

REPORT
OF
THE COMMITTEE OF INQUIRY

ACCIDENT INVOLVING INDIAN AIRLINES
DORNIER AIRCRAFT VT-EJW
AT KOCHI
ON
30th July, 1998

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Director Air Safety
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MINISTRY OF CIVIL AVIATION

Decision of Government of India on the report of the Committee of Inquiry which investigated accident to Indian Airlines (SHOD) Dornier aircraft DO-228 VT-EJW at Kochi on 30th July, 1998.

Indian Airlines (Short Haul Operations Department) Dornier DO-228 aircraft VT-EJW was involved in an accident at Kochi while operating scheduled flight IC-503 (Kochi to Thiruvananthapuram) on 30th July, 1998. The aircraft had earlier arrived at Kochi at 0505 UTC after operating flight IC-501 from Agati, Lakshadweep Islands. The pilot did not report any abnormality during the flight from Agati to Kochi. The aircraft took off from runway 17 at 0534 UTC. The take off was normal and after attaining a height of about 400 feet, it was seen pitching up steeply to a near vertical attitude and thereafter appeared to perform a manoeuvre similar to a stall turn to the right and crashed on the rooftop of the Component Repair Shop (CRS) building of the Naval Aircraft Yard. After impact, the aircraft caught fire and was completely destroyed. All the six occupants on board the aircraft comprising three crew members and three passengers received fatal injuries. Three persons working in the CRS were also fatally injured and six other persons received minor injuries.

The Government of India had appointed a Committee of Inquiry under Rule-74 of Aircraft Rules, 1937, headed by Air Marshal P. Rajkumar, Programme Director (Flight Test), Aeronautical Development Agency, Bangalore with Shri Babu Peter, General Manager (Engineering), Air India, Capt. I.D. Singh, Air India as members and Shri Subhash Chander, Director Air Safety, Mumbai as Member Secretary. The report of the Committee of Inquiry which was received on 16-11-98 is at Annexure A.

The Committee has concluded cause of the accident as under :

"After take off, the aircraft pitched up uncontrollably, stalled, fell to its right and crashed. The uncontrollable pitch up was caused by sudden uncommanded downward movement of the Trimmable Horizontal Stabilizer leading edge. This was due to partial detachment of its actuator forward bearing support fitting due non-installation of required hi-lok fasteners.

Poor aircraft maintenance practices at Short Haul Operation Department contributed to the accident."

The Committee of Inquiry has made 49 findings and 7 recommendations which are aimed at enhancing the safety of aircraft operations. The Government have accepted the report along with findings, cause and recommendations as indicated in Annexure-I.

Subject: Report of the Committee of Inquiry investigating the accident involving Indian Airlines Dornier aircraft VT-EJW at Kochi on 30th July, 1998.

CONCLUSIONS:

3.1 Findings:

	<u>GENERAL</u>	<u>Comments/Action taken/Action proposed</u>
3.1.1	The aircraft had a current Certificate of Airworthiness.	Noted
3.1.2	The AUV and CG of the aircraft were within limits.	Noted
3.1.3	The aircraft had sufficient fuel to complete the flight.	Noted
3.1.4	The flight crew held appropriate licences to undertake the flight.	Noted
3.1.5	Pilot error was not considered a factor in the accident.	Noted
3.1.6	The accident took place during day light fair weather conditions and weather was not considered a factor in the accident.	Noted
3.1.7	No characteristic signs of sabotage were observed and sabotage was not considered a factor in the accident.	Noted
3.1.8	Standard ATC procedures were followed and ATC was	Noted

not considered a factor in the accident.

- | | | |
|--------|---|---|
| 3.1.9 | The aircraft had not suffered a bird strike after its take off from Kochi. | Noted |
| 3.1.10 | There was no evidence of in-flight fire. | Noted |
| 3.1.11 | Both engines were developing power at the time of impact. | Noted |
| 3.1.12 | The DFR did not record any useful data as its recording function was defective. | Noted. An Air Safety Circular No. 2 of 1999 has been issued on the subject for guidance of all the operators. |

WHAT HAPPENED

Comments/Action taken/Action proposed

- | | | |
|--------|---|-------|
| 3.1.13 | On the morning of 30.7.98 the aircraft arrived at Kochi from Agati and no snag was reported by the Pilot-in-Command. | Noted |
| 3.1.14 | The aircraft was refuelled with 600 lbs of fuel to make a fuel state of 1600 lbs for the flight from Kochi to Thiruvananthapuram. | Noted |
| 3.1.15 | Pre-flight inspection schedule was carried out by the technician and Pilot-in-Command. | Noted |
| 3.1.16 | The flight crew carried out appropriate check lists and the aircraft took off for Thiruvananthapuram | Noted |

- with six persons on board.
- 3.1.17 The take off was normal and the aircraft attained a height of approx. 400 ft. Noted
- 3.1.18 The aircraft suddenly pitched up to a near vertical attitude. Noted
- 3.1.19 No R/T transmissions were made by the aircraft to the ATC after it pitched up. Noted
- 3.1.20 The aircraft stalled, fell to the right and crashed on the roof of the Component Repair Shop (CRS) building of the Naval Aircraft Yard NAY(K), Kochi. Noted
- 3.1.21 After impact with the CRS building, the aircraft caught fire and was completely destroyed. Noted
- 3.1.22 All six persons on board and three persons on the ground received fatal injuries. Noted
- 3.1.23 Fire fighting and rescue operations had started without any delay and no deficiencies were observed in the performance of these services. Noted

HOW IT HAPPENED

Comments/Action taken/ Action proposed

(Reconstructed by the Committee in consultation with experts from Dornier Luftfahrt GmbH)

- | | | |
|--------|--|-------|
| 3.1.24 | During take off, the Pilot-in-Command rotated the aircraft by moving the control column backward thereby holding on to a pull force. | Noted |
| 3.1.25 | As a normal reaction, the Pilot-in-Command trimmed out the pull force by blipping the trim switch to move the THS leading edge (LE) down. | Noted |
| 3.1.26 | As the THS LE moved down, the down load on the THS and elevator increased, which resulted in a push force on the actuator attachment fitting on Frame 34. | Noted |
| 3.1.27 | Following gear retraction as the aircraft accelerated, to counter the nose up trim change the Pilot-in-Command pushed the control column slightly forward moving the elevator trailing edge (T.E.) down. | Noted |
| 3.1.28 | To trim out this push force, the Pilot-in-Command trimmed forward to move the THS LE up, thereby converting the push force in area of Frame 34 to a pull | Noted |

- force.
- 3.1.29 At that stage of flight, the THS actuator forward attachment bearing support fitting on Frame 34 bulkhead suddenly tore loose partially. Noted
- 3.1.30 Partial detachment of the above fitting resulted in an increase in the arm length of the actuator moving the THS LE down. Noted
- 3.1.31 Movement of the THS LE down resulted in the initial pitch up of the aircraft. Noted
- 3.1.32 Pitch up of the aircraft at that stage prompted the Pilot-in-Command to push the control column forward, which moved the elevator TE down creating an upward force at the rear end of the THS/elevator surface. Noted
- 3.1.33 Considering the location of the hinge line and the centre of pressure of the THS, the upward force rotated the THS LE further down to 14 deg. Noted
- 3.1.34 Such a large movement of the THS LE downwards caused the violent pitch up to a near vertical attitude, which the pilot-in-command was Noted

unable to control with the elevator available to him.

3.1.35 Consequent rapid decrease of air speed caused the aircraft to stall and fall on its right side.

Noted

WHY IT HAPPENED

Comments/Action taken/Action proposed

3.1.36 THS actuator forward attachment bearing support fitting was removed for ECI during which it was found that it had excessive pitting and was therefore rejected.

Noted

3.1.37 Since a new fitting was not available in stores, a fitting of the same part no. was removed from another aircraft VT-EJU and installed on VT-EJW after subjecting it to ECI.

Noted

3.1.38 -During reinstallation of the fitting qty. 10 hi-lok fasteners attaching the longitudinal tang of the fitting to the Frame 34 structure were not installed.

Immediately after the accident DGCA had ordered inspection on all remaining Civil registered Dornier aircraft of the Horizontal Stabilizer aft Bracket on frame 34 for the presence of rivets and Hi-Lok fasteners after removal of access panel on either side of tailcone in the fuselage tail section.

No discrepancies were observed during this inspection.

The Defence Services including Coast Guard were also advised

- 3.1.39 The foreman who signed for the job completion did not physically check the completion of the job.
- 3.1.40 The Chief Manager (Engineering), duly approved for the job, certified the installation of the fitting after checking the installation from the rear face of the fitting only. He failed to inspect the fitting for the presence of 10 hi-lok fasteners which were required to be installed to attach the longitudinal tang of the fitting to the Frame 34 structure.
- 3.1.41 After about 300 hrs. of flight following fitting replacement, cyclic loading on the fitting resulted in cracking of Frame 34 bulkhead web along the right side rivet line under the rear face of the fitting.
- 3.1.42 The pull force on the THS actuator during nose down trimming of the aircraft resulted in partial detachment of the fitting from the web of Frame 34 bulkhead.

to carry out the above inspection on their fleet of Dornier aircraft.

Noted. Indian Airlines will be advised to take action against the involved foreman.

During the course of the investigation, when the said lapse of the Chief Manager (Engineering) came to light DGCA suspended on 7th August 1998 the Aircraft Maintenance Engineer licence of Chief Manager (Engineering) Sh. V.K. Shrivastava for having carried out perfunctory inspection of the stabilizer actuator attachment fitting after its installation on the aircraft with immediate effect till finalisation of the investigation..

Noted

Noted

3.1.43 Maintenance procedures, documentation and work practices that existed at SHOD of Indian Airlines were unsatisfactory and did not meet the requirements of an approved aircraft maintenance organisation.

Safety audit of engineering facilities of Indian Airlines (SHOD) at their Delhi & Calcutta bases were carried out by DGCA teams in August 1998 after the accident. Based on the Safety Audit Report the maintenance approval of SHOD was withdrawn. Only after remedial measures were taken and discrepancies observed during these Safety Audits have been rectified, the approval has been restored. The aircraft manuals, CARs, technical circulars, ADs, revised QC manual etc are now available with the organisation and are updated regularly. SHOD is on the mailing list of vendors. The aircraft are maintained by DGCA approved AMEs. Spot checks are carried out by QCM/Dy. QCM or his designated qualified representatives to ensure that job is done as per approved maintenance practices.

3.1.44 These poor maintenance practices at SHOD significantly contributed to the errors committed by the persons who carried out the installation of the THS fitting, which finally led to the accident.

Indian Airlines was advised to put functioning of SHOD under the control of their Director (Engg.), Director (Operations), Director of Flight Safety and Quality Control Manager (Engg.) to ensure that maintenance, Operational procedures & practices as adopted in Indian Airlines are also followed in SHOD. Indian Airlines will be advised to take action against the involved personnel responsible for poor maintenance practices.

- 3.1.45 Quality Control Manager, Chief Manager In-charge of maintenance, offg. General Manager (Engg) and Executive Director of SHOD did not take effective steps to arrest the falling standards of maintenance in time. Action will be taken by Indian Airlines against the personnel identified in the report for their lapses.
- 3.1.46 Non-availability of sufficient spare parts in the stores resulted in frequent cannibalization from other aircraft. Adequate spares and tools have been provided at regional bases. Spares holding policy with Indian Airlines is being followed.
- 3.1.47 Subsequent to the Government decision to merge Vayudoot with Indian Airlines, senior management Indian Airlines, when faced with problems of effecting a complete merger, created SHOD within Indian Airlines. This permitted the continuation of the poor work culture and wrong maintenance practices which had earlier prevailed in Vayudoot. This will be brought to the notice of Indian Airlines Management for ensuring that such wrong maintenance practices, poor work culture do not creep in future and are rectified as & when these are detected.
- 3.1.48 Lack of career progression in SHOD had lowered the morale of the work force at SHOD, which had a detrimental effect on the already poor work culture. Noted. The matter will be brought to the notice of the Indian Airlines for taking necessary action.
- 3.1.49 Oversight of SHOD maintenance Noted. The matter will be brought to the notice of the

activities by the regulatory authority could not produce the desired corrective effect as the internal audits carried out by SHOD at the behest of DGCA were ineffective. The management's response to the call for corrective action based on DGCA audits was not forthcoming in some cases and not prompt in others.

Indian Airlines for taking necessary action.

3.2 Cause of the Accident :

After take off the aircraft pitched up uncontrollably, stalled fell to its right and crashed. The uncontrollable pitch up was caused by sudden uncommanded downward movement of the Trimmable Horizontal Stabilizer leading edge. This was due to partial detachment of its actuator forward bearing support fitting due non installation of required hi-lok fasteners.

Poor aircraft maintenance practices at Short Haul Operations Department contributed to the accident.

ACCEPTED

4. Recommendations :

Comments/Action taken/Action proposed

4.1 Short Haul Operations Department (SHOD) of Indian Airlines should be brought under the Quality Control system of Indian Airlines and all the documentation and maintenance practices should be standardised.

Accepted.

DGCA has already advised Indian Airlines management to restructure the SHOD supervisory system. Indian Airlines have since taken action in the matter.

- 4.2 Since the lack of career progression had a demoralising effect on the work force, a time bound programme should be initiated to disband the SHOD and fully integrate the same with Indian Airlines.
- Accepted.
- The matter will be brought to the notice of the Indian Airlines for taking necessary action.
- 4.3 Indian Airlines should take stringent measures to make internal safety audits of SHOD more effective and discrepancies noticed should be acted upon immediately.
- Accepted.
- Indian Airlines has been advised to take necessary action in this regard.
- 4.4 Indian Airlines should improve the spares support to Dornier aircraft operations.
- Accepted.
- The matter will be brought to the notice of the Indian Airlines for taking necessary action.
- 4.5 Indian Airlines should monitor the flight recorders and ensure that these remained fully serviceable.
- Accepted.
- Action has already been taken by DGCA to monitor the Flight Recorder Data by using a computerised system by all operators to determine exceedences of the Critical Operational Parameters. This will also monitor the serviceability of the flight recorders.
- 4.6 Drawing upon the experience of the unhappy merger of Vayudoot with Indian Airlines, in future, while restructuring organisations dealing with aircraft operations and maintenance, the highest priority should be given to Air Safety.
- Accepted.
- Noted for future guidance.

4.7 In view of new airline operators entering the Civil Aviation sector in the post liberalization era, DGCA needs to be strengthened for effective a i r w o r t h i n e s s surveillance.

Accepted.

Strengthening of DGCA is already under consideration.

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**REPORT OF THE COMMITTEE OF INQUIRY ON THE ACCIDENT
INVOLVING INDIAN AIRLINES DORNIER DO-228 AIRCRAFT
VT-EJW AT KOCHI ON 30TH JULY, 1998.**

- a) Aircraft**
- | | | Engines |
|---------------|--------------|-----------------------|
| Type | : Dornier | Maker : Garrett |
| Model | : DO-228-201 | Type : TPE-331-5-252D |
| Nationality | : Indian | Left : S/N P39108 |
| Registration: | VT-EJW | Right : S/N H58014 |
- b) Owner** : Indian Airlines Limited,
New Delhi.
- c) Operator** : Indian Airlines Limited,
New Delhi.
- d) Pilot-in-Command** : Capt. S.R. Singh
- Extent of Injuries : Fatal
- e) Co-Pilot** : Capt. Manish Sharma
- Extent of Injuries : Fatal
- f) No. of Passengers** : Three (3)
- Extent of Injuries : Fatal
- g) Place of accident** : Naval Aircraft Yard at
Kochi Aerodrome.
- h) Date and time of accident** : 30.7.98; 0535 UTC

(All timings in the report are in UTC)

S U M M A R Y

Indian Airlines Dornier DO-228 aircraft VT-EJW arrived at Kochi at 0505 UTC on 30.7.98 after operating flight IC-

501 from Agati, Lakshwadeep islands. The Pilot-in-Command did not report any abnormality during the flight from Agati to Kochi. The aircraft was then scheduled to operate flight IC-503 from Kochi to Thiruvananthapuram. Capt. S.R. Singh was the Pilot-in-Command and Capt. Manish Sharma was the Co-Pilot. Shri S. Sajid was the flight purser. There were three passengers on board. The aircraft took off from runway (RWY) 17 at 0534 UTC. According to eyewitnesses, the take off was normal and after attaining a height of about 400', it was seen pitching up steeply to a near vertical attitude and thereafter appeared to perform a maneuver similar to a stall turn to the right and crashed on the rooftop of the Component Repair Shop (CRS) building of the Naval Aircraft Yard (NAY). After impact, the aircraft caught fire and was completely destroyed. All persons on board received fatal injuries. Three persons working in the CRS were also fatally injured and six other persons received minor injuries.

Initiation of Investigation :

On receiving information about the accident Shri Subhash Chander, Director Air Safety, Mumbai, along with S/Shri M. Rajendiran, Senior Air Safety Officer (Engineering), Mumbai and P.K. Bhakta, Senior Airworthiness Officer, Mumbai, proceeded to the accident site on 30.7.98. Investigation was started immediately in co-ordination with Naval authorities, Aerodrome authorities, Police and Indian Airlines officials at Kochi. Shri K. Gohain, Dy. Director General Civil aviation arrived at the accident site early on the morning of 31.7.98. Director General of Civil Aviation, Chairman & Managing Director, Indian Airlines, Secretary, Ministry of Civil Aviation along with Hon'able Minister of Civil Aviation also visited the accident site

on 31.7.98. Shri Subhash Chander, Director Air Safety, Mumbai 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 30.7.98. Subsequently the Govt. of India, Ministry of Civil Aviation constituted a Committee of Inquiry, under Rule 74 of Aircraft Rules 1937, vide Notification No.AV.15013/3/98-SSV dated 1.8.98, to investigate the accident. The Committee was headed by Air Marshal P. Rajkumar, Programme Director (Flight Test), Aeronautical Development Agency, Bangalore with Shri Babu Peter, General Manager (Engineering) Air India, Capt. I.D. Singh, Air India as members and Shri Subhash Chander, Director Air Safety, Mumbai as Member Secretary. The Headquarters of the committee was at Mumbai.

The Committee visited the accident site at Kochi on the morning of 4.8.98 and carried out an examination of the wreckage as well as examination of key eyewitnesses. During the course of the inquiry, the Committee visited Delhi to examine the maintenance facilities of the Short Haul Operations Department (SHOD) of Indian Airlines. Statements of various Indian Airlines officials were recorded. The Committee visited Kochi a second time on 12.8.98 for detailed examination of the wreckage and recording the statements of various officials of Indian Airlines/Naval authorities.

Notification of the constitution of the Committee was published in leading daily news papers at Kochi, Delhi, Mumbai and Thiruvananthapuram. The general public were invited to come forward to provide details of the accident which may be of material use to the conduct of the inquiry.

1. FACTUAL INFORMATION

1.1 History of the Flight :

1.1.1 Indian Airlines Dornier 228 aircraft VT-EJW had arrived at Kochi at 0505 UTC on 30.7.98 after operating flight IC-501 (Agati-Kochi). The aircraft was under the command of Capt. S.R. Singh with Capt. Manish Sharma as Co-Pilot and Shri S. Sajid as flight purser. The Pilot-in-Command had not reported any abnormality during the flight from Agati to Kochi and 'Nil' defect was recorded at Kochi. The aircraft was then scheduled to operate IC-503 (Kochi-Thiruvananthapuram) with the same crew. The Pilot-in-Command requested a fuel state of 1600 lbs for flight IC-503. An Indian Oil bowser refuelled the aircraft after carrying out a fuel sampling check. The aircraft was refuelled with 600 lbs. as the arrival fuel figure was 1000 lbs. Three passengers namely Shri Raju Samala, Shri Sasikant Ramani and Mrs. Vijaya Kalyani checked in at Kochi aerodrome for Thiruvananthapuram. There was only one piece of checked-in baggage. The load and trim sheet was computed by Mrs. Achamma Jacob, Senior Traffic Assistant on duty, and was signed by Capt. S.R. Singh. Preflight inspection schedule was carried out by Shri M. Vijayakumar, Sr. Aircraft Technician and was countersigned by Capt. S.R. Singh. On completion of the walk around inspection by the technician and the Pilot-in-Command, the aircraft was accepted by Capt. S.R. Singh at 0525 UTC. According to Shri Vijayakumar and Mrs. Achamma Jacob, Capt. S.R. Singh was in the left seat when the aircraft taxied out from the tarmac.

1.1.2 At 0527 UTC, IC-503 requested Kochi ATC for start up clearance as per the ATC tape transcript (Exhibit No.01). ATC approved the start up and passed temperature

27, QNH 1009 and informed IC-503 that level clearance was awaited. At 0530 UTC, IC-503 contacted ATC and stated that IC-503 was ready for taxi. ATC cleared IC-503 for taxi via link for RWY 17. At 0531 UTC, IC-503 requested ATC to enter, back track and line up for RWY 17 to which ATC asked the aircraft to standby. At 053130 UTC, ATC again informed IC-503 to remain on standby to enter RWY as level clearance was still awaited. At 053149 UTC, ATC cleared IC-503 to line up and hold as level clearance had still not been received. At 053336 UTC, ATC requested IC-503 to contact Thiruvananthapuram, as they were unable to establish contact. IC-503 informed ATC that they would do so at 3000' after take off to which ATC asked the aircraft to standby as at that very moment contact had been established with Thiruvananthapuram. At 053356 UTC, ATC cleared IC-503 to Thiruvananthapuram via flight planned route to cruise and maintain flight level 95, after departure from RWY 17, to climb straight ahead to 1000', turn left, and then climb on track. The clearance was read back by IC-503. At 0534 UTC, ATC instructed IC-503 to be on standby for take off as they were firing a cartridge to scare away a bird on the runway. At 053413 UTC, IC-503 was cleared for take off by the ATC after passing winds as 250/08 kts. There were no further transmissions between IC-503 and Kochi ATC.

1.1.3 Sub Lieutenant Darshan Lal who was one of the two duty air traffic controllers (DATCO) on duty at the tower stated that (Exhibit No.02) the look out on duty had reported to him that IC-503 was climbing very steeply on the take off path. He had moved forward from where he was standing and established visual contact with the aircraft. At that time, the aircraft was about 600' above ground level (AGL) having pitched up past the vertical, with the

nose having turned to the right through more than 90°. It had banked between 90°-120° to the right and the nose was just below the horizon. Thereafter the nose of the aircraft continued to drop and the aircraft rolled to the left to almost wings level attitude. By that time the aircraft nose had dropped sharply and the aircraft crashed on the roof of the CRS building at the NAY(K). He had viewed the aircraft through the glass panes of two frames measuring about 6' in width at the Control Tower.

1.1.4 Sub Lieutenant Rashmi Singh who was on duty at the tower as DATCO stated that (Exhibit No.03) when the aircraft had gained a height of approx. 500' after take off, the aircraft had gone out of her line of sight. The look-out on duty had reported that IC-503 was performing a loop and within a few seconds she saw the aircraft crashing on one of the buildings of NAY(K).

1.1.5 The look-out on duty at the tower, Leading Air Handler J.S. Biswas stated that (Exhibit No.04) the aircraft had gained height normally after take off till about 400'. The aircraft had then suddenly pitched up till it had become almost vertical. He had reported the same to the DATCO. Another look-out, Naval Air Handler R.K. Tripathi, who was on duty at the tower stated that (Exhibit No.05) the take off had been normal upto approx. 600' height. After that he had seen the aircraft pitch up sharply to approx. 90° attitude and then become inverted. Thereafter the aircraft had entered a dive. While diving it had rolled to the wings level position. The dive was quite steep and before impact, the aircraft had appeared to yaw slightly to the left and right.

1.1.6 Lt. Vikram Mahajan, an eyewitness stated that (Exhibit No.06) he was going to attend a squadron briefing, when he had seen an Indian Airlines Dornier emerge from behind the Flight and Tactical Simulator(FATS) building in a vertical attitude, eventually becoming inverted and then diving steeply, thereby appearing to complete a loop. He had not seen where it had crashed and in what attitude as it had been obscured by the FATS building. When inverted, it was facing North. The aircraft was visible to him for barely five to six seconds. Throughout this duration, both engines appeared to be operating normally.

1.1.7 Dy. Commandant T. Anil Kumar, an eyewitness stated that (Exhibit No.07) while walking towards the FATS building with his colleagues, he had seen a Dornier aircraft climbing vertically along the take off path of RWY 17, at a height of about 500'. From the vertical attitude, the aircraft had become inverted. At the end of the inverted phase, the nose had dropped and the aircraft had dived in a steep nose down attitude rolling to right. The aircraft wing was facing away from his position. The manoeuvre was a half loop. The aircraft while carrying out the manoeuvre had moved to the right from its initial position and had lost height simultaneously and was then obscured. During inverted flight, the aircraft had maintained a level attitude, horizontal to the ground and at no stage had the aircraft lost height in that phase of flight.

1.1.8 Lt. Cdr. Bhuri Singh, SATCO on duty stated that (Exhibit No.08) Indian Airlines Dornier 228 aircraft IC-503 had taken off from RWY 17 at about 0534 UTC and immediately after attaining a certain height, the aircraft was seen

performing an unusual maneuver by the personnel on duty at the ATC and the personnel on duty at the ATC garage. On seeing this, the Crash Fire Tender (CFT) crew manning the CFTs in the garage had driven their vehicles towards the runway entry point. The aircraft was then seen diving towards the west of RWY 17/35 and crashing on top of a NAY(K) building. By then the DATCO had sounded the crash siren and two CFTs had already crossed the runway and proceeded towards the NAY(K) complex. Both CFTs of the ATC had reached the crash site and commenced fire fighting by about 0536 UTC.

1.1.9 The aircraft had caught fire immediately after impact with the roof of the CRS building. The nose of the aircraft was entangled with the steel girders of the roof, half inside an Air Conditioned (AC) room and the tail was on top of the roof approx. 30 feet in the air. The crash crew were directed to break the AC windows and the side delivery hoses were taken inside to fight the fire from underneath the nose. The two CFTs and one Domestic Fire Tender (DFT) of Garuda had fought the fire from the top with main monitors and from the bottom with side delivery hoses. In the mean time three fire tenders from INS Venduruthy had also been deployed to fight the aircraft fire and also to replenish the water of the main CFTs.

1.1.10 The ATC had requisitioned the services of three DFTs from INS VENDURUTHY fire station, three DFTs from the Port Trust Fire station, one from the Kochi Ship Yard, two from the Kerala Fire Force, Gandhinagar, one from the Kerala Fire Force, Club road, two from the Kerala Fire Force, Mattancherry and ten ambulances from various hospitals. The fire was completely extinguished by 0555 UTC

by using ATC CFTs and Garuda/Venduruthy DFTs for fire fighting/replenishment of water in the CFTs. During the fire fighting a total of 2000 liters of foam compound were used to completely extinguish the fire on the aircraft and inside the room.

1.1.11 Rescue personnel wearing fire proximity suits could not gain entry into the aircraft wreckage since it was engulfed in flames when they had arrived on the scene. The wreckage was also disintegrating. As soon as the fire was brought under control, one crew member was removed by the rescue team without disturbing the wreckage. He was declared dead on arrival at the hospital. Removal of other personnel was difficult due to the position of the crashed aircraft inside the room of CRS with the tail sticking above the roof. The walls and roof of the building were also giving way. The major portion of the fuselage had compressed on impact and was enmeshed in the steel girders of the roof. The wreckage was suspended in the air with all bodies trapped inside.

1.1.12 The crash and salvage teams had used a crane and slings to lift the tail portion of the wreckage and place it on the roof. Part by part the wreckage was slung and lifted by the crane to free the remaining bodies. It had taken approx. 4½ hours to recover the last body from the wreckage.

1.1.13 All six persons on board IC-503 died in this accident. Two persons namely Shri K.G. Thomas and Shri Chandrasekharan, who were working in the hangar, also died. Another person Shri A. Radhakrishnan received serious

injuries and succumbed to his injuries on 7.8.98. Six other persons received minor injuries.

1.2 Injuries to Persons :

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	3	3	3
SERIOUS	Nil	Nil	Nil
MINOR/NONE	Nil	Nil	6

1.3 Damage to Aircraft :

1.3.1 The aircraft was destroyed by the impact with the CRS building and post impact fire. The condition of the wreckage may be seen in the photographs (Exhibit No.09).

1.4 Other Damage :

1.4.1 The aircraft crashed on a heading of 290° on the roof of the CRS building of NAY(K) located at a distance of about 700' to the right of RWY 17. After impact with the building, the aircraft caught fire. The rooms of the building as well as components/accessories kept inside the rooms at that time were damaged due to impact as well as fire. The Naval authorities at Kochi conducted an inquiry to ascertain the extent of damage to Naval assets.

1.5 Personnel Information :

1.5.1 Pilot-in-Command

1.5.1.1 Name : Capt. S.R. Singh
Date of birth : 16th July 1945
Age : 53 years
Licence Type : ALTP No. 1979
Endorsements : Pushpak, Piper Supercruiser,
(as Pilot-in-Command) PA-12, Piper Cub, J3C(by day)
Cessna 152A, Dornier-228

1.5.1.2 Capt. S. R. Singh got his endorsements on Dornier-228 aircraft on 26.5.95. He was earlier employed with M/s Jagson Airlines and was also approved as Check Pilot by DGCA on 17.6.97. He joined Indian Airlines (SHOD) on 21.6.97. He held FRT0 No.1327, which was valid upto 18.3.99 and RTR No.2069, which was valid upto 28.4.2001. His last LRC/IRC was carried out on 9.6.98 and last route check was carried out on 10.6.98 by Capt. V. Nagarajan.

1.5.1.3 He was last medically examined on 2.6.98 at the Air Force Central Medical Establishment (AFCME), New Delhi and was found fit subject to wearing of corrective bifocal look over glasses while exercising the privileges of his licence.

1.5.1.4 His flying experience was as follows :

	Total Hrs.	Hrs on type
i) Flying experience	: 5440:10	4831:55
ii) Experience during last 90 days:	170:05	170:05
iii) Experience during last 30 days:	35:15	35:15
iv) Experience during last 7 days :	5:15	5:15
v) Experience during last 24 hrs :	5:15	5:15

1.5.1.5 As per available records, he was not involved in an accident earlier.

1.5.2 Co-Pilot :

1.5.2.1 Name : Capt. Manish Sharma
Date of birth : 22nd August 1970
Age : 28 years
Licence Type : ALTP No. 2104
Endorsements : Cessna 152A (as Pilot-in-command), DO-228 (as co-pilot)
F-27-500 (as co-pilot)

1.5.2.2 Capt. Manish Sharma had held a Nigerian CPL since 26.9.91. He was later issued with Indian CPL No. 2835 on 8.7.94. He had flown about 408 hrs as co-pilot while employed in a German company in Nigeria. He was earlier employed with Jagson Airlines and NEPC Airlines before joining Indian Airlines Ltd. (SHOD) on 22.10.97.

1.5.2.3 His last local check and route check were carried out on 1.7.98 by Capt. V. Nagarajan. Capt. Sharma held FRTO No.5057, which was valid upto 27.9.99 and RTR No.6623, which was valid upto 27.9.2000.

1.5.2.4 He was last medically examined on 14.5.98 at AFCME, New Delhi and was found fit subject to wearing of corrective glasses while exercising the privileges of his licence.

1.5.2.5 His flying experience was as follows :

	Total Hrs	Hrs on type
i) Flying experience	: 2328:10	930:20
ii) Experience during last 90 days:	157:30	157:30
iii) Experience during last 30 days:	67:05	67:05
iv) Experience during last 7 days :	25:45	25:45
v) Experience during last 24 hrs :	5:15	5:15

1.5.2.6 As per available records, he was not involved in any accident earlier.

1.6 Aircraft Information :

1.6.1 Dornier 228-201 aircraft VT-EJW was manufactured by HAL, Kanpur in 1986. The aircraft had S/N HAL-K/DO228/1006. It was initially issued with a Certificate of

Airworthiness (C of A) No.1799 on 20.6.86 under Normal category and sub-division Passenger machine. The maximum all up weight authorised was 5980 kgs. It was earlier maintained by erstwhile Vayudoot Ltd. The aircraft was grounded on 6.3.93 for 1800 hrs/one year inspection and the C. of A of the aircraft had expired on 10.11.93. In 1994 there was a merger of Vayudoot Ltd with Indian Airlines and the Short Haul Operations Department (SHOD) was formed. In March 1997 SHOD took up the matter with Director of Airworthiness (DAW), DGCA, Delhi Region to resume operations with VT-EJW as a part of their programme to utilise their Dornier 228 fleet and submitted the following quantum of work for approval for the purpose of C. of A renewal.

- a) Thorough cleaning, inspection and corrosion prevention of the aircraft.
- b) 4800 flight hours (FH) and 8 Year inspection schedules (These were the highest Maintenance Schedules on the aircraft).
- c) All applicable SSIs.
- d) Compliance of all mandatory modifications, inspections and Service Bulletins.
- e) Installation of all serviceable lifed components and accessories.
- f) Installation of ATC Transponder.
- g) Installation of Flight Data Recorder.

- h) Installation of overhauled/serviceable engines.
- j) Installation of overhauled/serviceable propellers.
- k) Painting of aircraft.
- l) Weighing of the aircraft.
- m) Any other work required to comply the findings of the technical audit of M/s Dornier who had carried out detailed inspection of the Dornier 228 fleet of SHOD.

1.6.2 During the 4800 FH/8 year inspection schedule, the Trimmable Horizontal Stabilizer (THS) actuator attachment bearing support fitting was removed. It was sent for Eddy Current Inspection (ECI). The fitting failed to pass the ECI. Since no new fitting was available in the stores, a fitting of the same part no. was removed from another Dornier aircraft VT-EJU and installed on VT-EJW after it had passed the ECI.

1.6.3 On completion of the above quantum of work and C of A test flight on 14.4.98, C. of A was renewed on 27.4.98 for one year. At the time of C. of A renewal, the aircraft had done 13289:20 hrs since manufacture. It was registered with IA on 12.6.97 vide C. of R No.2279/3. It was fitted with Garrett TPE-331-5-252D engines (Left Engine S/N H58004 and right engine S/N H58014). On 6.5.98 left engine S/N H58004 was removed due suspected engine malfunction and overhauled engine S/N P39108 was fitted. The aircraft was fitted with constant speed reversible Hartzell propellers S/N CD 1710 on the left and S/N CD 2096 on the right.

1.6.4 The hours done by the aircraft as on date of accident were as follows :

Hours since new	:	13592:05
Hours since last C of A renewal (on 27.4.98)	:	302:15
Hours since last '2 months schedule' (on 14.6.98 at Agati)	:	145:00
Hours since last '3 months schedule' (on 11.7.98 at Agati)	:	57:50
Hours since last '300 hrs schedule' (on 21.7.98 at Agati)	:	31:45
Hours since last 'Flight Release' (on 21.7.98 at Agati)	:	31:45

1.6.5 The hours done by the engines as on date of accident were as follows :

	Left	Right
Hrs. since new	: 12250:33	11726:04
Hrs. since last O/H	: 285:10	302:45
Hrs. since C of A renewal (on 27.4.98)	: 285:10	302:45
Hrs. since last '2 months schedule' (on 14.6.98 at Agati)	: 146:00	146:00
Hrs. since last '3 months schedule' (on 11.7.98 at Agati)	: 57:45	57:45
Hrs. since last '300 hrs schedule' (on 21.7.98 at Agati)	: 31:45	31:45
Hrs. since last 'Flight Release' (on 21.7.98 at Agati)	: 31:45	31:45

1.6.6 The hours done by the propellers as on date of accident were as follows :

	Left	Right
Hrs. since new	: 7550:57	3295:10
Hrs. since last O/H	: 442:10	302:45
Hrs. since C of A renewal (on 27.4.98)	: 302:45	302:45
Hrs. since last '2 months schedule' (on 14.6.98 at Agati)	: 146:00	146:00
Hrs. since last '3 months schedule' (on 11.7.98 at Agati)	: 57:45	57:45
Hrs. since last '300 hrs schedule' (on 21.7.98 at Agati)	: 31:45	31:45
Hrs. since last 'Flight Release' (on 21.7.98 at Agati)	: 31:45	31:45

1.6.7 A list of snags reported and the rectification work done after the C of A renewal on 27.4.98, is at Exhibit No.10.

1.6.8 At the time of take off, the aircraft had an All Up Weight (AUW) of 4892 Kg against authorized max. take-off weight (MTOW) of 5980 kg. and the CG was 27.45%, which was within limits.

1.6.9 The primary flight controls consisted of ailerons, elevators and rudder and were operated manually from dual cockpit controls. Secondary flight controls consisted of electrically operated fowler flaps. The ailerons were linked to the flaps in such a way that they drooped

progressively as the flaps were extended. The ailerons were trimmed electrically, the rudder was trimmed manually and pitch trim was achieved by moving the complete horizontal stabilizer electrically. The positions of all three trimmed surfaces were indicated on a combined trim position indicator (Refer Annexure 1).

1.6.10 A stall warning system gave an audio-visual indication of the onset of a stall condition. A discrete signal from the lift computer illuminated the STALL warning lamp and sounded a stall warning horn if the airplane speed deviated into deep SLOW range. A press-to-test facility was incorporated into the STALL warning lamp to test the serviceability of the system.

1.6.11 The aircraft was trimmed about the pitch axis by an electrical actuator, which moved the complete horizontal stabilizer. The actuator was controlled by paired pitch trim switches on each control wheel. Movement of the actuator was limited by internal limit switches. The airplane VT-EJW was fitted with an autopilot. The stabilizer actuator could also be controlled by the vertical trim switch on the flight director mode controller. This switch allowed the pilot to trim the airplane about the pitch axis without disturbing the selected flight director mode or disengaging the autopilot. Aircraft VT-EJW was fitted with a single shaft THS actuator. Actuator in fully extended position corresponded to THS leading edge (LE) full down position and actuator in fully retracted position corresponded to THS LE full up position. Apart from actuator bottoming at the end of travel in the extended or retracted positions, there were

no other mechanical stops to prevent THS movement in either direction.

1.6.12 A Fowler type flap was fitted to each wing inboard of the aileron. Both flaps were driven by a single electrical central drive unit via flexible shafts and screw jack type flap actuators. Flap position was selected by the flap selector switch and controlled by the flap control unit mounted on the central drive unit. The central drive unit consisted of a reversible DC motor equipped with an electromagnetic brake. The motor drive was taken out via an overload clutch and reduction gearbox. Torque limiters protected the flexible shafts and flap actuators against overloading. An asymmetry control unit was fitted on the outboard ends of the left and right flap outer drive shafts. These two asymmetry units compared the positions of the left and right flaps and provided a fail-safe circuit to stop the flaps when an asymmetrical movement was detected.

1.7 Meteorological Information :

1.7.1 The accident occurred at 0535 UTC. As per Duty Met. Officer, Garuda (Exhibit No.11) the weather between 0500 UTC to 0600 UTC was as follows :

	0500	0530	0535	0600
Surface wind	250/08kts	250/06kts	250/06kts	250/06kts
Visibility	6 KM	6 KM	6 KM	6 KM
Weather	Cloudy	Cloudy	Cloudy	Cloudy
Clouds	2SC/1400'	2SC/1400'	2SC/1400'	2SC/1400'
	1 CU/2000'	1CU/2000'	1CU/2000'	1CU/2000'
	6 AC/8000'	6AC/8000'	6AC/8000'	6AC/8000'

Dry Bulb Temp.	27°	28°	28°	28°
Dew Point	24°	24°	24°	25°
QNH	1009.2	1009.0	1009.0	1008.9
QFE	1009.0	1008.8	1008.8	1008.7

1.8 Aids to Navigation :

1.8.1 Kochi aerodrome had a NDB (325 KHz) and a VOR/DME (114.6 MHz) as Radio Navigational aids. Both these navigational aids were reported serviceable on the date of accident. Besides the above a CADF (124.7 MHz) was also available as a controller interpreted navigational aid and was serviceable on the date of accident.

1.9 Communications :

1.9.1 Air Traffic Services were provided by Kochi ATC on Approach Control frequency 124.7 MHz and Aerodrome Control frequency 123.5 MHz. HF frequencies 6655 KHz and 8909 KHz were available for communication. 8909 KHz was unserviceable on the date of accident due to a cable fault. A NOTAM had been issued.

1.9.2 On the date of accident the aircraft had arrived at Kochi from Agati. The aircraft had remained in contact with Kochi Tower right from start up till take off and no abnormality was reported by the aircraft to the ATC regarding communications.

1.10 Aerodrome Information :

1.10.1 The Indian Navy managed Kochi aerodrome including its Air Traffic and Aerodrome Safety Services. It was at an

elevation of 5 ft AMSL at 09°57'N and 76°16'E. The aerodrome had a main RWY 17/35 with PCN 40. The other RWY 13/31 was mainly used for helicopter operations. The length of RWY 17/35 was 6000 ft with TORA of 6000 ft. Distance to Go Markers were available on RWY 17/35. RWY 35 was equipped with Precision Approach Path Indicator (PAPI) as a visual aid for landing.

1.10.2 The following NOTAMS were issued for Kochi aerodrome. The first NOTAM was regarding the Obstruction Clearance Altitude (OCA) for visual circling and NDB approach. The OCA had been revised to 750' AMSL. The other NOTAM was for pilots to exercise caution due to concentration of birds in the vicinity of the aerodrome.

1.11 Flight Recorders :

1.11.1 Cockpit Voice Recorder (CVR)

1.11.1.1 Dornier aircraft VT-EJW was fitted with a CVR manufactured by the Electronic Corporation of India Ltd. (ECIL). It was a MRU 101 model, Sl.no 0123. The unit was retrieved from the wreckage in a burnt condition. It was then dismantled at the facilities of the DGCA office, Delhi. The spool tape was released from the deck. The tape was then transported to a new spool with lead tapes attached to both the ends. Play back of the CVR was done on a spool type, four channel, instrumentation recorder and all the information on all four channels was transferred to a Digital Audio Tape Recorder (DAT).

1.11.1.2 The relevant tape transcript was prepared from the time the aircraft was cleared for take-off till the

aircraft crashed. It was of about 1 mt. 07 sec. duration. The tape transcript is at Exhibit No.12.

1.11.1.3 Replay of the CVR revealed that after the aircraft was cleared for take-off, the crew carried out before take off check lists and during the take off there were call outs of '80 kts.', 'V1', 'Rotate' and 'Positive rate'. No abnormality in the voices was detected till the 'positive rate' call out, which was given 40 seconds after the aircraft was cleared for take-off. Six seconds after the 'Positive rate' call out, there was an exclamation of "WHO GAYA AA GAYA" followed by aural warning (1.037Khz) which stopped after 2 seconds. One of the crew had then said 'Everything checked'. Thereafter there were abnormal sounds in the cockpit probably of the headset microphone getting mechanically disturbed. Another aural warning (1.025Khz) appeared 11 seconds before impact followed by an exclamation of "HARE RAM HARE RAM" by the Pilot-in-Command. Nine seconds prior to impact, sudden change in engine noise (drop in intensity of pitch of engine noise) was noticed which continued till impact. Aural warning (1.025 Khz), which had sounded earlier, stopped two seconds prior to impact. The Ground Proximity Warning System (GPWS) sounded a 'Too Low Pull Up' warning just before impact. Only "Too Low" was recorded as the aircraft crashed before the full warning was completed.

1.11.1.4 To detect the propeller RPM during the course of rotation and initial phase of climb of the aircraft, sound spectrum analysis was carried out at the facilities of DGCA office, Delhi (Exhibit No.13). Sound spectrum analysis revealed that while the RPM remained more or less between 90 to 100% upto -9 seconds before the crash, there was a

noticeable drop in its pitch from -8 to -3 seconds prior to crash. Upto -8 seconds prior to crash, the RPM remained within the required level. For the last 8 seconds, RPM evaluation could not be done as Blade Passing Frequency features could not be seen during the analysis.

1.11.2 Digital Flight Recorder (DFR) :

1.11.2.1 The aircraft was fitted with a Loral DFR, model F-800 having S/N 00684 U and part no.17M-900-274. It was manufactured by M/s L3 communication, Aviation recorders, USA in 1988 and was procured by Indian Airlines in April 1998. It was fitted on VT-EJW on 30.6.98 at Agati and had done about 90 hrs since installation till the date of accident. It was recovered from the wreckage without any fire damage. The recorder was sent to M/s VSM Aerospace, Bangalore for decoding the accident data and their report is Exhibit No.14. After dismantling the DFR, the recording capsule was removed and installed on a serviceable DFR. The unit was then run for nearly four hrs. However no useful data could be obtained. The recording capsule was then installed back on the accident DFR. A sample check of data on various tracks revealed that in each track some data on altitude, heading and 'g' trace were available with time, which was coupled with a large number of bad frames. The airspeed data appeared to be totally corrupt. In view of the above observation, 24 hrs. data dumping was performed in the 'read mode only' from the recording capsule of the accident DFR.

1.11.2.2 It was observed that recording capsule of the accident DFR had no relevant data recorded in it all through 24 hrs. There was a cyclic pattern between the bad

and partially good/good data over the 24 hrs. block. There was a spring valve blockage in the pitot and static input socket of the accident DFR. The blockage was due to a bent spring valve found in both the ports, which obstructed the airflow.

1.12 Wreckage and Impact Information :

1.12.1 The aircraft crashed on a heading of 290° on the roof of the CRS of the NAY(K) located at a distance of about 700' to the right of RWY 17. The sides of the CRS building had high buttresses approx. 7-8 ft. higher than the highest point of the roof. The aircraft caught fire after impact with the CRS building and the entire wreckage was confined at one location only in the building. There was no damage to the trees and buildings surrounding the CRS building. The final position of the aircraft wreckage indicated that the aircraft had nose dived into the CRS building at an angle of about 20° . The tail portion of the aircraft was up in the air on top of the roof at a height of about 30' (Refer Photograph 1). The sketch showing the crash site is at Annexure 2.

1.12.2 Examination of the wreckage indicated that the aircraft had crashed into the corridor wall of the CRS building (Refer Photograph 2). The cockpit was totally crushed. The front and mid portions of the fuselage were found entangled in the roof structure and had partially fallen in the corridor. The front instrument panel and the central pedestal were recovered from the hanging wreckage. Air speed indicator, three point encoding altimeter and torque transducer were also recovered. These were in a badly damaged/burnt condition and no useful readings could be ascertained. All the control switches were found damaged

and burnt. Some were jammed and some were found free to move. The steering actuator along with the associated steering mechanism components were found attached to the nose landing gear. The nose landing gear actuator was found in the extended position indicating that the nose gear was in the retracted position.

1.12.3 The front section between Frames 7-12 was badly damaged. Of the central section between Frames 12-24, the front section between Frames 12-18 was totally crushed. The lower portion of the fuselage between Frames 18-19 where the landing gear was mounted was recovered. The upper half of the section was found sheared off, Frames 18-19 were badly crushed and burnt and were hanging entangled in the roof structure. The main landing gear area of the fuselage was also recovered from the roof in a totally burnt condition. The left gear was fully retracted but the right gear showed partial extension. However there was no sign of fire on the extended portion of the right gear actuator indicating that the gear had partially extended during the process of removal of the wreckage. The hydraulic power pack and its associated components mounted between Frame 19 and 21 were found in the wreckage. These were broken and burnt. Air-conditioning equipment between Frames 15 and 16 was damaged and found burnt. All accessories/components in the Frames between 22-25 were damaged and burnt.

1.12.4 Examination of the wing section covering Frames 16-19A revealed that the left wing was in one piece and had broken off from the fuselage. It showed signs of fire towards the root end. Both the attachment bolts of the wing were found secured and safetied. Aileron control rods were found broken. Wing tip was found secured and intact. The

aileron was found attached to the wing and inner portion of the wing had burn marks. Aileron mass balance alongwith fairing was found secured. Only the outer portion of flap was found which had signs of burning. Flap linkages were found broken. Asymmetry control unit alongwith its electrical connection was found secured to the rear spar. Examination of flaps and screw jacks revealed that the flaps were in the extended position '1' (5° position). Examination of screw jacks showed that the outboard screw jack had 21 visible threads and the inboard had 19 visible threads. Inboard half of the wing had burn marks. Front portion of the feeder tank was found crushed. Mid-section of the front spar had less damage, whereas the outboard side of the front spar was found crushed. The engine was found uprooted from its mounting alongwith cowlings.

1.12.5 The right wing was found in a severely damaged state. The wing tip was broken. An outer portion of the wing was resting on a table in the room adjacent to the corridor. The flap had separated from the wing and was entangled in the roof structure. Examination of the screw jacks showed that the outboard as well as inboard screw jacks had 21 threads visible. Root end portion of the wing containing the feeder tank was found crushed and burnt. Engine was found uprooted from its mounting.

1.12.6 The tail portion of the aircraft, which had been lifted and placed on the roof while recovering the trapped bodies, was examined. The examination revealed that the tail portion including the vertical fin/rudder, horizontal stabilizer and elevator were intact. The elevator was found with no apparent external damage and properly secured. The tail cone was removed to gain access to the Trimmable

Horizontal Stabilizer (THS) actuator. The actuator was found attached to the bearing support fitting at the fuselage end and the THS at the other. The electrical connections were intact. The trim actuator was found in the retracted condition indicating that the stabilizer had been trimmed to the full aircraft nose down position. However the bearing support fitting connecting THS actuator to the fuselage bulkhead at Frame 34 was found partially detached. (Refer Photograph 3). Linkages of elevator control were found in position from the rear upto the passenger entry door.

1.12.7 There was no sign of damage to THS actuator, its end fitting bolts and attachment points (Refer Photograph 4). Near Frame 34, the fuselage skin had a slight bulge and a crack on the LHS at stringer 7 level (Refer Photograph 5). On the RHS at the same level, two rivets were found sheared off and two rivets were found partially pulled inward (Refer Photograph 6). Bulkhead at Frames from #30-#33 had no visual damage in the form of buckling, cracks, or pulled rivets or any other deformation. During inspection through LHS access panel, the bearing support fitting and its attachment to the fuselage brackets showed that 10 hi-lok fasteners were not installed (Refer Photograph 7). All the ten holes were clear and there was no visible distortion of the holes on the longitudinal brackets. Inside the rear fuselage shell, there was no sign of any sheared hi-lok fastener or collar.

1.12.8 The rudder was found attached to the fin and free to move. There was no apparent damage to the rudder trim, which was found trimmed to the right, approximately 1½ inches, from the neutral position.

1.12.9 For further examination of the THS actuator forward attachment bearing support fitting on Frame 34 bulkhead, the elevator, horizontal stabilizer and rudder were removed and the vertical fin was de-riveted from the tail section. Later on, the aft portion of the fuselage, containing Frames # 32, 33 and 34, was cut from the fuselage tail section and sent to the National Aerospace Laboratories (NAL), Bangalore, for further examination.

1.12.10 The THS actuator was sent to HAL Kanpur, for a functional check.

1.12.11 The left engine was in a damaged state. The yoke assembly had separated from its fittings and all fitting points had broken. Examination of the engine in-situ revealed no signs of burning. However sand and bricks pieces were found embedded in the engine components. Propeller Pitch Control (PPC) Unit mountings were found loose and reading on the PPC could not be ascertained since it was found free to rotate. Gear Box Section was found to be in good shape. However the mounting points of the yoke assembly on the gear box were damaged. The oil cooler and generator had detached from the engine. Shaft collar for propeller mounting was broken. Air intake was damaged and the impeller blades were not visible. Fuel Control Unit (FCU) mounting studs had detached from the engine. All control linkage rods on FCU, propeller pitch control unit and propeller governor were damaged. The visible turbine blades were normal.

1.12.12 The right engine was burnt and damaged. Examination of the engine in situ revealed that both the attachment brackets had broken and twisted. No signs of

distortion could be seen on the visible turbine blades. The components of the fuel systems were found in place. Fuel Control Unit mounting studs were found adrift from the gear box. Shaft Collar of the propeller mounting had broken. Air intake was damaged. Gear Box section and plenum chamber were found in place. The dial indicator on the PPC showed a reading of 80%. All drain pipes were bent and distorted and all electrical connections were burnt.

1.12.13 Both engines were sent to HAL, Bangalore for strip examination.

1.12.14 Examination of left propeller in situ revealed that three blades had sheared off at the tips. The leading edges of all the four blades bore tearing/shearing marks. The blades were found bent in different directions. The piston, cylinder, pitch change rod and spring were found detached from the propeller assy. The start locks were found to be off the locks. All propeller blades were off their respective creep marks. However, the extent of shift was different for different blades.

1.12.15 Examination of the right propeller in-situ revealed that one blade was broken and leading edges of all the four blades had cut marks. The blades were found bent in different directions. The spinner was found damaged. All propeller blades were found off their respective creep marks. However extent of shift was different for different blades. The start locks were found to be off the locks.

1.12.16 Both propellers were sent to HAL, Kanpur for further examination.

1.13 Medical and Pathological Information :

1.13.1 Surg. Lt. Cdr. S.S. Khanuja, who was on duty at the Medical Inspection (MI) room of INS Garuda, on the date of accident stated that (Exhibit No.15) at about 0535 UTC he heard a distinct soft thud followed by three short sirens. The Medical department at that time was fully manned. In the next 20-30 seconds, ATC ambulance arrived at the MI room and the driver informed him that a civilian aircraft had crashed on the opposite side of the runway. He immediately rushed to the crash site in the ambulance along with two medical assistants. All equipment for providing medical aid was already available in the ambulance. His colleague Surg. Cdr. P.R. Nair remained behind to initiate immediate measures to inform all concerned organizations, specifically Indian Navy hospital Sanjivini about the crash.

1.13.2 Surg. Lt. Cdr. Khanuja said that on reaching the accident site, a medical post was established just near the CRS building. The fire fighting team informed him that one severely burnt individual had been taken in a vehicle to the hospital. There were others who had very minimal injuries and who had been taken to MI room Garuda for first-aid. Surg. Lt. Cdr. Khanuja had positioned himself in front of the building where the main fire fighting operations were being carried out. In the meantime he was joined by Surg. Cdr. P.R. Nair. Immediately after the fire was brought under control, one dead body was found and removed from inside the building. He said that around 0605 UTC, one crash victim was removed from the aircraft. He examined the body and found all vital signs absent and the victim was dead. The body had a severe scalp injury about

12-15 cms. long and one leg was at an angle, which indicated both bones in the leg had broken. The body was also severely burnt. Five to ten minutes later another body was removed. This body was burnt beyond recognition and was in a pugilistic attitude. It appeared to him to be the body of one of the workers in the building at the time of the crash.

1.13.3 When the crane dragged the rear portion of the aircraft on to the undamaged portion of the roof of the building, he saw a part of the body of another victim from the roof. The body was not recognizable and extensively burnt. There were no vital signs of life. It was not possible to remove the body from that position. Thereafter attempts were made to remove the wreckage with the help of a crane. The combined efforts resulted in five more bodies falling from the aircraft wreckage on to the corridor. All the bodies were mutilated with various body parts missing. Two of the bodies were decapitated. One body from its features appeared to be that of a woman. All the bodies were put on a stretcher, covered by a bed sheet and removed in ambulances to the Medical Trust Hospital. The last body was recovered at about 0900 UTC. He alongwith Surg. Cdr. P.R. Nair, and the medical staff left the crash site at around 0930 UTC.

1.13.4 Surg. Cdr. P.R. Nair stated that (Exhibit No.16) at about 0535 UTC while he was attending to his duties at MI room of INS Garuda, he heard the crash siren being sounded followed by a telephone message that a civil aircraft had crashed adjacent to the runway near NAY(K). His colleague, Surg. Lt. Cdr. S.S. Khanuja left immediately in the crash ambulance with a medical team. Thereafter, he

informed the Indian Naval Hospital (INH) Sanjivani to keep all Medical Officers on standby to assist/receive casualties. He also instructed the reception Medical Assistant in the MI Room to inform the Civil hospitals viz. Medical Trust Hospital, Ernakulam General Hospital, to activate their crash and rescue services. Then he left for the crash site and joined the medical team. They informed him that a few casualties have already been sent to the INH Sanjivani. At about 0605 UTC, a charred lifeless body was removed from the room on whose roof the aircraft had crashed followed by a similar body soon after. In the meanwhile ambulances and medical teams from various hospitals of Kochi had arrived. The two charred bodies were placed in the ambulance and sent to the hospital. Thereafter on inquiring from the MI Room, he was informed that three cases with minor injuries had been received. He instructed that they should be sent to INH Sanjivani. Thereafter he spoke to Surg. Cdr. Ratna Mahendra at INH Sanjivani to gather details of casualties already received. She informed him that one was brought in dead and was removed to the mortuary. One Petty Officer Radhakrishnan had suffered 85% burns and was admitted in the Intensive Care Unit (ICU) and placed on the Dangerously Ill List (DIL). A few others had sustained minor injuries and had been admitted for observation.

1.13.5 Surg. Cdr. Ratna Mahendra stated that (Exhibit No.17) the first casualty to arrive was Petty Officer Radhakrishnan, who was conscious and had 85% burns. Emergency first aid, including removal of burnt clothing, administration of oxygen, establishment of an intravenous line and Inj. morphine IV, was given and he was transferred to the ICU for further management by the Surgical

Specialist. Three persons, who had superficial injuries, were brought to the MI Room at 0600 UTC, given first aid and later admitted to the hospital for observation. At 0610 UTC, S. Sajid, Indian Airlines employee, was brought to the MI Room. On arrival it was observed there were no signs of life. The individual did not respond to any stimuli, there were no heart sounds or respiratory effort, blood pressure was not recordable and both pupils were dilated and fixed. His clothing was partially burnt. He had extensive burns (100%), surgical emphysema over face, chest, upper arm, A 15 cm long full thickness laceration of the scalp, extending between the two temporoparietal regions and compound fracture right tibia/fibula. Despite the above, resuscitative measures were instituted and continued for 30 minutes to give the individual the maximum benefit of a chance to recover. This included establishment of the airway, administration of oxygen through an endotracheal tube, intravenous lifeline and continuous cardio-pulmonary resuscitation. Inj. Adrenaline was given intravenously and intra-cardiac. 320 Joules DC shock was given twice. However, not withstanding the efforts made, the individual could not be resuscitated and was declared "BROUGHT IN DEAD" at 0610 UTC.

1.13.6 In all, nine persons died in the accident. These were the three crew members, three passengers on board and three persons on the ground. Autopsy of all the bodies was carried out. Histopathological examination and bio-chemical toxicological examination in respect of bodies of Capt. S.R. Singh and Capt. Manish Sharma were also carried out.

1.13.7 Capt. S.R. Singh's body was found decapitated. The burns and other injuries were equally sufficient to cause death. The Post-mortem report is at Exhibit No.18.

1.13.8 Histopathological examination of Capt. S.R. Singh's viscera had revealed (Exhibit No.19) that most of the organs showed autolytic changes. Changes in lungs and heart were consistent with traumatic origin. Burns were post-mortem. There was no evidence of any pre-existing disease. Alcohol was not found in his blood sample. Carbon mono-oxide levels were not raised and lactic acid was within normal limits, indicating no evidence of hypoxia.

1.13.9 Capt. Manish Sharma's body was found decapitated. The burns and other injuries were equally sufficient to cause death. The Post-mortem report is at Exhibit No.20.

1.13.10 Histopathological examination of Capt. Manish Sharma's viscera revealed (Exhibit No.21) that most of the organs showed autolytic changes. Changes in lungs and heart were consistent with traumatic origin. Burns were post-mortem. There was no evidence of any pre-existing disease. Alcohol was not found in his blood sample. Carbon mono-oxide levels were not raised and lactic acid was within normal limits, indicating no evidence of hypoxia.

1.13.11 The autopsy of Shri S. Sajid, Flight Purser, revealed (Exhibit No.22) the cause of death to be burns and multiple injuries specially that of the cervical vertebra.

1.13.12 The autopsy of the passengers revealed that the cause of death of Shri Raju Samala was due to severe burns involving the entire body (Exhibit No.23) and that of Sh.

Sasikant Ramani was due to injury to the skull and burns (Exhibit No.24) and that of Mrs. Vijayakalyani was due to multiple injuries especially head injury and burns (Exhibit No.25).

1.13.13 Autopsy of the three persons who died on the ground revealed that the cause of death of Shri K.G. Thomas and Shri Chandrashekharan was due to severe burns (Exhibit No.26). The autopsy of Sh. Radhakrishnan, who had received 85% burns during the accident on 30.7.98 and died on 7.8.98, revealed that the cause of death was due to burns (Exhibit No.27).

1.13.14 Six other persons on ground had received minor injuries and were discharged later on.

1.14 Fire :

1.14.1 The aircraft was destroyed due post impact fire. There was no inflight fire, which was evident from the fact that there was no fire damage to the empennage portion of the aircraft when it had nose-dived and impacted the CRS building.

1.14.2 The aircraft had 1600 lbs. fuel on board when it taxied out at 0527 UTC. It took off at 053413 UTC and crashed after about one minute. It caught fire immediately after the impact with the CRS building. Safety services had reached the site of accident within a minute of the crash. The fire was completely extinguished within 25 minutes by using ATC CFTs and Garuda/Venduruthy DFTs. ATC had also requisitioned the services of 12 fire vehicles from six different fire stations. During the fire fighting, a total

of 2000 liters of foam compound was used to completely extinguish the fire on the aircraft as well as inside the building.

1.15 Survival Aspects :

1.15.1 The accident was not survivable. The aircraft had caught fire immediately after impact with the CRS building. The impact was so severe that the bodies of the two pilots were found decapitated. Autopsy of four more persons on board the aircraft indicated that their deaths were due to injuries and severe burns.

1.16 Tests and Research :

1.16.1 Strip Examination of the Engines :

1.16.1.1 Both engines were strip examined at the facilities of HAL, Engine Division, Bangalore. The strip examination report is at Exhibit No.28.

1.16.1.2 The pre-strip survey as well as the strip examination indicated considerable burning of the right engine and extensive damage to both engines. Critical examination of the damaged components indicated that the damage was all post impact and there had been no failure of any component or system which could have caused malfunctioning of any engine, resulting in reduction or loss of power.

1.16.1.3 The report stated that the type of failure of the torsion shaft of both engines proved that the engines were developing power at the time of impact. The shafts had

failed at the same location and due to the same reason of high torsional load. The shafts experienced very high torsional load due to sudden stoppage of the propellers on impact.

1.16.1.4 All damage observed on the engine internally and externally was caused by impact. There was no evidence of any failure or malfunction of any component or system. It was confirmed that both engines were developing power at the time of impact.

1.16.2 Examination of Propellers :

1.16.2.1 Both propellers were examined in detail at HAL, Kanpur. The examination report is at Exhibit No.29.

1.16.2.2 Examination revealed that on the right propeller, one blade was broken and leading edges of all the four blades had cut marks. Besides, the blades had slipped within the clamps as was indicated by the shift in the position of the red alignment marks. This led to the conclusion that the propeller was rotating at the time of impact. The force of rotation was adequate to cause shearing/tearing of the blade, which meant the propeller was rotating at high RPM under power. Thus it could be concluded that power was being developed at the time of impact.

1.16.2.3 On the left propeller, three blades tips had sheared off. The leading edges of all the four blades bore tearing/shearing marks. It could be concluded that the left propeller was rotating under power at high RPM and

that the left engine was developing power at the time of impact. Slippage of the blades within the clamps was non-uniform. The non-uniform slippage could have occurred due to impact. Thus it could be concluded that power was being developed at the time of impact.

1.16.2.4 The feathering spring assembly consisting of pitch change rod and the piston was found broken. This led to loss of oil. Loss of oil in the pitch change mechanism made the propeller blades move to the 'feather' position.

1.16.2.5 This also led to the conclusion that the propeller system was functioning properly before impact.

1.16.2.6 Further distortion of shape of the blades occurred during final settling down of the aircraft causing impact damages yet again. Thus the secondary impact damage with stationary or low speed propellers distorted the pattern of damage of the propellers which had occurred during the initial impact.

1.16.2.7 In the Flight Mode, RPM was always maintained between 96-100% and to change from 'Flight Mode' to 'Ground Operating Mode', the power lever of the engine had to be lifted up and brought back. Chances of such an inadvertent operation by the pilot were remote.

1.16.2.8 Considering the above and observations made in the preceding paragraphs, it was concluded that the propellers were in the Flight Mode of 96-100% RPM.

**1.16.3 Examination of the Installation of THS Actuator
Forward Attachment Bearing Support Fitting on
Frame 34 Bulkhead :**

1.16.3.1 Installation of the THS actuator forward attachment bearing support fitting on Frame 34 bulkhead was examined at the facilities of NAL, Bangalore. The examination report is at Exhibit No.30.

1.16.3.2 The bearing support fitting had a vertical flange which was attached to the web of Frame 34 bulkhead using four hi-lok fasteners at the corners and quantity five each 'D' rivets on the left and right vertical sides respectively (Refer Photograph 8). It also had a longitudinal tang at the forward side, which was sandwiched between two brackets (Refer Photograph 9) and held by means of qty. 10 hi-lok fasteners.

1.16.3.3 Examination revealed that the fitting had moved out of the plane of Frame 34 with clear evidence of structural damage. The structural damage consisted of fracture of the thin aluminum alloy web to which the fitting was attached originating from the rivet holes on the right hand vertical side extending across the lower edge of the fitting to the left hand side (Refer Photograph 9). However the fitting remained attached to the bulkhead web at the upper edge with qty. two hi-lok fasteners at the top left and right corners. This made the forward lower corner of the longitudinal tang of the fitting move in a downward arc, producing a deep groove on the upper surface of the bottom lateral beam spanning fuselage Frame 34. This rotation also created a 'V' shaped notch on the aft support angle of the beam as it broke free (Refer Photograph 10).

1.16.3.4 In view of the rotary movement of the tang of the fitting, the fitting and the adjacent structure was examined for broken fasteners and evidence of shear damage. None of the fasteners were found. There was not a single sheared-shank of the hi-lok fasteners that were supposed to have been used as per the DORNIER Structural Repair Manual. Neither were any of the sheared-off heads, shanks and collars of hi-lok fasteners found on the supporting brackets and tang nor were they inside the rear fuselage shell of the aircraft. This led the Committee to conclude that qty. 10 hi-lok fasteners had not been installed at that crucial control surface fitting, which was a Critical Structural Element(CSE) in DO-228 aircraft.

1.16.3.5 It was observed that the holes in the tang had melted primer and soot. Microscopic examination of the fractured surfaces of the attachments at Frame No. 34 was carried out using a Scanning Electron Microscope. Scanned fractograph of the fracture surface showed extensive oxidation of the surface and cracking up of the oxide layer, which was caused by the post crash fire.

1.16.4 Examination of the Trimmable Horizontal Stabilizer Actuator :

1.16.4.1 The Trimmable Horizontal Stabilizer (THS) actuator was sent to HAL, Kanpur for a functional check. The examination report is at Exhibit No.31. The report stated that there was no physical damage to the actuator. The functional test included the potentiometer test, travel checks, load tests, slip test and di-electric test. Results of the functional tests were found to be within acceptable

limits and the trim actuator was found serviceable. As a confirmatory test, a functional check was carried out after operating the actuator continuously for 100 cycles. All readings were once again within specified limits. It was confirmed that the THS actuator was serviceable even after one hundred continuous cycles in the second functional test.

1.16.4.2 In view of the fact that in both functional tests, the actuator was found serviceable, it was inferred that it was serviceable after the accident. By the same observation, it was inferred that the actuator was serviceable before the accident. The accident had not damaged it at all.

1.17 Organizational and Management Information :

1.17.1 Sh. P.C. Sen was the Chairman & Managing Director of Indian Airlines and Shri V. Kashyap was the Executive Director of Short Haul Operations Department (SHOD) of Indian Airlines. Shri S.B. Gokhale was the Off. General Manager Engineering of SHOD.

1.18 Additional Information :

1.18.1 A meeting was held at Mumbai on 24.9.98 and 25.9.98 between the Committee of Inquiry and Dornier Luftfahrt GmbH experts from Germany and the possible scenario of the accident was discussed. Dornier experts were requested to provide details regarding transfer of trim actuator loads on to the fuselage structure. Operational loads on trim actuator under normal operation as well as with 10 hi-lok fasteners missing were also requested. The experts were

asked to provide an assessment of longitudinal controllability with partially detached trim actuator forward attachment bearing supporting fitting of the THS.

1.18.2 Regarding transfer of trim actuator loads on to the fuselage, the experts stated (Exhibit No.32) that the trim actuator horizontal load was transferred via fitting lug, forward tang, lateral shear ribs, upper supporting beam(20%) and lower supporting beam(80%) to the side of the fuselage. Trim actuator vertical (and lateral) loads were transferred via fitting shear flange to web of Frame 34. For a structure with 10 hi-lok fasteners missing, the shear load transfer from fitting forward tang to lateral shear ribs decreased rapidly. For positive horizontal loads (tension) the carrying capacity changed from +300...500 daN (fitting vertical shear flange riveting to Frame 34 web intact) to about 0 daN for a fitting in the dislocated position (fitting vertical shear flange lower rivets broken, or web skin around fitting broken). Negative horizontal loads (compression) were not reduced due to the fitting being supported by supporting beams.

1.18.3 As per data supplied by Dornier, the only significant trim actuator tension load occurred in a push over maneuver.

1.18.4 Dornier stated that operating with 10 hi-lok fasteners missing from the fitting forward flange was possible, as long as the trim actuator tension load did not exceed 300...500 daN. Such a load would occur during a push over maneuver. Probably the residual trim actuator tension load decreased continuously (structural configuration; riveting vertical shear flange to Frame 34 and lower

supporting beam intact) to 0 daN (nearly complete fitting dismounted, no connection between fitting and Frame 34 or lower supporting beam) over a defined period. The period in which significant trim actuator tension loads may occur will vary.

1.18.5 Regarding assessment of longitudinal controllability with partially detached trim actuator of THS, Dornier stated that from the wreckage scenario, a pull force on the fitting must be assumed, which can hardly be considered as a result of the impact mass forces, which tend to create a push force on the fitting. Therefore the detachment of the fitting has to be considered as an in-flight event, which was generally assessed to be uncontrollable by the pilot. They stated that as known from flight test measurements the force on the trim actuator (or the fitting) resulting from mass and aerodynamic forces in a trimmed condition was a low push force, which increased when the pilot pulled the control column (for instance to increase the load factor). On the other hand the push force at the actuator decreased and became a pull force, when the pilot pushed the control column forward for instance to correct the attitude or to counteract a pitch up mistrim. They stated that assuming a push input of the pilot high enough to start the detachment of the bracket the consequent displacement of the THS due to the detachment was leading edge (LE) down, which meant the aircraft would tend to pitch up despite the push input of the pilot. Any instinctive push on the column by the pilot to counteract the pitch-up increased the pull force on the trim-actuator. From the damage to Frame 34 it can be assumed, that the fitting remained attached only with the upper bolts and the fitting could swivel about that axis. An additional deflection -14° (LE down) of the THS

had to be taken into account at minimum, not considering any elastic deformation of Frame 34. With the fitting fully detached a maximum of -17° (LE down) deflection of the THS was possible. At this deflection the upper surface of the THS hit the rudder. The trim actuator was found fully retracted corresponding to full nose down trim ($=+1.6^{\circ}$ LE up). The trim position for a speed of 110 KCAS and the loading condition of the aircraft was about $+0.5^{\circ}$. With the displacement of the detached fitting an effective deflection of -12.4° (LE down) had to be considered at a minimum. A sudden mistrim of 14° from trimmed flight could not be counteracted by elevator control regardless of the stick-forces which would be required. With the maximum elevator (TE down) deflection of 25° a maximum of about 10° mistrim was controllable requiring at 110 KCAS a pilot force of a minimum of 50 daN. Even with optimum pilot effort a pitch up could not be avoided. The pitch up would give rise to a positive load factor of estimated 2g. An uncontrolled increase of the angle of climb would be the consequence with rapid decrease of airspeed.

1.18.6 Shri V. Kashyap, Executive Director, SHOD, deposed before the Committee of Inquiry on 6.10.98 (Exhibit No.33). Regarding lack of orderly lines of communication in the maintenance wing of SHOD and the working environment not being fully congenial and friendly, he stated that the SHOD was formed in partial compliance of Government of India orders for merger of Vayudoot with Indian Airlines. The Ministry of Civil Aviation decided in May, 1993 that Vayudoot should be merged with Indian Airlines. This decision was taken by Govt. without eliciting any views from Indian Airlines. The decision of the Govt. evoked opposition from Indian Airlines as well as Vayudoot

employees. While on the one hand, Indian Airlines employees objected to the merger on the grounds that induction of Vayudoot employees would have an adverse effect on their career progression, Vayudoot employees objected to the merger on the grounds that according to the prevalent rules of Indian Airlines they would have to join at the lowest rung of a particular cadre. The trade unions of Indian Airlines had even formed a coordination committee for this purpose. On the other hand, Vayudoot employees started agitations/hunger strikes resulting in disruption of work. One employee of Vayudoot even threatened self-immolation. In this surcharged atmosphere Indian Airlines had no option but not to proceed with the legal merger and absorb the employees in the respective departments. It, therefore, created a Short Haul Operations Department in which employees of Vayudoot were placed separate from the cadres of Indian Airlines. The facilities of Vayudoot were also not merged with the respective facilities of Indian Airlines. The procedures and systems of Vayudoot, therefore continued in totality. The communication channels, which had earlier existed in Vayudoot also continued. The Airworthiness Authorities had approved these systems and procedures as they had accorded their approval to the SHOD for maintenance of Dornier aircraft. He said Vayudoot was formed in 1982 and their procedures, systems and lines of maintenance had been in vogue since the formation of the company and it had become a "way of life" with the officers and employees of the organisation. It is only after the unfortunate accident at Kochi that the Directorate General of Civil Aviation had withdrawn the approvals of the SHOD and its Quality Control Officers. The first maintenance audit by the Directorate General of Civil Aviation was carried out after the accident.

1.18.7 With reference to the delay in merger of employees in the respective departments of Indian Airlines so that they could be fully functional with the system of procedures of Indian Airlines, he said the employees of SHOD were not ready to enter at the bottom of the respective cadres as applicable in Indian Airlines. A number of employees of SHOD had also filed legal suits. A stream of representations continued to be received by the management of Indian Airlines regarding employees of SHOD not getting their due while they were working in Vayudoot before 1993. He added that normally when a merger of two public sector undertakings was announced by the Government, the Govt. also issued a scheme of absorption of the merging organizations. In the present case no such scheme was issued by the Government of India. Even recommendations of the Absorption Committee formed by the Govt. of India have been questioned by the employees of SHOD in courts and other fora. The Govt. held the first meeting to consider the absorption of employees in the respective cadres of Indian Airlines in March 1998. This was followed by another meeting in April 1998. Only a handful of employees of SHOD had agreed with the recommendations made at these meetings and problems of large sections still remained unresolved. Under these circumstances it may still take quite some time for a complete merger of seniority of the SHOD employees in the respective departments of Indian Airlines. In the absence of this the old way of life with the Short Haul Operations Department will continue till SHOD convert to work practices, systems, procedures and lines of communication practiced in Indian Airlines.

1.18.8 Regarding paucity of funds for repair of aircraft of SHOD or any inadequacy in budgetary allocation, he stated that no budgetary problems were faced in repair of the aircraft of SHOD by Indian Airlines. The company in fact was spending a very large amount on the wage bill of SHOD employees and was also meeting all other obligations for maintenance of aircraft, engines and components. This will be borne out by the evidence that all operational aircraft had valid Certificate of Airworthiness from the Directorate General of Civil Aviation. The Dornier aircraft VT-EJW was placed in service after incurring an expenditure in excess of Rs.3 crores. The Company had also agreed to spend in excess of Rs. 4 cores to put another aircraft back into service.

1.18.9 As for the decision taken to put back aircraft VT-EJW into service, he stated that Vayudoot had a fleet of eight Dornier aircraft in 1993 at the time of the merger of Vayudoot with Indian Airlines. Of these only three aircraft were operational in the North-East and the remaining five were not in use. All five aircraft were evaluated and assessed by M/s Dornier, the aircraft manufacturers. The Company had expressed a view that two more aircraft could be economically repaired and put back into service while the other three aircraft were beyond economical repair. Based on this opinion the company decided to repair Dornier aircraft VT-EJW.

1.18.10 Regarding the areas of responsibility of various officers in the maintenance and quality control set up, he stated that while day-to-day maintenance at Delhi was supervised by Shri V.C.M Kutty, Chief Manager, Indian Airlines had brought on deputation Shri J.K. Dasgupta of

Eastern Region to supervise maintenance activities at Calcutta. Shri S.B. Gokhale, Dy.General Manager of Indian Airlines was seconded to be the overall incharge of engineering and aircraft maintenance wings of the SHOD. He was designated as Off. General Manager (Engg) of SHOD. Shri Kutty and Shri Dasgupta reported to Shri Gokhale. Shri O.K. Bakshi was the Quality Control Manager of the SHOD. He reported to the Executive Director. He (Sh. Kashyap) had met all the officers on a number of occasions and at no point of time had they brought to his notice any difference of opinion among themselves. None of them had on any occasion brought any problem regarding maintenance of the aircraft or non-availability of funds to his notice. Shri V.C.M Kutty had represented on many occasions directly or through a number of outside officers to be appointed as Head of the maintenance organisation. Shri O.K Bakshi had some personal matters regarding his designation and emoluments which were resolved way back and had no other complaint pending against the management of Indian Airlines.

1.18.11 Shri P.C. Sen, Chairman and Managing Director of Indian Airlines, deposed before the Chairman, Committee of the Inquiry on 9.11.98 (Exhibit No.34). Shri Sen explained the compulsions under which SHOD was formed as a separate department of Indian Airlines. He gave the reasons why a complete merger could not be effected to date. The higher management organisation of Indian Airlines was also explained by him. As far as SHOD was concerned, he said he had created the post of an Executive Director and empowered him to manage that department.

1.18.12 Shri N. Ramesh, Dy. Director General of Civil Aviation at DGCA (Headquarters), Delhi deposed before the Committee on 29.10.98. He stated that (Exhibit No.35) he held the responsibility of supervising the Airworthiness Directorate in addition to some of the responsibilities of Air Transport Directorate. The responsibility basically revolved around framing of airworthiness policies in the light of ICAO document, FAR and issuing them in the form of Aircraft Rules, Civil Aviation Requirements and Advisory Circulars. Also the implementation of various requirements by Regional/sub-regional airworthiness officers was done through issuance of Airworthiness Instructions, which was the hand book of Airworthiness Officers for implementation of airworthiness policies. Besides he supervised the training of officers on aircraft operating in India including training of officers abroad whenever a new type of aircraft was introduced into the country so that the officer entrusted with the responsibility of supervising maintenance of these aircraft had full knowledge of the aircraft and operation of various systems installed in it.

1.18.13 With reference to maintenance of Dornier aircraft by SHOD of Indian Airlines, he said the Airworthiness Directorate at Headquarters had been monitoring their maintenance through surveillance/audit/spot check reports received from the Director of Airworthiness (DAW), Delhi and other offices. The DAW, Delhi had been continuously monitoring maintenance of Dornier aircraft of SHOD. He had carried out an audit in Sept. 97 while renewing the firm's approval for maintenance. Discrepancies noticed had been brought to the notice of Quality Control Manager (QCM), SHOD for necessary corrective action. Similarly detailed audit at the instance of Headquarters was carried out by

DAW, Delhi in March,98 wherein several serious discrepancies had been noticed and were brought to the notice of QCM, SHOD for taking immediate corrective action. Similarly, office of the Controller of Airworthiness, Thiruvananthapuram had carried out an audit of Agati base in July,97 where again certain deficiencies were observed and the same were brought to the notice of QCM, SHOD for taking appropriate corrective action. He said the DGCA of late had introduced an internal audit by the operators to make them responsible for adhering to airworthiness standards.

1.18.14 DGCA had been carrying out continuous surveillance checks on the maintenance activities of SHOD.

1.18.15 To assist the Regional/sub-regional offices in carrying out meaningful surveillance/safety audit/spot checks, detailed check lists had been prepared by Headquarters on various inspections like inspection of aircraft, inspection of hangars, inspection of Quality Control department, inspection of overhaul shops and these had been distributed to all the Regional/Sub-regional offices with the advice that these check lists were to be used while carrying out surveillance/ audit. They had further been advised to amend the check lists wherever necessary to meet the local requirements. Officers from various regions were sent to different regions to carry out the audit of various operators so that the technical skill of the officers for carrying out surveillance was fine tuned/enhanced.

1.18.16 He said that DGCA had contributed to the training programme of International Civil Aviation Organisation

(ICAO) wherein they will be training DGCA officers to carry out surveillance/safety audit at par with international standards. He said that it was a fact that a lot more required to be done by the Airworthiness Directorate to shoulder the responsibilities entrusted to them. However, there was a great need for additional man-power as at present the Airworthiness Directorate was also required to do additional work such as invigilation of examinations, conduct of oral examinations, attending to VVIP movements and administration, which tied down a big proportion of manpower and reduced the time available to carry out meaningful surveillance.

1.18.17 He said that the present system of maintenance of an approved firm worked under delegated system of responsibility wherein the QCM who was approved by DGCA shouldered the entire responsibility of adhering to airworthiness standards as laid down by DGCA. The DGCA's responsibility was to carry out surveillance and spot checks.

1.18.18 Wg. Cdr. S.C. Sharma (Retd.), father of late Capt. Manish Sharma (Co-pilot) expressed a desire to depose before the Committee. He deposed before the Committee on 9th and 10th September, 98. During the deposition, he requested permission to hear the CVR and read the DFR output. Permission was granted by the Committee. He heard the CVR, read the DFR output and thereafter expressed his views about the crash.

1.18.19 Shri P. Mohanan, Regional Dy. Commissioner of Security (RDCOS), Chennai visited the site of accident at Kochi on the morning of 31.7.98. The Committee had

requested Commissioner of Security, Civil Aviation, Delhi on 20.8.98 to forward the report submitted by Shri Mohanan covering sabotage/explosive aspects. A reminder was sent to the Commissioner of Security, Civil Aviation, on 7.9.98 to forward the report. On 11.9.98, Shri S. Banerjee, Dy. Commissioner of Security, Civil Aviation informed the Committee that an inquiry on possible sabotage/explosive aspects of the crash was being conducted by him and some documents were awaited and on completion of the detailed inquiry, the report would be made available. Further reminders were sent on 15.9.98, 21.9.98, 5.10.98 and 13.10.98 to the Commissioner of Security, Civil Aviation requesting him to expedite submission of the report. While the accident was still under investigation by the Committee of Inquiry, the office of Commissioner of Security, Civil Aviation directly informed the Ministry of Civil Aviation on 21.10.98 (Shri S.K.Singhal, Under Secretary) that Shri Banerjee had been deputed to conduct a detailed inquiry into the incident and his report had been received at Office of Commissioner of Security, Civil Aviation. He stated that on the basis of the report, no characteristic sign of sabotage was found with respect to the crash of IC-501, DO-228 VT-EJW. A copy of the above note to the Ministry of Civil Aviation was also endorsed to the Committee of Inquiry.

1.18.20 On 21.10.98, Commissioner of Security, Civil Aviation was again reminded to expedite submission of the detailed report on the aspect of sabotage/explosive. On 23.10.98, the Office of Commissioner of Security sent the report to the Committee. The report is at Exhibit No.36.

1.18.21 The report stated that as per the order (dated 2.9.98) of the Commissioner of Security, Civil Aviation, Shri Banerjee, visited Kochi on 8.9.98 to conduct a detailed inquiry to ascertain whether there was any sabotage due to a lapse of security measures or any kind of unlawful obstruction to Civil Aviation in respect of crash of IC-503.

1.18.22 The report said that forensic survey of the splinters as well as of the wreckage was conducted by a Forensic Science Laboratory (FSL) team from Thiruvananthapuram in the presence of Shri Mohanan and as per their report submitted to BCAS, "No characteristic features of any explosion could be noticed. There was smell of burnt and charred organic material inside the building on which the aircraft crashed".

1.18.23 Shri Banerjee concluded in his report that based on the available documents and facts of the case, there was no sabotage involved in the crash of the said flight. However the report pointed out that as per the FSL team samples had not been collected from the spot because it was not allowed by "aerodrome officers" present at the crash site. The report pointed out that as per Shri Mohanan's message, DGCA officials had discouraged the team from collecting samples. The report also stated that non-collection of samples by the FSL team should be viewed seriously as they were not duty bound to follow the advice/instructions of "aerodrome officers".

1.18.24 Shri Mohanan, deposed before the Committee of Inquiry on 29.10.98. He said (Exhibit No.37) he reached the site of accident at Kochi on 31.7.98 on the instructions of

Commissioner of Security, New Delhi. He examined the crash site and the aircraft. He also conducted a survey for any explosive material at the crash site or nearby along with the FSL team, which had arrived from Thiruvananthapuram. The FSL team confirmed to him that they had not found any evidence of explosion. He stated that after few days he was instructed by Commissioner of Security, Civil Aviation, to get a report from FSL, Thiruvananthapuram. He contacted Shri Viswanathan, Joint Director, FSL and he (Shri Viswanathan) was apologetic saying that they could not collect any samples as Civil Aviation officials and perhaps DGCA officials had not allowed them to collect the samples. They had felt discouraged by this refusal and therefore no test of the samples was carried out.

1.18.25 Shri Mohanan confirmed during the deposition before the Committee that the FSL team had not informed him about any difficulty in collecting the samples on 31.10.98 at the crash site.

1.18.26 From the foregoing, it was clear that the FSL team had surveyed the crash site along with Shri Mohanan on 31.7.98 and confirmed to him that that they had not found any evidence of an explosion. It was evident that the FSL team had not felt the necessity to collect samples as they had not informed Shri Mohanan about any difficulty in collecting the samples, while conducting a survey of the crash site along with him. On the instructions of Commissioner of Security Civil Aviation, Shri Viswanathan was asked for a report by Shri Mohanan at a later date. Shri Viswanathan then tried to apportion blame on some aerodrome official perhaps DGCA official (of which he was not sure) to cover up the failure of the FSL team to

collect samples. They could have taken samples if they felt it necessary for their examination as they were not duty bound to follow the advice/instructions of any aerodrome official while discharging their duties for which they were deputed to the site of the accident.

1.18.27 As Shri Banerjee had drawn a firm conclusion that there was no evidence of an explosion, the Committee did not feel it necessary to probe this aspect further.

1.19 Useful or Effective Investigation Techniques :

Nil

2. ANALYSIS :

2.1 Airworthiness Aspects :

2.1.1 The aircraft was manufactured by HAL Kanpur in 1986 and was operated and maintained by erstwhile Vayudoot Ltd. It was grounded on 6.3.93 for 1800 hrs/1 year inspection and the C of A of the aircraft expired on 10.11.93. In 1994, there was a merger of Vayudoot with Indian Airlines and the Short Haul Operations Department (SHOD) was formed. In March 97, Indian Airlines (SHOD) took up the matter with DAW (DGCA) Delhi region to resume operating VT-EJW and submitted the quantum of work, as mentioned in para 1.6.1, for approval for the purpose of C of A renewal. Rebuilding of the aircraft (VT-EJW) started on 27.5.96 and continued till 14.4.98. Rebuild included compliance of 4800 flying hours/8 years inspection schedules. While carrying out these schedules, THS actuator fitting was removed and sent to the non-destructive testing

(NDT) shop for eddy current inspection (ECI). During the NDT inspection, it was found that it had excessive pitting and was therefore rejected. Later on, a fitting of the same part no. was removed from aircraft VT-EJU and sent for ECI. The fitting was declared serviceable and installed on VT-EJW.

2.1.2 The aircraft was test flown for C of A renewal and the same was renewed on 27.4.98. At the time of C of A renewal, the aircraft had done 13289:20 hrs since manufacture. The aircraft was positioned at Agati for scheduled operations. On 21.7.98, 300 hrs inspection schedule was carried out and also the flight release was issued at Agati. Inspection schedule at 300 hrs called for removal of the tail cone fairing for lubrication of the rudder trim chain. With the tail cone fairing removed, Frame 34 area would have been visible. Apparently no signs of damage to the actuator attachment fitting and the surrounding area were observed by maintenance personnel. On the morning of 30.7.98, Check 'B' inspection schedule was carried out by Shri Anurag Yadav (licence Cat.'A') and Shri Satish Raina (licence Cat.'C') and the aircraft was released to operate the scheduled flight IC-501, (Agati-Kochi-Tiruvanathapuram). The flight from Agati to Kochi was uneventful. While proceeding on the Kochi-Tiruvananthapuram leg, the aircraft crashed about a minute after take off from Kochi.

2.1.3 During examination of the wreckage, it was observed that near Frame 34, the fuselage skin had a slight bulge and a crack on the left at stringer 7 level. On the right at the same level, two rivets were found sheared off and two were found partially pulled inward. Frames 30 thru

33 had no visual damage in the form of buckling, cracks, or pulled rivets or any other deformation. During inspection through access panels on the LHS and RHS of the rear fuselage, it was observed that 10 hi-lok fasteners, which attach the forward tang of the actuator bearing support fitting to two longitudinal brackets, were not found in place. All ten holes were clear and there was no visible distortion of the holes on the longitudinal brackets. Inside the rear fuselage shell, there was no sign of any sheared hi-lok fastener or collar.

2.1.4 Frame 34 web, the bearing support fitting, two longitudinal brackets on either side and the top and bottom mounting plates were sent to the National Aerospace Laboratories (NAL), Bangalore for further examination. The examination report is at Exhibit No.30. The parts were observed visually and under a stereobinocular microscope and scanning electron microscope. During examination, the actuator bearing support fitting (aluminium alloy 7010 milled part) was found covered with a thin layer of soot deposit in some regions (Refer Photograph 11). Ten fastener holes on the tang of the bearing support fitting had not suffered any deformation or damage. The insides of the holes were covered with soot, melted paint etc. The two eye ends were intact with the steel bushes in place. The two sheet metal (aluminium alloy 2024) brackets on either side of the bearing support fitting were found relatively intact (Refer Photograph 12). The 10 holes on each of the brackets where the bracket was attached to the bearing support fitting were relatively undamaged (Refer Photograph 13). Except for two or three fastener holes, which showed slight ovality due to deformation and fastener impressions caused during derivetting, the rest of the holes were undamaged.

All holes had soot deposits. No fasteners, broken pieces or collars were found in the wreckage. The angle in front of the bottom base plate on which the fitting and the longitudinal support plates were mounted had fractured along with the fitting. It had also buckled in the region where the longitudinal brackets were mounted (Refer Photograph 14). The web of bulkhead at Frame 34 to which the bearing support fitting was attached was found torn, running along the rivets on one side and away from the rivets on the opposite side (Refer Photograph 15). The fracture surfaces were covered with soot deposits and were rubbed in some areas, but the gross features of the fracture indicated tearing under tensile load. Fractured pieces from the angle in front of the bottom base plate were observed under a scanning electron microscope. The fractured surfaces were oxidized due to post impact fire. Some regions showed features resembling dimpled rupture. Fatigue striations were not visible due to oxidation. However, based on the macroscopic fracture morphology and the absence of gross plastic deformation on the fracture surfaces, fatigue could not be ruled out.

2.1.5 Lack of significant deformation or damage to the fastener holes of the tang of the bearing support fitting and the two longitudinal brackets, and the absence of any broken pieces of fastener in the space between the tang and the brackets suggested that the fasteners were not present at the time of the crash. If the fasteners had been in position, the force required to shear them would have led to significant deformation of the fastener holes and even tearing of the holes atleast in the thin bracket sheets. Also, some of the broken fasteners should have been retained in place trapped on the tang since the holes in it

were blinded due to its displacement with respect to brackets. This suggested that the fasteners were not fixed in place.

2.1.6 It was concluded that the type of damage observed on the tang and the brackets suggested that the hi-lok fasteners were not fixed on to the holes. The absence of 10 hi-lok fasteners led to excessive loading on the bottom angle, which finally fractured.

2.1.7 From the foregoing, it was evident that while reinstalling the THS Actuator attachment bearing support fitting, after the ECI, 10 hi-lok fasteners were not installed. Examination of maintenance documents revealed that for removal and replacement of THS fitting, the job sheet was prepared by Shri V.K. Srivastava, Chief Manager Engineering, SHOD, Indian Airlines. After removal and reinstallation of the fitting, job sheet was signed on 18.2.98 by Shri Sher Singh, foreman employed on contract against the mechanic column and Shri V.K. Srivastava against the AME column.

2.1.8 During deposition before the Committee on 7.8.98, Shri Sher Singh stated (Exhibit No.38) that he was working as a foreman in SHOD on a yearly contract. Earlier he had worked in Indian Airlines as a bench fitter and sheet metal repair mechanic and after his retirement from Indian Airlines, he was on contract with erstwhile Vayudoot. Three regular staff of SHOD of Indian Airlines namely Shri T.D. Paul, Shri Om Prakash, both technicians, and Shri Satish Khanna, a helper, were attached with him for day-to-day work. Shri Sher Singh stated that regarding the THS trim actuator fitting, Shri T.D. Paul and Shri Khanna had

2.1.9 Shri T.D. Paul, the technician, during his deposition before the Committee on 7.8.98 stated (Exhibit No.39) that he had earlier worked as a sheet metal repair technician in erstwhile Vayudoot along with Shri Sher Singh. He had joined the SHOD of IA in 1994. At present his

Khanna had been installed by them.

fasteners which were given to Shri T.D. Paul and Shri fasteners on the fitting. He said he had presumed that the sheet without checking for the presence of all the stated that it was his mistake that he had signed the job fitting. The job took about 3-4 days to be completed. He not signed on the same day after installation of the which was prepared by Shri Srivastava. The job sheet was fitting along with Shri V.K. Srivastava in the job sheet, fasteners. He had signed for the installation of the checked for their presence after installation of the Shri Khanna installing the hi-lok fasteners. He had not fasteners. He had not personally seen Shri T.D. Paul and at the diameter and the grip length of the removed flange of the fitting. Hi-lok fasteners were chosen looking asked Shri T.D. Paul to install the rivets on the vertical allen key for installing the hi-lok fasteners. He had then them over to Shri T.D. Paul along with the ratchet and he collected 'D' rivets and hi-lok fasteners and handed of fasteners left behind by a Dornier repair team. He said required for installation had been picked up from a number after ECI inspection. He said the fasteners and rivets VT-EJU. It took about a week for the fitting to come back with the same part no. was removed from Dornier aircraft new fitting was available in the stores, another fitting the NDT shop. The removed fitting was found pitted. As no removed the fasteners. The fitting was then sent for ECI to

designation was Aircraft Technician. He had been asked by Shri Sher Singh to remove the fitting from aircraft VT-EJW. He along with Shri Rawat and Shri S.K. Khanna removed the fitting. There was no AME present at that time. Normally the work was given to them by the foreman verbally and no AME was available to give instructions. He had initially drilled out the rivets on the rear face of the fitting and then the hi-lok fasteners from inside the fuselage through the access panel. The fitting was then taken to the NDT shop. After that he had applied the primer and did not remember after how many days the fitting was brought back to the aircraft for fitment. Along with the fitting, rivets and hi-lok fasteners had also been given to him. He had installed the fasteners. Shri Sher Singh, Shri Rawat and Shri Khanna were with him but he could not recollect whether any particular fastener was installed by him or not. He did not remember whether any of the fasteners was installed by him. After completion of the job, he had informed the foreman that the job had been completed and he had not seen him (Shri Sher Singh) inspecting it. He had not seen any AME inspecting that job. Normally after small repairs whenever he was told to sign the work sheet, he used to sign it. In this particular case, he had not been asked to sign anywhere and therefore had not signed.

2.1.10 Shri Satish Khanna, helper, during deposition before the Committee on 7.8.98 stated (Exhibit No.40) that he had been working with Shri Sher Singh and Shri T.D. Paul and did jobs like painting, removal of paint, cleaning and moving things from one place to another. He was aware that VT-EJW aircraft which was parked outside the hangar for a long time had been brought inside the hangar. He was also aware that the fitting, which was shown to him, was

connected to the stabilizer actuator. He had cleaned the whole fitment area and applied primer. The fitting had been removed and given to him by Shri Sher Singh for cleaning. After cleaning, the fitting was sent to the NDT shop. He could not recollect after how many days the fitting had come back for fitment on the aircraft. When the fitting was being installed, he had helped Shri T.D. Paul to rivet the fitting. He had held the dolly from the inside. He was aware that there were four hi-lok fasteners on the rear face of the fitting and the remaining were rivets. When he was installing the rivets, he had noticed that the four hi-lok fasteners on the face of the fitting had already been installed. When he was helping to install the rivets, at that time the lateral hi-lok fasteners on the tang of the fitting had not been installed. If these had been installed, it would have been difficult for him to hold the dolly for doing the riveting. After the riveting job, he had been sent for some other work. He had not seen anybody installing the hi-lok fasteners on the tang of the fitting. He had cleaned the entire area before the installation of the fitting.

2.1.11 Shri V.K. Srivastava, Chief Manager Engineering, during deposition before the Committee on 7.8.98 stated (Exhibit No.41) that he had earlier been working in Agro Aviation, Directorate of Agricultural Aviation and was sent on deputation to Vayudoot in 1988. In 1990 Agro Aviation merged with Vayudoot and in 1994 Vayudoot merged with Indian Airlines. His present designation in SHOD was Chief Manager Engineering and his primary responsibility was for Production Planning and Control (PPC).

2.1.12 He stated that when he was working in the Directorate of Agricultural Aviation, he had undertaken a lot of structural work on aircraft. Even though he had a 'B' licence on small aircraft, at present he was not making use of that. Whatever structural jobs were done, were being done on specific approvals.

2.1.13 He stated that the job sheet, which was used for replacement of the THS actuator attachment fitting, was prepared by him. When questioned by the Committee, he agreed that it was not an approved procedure sheet. He had looked into the Illustrated Parts Catalogue (IPC) and Structural Repair Manual (SRM) and prepared the job sheet. He had not mentioned the fastener part nos. in the job sheet. He added that initially he was not involved in replacement of the THS actuator attachment fitting. He had therefore not supervised the removal of the fitting. He was not aware, who had removed the fitting. His name had been proposed for riveting and deriveting at a later stage. He felt that he was given the approval based on his earlier experience of structural repairs. By the time the approval was given to him, the fitting had already been installed. He had been aware that the required hi-lok fasteners were not available in the stores, but Shri Sher Singh had informed him that the required fasteners were available with the surplus stock left behind by the Dornier repair team.

2.1.14 He had inspected the fitting from the outside, after its installation on aircraft VT-EJW and found that the fitting had been installed properly. He had not inspected the fitting on the forward side of Frame 34 through the access panels. He had not used a trestle

required to reach the access panel to carry out the inspection of the fitting. Instead he had checked up with Shri Sher Singh regarding installation of the fitting and he (Shri Sher Singh) had confirmed to him that everything had been installed. He had then referred the IPC of Dornier aircraft and made the job sheet. He was aware that the installed fitting was serviceable because the same had been confirmed to him by Shri V.K. Jain, who had carried out the ECI.

2.1.15 Shri Sher Singh again deposed before the Committee on 9.9.98. On being asked as to who had given him instructions for removal of the fitting, he stated that (Exhibit No.42) he did not remember who had done so. He said there was no proper system by which these instructions were given. On being queried again as to who would have given instructions for such jobs, Shri Sher Singh stated that the engineer who looked after that area would normally have given instructions but for that particular work no structural engineer was available. On being asked that if the engineer was not there, whether there was anybody else higher than the level of an engineer to give instructions, he stated that Shri V.C. Mathoo Kutty, the Chief Manager Engineering was at a higher level but he normally did not come to the aircraft. He came to the floor level only at times to check the progress of the work. Regarding removal of the fitting from another aircraft (VT-EJU), he was asked who had given him instructions for that work. Shri Sher Singh stated that he did not remember but he had instructed Shri T.D.Paul to remove the fitting from the other aircraft (VT-EJU) and it was possible that he had taken the decision himself. Regarding installation of any fasteners on the fitting, he stated that he could not

recollect, but he may have helped to install some fasteners in a difficult location.

2.1.16 Shri T.D. Paul while deposing before the Committee on 9.9.98, stated that (Exhibit No.43) neither had Shri Sher Singh told him to remove the fitting from another aircraft (VT-EJU) nor had he removed the same. He added that he had installed the fitting on VT-EJW along with Shri Sher Singh and Shri Khanna and whenever he had been working on VT-EJW, he had also been entrusted with other jobs occasionally. On being queried whether he was in the habit of checking whether all the fasteners had been installed before reporting the completion of the job, he stated that Shri Sher Singh had also been with him.

2.1.17 Shri V.K. Srivastava deposed before the Committee on 9.9.98 and on being asked who had given instructions for removal of the fitting from VT-EJW, he stated that (Exhibit No.44) he had been asking everybody, but nobody had been willing to come out with the answer as to who had given these instructions. Possibly, Shri Mathoo Kutty might have given the instructions. When asked at what stage he had come to know that the fitting was to be certified by him, he stated that Shri O.K. Bakshi, Quality Control Manager (QCM), had informed him that he (Shri Srivastava) had the approval for riveting and de-riveting. By that time, the actuator attachment bracket installation had already been completed. He had inspected the fitting from the rear of Frame 34 and had been informed by Shri Sher Singh that hi-lok fasteners had been installed. When queried about such a haphazard style of working in SHOD, he replied that as far as he was concerned, he did not belong to maintenance at all. He had always been in PPC. It was only when he was

asked to do some work in maintenance, did he go there. If there had been a proper organisation in SHOD, he would not have been called for that work at all. Regarding the pressure of completing the work on the aircraft, he stated that pressure had been there. The work had already slipped behind schedule and he felt that higher authorities wanted the aircraft flying as soon as possible.

2.1.18 Other officials of SHOD, namely Shri O.K. Bakshi, Chief Manager (Engg) and Shri Anurag Yadav, AME also deposed before the Committee.

2.1.19 Deposing before the Committee on 10.9.98, Shri O.K. Bakshi, who had been functioning as QCM, stated (Exhibit No.45) that when the rebuild of VT-EJW was undertaken, Director of Airworthiness, Delhi region had granted a general approval to Shri Srivastava to carry out de-riveting and riveting on the aircraft whenever required. He stated that Structural Sampling Inspection (SSI 53-21) required ECI of the fitting in question. To facilitate this inspection, the fitting had to be removed from the aircraft from Frame 34 and sent to the NDT Shop for ECI. The fitting was to have been reinstalled on the aircraft after passing ECI. In his opinion, that job was a simple case of removal and installation and could not be termed a major structural job. He stated that whenever a part was removed from an aircraft and it failed during inspection, it was normally replaced by a serviceable part drawn from the stores. However, at times, if the specific part was not available in the stores, the same was cannibalized from another aircraft. The decision/ instruction for cannibalization of any part was normally given by an officer at the managerial level. The Quality Control (QC) office was not aware of the

failure of the original fitting belonging to VT-EJW to pass ECI and subsequent cannibalization of the fitting from another aircraft for fitment on VT-EJW.

2.1.20 He stated that procedure sheets were prepared by the QC section only in respect of major jobs like engine change, landing gear change, engine power assurance checks and for overhaul of rotatable components in various workshops. For all other works which were carried out on an aircraft, the aircraft engineer was required to use off-job sheets on which he had to write step-wise details of the work carried out by him or any instructions to technicians in regard to the work being carried out. Individual jobs carried out on the aircraft by technicians or helpers were under the direct supervision of the Aircraft Engineer allotted on that particular system/job. However, all activities in the engineering hangar were under guidance/supervision of the Manager in-charge of maintenance.

2.1.21 He stated that VT-EJW had undergone 4800 hrs and 8 yearly inspection schedules during the build up. A scrutiny of these inspection schedules indicated that the Frame 34 area was inspected for general condition, integrity of parts etc. The above inspection of Frame 34 area was also covered in various lower schedules. Frame 34 area would have been visible even during the 300 hrs inspection schedule when the tail cone fairing had to be removed to lubricate the rudder trim chain.

2.1.22 When asked who took the decision to transfer the fitting from aircraft VT-EJU, he replied that he did not know the answer. He had not even been aware that the

original fitting of VT-EJW had been rejected. It could not have been at A & C level. An appropriate level may have been Shri V.C.M Kutty, Chief Manager Engineering or Shri S.B Gokhale, Off. General Manager Engineering.

2.1.23 While deposing before the Committee on 10.9.98, Shri Anurag Yadav, AME (Cat.A licence) stated (Exhibit No.46) that he had not known anything about the removal of the fitting. He had gone to Agati for a month on temporary posting. Regarding the 300 hrs inspection schedule at Agati on 21.7.98, he stated that the tail cone had been removed to grease and to lubricate the rudder trim chain. After removal of the tail cone, he had inspected that area and had found no abnormalities. Regarding checks to be done during daily inspection, he stated that he had checked the aircraft. He had checked full and free movement of the elevator control and had also checked for any radial play of the stabilizer bearing. On 30.7.98, he had carried out all the checks at Agati.

2.1.24 From the foregoing, it became clear to the Committee that the THS actuator attachment bearing support fitting had been removed for ECI during rebuild of VT-EJW. When the fitting failed the ECI, another fitting was removed from aircraft VT-EJU and subjected to ECI. After being declared serviceable, it was installed on VT-EJW. During installation of the fitting, 10 hi-lok fasteners were not installed. The fitting was not inspected properly after installation. On completion of the schedules, the aircraft was test flown for C of A renewal, which was renewed on 27.4.98.

2.1.25 Shri V. Kashyap, Executive Director, SHOD had deposed before the Committee on 6.10.98 and the statements made by him have been enumerated at para 1.18.6. From his statements it became quite evident that when faced with the problem of merging Vayudoot with Indian Airlines, senior management of Indian Airlines overcame the problem by creating SHOD as a separate department within Indian Airlines. This permitted the continuation of the poor work culture and wrong maintenance practices, which had prevailed in Vayudoot. Even the maintenance documents, when examined by the Committee, revealed that some of these formats still bore the Vayudoot name. Lack of career progression in SHOD had also lowered the morale of the work force, which had a detrimental effect on the already existing poor work culture. Shri Kashyap had stated that the first maintenance audit by the Directorate General of Civil Aviation was carried out after the subject accident. On the other hand Shri Ramesh Dy. Director General of Civil Aviation who deposed before the Committee on 29.10.98 clarified that at the instance of DGCA Headquarters an audit of SHOD was carried out by Director of Airworthiness, Delhi Region in March, 98 and the deficiencies were brought to the notice of the QCM of SHOD. Prior to that also DAW, Delhi had carried out an audit in Dec. 97 at Delhi. Agati base was checked in July. 97 by the Thiruvananthapuram office. Further DGCA had introduced an internal audit system by the operators to make them responsible for adhering to airworthiness standards. DGCA had been carrying out continuous surveillance checks on the maintenance activities of SHOD. Shri Ramesh stated that the QCM who was approved by DGCA was required to shoulder the entire responsibility of adhering to airworthiness standards as laid down by DGCA. Shri Kashyap during his deposition had

stated that the QCM was reporting to him directly and he (Shri Kashyap) had met all the officers on a number of occasions and none of them had brought to his notice any problem regarding maintenance of the aircraft. When Shri Bakshi, QCM was questioned about the effectiveness of this arrangement he said that on several occasions when he took up engineering problems with Shri Kashyap, he was directed to Shri Gokhale for a solution. This effectively negated the effectiveness of independent functioning of the QCM.

2.1.26 The Committee could not understand why Indian Airlines had not introduced changes in SHOD engineering. Senior level management perhaps failed to appreciate that safety started at the top. Neither the three monthly internal audits carried out by SHOD at the behest of DGCA were effective nor was the response of the management to the call for corrective action based on DGCA audits forthcoming. Shri Ramesh during his deposition had also brought out that a lot more required to be done by the Airworthiness Directorate to shoulder the responsibilities entrusted to them. There was an urgent need for additional manpower as at present the Airworthiness Directorate was also required to do additional work such as invigilation of examinations, conducting oral examinations, attending to VVIP movements and administration, which tied down a big proportion of manpower and reduced the time available to carry out meaningful surveillance. Shri Ramesh pointed out to the Committee that DGCA was functioning with less than sanctioned manpower. The Committee felt that with liberalisation of the civil aviation sector in the country and new operators entering the field with different types of aircraft, there was a need for additional man power over

and above sanctioned levels as DGCA needed to be strengthened in order to do justice to the surveillance role.

2.1.27 The Committee visited the maintenance facilities of SHOD at Delhi on 6.8.98 and observed that the work culture as well as maintenance practices were not upto required aeronautical standards. The hangar was littered with junk, the floor had not been swept and unserviceable Dornier 228 aircraft were parked outside in a haphazard manner. During a subsequent visit to the maintenance facilities at Delhi on 10.9.98, it was found that the place had been cleaned up and the Dornier aircraft, which were parked outside the hangar earlier, had been moved away and efforts had been made by SHOD to show their maintenance facilities in better light. The management of SHOD should have acted earlier on their own, rather than waiting for a mishap to occur. The top management either lacked the will to improve maintenance practices at SHOD or were unaware of what was going on there. Either way, they cannot evade responsibility for the accident caused by poor aircraft maintenance practices at SHOD of Indian Airlines.

2.2 Weather :

2.2.1 The weather report issued prior to take-off at 0530 UTC by Duty Met officer INS Garuda, indicated cloudy weather with visibility as 6 KMS with surface wind as 250/06 kts. Observations recorded at the time of accident (0535 UTC) did not indicate any deviation from the weather report issued at 0530 UTC. The crash took place about one minute after take off and the pilot had also not reported any abnormality about weather to the ATC. It can therefore

be concluded that the weather was not a factor in the accident.

2.3 Sabotage Aspects :

2.3.1 Office of Commissioner of Security, Civil Aviation, conducted an inquiry to ascertain whether there was any sabotage due to lapse of security measures. A firm conclusion was drawn by them that sabotage was not a cause of the accident.

2.4 Flight Recorders (CVR & DFR) :

2.4.1 CVR was replayed at the facilities of the DGCA office, Delhi. The relevant CVR tape transcript was prepared from the time the aircraft was cleared for take off till the aircraft crashed. It was of about 1 min. 07 seconds duration. Analysis of the CVR has revealed that no abnormality in the voices was detected till the "positive rate" call out, which was given 40 seconds after the aircraft was cleared for take off. Six seconds after the 'positive rate' call out, there was an exclamation of "WHO GAYA AA GAYA" followed by an aural warning which stopped after 2 seconds. It appeared that the crew experienced some abnormality as the exclamation "WHO GAYA AA GAYA" was not a conventional one and not uttered under normal circumstances. Thereafter, there was an abnormal sound in the cockpit probably of the head set microphone getting mechanically disturbed followed by an aural warning (1.025 KHz). At this stage, the aircraft had stalled. As per Dornier-228 Pilot's Operating Handbook, the continuous non-mutable acoustic stall warning triggers at 1.0 Khz. The stall warning remained for 9 seconds and during the stall

of the aircraft, the crew headset microphone must have contacted some part of cockpit giving rise to abnormal sound as stated above. There was an exclamation of "HARE RAM HARE RAM" by the Pilot-in-Command 10 seconds before the crash which was not a conventional one and not uttered under normal circumstances. It was evident that the aircraft was totally out of control and the Pilot-in-Command realizing that a catastrophe was inevitable, uttered "HARE RAM HARE RAM". Two seconds before the crash, a Ground Proximity Warning System (GPWS) aural warning "TOO LOW" was triggered. The full warning of "TOO LOW PULL UP" was not heard as the aircraft had crashed by then.

2.4.2 The DFR was decoded at the facilities of VSM Aerospace, Bangalore. After dismantling the DFR, the capsule was removed and installed on a serviceable DFR. The unit was run for nearly 4 hours. However, no useful data could be obtained. The accident capsule was then installed back on the unit. A sample check of data on various tracks revealed that in each track some data on altitude, heading, and 'g' trace was available with time, which was coupled with a large number of bad frames. It was observed that no relevant data was found recorded in it all through 24 hours. There was a cyclic pattern between the bad and partially good/good data over the 24 hours block. The precise cause behind the failure of the recorder, in its recording function, could not be established.

2.4.3 Due to non-availability of data from DFR, the correlation of CVR and DFR data could not be done. An opportunity to obtain a better picture of the flight profile of the aircraft from take-off till impact was thus lost.

2.5 Circumstances Leading to Uncontrollable Pitch Up of the Aircraft :

2.5.1 As stated in para 2.1.7, while reinstalling the THS actuator fitting after the ECI, the hi-lok fasteners (which attach the tang of fitting to the two side brackets of Frame 34) were not installed. The aircraft was operating with 10 hi-lok fasteners missing. Dornier confirmed that operating with 10 hi-lok fasteners missing from the forward tang of the fitting was possible as long as the trim actuator tension load did not exceed 300-500 daN. The aircraft had flown for over 300 hrs with 10 hi-lok fasteners missing and the fitting had experienced cyclic loads during operation of the THS actuator. During 300 hrs inspection, when the tail cone fairing was removed for lubrication of the rudder trim chain, no sign of damage to the area around the actuator attachment fitting was observed by maintenance personnel. During the subsequent 30 hrs of flight, Daily Inspections/Transit checks had not revealed any structural or control anomalies.

2.5.2 During the take off from Kochi for Thiruvananthapuram, the THS actuator attachment fitting was on the verge of tearing away from the web of Frame 34. During take off, the Pilot-in-Command would have rotated the aircraft by moving the control column backward thereby holding on to a pull force. As a normal reaction, the Pilot-in-Command would have trimmed out the pull force by blipping the trim switch to move the THS leading edge (LE) down. As the THS LE moved down, the down load on the THS and elevator increased, which resulted in a push force on the actuator attachment bracket on Frame 34. Following gear

retraction as the aircraft accelerated, a nose up trim change would have occurred making the pilot push the control column slightly forward moving the elevator trailing edge (TE) down. The pilot would then have held a push force on column and to release this, he would have trimmed forward to move the THS LE up, thereby converting the push force in area of Frame 34 to a pull force. At that stage of the flight, THS actuator forward attachment bearing support fitting on Frame 34 bulkhead suddenly tore loose partially. Partial detachment of the above fitting resulted in an increase in arm length of the actuator thereby moving the THS LE down. This caused the initial pitch up. Normal pilot reaction to the pitch up would have been to push the control column forward, which moved the elevator trailing edge down creating an upward force at the end of the THS/elevator surface. Due to the location of the hinge line and the centre of pressure of the THS, the upward force rotated the THS LE further down to a minimum of 14° thus reversing the effect of elevator control. The resulting pitch up to a near vertical attitude could not be controlled by the pilot using full elevator deflection available to him. This reconstruction of sequence of events was made by the Committee in consultations with experts from Dornier.

2.6 Pilot Factor :

2.6.1 Capt. S.R. Singh held a valid ALTP licence (No.1979). The licence had a Pilot-in-Command endorsement on Dornier-228 aircraft. He had a total experience of over 5400 hrs, out of which over 4800 hrs were on Dornier-228 aircraft. Capt. Manish Sharma held a valid ALTP licence (No.2104) which had a Co-pilot endorsement on DO-228

aircraft. He had a total experience of over 2300 hrs, out of which 930 hrs were on Dornier 228 aircraft. Both were found medically fit during their last medical examination.

2.6.2 Prior to departure of the flight to Thiruvananthapuram on 30.7.98, the Pilot-in-Command had carried out a preflight inspection schedule at Kochi. After the aircraft was cleared for take off by the ATC, the crew carried out the required check list and during the take off standard call outs were made and found recorded during replay of the CVR. After take off, the aircraft attained a height of approx. 400' and then suddenly pitched up to a near vertical attitude. The Pilot-in-Command was unable to control the aircraft with the elevator available to him.

2.6.3 Dornier with whose representatives the accident scenario had been discussed by the Committee during their visit to Mumbai, stated that a sudden mistrim of 14° from trimmed flight could not be counteracted by elevator control regardless of control forces, which would be required. Even with optimum effort a pitch up could not have been avoided. The pitch up led to a load factor estimated at 2 'g'. An uncontrolled increase of angle of climb was the consequence with rapid decrease of speed. Rapid decrease of air speed caused the aircraft to stall and fall on its right side. No piloting errors were made. Pilot error was not a contributory factor to the accident.

2.7 Organisational Aspects :

2.7.1 Shri V.C. Mathoo Kutty, while deposing before the Committee on 10.9.98 stated (Exhibit No.47), he was a regular employee of SHOD, IA and had been absorbed from the

erstwhile Vayudoot along with other employees. He held AME licence covering Dornier DO-228 aircraft in the Categories 'A', 'C' and 'I' apart from 'X' on DR and RR Compasses. He stated that he was mainly involved in administration and when demanded maintenance. On being asked who had given orders for removal of the fitting from Frame 34 of VT-EJW for NDT and subsequent installation, he stated that he was not aware and added that it was the sole responsibility of the person, Shri V.K. Srivastava, who had certified the work after removal, installation and inspection. He stated that for carrying out special jobs involving riveting and deriveting, Shri Srivastava had been approved and was directed to carry out the job by the QCM. He said Shri Srivastava was handling the despatch of items to other stations and used to get items removed from various aircraft without his (Shri Kutty's) knowledge or consent. He stated that the engineers themselves used to voluntarily make job allocations on various systems and whenever there was a serious problem, they used to come to him. He also stated that Shri Srivastava and Shri Bakshi were directly tasked by Shri S.B. Gokhale, offg. GM (Engg) regarding the jobs to be done and they were not in the habit of informing him. Shri Gokhale used to hold meetings in Shri Srivastava's room or in Shri Bakshi's room. He was never consulted or informed. However, whenever there was a serious problem, not under his (Shri Gokhale's) control, he (Shri Gokhale) used to engage him (Shri Mathoo Kutty).

2.7.2 Depositing before the Committee on 10.9.98 (Exhibit No.48) and 6.10.98 (Exhibit No.49), Shri S.B. Gokhale stated that in 1993 the Govt. had decided that Vayudoot be merged with Indian Airlines. Indian Airlines management had asked him to revamp the maintenance of DO-228 aircraft. He

had been working as Offg. General Manager (Engg) since 1994 and looking after the newly created Short Haul Operations Department (SHOD) of IA. Regarding the steps taken by him to monitor actual work in SHOD, he stated that his job was basically to put the right people at the right place. He used to visit the hangar twice a week. He believed maintenance people knew how to do their job properly. Therefore, he concentrated more on the areas of material support, PPC etc. They used to meet in Shri Kutty's office. In those meetings, Shri Kutty never mentioned the existence of any serious problems but he used to ask for additional facilities to be provided in the hangar. On being asked whether non-availability of the stabilizer trim actuator fitting on Frame 34, had ever been discussed at their meetings, he replied in the negative and stated that Shri V.K. Srivastava was looking after rotatable control and material management. Even though Wg. Cdr. Yadav was in-charge of PPC, he usually studied the capital requirements, preparation of budget and arrangement for calibration of equipment etc. Regarding the total break down of the maintenance system in SHOD he stated that when there was no basic discipline, there was hardly anything a G.M could do. Everybody got full attendance and overtime. Whatever responsibility was given to him, he tried to discharge the same to the best of his ability. May be he had not succeeded and may be he should have been more vigilant. All managers in-charge of various sections were expected to discharge their duties and the organisation could not expect everything to be done by one person.

2.7.3 From the deposition of various officials, it was evident that laid down maintenance procedures were not being followed in SHOD. The THS actuator attachment bearing

support fitting had been removed from VT-EJW and nobody knew who had ordered the removal of the fitting. Right from the level of foreman Shri Sher Singh to the level of Chief Managers (Engg) (S/Shri V.C.M.Kutty, V.K. Srivastava, and O.K. Bakshi) and at the higher level of Off. GM (Engg) (Shri S.B. Gokhale), nobody knew who had issued instructions to remove and reinstall the fitting. Though there was a transfer register maintained for entering items removed/installed from one aircraft to another, no entry pertaining to the removal/installation of the above fitting had been made in the transfer register.

2.7.4 The Committee was convinced that partial detachment of the THS actuator attachment fitting was caused due non-installation of 10 hi-lok fasteners. Verbal instructions were given to Shri Sher Singh for removal and installation of the fitting. Shri V.K. Srivastava, who finally certified the installation was not approved for the job at the time of removal and installation of the fitting. Therefore he did not supervise the removal and installation. He normally looked after PPC functions and was brought in to certify structural jobs under approval from DGCA as qualified and experienced engineers were not available in maintenance. When the original fitting failed ECI, a replacement fitting was not available in the stores. Therefore instead of ordering a new fitting, one was removed from another aircraft VT-EJU. The above fitting had 24 fastener holes. It was very unlikely that all the fastener holes on the fitting removed from VT-EJU would have matched within SRM limits to the existing holes on the structure of VT-EJW. During the course of the Committee's discussion with experts from Dornier, they opined that the fitting in question was not jig aligned. The transfer of

the fitting from one aircraft to another could result in mismatch of installation holes. Hence they did not recommend a transfer. 'D' rivets and hi-lok fasteners required for installation were not available in stores. Therefore the fasteners were picked up from left over spares from an earlier structural job undertaken by technicians from Dornier. Fasteners were chosen by comparing their dimensions. A transfer of an item from one aircraft to another was required to be entered in the Transfer of Components (TC) register. This procedure was also not adhered to. There was a considerable time gap between removal and re-installation of the fitting. This along with non-availability of the required attachment parts must have contributed to the non-installation of the hi-lok fasteners on the fitting.

2.7.5 Since Shri Srivastava was not involved at the time of removal and installation of the fitting, probably he was not fully aware of the shape and the attachment requirement of the fitting. By certifying a fitting which was already installed, he could not have ensured proper matching of holes within SRM limits and also installation of the correct fasteners as per the requirement.

2.7.6 From the evidence gathered from the statements of the staff and executives in SHOD, the Committee was convinced there were serious inter-personal differences existing within the Engineering management cadre of SHOD. Shri Kutty who was incharge of maintenance deposed before the Committee that work was being carried out on the aircraft without his knowledge or instructions. He had issued a Staff notice in the year 1997 advising engineers to refrain from undertaking such jobs without his

clearance. However, the Committee felt that the same situation persisted even at the time of the accident. Shri Bakshi, QCM who was required to detect and prevent any deviation from required maintenance procedures, claimed no knowledge of the work being carried out on the aircraft. Regarding the replacement of the THS fitting on VT-EJW he stated that QC came to know about the same only after the wreckage inspection at Kochi. Shri Gokhale, who was deputed to SHOD from Indian Airlines as Offg.GM did not succeed in making any improvement in the poor work culture which existed in SHOD. Shri Kutty who was supposed to supervise day-to-day maintenance activities had concentrated more on administration by his own admission. Shri Gokhale as incharge of SHOD engineering was not able to rectify the situation but made it worse by bypassing Shri Kutty and dealing with his subordinates and colleagues directly in matters connected with maintenance of aircraft.

2.7.7 From the foregoing it was apparent that :

2.7.8 Shri Sher Singh, Foreman appointed on contract undertook work without proper written instructions. He failed to complete the work started by him and advised Shri V.K. Srivastava wrongly about work completion. He also signed for completion of the work without physically checking it.

2.7.9 Shri V.K. Srivastava was negligent and undertook certification of work carried out without his supervision. He carried out the inspection in a perfunctory manner and failed to notice the absence of 10 hi-lok fasteners. He relied on the assurance of Shri Sher Singh that the work has been completed and certified the same.

2.7.10 Shri O.K. Bakshi did not exercise proper quality control on maintenance activities. He did not ensure proper documentation of the work undertaken. Mandatory internal audits did not detect and correct deviations from Airworthiness requirements.

2.7.11 Shri V.C.M. Kutty as the officer in-charge of maintenance did not assert his right to control maintenance activities within his jurisdiction. Instead he put his views down in writing and kept himself aloof from day-to-day maintenance activities.

2.7.12 Shri S.B. Gokhale as offg. General Manager in-charge of SHOD engineering failed to ensure observance of correct maintenance practices in SHOD. He also failed to create an effective team at SHOD engineering.

2.7.13 The Committee came to a unanimous and firm conclusion that poor maintenance practices which existed at SHOD significantly contributed to the errors committed by individuals Shri Sher Singh and Shri Srivastava and finally led to the accident.

2.7.14 The primary concern of senior management of an airline should be the safety of fare paying passengers. It is an accepted norm in airline management the world over that air safety starts at the top. An abiding interest in safety matters demonstrated by the senior management will send the right message down the line to the work force. In today's complex world of aviation some top managers use intractable labour problems as an excuse not to adequately address air safety issues. They leave them to be addressed

by personnel at the floor level. This was the case at SHOD. Shri V. Kashyap the Executive Director of SHOD failed to establish a suitable feed back mechanism to effectively monitor the activities of the engineering department and arrest falling standards of maintenance in time.

3. CONCLUSIONS :

3.1 Findings :

GENERAL

3.1.1 The aircraft had a current Certificate of Airworthiness.

3.1.2 The AUW and 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 held appropriate licences to undertake the flight.

3.1.5 Pilot error was not considered a factor in the accident.

3.1.6 The accident took place during day light 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 ATC procedures were followed and ATC was not considered a factor in the accident.

3.1.9 The aircraft had not suffered a bird strike after its take off from Kochi.

3.1.10 There was no evidence of in-flight fire.

3.1.11 Both engines were developing power at the time of impact.

3.1.12 The DFR did not record any useful data as its recording function was defective.

WHAT HAPPENED

3.1.13 On the morning of 30.7.98, the aircraft arrived at Kochi from Agati and no snag was reported by the Pilot-in-Command.

3.1.14 The aircraft was refuelled with 600 lbs of fuel to make a fuel state of 1600 lbs for the flight from Kochi to Thiruvananthapuram.

3.1.15 Pre-flight inspection schedule was carried out by the technician and Pilot-in-Command.

3.1.16 The flight crew carried out appropriate check lists and the aircraft took off for Thiruvananthapuram with six persons on board.

- 3.1.17 The take off was normal and the aircraft attained a height of approx. 400 ft.
- 3.1.18 The aircraft suddenly pitched up to a near vertical attitude.
- 3.1.19 No R/T transmissions were made by the aircraft to the ATC after it pitched up.
- 3.1.20 The aircraft stalled, fell to the right and crashed on the roof of the Component Repair Shop (CRS) building of the Naval Aircraft Yard NAY(K), Kochi.
- 3.1.21 After impact with the CRS building, the aircraft caught fire and was completely destroyed.
- 3.1.22 All six persons on board and three persons on the ground received fatal injuries.
- 3.1.23 Fire fighting and rescue operations had started without any delay and no deficiencies were observed in the performance of these services.

HOW IT HAPPENED

(Reconstructed by the Committee in consultation with experts from Dornier Luftfahrt GmbH)

- 3.1.24 During take off, the Pilot-in-Command rotated the aircraft by moving the control column backward thereby holding on to a pull force.

3.1.25 As a normal reaction, the Pilot-in-Command trimmed out the pull force by blipping the trim switch to move the THS leading edge (LE) down.

3.1.26 As the THS LE moved down, the down load on the THS and elevator increased, which resulted in a push force on the actuator attachment fitting on Frame 34.

3.1.27 Following gear retraction as the aircraft accelerated, to counter the nose up trim change the Pilot-in-Command pushed the control column slightly forward moving the elevator trailing edge (T.E) down.

3.1.28 To trim out this push force, the Pilot-in-Command trimmed forward to move the THS LE up, thereby converting the push force in area of Frame 34 to a pull force.

3.1.29 At that stage of flight, the THS actuator forward attachment bearing support fitting on Frame 34 bulkhead suddenly tore loose partially.

3.1.30 Partial detachment of the above fitting resulted in an increase in the arm length of the actuator moving the THS LE down.

3.1.31 Movement of the THS LE down resulted in the initial pitch up of the aircraft.

3.1.32 Pitch up of the aircraft at that stage prompted the Pilot-in-Command to push the control column forward, which moved the elevator TE down creating an upward force at the rear end of the THS/elevator surface.

3.1.33 Considering the location of the hinge line and the centre of pressure of the THS, the upward force rotated the THS LE further down to 14°.

3.1.34 Such a large movement of the THS LE downwards caused the violent pitch up to a near vertical attitude, which the pilot-in-command was unable to control with the elevator available to him.

3.1.35 Consequent rapid decrease of air speed caused the aircraft to stall and fall on its right side.

WHY IT HAPPENED

3.1.36 THS actuator forward attachment bearing support fitting was removed for ECI during which it was found that it had excessive pitting and was therefore rejected.

3.1.37 Since a new fitting was not available in stores, a fitting of the same part no. was removed from another aircraft VT-EJU and installed on VT-EJW after subjecting it to ECI.

3.1.38 During reinstallation of the fitting qty. 10 hi-lok fasteners attaching the longitudinal tang of the fitting to the Frame 34 structure were not installed.

3.1.39 The foreman who signed for the job completion did not physically check the completion of the job.

3.1.40 The Chief Manager (Engineering), duly approved for the job, certified the installation of the fitting after checking the installation from the rear face of the fitting only. He failed to inspect the fitting for the presence of 10 hi-lok fasteners which were required to be installed to attach the longitudinal tang of the fitting to the Frame 34 structure.

3.1.41 After about 300 hrs of flight following fitting replacement, cyclic loading on the fitting resulted in cracking of Frame 34 bulkhead web along the right side rivet line under the rear face of the fitting.

3.1.42 The pull force on the THS actuator during nose down trimming of the aircraft resulted in partial detachment of the fitting from the web of Frame 34 bulkhead.

3.1.43 Maintenance procedures, documentation and work practices that existed at SHOD of Indian Airlines were unsatisfactory and did not meet the requirements of an approved aircraft maintenance organisation.

3.1.44 These poor maintenance practices at SHOD significantly contributed to the errors committed by the persons who carried out the installation of the THS fitting, which finally led to the accident.

3.1.45 Quality Control Manager. Chief Manager In-charge of maintenance, Offg. General Manager (Engg) and Executive Director of SHOD did not take effective steps to arrest the falling standards of maintenance in time.

3.1.46 Non-availability of sufficient spare parts in the stores resulted in frequent cannibalization from other aircraft.

3.1.47 Subsequent to the Government decision to merge Vayudoot with Indian Airlines, senior management Indian Airlines, when faced with problems of effecting a complete merger, created SHOD within Indian Airlines. This permitted the continuation of the poor work culture and wrong maintenance practices which had earlier prevailed in Vayudoot.

3.1.48 Lack of career progression in SHOD had lowered the morale of the work force at SHOD, which had a detrimental effect on the already poor work culture.

3.1.49 Oversight of SHOD maintenance activities by the regulatory authority could not produce the desired corrective effect as the internal audits carried out by SHOD at the behest of DGCA were ineffective. The management's response to the call for corrective action based on DGCA audits was not forthcoming in some cases and not prompt in others.

3.2 Cause of the Accident :

After take off the aircraft pitched up uncontrollably, stalled, fell to its right and crashed. The uncontrollable pitch up was caused by sudden uncommanded downward movement of the Trimmable Horizontal Stabilizer leading edge. This was due to partial detachment of its actuator forward bearing support fitting due non-installation of required hi-lok fasteners.

Poor aircraft maintenance practices at Short Haul Operations Department contributed to the accident.

4. Recommendations :

4.1 Short Haul Operations Department (SHOD) of Indian Airlines should be brought under the Quality Control system of Indian Airlines and all the documentation and maintenance practices should be standardised.

4.2 Since the lack of career progression had a demoralising effect on the work force, a time bound programme should be initiated to disband the SHOD and fully integrate the same with Indian Airlines.

4.3 Indian Airlines should take stringent measures to make internal safety audits of SHOD more effective and discrepancies noticed should be acted upon immediately.

4.4 Indian Airlines should improve the spares support to Dornier aircraft operations.

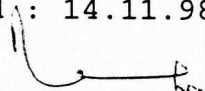
4.5 Indian Airlines should monitor the flight recorders and ensure that these remained fully serviceable.

4.6 Drawing upon the experience of the unhappy merger of Vayudoot with Indian Airlines, in future, while restructuring organisations dealing with aircraft operations and maintenance, the highest priority should be given to Air Safety.

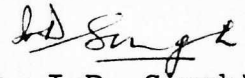
4.7 In view of new airline operators entering the Civil Aviation sector in the post liberalization era, DGCA needs to be strengthened for effective airworthiness surveillance.

Mumbai-29

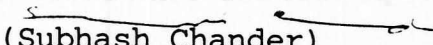
Dated: 14.11.98


(Babu Peter)

GM(Engg), Air India, Mumbai
Member


(Capt. I.D. Singh)

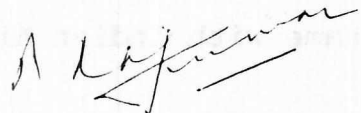
Pilot, Air India, Mumbai
Member


(Subhash Chander)

Director Air Safety

Civil Aviation Department, Mumbai

Member Secretary


(Air Marshal P. Rajkumar)

Programme Director (Flight Test)

Aeronautical Development Agency, Bangalore

Chairman

ACKNOWLEDGEMENTS

1. The Govt. of India appointed me as the Chairman of an Inquiry Committee constituted to investigate the accident involving Indian Airlines Dornier 228 aircraft VT-EJW on 30.7.98 at Kochi vide Notification No.AV.15013/3/98-SSV dated 1.8.98. Shri Babu Peter, General Manager (Engineering), Air India, Capt. I.D. Singh, Air India were appointed Members with Shri Subhash Chander, Director Air Safety, Civil Aviation Department, Mumbai as Member Secretary. The investigative task was complex and challenging. The help, assistance and co-operation of a number of persons made it possible for the Inquiry to be completed in a short time. I would like to place on record my gratitude to all of them.

2. I must start by conveying my thanks to Shri H.S. Khola, Director General of Civil Aviation for providing all assistance and cooperation to the Committee specially in the initial stages of commencement of the Inquiry.

3. Before proceeding any further, I must place on record my appreciation and gratitude to the two Committee Members and the Member Secretary. Shri Babu Peter's engineering acumen is well known in civil aviation circles. His vast knowledge of aircraft maintenance procedures, mature judgement and wisdom were of immense value. He was the technical pillar of the Committee. Capt. I.D Singh's considerable flying experience on the Dornier 228 made him a veritable gold mine of information on flying and aircraft systems. Without his contribution much of the Committee's time would have been lost in trying to gain an insight into these aspects. Shri Subhash Chander performed his onerous task as Member Secretary with great enthusiasm and indefatigable energy. To him goes the credit for superb co-ordination and

staff work. All three members maintained an unfailingly cheerful disposition during the Committee's sittings and made working with them a real pleasure.

4. I must thank the Managing Director, Air India for his assistance in providing a comfortable room at the Air India Complex, Old Airport, Mumbai for use of the Committee. Office equipment and telephones were also provided by Air India.

5. I am indebted to Vice Admiral Sushil Kumar PVSM, UYSM, AVSM, NM Flag Officer Commanding-in-Chief, Southern Naval Command for giving me a Carte blanche to make use of whatever Naval facilities the Committee would require during the investigation. My special thanks are due to Commander V.N Sharma of INS Garuda who acted as my liaison officer during my three visits to Kochi.

6. I express my gratitude to Dr. T.S. Prahlad, Director, National Aerospace Laboratories (NAL) and Dr. B.K. Parida, Dy. Director, NAL and his team for the readiness with which they agreed to participate in the investigation. They provided the Committee with the scientific explanation for the partial detachment of the THS actuator forward attachment bearing support fitting on Frame 34 bulkhead.

7. All credit must go to Shri V.K. Chandna, Director Air Safety at DGCA Headquarters for unearthing evidence of the missing hi-lok fasteners. His seasoned eye fell on some unusual damage in the wreckage and his inquisitive nature made him probe further and come up with the answer to the strange behaviour of the aircraft after take off. My gratitude goes to him.

8. Shri Chinnadurai, Deputy Director R&D at DGCA Headquarters was responsible for deciphering the CVR. He was also involved in attempts to retrieve DFR data at Messrs VSM Aerospace, Bangalore. I acknowledge his contribution with gratitude.

9. Shri Satendra Singh, Deputy DGCA at Headquarters guided the Committee members in the initial stages of preparing the CVR transcript. His great experience in this specialised field was invaluable. My thanks go to him.

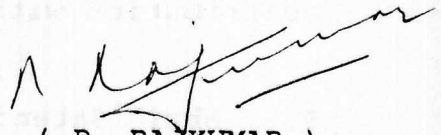
10. Shri K. Gohain, Dy. DGCA at Headquarters guided the Committee during the first two days of the investigation at Kochi. His association was of great value. My thanks go to him.

11. I am deeply indebted to Chairman, HAL, the Executive Director of HAL, Kanpur and the General Manager Engines Division at Bangalore for their prompt assistance in strip examining the propellers, THS actuator and the engines.

12. The Officers and staff of the Director of Air Safety, Mumbai played a special part in organising the Committee's work. S/Shri M. Rajendiran and J.S. Rawat were ever-willing to take on additional work on the Committee's behalf. Their cheerful nature was most praiseworthy. My thanks go to them.

13. Shri K.V. Suryanarayana, PA to Director Air Safety, Mumbai did all the typing work and produced a number of drafts in quick time. The long hours of extra effort that he had to put in did not upset him at all. My special thanks go to him.

14. Shri Suresh A. Jaitapkar and Shri Anil S. Prabhu of Director Air Safety's staff also worked long hours to meet the Committee's requirements of transportation and refreshments. I thank them both for their good work.



(P. RAJKUMAR)

AIR MARSHAL

CHAIRMAN

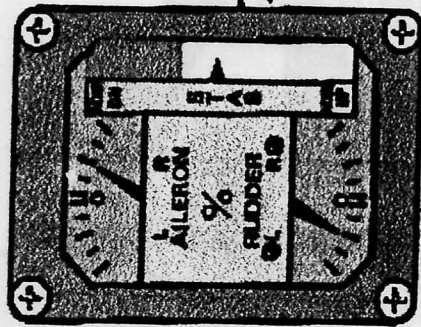
ELEVATOR CONTROLS

- 1 - Dual Pitch Trim Switches (27-40-00)
- 2 - Electric Trim Actuator (27-40-00)
- 3 - Horizontal Stabilizer (27-40-00)
- 4 - Elevator
- 5 - Spring (- 200 version only)
- 6 - Pitch servo

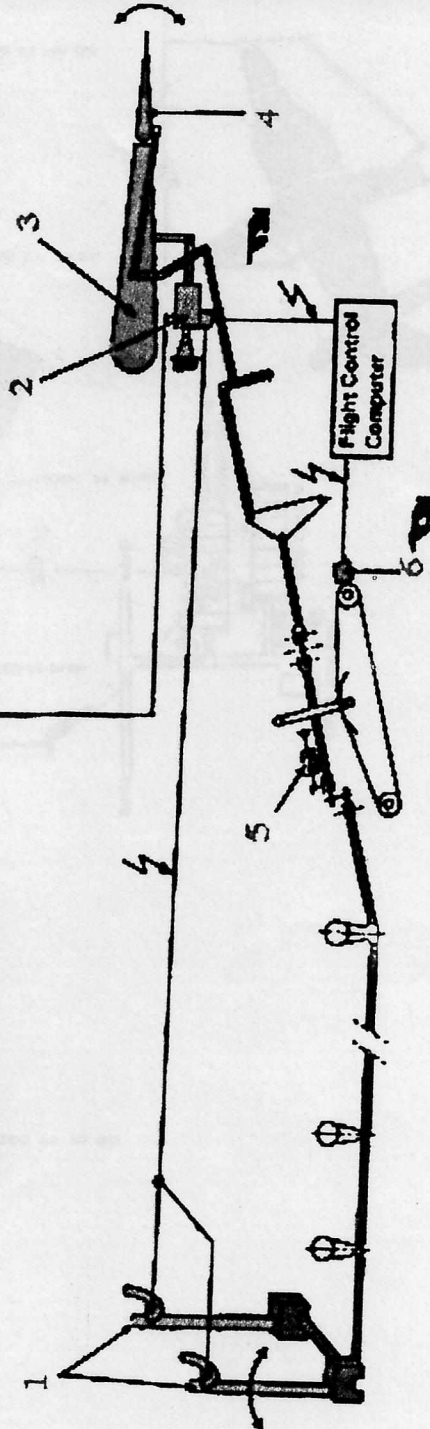
⚡ Electrical connections

NOTE

Flight Control Computer
Pitch Servo } only if Autopilot fitted.



Trim Position Indicator



SKETCH SHOWING CRASH SITE
(NOT TO SCALE)

