were being operated from the airfield. Hence, a shorter runway, which was free from obstructions, sufficed. The zoological garden came into existence subsequently and was declared a reserve forest even though it was within the city limits. As long as only light aircraft were being operated, there were no restrictions to their operation, which is true even today in spite of several obstructions on either side.

The operation of big commercial jets from Patna airport started in the 70s with the Boeing 737 and later on in 90s, with the Airbus 320. The runway length was extended to its present dimension, which was the maximum the airfield could accommodate. Even with this extension, the thresholds on either end had to be displaced because of the restrictions mentioned above. These restrictions caused several operational constraints. In the summer months, the maximum take off weight that an Airbus 320 could operate with had to be severely restricted because of the insufficient runway length for take off. This, in turn, meant financial loss to the Operator and inconvenience to the passengers due to non-availability of seats during the peak holiday season. The biggest concern, however, was the narrow margin of safety, with which these aircraft operated and the tension the Pilots had to undergo because of displaced thresholds and high trees in the Approach Funnel of R/W 25.

While it was understood that the runway length could not be extended in its present alignment, it was possible to remove at least some of the restrictions and improve the margin of safety for normal operation of scheduled services with Boeing 737 and Airbus 320 aircraft.

RUNWAY 25

The threshold of this runway was displaced by 400'. This was because of trees of the zoological garden, which fell in the Approach Funnel and the vehicular traffic on the airport road, the latter being the controlling factor. The Secretariat Clock Tower did not pose a restriction as it was below a gradient of 2.5% from the runway threshold which was within the permissible limit. The zoological garden had 3700 trees, which fell in the Approach Funnel. Over the years, the trees had grown tall and will continue to grow. Pilots tend to instinctively stay above the normal glide path because of presence of tall trees on short finals just before the threshold. This resulted in a late touch down further up the runway from the normal touch down point and consequent severe use of thrust reversers and brakes. In conditions of poor visibility, rain and at night, this could have serious consequences.

It was necessary to control the height of the trees so as to provide a clear approach path to landing aircraft. The pruning of trees had to be done on a continuous basis since in the fertile Gangetic Plain, trees grew quickly. Alternatively, the Approach Funnel should be totally denuded of all tree cover.

Vehicular traffic on the airport road should be relatively easy to control. Traffic could be diverted on a different route which is readily available. The second option would be to allow only vehicles with restricted height i.e. passenger cars and stop the passage of buses and trucks on this stretch of road. All traffic should be stopped during the arrival and departure of aircraft.

RUNWAY 07

This threshold at this end of the runway was displaced by 1500 feet because of non-availability of the basic strip. The restoration of the basic strip for the entire 1500 feet required rerouting of the main railway line and shifting of the Phulwari Railway Station, which was next to the runway. To the north, the Transport Workshop needed to be shifted. Rerouting of the railway line may prove to be a difficult task. It may, however, be possible to extend the basic strip by a certain length without affecting

the railway line and this would help to increase the available runway length.

2.8.2 **Air Force Station Bihta**

Air-Force Station Bihta was approximately 32 kms. south-west of Patna city. The runway length available at this airfield was 8200 feet. This airfield was totally free of the type of the obstructions existing at Patna airport. Shifting scheduled airline traffic from Patna to Bihta could be an alternative solution. However, the existing runway needed to be strengthened to allow operation of Airbus A-320 class of aircraft. There were no facilities for handling of aircraft, passengers and baggage. A new Terminal Building with Control Tower and Navigational Aids would have to be provided.

A complete township with all civic amenities would have to be created for the people working at the airport since no such infrastructure was presently available at Bihta. The Approach Funnels at either end of the runway would have to be permanently protected to avoid similar kinds of problems as at Patna. Bihta is connected to Patna by road passing through Danapur cantonment. The journey from Patna to Bihta takes anywhere between 1 to 1½hrs. due to congestion and poor condition of the road. This would need to be improved by providing either

a completely new road or improving the condition of the existing road.

In conclusion, there was an urgent need to improve conditions at Patna airport to provide an acceptable margin of safety for operation of Boeing 737 and Airbus A-320 aircraft. This would need concerted effort on the part of the Ministry of Civil Aviation, Airports Authority of India, DGCA and the State Government of Bihar.

2.8.3 **Communication And Navigational Aids**

Patna Airport was equipped with standard navigational aids such as Non Directional Beacon (NDB), Doppler Very High Frequency Omni Range (DVOR), Distance Measuring Equipment (DME) and Instrument Landing System (ILS) with Localizer and Glide Slope.

The records indicated that all the equipment were functioning satisfactorily on 17th July, 2000. The daily and weekly check schedules had been completed satisfactorily. The air calibration of ILS was last done on 5th to 8th February, 2000. The next calibration was due 4+1 month later as per the ICAO guidelines adopted by AAI.

The calibration, which should have been completed by 8th June, 2000 was overdue on 17th July, 2000. Earlier attempts at calibration in the month of July, 2000 did not succeed due to growth of vegetation in sensitive areas. The calibration was subsequently carried out on 21st July, 2000. It did not show any change from the earlier records.

ICAO guidelines have been revised subsequently to six monthly periodicity. It was observed from previous records that the periodicity of 120 days had not been adhered to in many cases. The primary reason for this appeared to be the non-availability of calibration aircraft due to various reasons. Presently, the Airports Authority of India (AAI) carried out calibration by using two Dornier aircraft. It is necessary that AAI should review this availability with the requirement to adhere to the calibration schedule. It was argued on behalf of AAI that the ILS did not cease to be functional at the end of the calibration period. It was not possible to agree to this viewpoint. AAI may draw up a realistic schedule and adhere to it without further delay. If it was different from that of ICAO guidelines, the possibility of filing a difference with ICAO always existed.

The communication equipment at Patna airport was in satisfactory condition on 17th July, 2000. The recording of conversation between Patna Tower and the aircraft

both on ATC tapes and the CVR was clear and unambiguous.

2.8.4 The Court visited Patna several times in connection with the inquiry. The Court utilised the opportunity to fly the same route (Kolkata-Patna) as that of ill fated aircraft on similar type of aircraft (Boeing 737). An ILS approach to R/W 25 in four kilometers visibility was carried out with the Court seated in the jump seat of the aircraft. The Court also observed approaches to R/W 25 and R/W 07 at Patna from the cockpit of Airbus A-320.

The Court observed that tall trees in the approach funnel of R/W 25 posed a hazard to landing aircraft. Several meetings were held with senior functionaries of the State Govt. of Bihar including the Chief Secretary, the District Magistrate, Forest Dept. officials and the Superintendent of the Zoological Park to impress upon them the urgent need to remove all obstructions in the approach funnel of R/W 25.

Similar meetings were held at Delhi with officials of the Ministry of Civil Aviation, DGCA and Airports Authority of India.

A survey of the trees in the approach funnel of R/W 25 was carried out and the trees were marked. Some

trees outside the Zoological Park and some even inside were trimmed. However the effort fell far short of the requirements.

The Court last visited Patna airport and its environs on 15th March, 2001 and noted that no effort had been made to trim or remove the offending trees in the last four months. The stand taken by the State Govt. of Bihar was that the Zoological Garden had been declared a reserve forest and hence the trees could not be touched even though they posed a hazard to landing aircraft.

The net result was that the available runway was shortened by 400', the ILS glide slope was available only up to 300' and Pilots had difficulty in following the correct glide path during the terminal phase of the approach to R/W 25. The runway length available may just be within the performance capability of the Airbus A-320 as specified in the Operating Manuals. There was, however, no margin of error available to the Pilot when landing at night, in bad weather, on a wet runway or with an aircraft system malfunction or any combination of these conditions.

3. CONCLUSIONS

3.1 FINDINGS

3.1.1 The aircraft had a current Certificate of Airworthiness. The inspections of the aircraft were carried out as per the required schedule of maintenance. No system was released under Minimum Equipment List (MEL). Age of the aircraft was not a factor in the accident.

3.1.2 The All Up Weight (AUW) and Centre of Gravity (CG) of the aircraft were within limits.

3.1.3 The aircraft had sufficient fuel to complete the flight.

3.1.4 The flight Crew had appropriate licences to undertake the flight.

3.1.5 Captain Sohanpal, Commander of the flight who was not qualified as an Examiner/Instructor/Check Pilot was occupying the Right Hand Seat (Co-Pilot seat). Captain Bagga, Co-Pilot, was occupying the Left Hand Seat and was at the controls at the time of the accident.

3.1.6 The accident took place during day light in fair weather conditions and weather was not considered a factor in the accident.

3.1.7 No characteristic signs of sabotage were observed and sabotage was not considered a factor in the accident.

3.1.8 Standard Air Traffic Control (ATC) procedures were followed and ATC was not considered a factor in the accident.

3.1.9 There was no evidence of a bird strike on the aircraft.

3.1.10 There was no evidence of in flight fire.

3.1.11 Both engines were operating and developing thrust at the time of impact.

3.1.12 There was no evidence of any pre-impact failure of the aircraft structure or malfunction of the aircraft flight controls or of any other aircraft system.

3.1.13 The crew did not report any malfunction or difficulties.

3.1.14 Tall trees have been allowed to grow in the Approach Funnel of R/W 25. Some trees were in the close vicinity of the threshold of R/W 25. These trees have affected the radio beam of the glide path which has been terminated at 300' for this reason. The runway threshold has been

displaced by 400’ due to traffic plying on the airport road just short of the threshold of R/W 25.

There is no basic strip available for full length of the runway. The threshold has been displaced by 1500’ at the R/W 07 end because of this.

3.1.15 The air calibration of Instrument Landing System and Navigational Aids was not being carried out within the ICAO time schedule adopted by AAI.

3.1.16 The Court observed that Fire Fighting and Rescue Operations had been carried out with due diligence. There was no lack of effort on the part of either AAI, the civil administration and the public in general. However, the crowd which had collected at the crash site and PMCH considerably hampered the work of genuine rescue workers.

3.2 **Cause of the Accident**

The cause of the accident was loss of control of the aircraft due Human Error (air crew). The crew had not followed the correct approach procedure, which resulted in the aircraft being high on approach. They had kept the engines at idle thrust and allowed the air speed to reduce to a lower than normally permissible value on approach. They then maneuvered the aircraft with high pitch attitude

and executed rapid roll reversals. This resulted in actuation of the stick shaker stall warning indicating an approaching stall. At this stage, the crew initiated a Go Around procedure instead of Approach to Stall Recovery procedure resulting in an actual stall of the aircraft, loss of control and subsequent impact with the ground.

4 **RECOMMENDATIONS**

4.1 Alliance Air should review their pilot training and following aspects should be emphasised.

4.1.1 Discipline in the air

4.1.2 Cockpit Resource Management (CRM)

4.1.3 Adherence to Standard Operating Procedures (SOP)

4.1.4 Training curricula should include procedures such as recovery from “Approach to Stall” and “Clean Stall”.

4.2 Indian Airlines and Alliance Air should review their Quality Control Organisation to streamline the maintenance of Boeing 737 aircraft in order to remove the duality in command and control with respect to this activity.

4.3 The Ministry of Civil Aviation, Govt. of India, Airports Authority of India and State Govt. of Bihar should ensure proper coordination to rid the approach funnel of R/W 25 of trees. Vehicular traffic on the airport road at Patna, which runs very close to the threshold of R/W 25, must be controlled. Only light vehicles should be allowed to ply on this road and even this traffic should be stopped during the arrival and departure of scheduled airline traffic.

4.4 The above agencies should also coordinate their efforts to extend the basic strip at R/W 07 end by acquiring railway land to the South and State Transport Corporation land to the North.

4.5 Keeping in view the future growth of air traffic and restrictions at the present Patna airport, the Govt. should consider development of Bihta Airport for civilian traffic by providing the necessary infrastructure in a time bound manner.

4.6 The Airports Authority of India (AAI) should maintain airport equipment and navigational facilities at all airports in the country to the required standards. AAI should review availability of the necessary equipment such as aircraft for air-calibration, crash fire tenders and other equipment so as to maintain them within stipulated standards.

4.7 The Patna Medical College Hospital (PMCH) should review its available facilities and provide a properly equipped mortuary. The routine maintenance of the facilities should be carried out.

PLACE : NEW DELHI

DATE : 31st MARCH, 2001

(SHAILESH DESHMUKH)
GENERAL MANAGER-(ENGG-QC&TS)
AIR INDIA, MUMBAI
(ASSESSOR)

(CAPT. N.S. MEHTA)
DIRECTOR AIR SAFETY (RETD)
AIR INDIA, MUMBAI
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(AIR MARSHAL P. RAJKUMAR)
PVSM, AVSM, VM
PROGRAMME DIRECTOR (FLIGHT TEST)
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THE COURT

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I am indebted to the various participant parties and their learned counsels for their painstaking work in helping the court to arrive at its conclusion. I am very appreciative that they were fully cooperative in enabling the court to complete its task satisfactory. I am specially grateful for all the assistance rendered by M/s Boeing Company in this investigation.

And, finally I am extremely appreciative of the hard work and long working hours put in by Court's Secretary Shri S.N. Dwivedi, Dy.Director, DGCA. He was really an asset to me.

(AIR MARSHAL P. RAJKUMAR)
PVSM AVSM VM
THE COURT

NEW DELHI
31ST MARCH 2001