Ref. No. AV.15013/01/2012-DG Date: 22nd April'2013

REPORT
OF
COMMITTEE OF INQUIRY

ACCIDENT TO BSF (AIR WING) DHRUV HELICOPTER VT-BSN
AT RAIPUR AIRPORTON 15th JAN 2012

BY

CHAIRMAN

Air Cmde G S Cheema (Retd) AVSM, VSM & Bar

MEMBER

Capt. Sheelpriya Verma
Helicopter Pilot

MEMBER SECRETARY

Sh. Maneesh Kumar
DDAS, O/o DGCA

Foreword

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts and laboratory reports. The investigation has been carried out in accordance with Annex 13 to the convention on International Civil Aviation and under the Rule 74 of Aircraft Rules 1937 of India. The investigation is conducted not to apportion blame or to assess individual or collective responsibility.

The sole objective of investigation is to draw lessons from this accident which may help to prevent such future accidents or incidents.

CONTENTS

FINAL INVESTIGATION REPORT ON ACCIDENT TO BSF DHRUV HELICOPTER VT-BSN AT RAIPUR AIRPORT 15TH JANUARY 2012			
1	Aircraft	Type	Dhruv Helicopter (ALH Wheel Version)
		Nationality	Indian
		Registration	VT-BSN
2	Owner		Border Security Force (Air Wing), Ministry of Home Affairs, NirmanBhavan, New Delhi
3	Operator		Border Security Force (Air Wing), Ministry of Home Affairs, NirmanBhavan, New Delhi
4	Pilot – in –Command		Under Rule 160
	Extent of injuries		Minor
5	Co-Pilot		CPL (H)
	Extent of Injuries		Serious
6	No. of Passengers on board		Three
	Extent of Injuries		Minor injuries incurred by 02 maintenance crew
7	Last point of Departure		RaipurAirport
8	Intended landing place		RaipurAirport
9	Place of Accident		Runway, RaipurAirport
10	Date & Time of Accident		15th January 2012; 0657 UTC

SYNOPSIS

1. On 15th January 2012, Border Security Force (BSF), Ministry of Home Affairs, Govt of India, Dhruv Advanced Light Helicopter (ALH) VT-BSN, met with an accident at Raipur Aerodrome at 06:57 UTC. The helicopter was undergoing a Vibrex Check for Dynamic Balancing after Tail Rotor (TR) blade paint touch up work. On completion of first part of the check in 'Out of Ground Effect' (OGE) hover, the PIC had initiated a vertical descent wherein descent rate became high. He raised the Collective pitch lever to arrest the descent which further aggravated the situation. The descent continued and the helicopter impacted ground uncontrolled. It bounced upwards after the initial impact and settled back on runway after rotation through approximately 360 degrees. The helicopter was extensively damaged and all five occupants, including two Flight Crew received injuries to varied extent. There was no fire. The accident occurred during daylight. The helicopter was being operated by M/s Pawan Hans Helicopters Ltd (PHHL), a sub-contractor of M/s Hindustan Aeronautic Limited (HAL) for Operation & Maintenance (O&M) of the BSF Dhruv fleet.

2. The Ministry of Civil Aviation, Government of India ordered the investigation by appointing Committee of Inquiry under Rule 74 of the Aircraft Rules 1937 vide Order No. AV.15013/01/2012-DG dated 01 March 2012 to determine the causes and contributory factors of the accident. The Committee issued a public notification in the leading newspapers of Chhattisgarh seeking inputs on facts and circumstances related to the accident.

3. Investigations revealed that the accident was caused due to loss of Situational Awareness wherein the helicopter entered Vortex Ring during descent in OGE hover. Excessive lowering of Collective Pitch had resulted in high rate of descent which led to onset of the condition. The situation was not comprehended and the pilot raised Collective lever to arrest the sink, without breaking the Vortex Ring state. This led to intensification of vortices and thus increasing the rate of descent. The helicopter continued to descend and impacted ground uncontrolled. Inadequate knowledge of onboard systems and fixation to speculated failures were contributory factors. Inadequacies in training, consolidation and Cockpit Resource Management were other contributory factors. The Flight Crew had not undergone Simulator Training.

4. In view of the findings, the Committee recommends that HAL should review and customise training syllabus for Dhruv helicopter taking into consideration previous experience and capability of under conversion pilots. This may be over and above Regulator's training requirement.

1. FACTUAL INFORMATION

1.1 History of the Flight

1.1.1 BSF owned Dhruv helicopter VT-BSN was stationed in Raipur since 30th December 2010 to meet operational requirement of Central Reserve Police Force (CRPF) in Chhattisgarh sector. PHHL was handling Operations and Maintenance (O&M) activities as sub-contractor of HAL. Paint touch up work was undertaken on TR blades to address flaking on the paint. The work was completed by HAL team on 5th January 2012 and TR assembly was installed on the helicopter on 14th January 2012 after static balancing. The helicopter was prepared for Dynamic Balancing of TR blades in accordance with Dhruv Maintenance Manual and was released by the AME for Vibrex Check on 15th January. The exercise entailed checking of TR vibrations on ground, at OGE hover and in straight and level flight in speed regimes of 80 and 120 KIAS respectively.

1.1.2 The Flight Crew filed a Visual Flight Rules (VFR) flight plan at 05:00 UTC with Raipur ATC for a flight check at 4000 ft.

1.1.3 The helicopter was started for a ground run wherein TR vibration values were noted and weight corrections applied after switching off the helicopter. The values were found satisfactory in the next ground run, and the helicopter was cleared for an OGE hover and subsequent flight checks by the AME.

1.1.4 The PIC initiated a hover at 6:53:23 UTC after lining up on Runway 24 and commenced a climb for OGE hover. At 6:53:57UTC, while the helicopter was ascending through 105 ft Radio Height (RH), the pilot engaged Hover Height (H.HT) hold which got disengaged after six seconds at 140.6 ft Radio height (RH), It was indicated by illumination of AFCS annunciator on Centralised Warning Panel (CWP) followed by activation of Master Warning (MW) caption. The helicopter continued to gain height and at 6:54:26 UTC (215 ft RH), the Co-pilot told the pilot to stop the same. At 6:56:29 UTC (495.9 ft RH), the Co-pilot called out that they were almost at 500 ft. The PIC controlled the ascent for a brief duration and executed a spot turn in OGE condition. The helicopter continued to ascend during and after the turn.

1.1.5 On completion of hover check, the AME informed the PIC and called out parameters required for the next check in forward flight. At 6:57:11UTC, the pilot commenced a vertical descent to go down to a lower height, for initiating a take off for forward flight. After an initial reduction, the PIC continued to lower the Collective Pitch (Dtheta). It was lowered by about 7% resulting in with Torque (Q) reduction from 83.9% & 80.9% to 57.5% & 53.8% for No. 1 & No. 2 engines, respectively. Rate of descent (ROD) increased significantly and led to onset of Vortex Ring wherein ROD increased to about 1200 ft/min. Application of power by upward movement of collective lever at this juncture aggravated the condition and ROD increased further exceeding 2000 ft/min. Collective lever was lowered thereafter, for about four seconds but that did not help in reducing or controlling the sink. At 6:57:38 UTC (273 ft RH), the PIC raised the collective lever to the possible extent wherein Torque values went up to 98.5% & 107%, with Dtheta going to 100.6%. Audio Warning System (AWS) and Voice Warning System (VWS) were activated for high Torque. The helicopter continued to descend and impacted the ground at 06:57:45 UTC. It bounced off the surface after initial impact and then settled back on runway surface after rotation through near 360 degrees, remaining upright throughout. Crash services were promptly activated by Raipur ATC and occupants evacuated out of the crashed helicopter.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	1	Nil	Nil
Minor/ None	1	3*	

* Maintenance Crew

1.3 Damage to Helicopter

Dhruv helicopter VT-BSN was substantially damaged as a result of the accident**.**

1.4 Other Damage

Runway surface was damaged due to crash impact and fuel spillage.

1.5 Personnel Information

1.5.1 Pilot-in-Command A retired Army Aviation helicopter pilot whose initial helicopter training was conducted at Helicopter Training School, Air Force Station Hakimpet, Hyderabad. The pilot underwent endorsement training on Dhruv helicopter from 15.09.2009 to 15.10.2009 at HAL Bangalore while on deputation with PHHL. The training did not include Simulator Flying. He joined PHHL on contractual basis with effect from 01.08.2011 after completing his military service. Old flying Log Books/ transcript were not available for scrutiny.

1.5.1.1 License Details:

License type	:	Was granted exemption under Rule 160 of the Aircraft Rule 1937 from holding CHPL and FRTOL
Date of Birth	:	5.05. 1957
Medical valid up to	:	18.06. 2012 (Last medical carried out on 19.12.2011)
FRTO valid till	:	N/A
Date of last IR check	:	Not rated
PC Check	:	24.08.2011

Recurrent Simulator training once in two years required to be done till 14.09.2011 was not carried out.

1.5.1.2 Helicopter flown : Chetak, Cheetah

1.5.1.3 Flying Details

Total Flying Experience : 1706:25 Hrs (PIC: 666:40 Hrs)

Total Simulated : 8:00 Hrs;

Actual Hrs : 88:00*

(* Not verified due to non-availability of earlier records)

Experience on type : PIC: 09:15Hrs; Co-pilot:188:20 Hrs; Total: 197:35 Hrs

Flying during (excluding the accident flight)
Last 365 days : 95 Hrs

Last 6 months : 38.25 Hrs Last 90 days : 9:15 Hrs

Last 30 days : 9:15 Hrs Last 7 days : Nil

Last 24 hours : Nil

1.5.2 Co-pilot A retired Army Aviation helicopter pilot whose initial helicopter training was done at Helicopter Training School, Air Force Station Hakimpet, Hyderabad. There was a significant break between his military flying that ended in June 1993 and civil flying that commenced in July 2009. He flew Bell 407 helicopter until February 2010. He joined PHHL on contractual basis on 03.3.2010 and underwent endorsement training on ALH helicopter from 20.04.2010 to 29.04.2010. The training did not include simulator flying.

1.5.2.1 License Details

License type	:	CHPL
CHPL Valid up to	:	31.08.2014
Date of Initial Issue	:	01.09.2009
Date of Endorsement of Dhruv Helicopter	:	18.05.2010
Date of Birth	:	07.07.1952
Medical valid up to	:	27.05.2012 (Last medical carried out on 28.11.2011)
Date of last IR Check	:	Not rated
PC Check	:	24.12.2011

Recurrent Simulator training once in two years required to be carried out till 17.05.2012 not carried out.

1.5.2.2 Helicopter Flown : Bell 407, Chetak, Cheetah

1.5.2.3 Flying Details

Total Flying Experience	:	1814:30 Hrs (707:05 Hrs as PIC)
Experience on type	:	Total: 242:15 Hrs; (P1 under supervision 09:20 Hrs)
Flying during Last 365 days	:	158:30 Hrs
Flying during Last 6 months	:	71:20 Hrs
Flying during Last 90 Days	:	24:55 Hrs
Flying during Last 30 days	:	00:45 Hrs
Flying during last 7 days	:	Nil

1.5.3 Aircraft Maintenance Engineer

1.5.3.1 The AME is holding Cat 'A & C' license endorsed on Dhruv helicopter and TM 333 2B2 engines. Validity of his licence is till 10.06.2013. He has been issued organisation approval by the Quality Manager PHHL (NR) under the authority of CAR 145 Para 145.A.35.

1.5.3.2 The scope of approval is to carryout, certify and issue CRS of the below mentioned inspections on Dhruv (ALH) Helicopter fitted with TUBOMECA TM 333 2B2 Engine.

- Up to 250 hrs inspection (Airframe & Engine)
- 300 hrs inspection (Engine)
- 12 monthly inspection

1.5.4 HAL Certifying Staff

1.5.4.1 HAL staff tasked for certifying the repair work was a 40 years old engineer holding M Tech, AME (A&C) qualification. He had undergone practical training on "Wet layup Capping repair on Flex beam (ALH-TRB) and resins touch up in discoloured area of Tail Rotor blade and Paint Touch up on Tail Rotor blade" held at HAL from 11.01.2012 to 12.01.2012.

1.5.4.2 The certifying staff was issued authorisation by the Quality Manager, HAL Helicopter division on 12.01.2012 for under mentioned tasks:

- TR repair procedure
- Documentation
- Curing
- Static balancing procedure

1.6 Helicopter Information

1.6.1 General Description

1.6.1.1 Dhruv Advanced Light Helicopter (ALH) is a twin engine multi role helicopter with a tricycle landing gear. Designed and manufactured by HAL, it is, capable of operating in all weather and geographical conditions. The main rotor consists of four composite hinge less blades, main rotor hub and upper control system which is positioned inside gearbox housing and rotor drive shaft. The combination of main gearbox, upper controls & rotor head as a single unit is called Integrated Dynamic System (IDS). Assembly of carbon composite hub plates with titanium alloy centre piece constitutes the rotor hub. Radial elastomeric bearing is housed inside centre piece and conical elastomeric bearing is attached to blade spoon and fixed to hub plates by a main bolt. The tracking link attached between the blade fork and radial bearing is used for final adjustments of blade angles.

1.6.2 Automatic Flight Control System (AFCS)

1.6.2.1 The Dhruv AFCS is a fully digital four axes system for stabilization as well as flight path control. It consists of two identical computers of dual architecture and one Pilot Control Unit (PCU). The heart of the system is the AFCS computer and it encompasses/ interfaces with other important systems of the Dhruv such as Flight control system, Hydraulic system, Radio Navigation system, Centralised Warning Panel (CWP), Engine control system Full Authority Digital Electronic Control (FADEC). It works on closed loop feedback principle. Whenever the helicopter is deviated from its original position, the sensors pick up the deviation signal. The AFCS computers process the signal and gives corrected signal to servo actuators in turn operate the necessary control to restore the changes. The quantum of correction applied is sent to computer as feedback.

1.6.2.2 Sensors associated with AFCS are**:**

- 02 Attitude and Heading Reference Systems (AHRSs) including 02 magnetometers, one panel mounted Gyro Horizon.
- 02 Air Data Units (ADUs) for Baro altitude, indicated Air speed and True Air speed

- One Radio altimeter.
- Heading selector equipped 02 RMIs for providing magnetic heading.
- A Set of selection reconfiguration switches.
- FADEC

1.6.2.3 Actuators There are seven Control Stability Augmentation System (CSAS) or series actuators with associated pickoffs and four trim or parallel actuators. CSAS actuators include two each for pitch, roll, collective and one for yaw axis.

1.6.2.4 Pilot Control Unit (PCU) The PCU ensures man-machine interface, installed at centre console within the reach of both pilots. It gathers AFCS engagement/disengagement control stabilization, upper modes and trim configuration. It also ensures basic failure annunciation. Following control and indications comprise upper modes:-

- ALT- Altitude.
- A/S -Air speed
- HDG- Heading
- NAV-Navigation
- H. HT (radio altimeter)-Hover

1.6.2.5 Annunciator Panel (ANP) indicates AFCS related failure and engagement of upper modes.

1.6.2.6 Centralized Warning Panel (CWP) indicates AFCS failure by means of single amber light along with master warning light flashing. It may be noted that failure indications by this device on AFCS require immediate pilot action.

1.6.2.7 Upper Mode Functions H.HT mode holds through the collective axis the radio height as indicated by the radio altimeter existing at the mode engagement at hover and low ground speeds. It can be engaged only between 25 feet to 380 feet. Pilot action on the collective stick release disengages the mode which also gets disengaged one second after display of excessive deviation which happens when the difference between the actual and reference exceeds the pre-defined threshold (30 ft in case of Dhruv). This is indicated on ANP(Annuciator Panel) as “C>”.

- **Mode engagement** By depressing “H.HT” push button on the PCU.

- **Display**

  - Green “ON” engraving illuminates on the PCU “H.HT” push buttons.
  - Green “H.HT” annunciation illuminates on the annunciator panels.

- **Prerequisites**

  - Collective axis valid - at least one AFCS lane engaged.
  - Auto trim enabled on collective axis.
  - Filtered radio height information valid.
  - Radio height > 25 feet.

- **Minor Degradation.**

  - H.HT amber light illuminates on the annunciator panel.
  - Only one radio height is valid.
  - Compensated accelerations invalid
  - Vertical acceleration invalid

1.6.2.8 On perusal of Flight Manual of Dhruv civil (wheel) version it has emerged that system details on H.HT have not been comprehensively described wherein automatic disengagement of the system on excessive deviation is cursorily covered as opposed to well enunciated procedures for handling system malfunction.

1.6.3 Brief Helicopter Details

Manufacturer	M/s Hindustan Aeronautics Limited
Type	Dhruv Mk-1 (Wheel Version)
Constructors S.NO.	DCWF-05
Year of Manufacturer	2010
Certificate of Airworthiness	6035 (Issued on 31.03.10 Valid up to 30.03.2015)
Category	Normal

Sub Division	Passenger	
Certificate of Registration	3926/2 ; Category –A issued on 14/06/2011	
Owner	Border Security force (Air Wing)	
Min Crew Required	Two	
Maximum AUW Authorised	5500 Kgs	
Airworthiness Review Certificate	027/ BSN/6055 (Last issued on 15.3.2011. Valid up to 30.3.2012 at 117:56 hrs)	
Last Major Inspection	250 hrs inspection schedule carried out on 16.11.2011 at 250:56 airframe (A/f) hrs.	
Last Inspection	Pre-flt inspection	
A/f Hrs since new	334:51 hrs	
Airframe Hrs since last ARC	216:55 hrs	
Aeroengines		
Manufacturer	Turbomeca	Turbomeca
Type	TM333 2B2	TM333 2B2
Serial No.	1260	1266
Hrs Done Since New	329:24	324:36
Last Inspection Carried Out	25 Hrs Monthly inspection carried out at 23 :51 airframe hours on 23.12.2011	25 hrs/ Monthly inspection carried out at 323 :51 airframe hours on 23.12.2011
Last Major Inspection Carried out	300 hrs engine inspection carried out at 288:10 engine hours & 298:51A/f hours on 10.12.2011	300 hrs engine inspection carried out on at 292:40 engine hours & 298 :51 A/f hours on 10.12.2011

1.6.4 Scrutiny of Maintenance Record

1.6.4.1 Service bulletins up to SB201553361 (Rev A) and Alert service bulletins up to ASB201620A386 (Rev. A Dated 06.12.11) issued by the manufacturer were complied with on this helicopter. Manufacturer issued SB No. 201 761 382(Rev A) dated 28.10.2011 to improve the reliability of collective pitch anticipator (CPA) potentiometer by providing vendor improvements on clamping of cables at exit of CPA potentiometer and provision of threaded type connector. The accomplishment of this service bulletin is mandatory during 500 hrs or 1000 hrs servicing of helicopters whichever is earlier, after June 2012. This SB was not accomplished on this helicopter as the 500 hrs inspection had not fallen due.

1.6.4.2 Scrutiny of the snags for last six months reveals that vibration snag was reported on number of occasions. Tail rotor vibration snag was reported on 9th July, 27th August, 17th September & 15th September 2011 and main rotor vibrations were reported on 15th & 28th November 2011. Required rectification/ weight adjustments after Vibrex checks were carried out.

1.6.4.3 Paint peel off/ erosion was observed on tail rotor blades during 25 hrs monthly inspection schedule on 23.12.2011. Blade wise extent of paint peel off/ corrosion was as under:

- Red Blade: At parabolic region paint peel off/ erosion of 55 mm observed.
- Green Blade: At parabolic region paint peel off/ erosion of 35 mm observed
- Blue Blade: At parabolic region paint peel off/ erosion of 35 mm observed.

1.6.4.4 Helicopter was declared serviceable in consultation with HAL and flown till 28.12.2011. Snag of tail rotor(Paint Peel off) was entered on 28.12.2011.

1.6.4.5 Reason given for paint peel off was sand/ dust particles in the operating environment. It was mentioned that TR imbalance was reported twice within a span of one month after recent major inspection of 250 hrs. On getting referred, HAL recommended re-painting of TR blades which was carried out under supervision of HAL engineer, holding authorization for the scope of work issued by QM HAL. Static balancing was certified by the PHHL AME. TR assembly was installed after painting and rigging checks were carried out on TR flight controls. Helicopter was offered for dynamic balancing of TR on 15th January 2012, comprising ground and flight regimes. Vibration value was corrected in radial channel, by weight adjustments on the basis of Chadwick Balance – Analyser. The same was found satisfactory in the subsequent ground run.

1.6.4.6 Power Assurance Check of engines was being carried out at regular interval as recommended by the manufacturer i.e., every 25 hrs inspection. The number of cycles completed by the engine and percentage of creep had also been downloaded from FADEC during these inspections. The last engine power check was carried out on 23.12.2011. Torque and T4 margin were recorded as follows:

- On #1 Engine: 8% and 05°C
- On #2 Engine: 4.5% and 30°C

1.6.4.7 Downloading of EECU Data The data was downloaded from the EECU Serial Nos. 30357 and 30356 installed on helicopter VT-BSN. The downloading was carried out at HAL facility. No discrepancy was observed. The time and event counter data is as follows:

Event	**Values**	
	Sl No. 30357	**Sl No. 30356**
Conformation resistance (ohm)	267.00	273.81
Maximum reached NTL speed (%)	0.0	113.6
Engine serial number	1266	1260
Creep damage counter (%)	1.1	1.0
Gas generator cycles (cycles)	422.9	436.5
Power turbine cycles (cycles)	387.2	399.8
MCR operating time (mm:ss)	00:29	00:26
ICR operating time (hh:mm:ss)	0:15:14	0:13:54
Total time of flight in progress (hh:mm:ss)	0:14:06	0:12:27
Total cumulated time of flight (hh:mm:ss)	323:39:30	328:28:57
Total number of MCR selection (times)	388	401
Total number of SCR selection (times)	242	266
Total number of SCR using (times)	0	0

Total number of MCR using (times)	7	6
Total number of engine starting (times)	336	344

1.6.5 Load & Trim Sheet

Calculated All Up Weight (AUW) of the helicopter at the time of start up for the first ground run was 5145 Kgs with 1050 Kgs of fuel, two pilots and three other crew members. AUW after grounds run, taxy and line up is calculated to be approximately 5100 Kgs. CG of the helicopter was within the prescribed limits as worked out in the trim sheet.

1.7 Meteorological Information

1.7.1 Meteorological briefing was provided to the pilot by Aviation Meteorological Services (AMS) Raipur at 0430 UTC on 15th January 2012. The Met briefing consisted of terminal area forecast (TAF), Area Forecast for VARP and 150NM around/Local forecast for VARP and 50 NM around (valid from 2200 UTC of 15.01.2012 to 0600 UTC of 15.01.2012) and METAR.

1.7.2 Met Report: Raipur Aerodrome (VARP)

Time (UTC)	**05:30**	**06:00**	**06:30**	**0730**
Wind	CALM	CALM	CALM	CALM
Vis	6000 M	6000 M	6000 M	6000 M
Weather	-	-	-	-
Clouds	NSC	NSC	NSC	NSC
Temp	21˚C	23˚C	24˚C	25 ˚C
QNH	1017 hPa	1016 hPa	1016 hPa	1015 hPA

1.8 Aids to Navigation

It was local VFR flight. The airport is equipped with ILS, DVOR & DME as navigation aids. These facilities were working satisfactorily on 15.01.2012 from 1955 UTC to 1100 UTC.

1.9 Communication

The helicopter was in radio contact with Tower / Approach of Raipur at frequency 122.3 MHz up to 6:50:31 UTC. Radio contact was established by the helicopter with tower at 6:40:02 UTC, and at 6:40:17UTC. It had requested for start for ground run at BSF Hangar, followed by a Flight Check. Start up was approved at 6:48:05UTC with QNH 1016 hPa. Taxi was requested at 6:48:37 UTC for which Tower asked VT-BSN to backtrack and line up on Rwy 24. The helicopter confirmed lining on Rwy 24 at 6:50:31 UTC.

1.10 Aerodrome information

1.10.1 The administrative authority of the airport is vested with Airports Authority of India (AAI), Raipur and Air Navigation Services is provided by AAI.

1.10.2 The elevation of Raipur aerodrome is 317.26 m (1041 ft). The geographical coordinates of airport reference point are 21 10 52.0 N & 81 44 18.5 E.

1.10.3 The runway available is 06/ 24 and details are as follows:

Designation RWY NR	TRUE & MAG BRG	Dimensions of RWY (M)	Strength (PCN) & surface of RWY / SWY	THR Coordinates	THR Elev & Highest Elev of TDZ of Precision APP RWY
1	2	3	4	5	6
06	058°30’ GEO 059°30’MAG	1955x45	50/F/B/W/T Bitumen	211033.1N 0814350.2E	THR308.1 M/ 1011 Ft
24	238°30’ GEO 239°31’ MAG	1955x45	50/F/B/W/T Bitumen	211103.9N 0814444.6E	THR316.4 M/ 1038 Ft

Designation RWY	TORA(M)	TODA (M)	ASDA (M)	LDA (M)	Remarks
1	2	3	4	5	6
06	1955	1955	1955	1825	Slope 1:50
24	1955	1955	1955	1955	Slope 1:50

1.10.4 As per the AIP Raipur, services category of fire and rescue services is VI**.** However, as per the information provided by the airport, it has category VII fire and rescue services. Details of equipment and material are as follows:

- No of Crash Fire Tenders (CFTs) : 02
- No of Ambulances : 03
- Available water in airport : 14000 Ltr
- Discharge rate of foam solution available in airport : 6400 Ltr / min
- Dry chemical powder available in airport : 450 Kg
- Carbon dioxide (CO_2) : 45 Kg
- Halotron (Halon Alternate) : 45 Kg

1.11 Flight Recorders

1.11.1 The helicopter was equipped with Model FA 2300 Madras – CVDR manufactured by L-3 Communications, Part No.2316-1501-01, Sl. No. 000600831. There was no damage to the unit (Fig. 1). The data was retrieved at HAL facility. CVDR records FDR time and GMT/UTC time. GMT/UTC recorded in the CVDR matches with time recorded by ATC. However, internal FDR time is 29 min 23 seconds behind UTC. Correlation between CVR and DFDR is given in Appendix-1.

Fig. 1 Recovered CVDR

1.11.2 CVR Analysis

1.11.2.1 The CVR of the aircraft was capable of recording three independent channels, viz., Pilot Station, Co-Pilot Station and the Cockpit Area Mic. The CVR recording does not have a time stamp. Hence, time correlation was established by using audio warning recordings with corresponding FDR events. Information gathered from the CVR recordings is given in internal FDR time after aligning.

- **6:40:02 UTC** (PIC requested for ATC clearance for ground run followed by Flight Check. The same was approved. QNH was 1016 hPa. Checks before/ after start was carried out but were not in the prescribed manner.
- **6:47:46 UTC** AFCS was checked before taxiing. No abnormality was observed in its serviceability.
- **6:50:17 UTC** PIC asked why the wheel was jammed. The Co-pilot pointed out the upslope and extra power requirement for initial inertia. This query reflects poor general awareness.
- **6:52:24 UTC** The PIC read out the twin engine Torque (Q) in hover as 60% &

- 65%. The helicopter had not settled in stable hover as evident in FDR.
- **6:53:41 UTC** The Co-pilot suggested use of H.HT. The PIC accepted the advice and H.HT was engaged at 06:24:34(6:53:57 UTC) / 105 ft RH (seen in FDR).
- **6:53:57 UTC** The Co-pilot began calling out radio heights, "90, 95, 100 ft & 105 ft". Despite the inputs, the PIC did not stabilise at the desired height prior to engaging H.HT.
- **6:54:05UTC** The PIC called out "Warning light is Flashing". Co-pilot confirmed the same and after 10 secs, he called out "Goes off". The MW light had been triggered by disengagement of HHT mode due to RH exceeding the Excessive Deviation (ED) in accordance with its design philosophy. The crew did not deliberate on the cause of illumination of caution lights.
- **6:54:26 UTC** The Co-pilot said "Bus Karo" implying stopping of further ascent at 215.8 ft RH. The PIC had not re-adjusted power to stop further climb despite Co-pilot's earlier height call outs.
- **6:54:48 UTC** Pointing out higher vibration level, the Co-pilot said: "May be we are away from the wind and slight manoeuvring for getting into wind will reduce the same."
- **6:55:26 UTC** the PIC queried whether the hover (for the check) should be into wind. On getting an affirmative from AME, the pilot executed a right 360 deg spot turn (FDR input) in OGE configuration.
- **6:55:29 UTC** Winds were assessed during the turn by the PIC and thereafter he confirmed being into wind. This was acknowledged by AME for recording OGE values.
- **6:56:24UTC** The Co-pilot advised the PIC that take off for forward flight should be from a lower height and further said that they were almost at 500 ft. This fact is validated by RH recorded in the FDR which is 495.9 ft. RHs as recorded in FDR are not in consonance with heights mentioned by the pilots in their statements whereby maximum height during the exercise did not exceed 400 ft. This reflects inadequate situation awareness of the crew.
- **6:57:08 UTC** The AME confirmed completion of vibration recordings at OGE hover and asked the PIC to initiate straight and level flight at 80 Kts. The PIC said "okay" and commenced the descent. There however, was no communication from the PIC during the ensuing situation.

- **6:57:34 UTC**
  - Audio Warning System (AWS) and Voice Warning System (VWS) came 'ON', indicating that Torque had exceeded 91% on one or both engines.
  - An unusual light thud sound was observed in CH3 mike recording in Co-pilot / AME station. Detailed investigation and deliberations revealed that the noise was attributed to dropping of Chadwick Balancer-Analyser equipment (Vibration Analysis Unit) along with his headset by the AME. This was done to brace himself prior to impending impact of aircraft to the ground. This noise was not discernible in PIC's mike.
- **6:57:41 UTC**
  - Co-pilot exclaimed 'Kya Ho Gaya' (what happened)?
  - AWS & VWS alarm for Torque came ON.
- **6:57:45 UTC** Co-pilot called out "Forward forward…" wherein he prompted for forward pressure on the Cyclic. Further ICS communication was interrupted by a long beep warning that could have been triggered while descending through the pre-set DH on Radio Altimeter.

1.11.3 FDR Analysis FDR recording of helicopter parameters is organised in eight groups to facilitate analysis. Data retrieved was analysed to determine the sequence of events in the flight. The time stamp recorded in the FDR records both FDR and UTC time. The former is 29 min 23 sec behind UTC. All timings mentioned in the analysis below are FDR internal timings.

1.11.3.1 MW Activation MW (Master Warning) light was found flashing from 6:54:03 UTC to 6:54:13 UTC during climb to OGE hover. This had been observed by the Flight Crew. The warning was associated with AFCS annuciator flicker and un-commanded disengagement of H.H.T because due to exceeding of the stipulated ED limit of 30 ft from the reference hover height. This sequence was validated in a flight in same configuration.

1.11.3.2 AFCS Data Gp 7 and Gp 8 of FDR contain AFCS state and the same was scrutinised. AFCS Lanes 1 & 2 were engaged before Pick Up at 6:53:10 UTC & 6:53:09 UTC, respectively. The lanes remained engaged until the impact. The H.HT mode was engaged at 6:53:57 UTC (105 ft RH) which went off at 6:54:02 UTC (140.6 ft RA). In the duration that the AFCS could stabilize and bring the helicopter to the reference height, permissible ED of 30 ft was exceeded. This led to disengagement of H.HT mode. Torque (Q) used at time of the engagement was 85.3% & 80.9%, which was well above OGE hover power requirement 72% & 72% for 1050 ft elevation/ 25 deg C. Collective Pitch was constant during the period, indicating that AFCS tried to bring the helicopter back to the reference height as seen from reduction in Q to 80.9% & 76.5% until the disengagement. AFCS function during the hover was found in consonance with the design philosophy and considered normal.

1.11.3.3 Barometric Altitude & Air Speed The barometric (baro) altitude, indicated airspeed and true airspeed of the aircraft are detected by ADU 1 & 2. This data transmits from ADU to AHRS 1 & 2 for further transmission to FDR. The AHRS information is recorded in Gp 5 and Gp 6 of the FDR parameters. Certain critical status messages of the AHRS are also recorded in these groups. The baro altitude provided by ADU is on standard QNH setting (1013 hPa) and thus requires correction for obtaining actual altitude. FDR altitude therefore, needs to be increased by 80 ft approx to get altitude corresponding to prevailing QNH of 1016 hPa. Maximum attained baro altitude (Zp1/ Zp2) as per FDR was 500 m/ 520 m (1640 ft/ 1706 ft) wherein sample recording is seen to be in multiples of 20 m (56 ft) thereby, limiting its accuracy. Recorded Zp values when corrected for QNH and converted into height above airfield elevation, translate into 680 ft/ 746 ft AGL. Tolerance error of approx 55 to 71 ft is expected in ADU 1 due to static leak observed during the lab tests. Zp 1 value, based on ADU 1 inputs could therefore, be ignored and maximum baro height may be based on ADU 2 inputs ie, Zp 2 and taken as approx 750ft+56 ft. This may marginally under read during hover due to downwash induced static pressure variation.

1.11.3.4 Radio Height Radio Height (RH) parameters recorded in Gp 2 of FDR were analysed. It was observed that RH recorded between time 6:57:16 UTC and 6:57:20 UTC was not in consonance with associated parameters. The value recorded at 6:57:16 UTC is 829 ft and at 6:57:20 UTC is 930.8 ft. While the HAL specialists consider this to be within the given accuracy range of the instrument viz. $\pm$7% (height above 500 ft) it is felt that such abrupt variation ought to have some trigger. Not withstanding that, the height gain (101.8 ft) in five seconds after 6:57:16 UTC may be discarded as spurious recording as this does not conform with other parameters including power settings and baro altitude (Zp2). RH attained during this period thus could be taken as 830 ft approximately.

1.11.3.5 Engine Parameters The engine parameters in the FDR were analysed to check for functioning of the engines. The engine operation had been normal till the impact. Thereafter N_G, Q and TGT started winding down. Variation in NR values recorded was observed over the entire operating range. This however, is not considered to have any bearing on the accident and as per the OEM this may be attributed to electromagnetic cross feed from N_{FT} in the CVDR. This is illustrated in SB NO. 2316-1501-01-014r1 dated 3.03.2011 issued by M/s L3 Aviation Recorders for incorporation of Mod. 12. Following aspects were also studied to preclude malfunction in the Collective Pitch Anticipator (CPA):

- Engine parameters found normal.
- Torque values and split therein not indicating CPA malfunction.
- No CPA related warning manifested in FADEC.
- In-flight manifestation of power loss not indicated.
- Characteristic 'N_R droop' associated with CPA malfunction not observed.

1.11.3.6 Normal Acceleration (N_Z) Maximum Nz recorded by the port & starboard sensors was 17 g & 10.7 g. The cockpit G-meter however, recorded 4.8 g(Range is up to 5g) indicating that the impact was absorbed to a large extent by the undercarriage, stub wings and airframe .

1.11.3.7 Position Keeping Lat/ Long reference at the time of pick up was 21° 10' 51" N/ 81° 44' 21" E. There was no significant variation in ground position for the duration of hover. Total change in ground position revealed from Gp 2 of the FDR was negligible and as under:

- +1" & - 2" N
- +1" & - 3" E

1.11.3.8 Pilot's Handling

1.11.3.8.1 Initial Phase

6:53:21 UTC The helicopter lifted off with Collective Pitch (Dtheta) at 69.5%. Q was 70.7% & 70.7 % against IGE requirement of 65% & 65%. Hover power was read out at 60% & 65% without stabilizing in IGE while the helicopter had been in a state of ascent.

1.11.3.8.2 Climb Phase

- **6:53:25 UTC** RH 6.9 ft. Power was further increased; Dtheta 70.6% and Q 72.1% & 72.1% against an OGE hover requirement of 72% & 72%.
- **6:53:45 UTC** RH 34.2 ft. Dtheta increased to 75.3 % and Q to 82.4%. & 79.5% and the helicopter gained 70.8 ft in next 12 secs, at a Rate of Climb (ROC) of 350 ft/min.
- **6:53:57 UTC** H.HT hold was engaged at 105 ft RH without stabilization. ROC at the time was 438 ft/ min and Collective settings significantly higher than OGE hover requirement with Q 85.3 & 80.9%. In the duration that the AFCS could stabilize and bring the helicopter to the reference height, it had exceeded the maximum permissible deviation of 30 ft, resulting in disengagement of H.HT mode. Collective settings remained constant while the AFCS tried to bring the helicopter back to the reference height, as seen from reduction in Q to 80.9%+76.5% at the time of disengagement. From then on, the helicopter continued to climb. The events indicate following:
    - Reduction in power was not anticipated for intended hover height.
    - Power settings continued to be significantly in excess of OGE hover requirement after reaching intended height.
    - Power settings continued to be significantly in excess of OGE hover requirement after reaching intended height.
    - Pilot was not conversant with AFCS utilization limitations.
- **6:55:28 UTC** The PIC reduced Q for stabilising the hover height after being asked to stop the climb. It was subsequently increased again during the 360 deg spot turn. The turn had been initiated at 6:26:11 was intended to assess and realign the helicopter into wind. The helicopter gained height during and after the turn.

1.11.3.8.3 Descent Phase Time of commencement of descent was inferred from associated parameters. Highlights are as follows:

- **6:57:10UTC** Dtheta reduced by 3.4 % (75.2% to 71.8 %) in next two secs. Corresponding reduction in Q was 19.5% (83.9% & 80.9 % to 75.1% & 69.2%) which was significant but remained above OGE hover power requirement. The helicopter continued to gain height as also corroborated from baro altitude.
- **6:57:13 UTC** Descent begins as inferred from reduction in power settings and baro altitude. Helicopter descended by 20m (71 ft) approx in 10 secs, averaging to 426 ft/ min. Maximum attained height had been earlier inferred as 830 ft approx.
- **6:57:22 UTC**
  - Dtheta lowered to 67.9% (3.7 % reduction) with Q reducing to 59% & 53.8 (31.5 % reduction).
  - Height down to 786.9 ft after losing 12.7 ft in last one second. (ROD 762 ft/min).
  - Downward acceleration continued and the helicopter entered the Vortex regime.
- **6:57:24 UTC**
  - Dtheta reduced to 67.5 % (0.4 % reduction) with marginal reduction in Q to 57.5 & 53.8%.
  - Height was down to 749.2 ft with 16.7 ft descent in last one second (ROD 1002 ft/min).
  - Downward acceleration continued.
  - Onset of Vortex Ring not realised.
- **6:57:26 UTC** Downward acceleration continued. Height was down to 709ft. Lost 21ft in one second (ROD1260 ft/ min). Co-pilot did not caution the pilot on excessive descent rate.
- **6:57:34 UTC** Collective lever raised with Dtheta going to 82 % and Q to 98.5% & 94.1%. Height was down to 414.1 ft with 43 ft descent in last one second. ROD 2580 ft/ min.
- **6:57:36.UTC** Height down to 366.7 ft with 47.4 ft descent in last one second (ROD 2862 ft/ min). The pilot lowered the Collective lever with Dtheta going down to 61.2%. As the helicopter continued to sink, the pilot started raising the Collective.
- **6:57:44 UTC** Q reached highest value of 113.1% & 99.9% just prior to the impact.

- **6:57:45 UTC** Th**e** helicopter impacts the ground with Dtheta value going to100.6%.

1.12 Wreckage and Impact Information

1.12.1 During the test flight at Raipur Airport, Advanced Light Helicopter VT-BSN impacted the runway surface at 1356 m from Runway 24 end. The coordinates of the accident site are 021°10.817″ N 081°44.297″ E. Location of accident is given in Appendix A-2.

1.12.2 Deep circular marks at two places were seen on the runway surface indicating that the helicopter had lifted up after initial impact and then settled back. Before coming to rest at the final position, the helicopter turned by 360 degree and the ground marks were made by the collapsed right main landing gear and the tail skid bumper. Helicopter was resting on its belly and the belly area was damaged (Figs 2 & 3). Fuel was leaking from fuel tank. A patch of 1m x 1m was observed on runway and its top bituminous surface had loosened. The damage was caused due to leakage of ATF from fuel tank. Separated parts of the helicopter were spread over the runway.

Fig. No. 2 Helicopter in the final resting position on the Runway

1.12.3 The wreckage was removed from the runway to the BSF hangar for detailed inspection. Observations made during the inspection of the wreckage are listed in succeeding paragraphs.

1.12.3.1 Fuselage The fuselage was intact. Main gear box along with mounting, main rotor blades, both engine along with their mounting were intact and in place. All gear box attachments were checked and found satisfactory. Both the main landing gears, nose landing gear and tail boom were attached to the fuselage.

1.12.3.2 Station 1-3 Nose Compartment Equipment's were damaged, including Weather Radar, Junction Box, and ADU 1 & 2. Radar array and its mounting points were damaged. Air Conditioning ducts and Ram Air entry ducts (LH & RH) were found damaged. Outer frame cockpit (including Radome) found damaged. Windshield, windshield wipers, cockpit canopy found blown out. Pilot & Co-pilot door found damaged. Air Conditioning Hose, Glass Silicon Sleeve, T- Connector found damaged. Centre Post Panel found cracked. ELT & its Antenna appeared to be Intact.

Fig. No. 3 Helicopter in the final resting position as viewed from rear

1.12.3.3 Cockpit

- Encoding Altimeter and Baro Altimeter indicating 1013mb, 1200 ft.
- Centre Post & Overhead panels- All CBs were in 'IN' (Push) position.
- Overhead panel - All CBs were in 'IN' position.

- Both side Pilot and Co-pilot FADEC were in normal position.
- Both side CONT switch were in Auto position.
- Both side over speed switch were in Normal position
- Transfer pump and primer pump were in ‘OFF’ position.
- MFCL was in most rearward position.
- Centre Console
  - Pitot static heater –‘OFF’ position.
  - AFCS and AHRS were in ‘ON’ position.
  - Heading Bug - Pilot Side.
  - ADU switch & Cal/ DG in ‘Normal’ position.
  - Master Power - ‘Off Power’ selection.
  - Fuel Cock 1&2 – ‘Close’ position.
  - Engine Start Switch- ‘IN Flight’ position.
  - ELT remote switch-‘Normal’ position.

1.12.3.4 EPS for Stand by Gyro battery intact but connectors found cracked. Pitot & Static lines found damaged. Glare shield of Main Instrument Panel found cracked. CWP Panel found out of its mounting. Headsets (pilot & co-pilot) were not found in their jacks. Station 3 Fuselage Top portion damaged. DME and Nav Concentrator appeared to be intact. VHF 1 & DME antenna appeared to be intact. Center Post panel was found cracked, ELT and its Antenna were intact.

1.12.3.5 Station 3-5 Troop Seat forward & RH side installation bracket found bent. Station 5 Maintenance Platform found cracked. First Aid Kit, Cabin Fire Extinguisher Bottle found intact. Passenger Doors (LH & RH) side found damaged. Emergency Exit window (LH & RH) found broken. Stub Wing Assembly (LH& RH) found broken. Aft & forward Float Cover Installation found damaged. Station 04 and 05 frames were found damaged. Battery compartment area found damaged. Aircraft Battery (RH) Connector found broken. Battery displaced from its installation. Aircraft Battery (LH) loosened from its mounting. Upper fuselage found cracked. Floor Board Cover found open.

1.12.3.6 Station 5-9 Frames 5 & 6 were found damaged. HF antenna supporting mast found damaged. Maintenance Platforms (Station 5-6) found damaged. Frame 7 was found to be damaged. VHF 2, ADF and MARKER Antenna found damaged. CVFDR appeared to be intact.

1.12.3.7 Station 9-12 Tail Boom area and Fairing found damaged. Equipment bay RH and LH frame damaged. Tail section/empennage disconnected from station 10. IGB at station 10 found disconnected from the TDS. IGB locking found intact. Rubbing marks observed on TDS segment-03. Hydraulic Lines to TR found damaged. TR Control Rod found broken. Tail Skid Bumper found damaged and separated. Horizontal Stabilizer and End Plates found damaged. GPS Antenna, Position lights were intact.

1.12.3.8 Stub Wing Damage was observed on both LH and RH Stub Wing Assembly On the left stub wing side strut found damaged and separated from the stub wing mounting point (Fig. 4)

Fig. No. 4 Left Stub Wing

1.12.3.9 Main Rotor Assembly

- All Main rotor blade attachments were checked and found satisfactory.
- Green, Blue and Yellow blades were damaged at the tip area. Blue blade was damaged from collar area.
- MR Blade Head Assembly. Rotor Star Assembly, Titanium Centre piece, Top and Bottom Hub plate, Lead Lag Dampers were intact.

1.12.3.10 TR Assembly

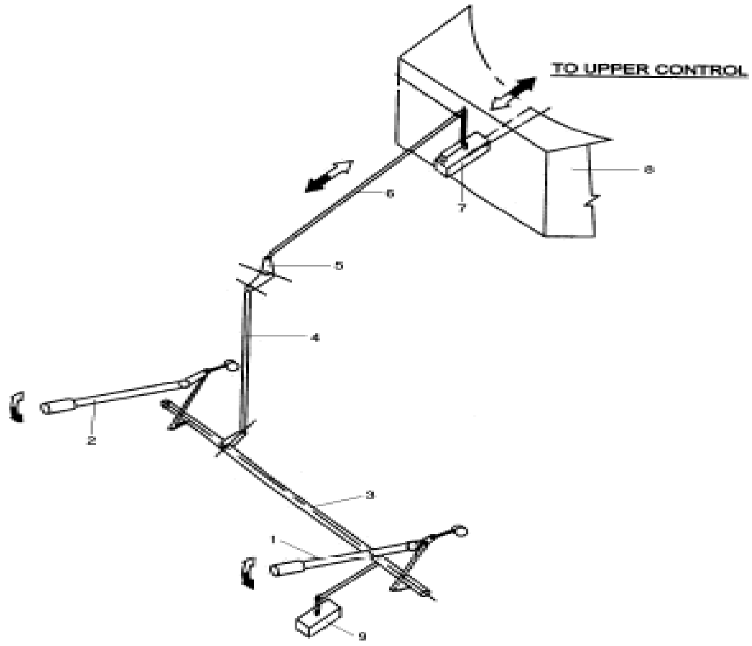
- TR assembly was intact.
- TR servo assembly found intact with no external damage.
- TR Spider assembly with Pitch link Barrel, bonding Braid, Pitch Link Horn, Spider Retention Nut, and Hub Retention Nut was intact.
- TR blades damaged due to impact with the surface while in motion. Anti-Collision light found intact.

1.12.3.11 Nose Landing Gear Nose wheel Landing Gear Shock Strut had collapsed and found cracked. Nose wheel LH side hub had cracked. Both Nose wheel Tyres were found burst. Nose Landing Gear bottom structure assembly found open.

1.12.3.12 Main landing Gear Both the landing gears were in extended position. LH tyre had burst while the RH tyre had full tyre pressure. RH strut was found damaged and separated from the Stub wing mounting point. Brake unit was found leaking.

Fig.No. 5 CPA in Situ Condition

1.12.3.13 Flight control circuit was checked for collective pitch anticipator (Fig. 5) and Booster control rods, connecting the upper control system and MR collective actuators and found satisfactory.



1. Collective lever-copilot
2. Collective lever-pilot
3. Torque tube
4. Control rod
5. Bell crank on swinging arm
6. Control rod
7. Servo actuator-collective
8. MGB housing
9. Force feel & trim actuator

Fig. No. 6 Collective Control Channel

1.12.3.14 All the linages,couplings and joints in the collective control system from crew collective controll lever to the bell crank on swinging arm; from bell crank on swinging arm to collective servo actuator; from collective servo actuator to collective bell crank were inspected. These were found to be be intact. No Bending or damage was seen on any of the linkages and torque tube(Fig. No. 6 & 7).

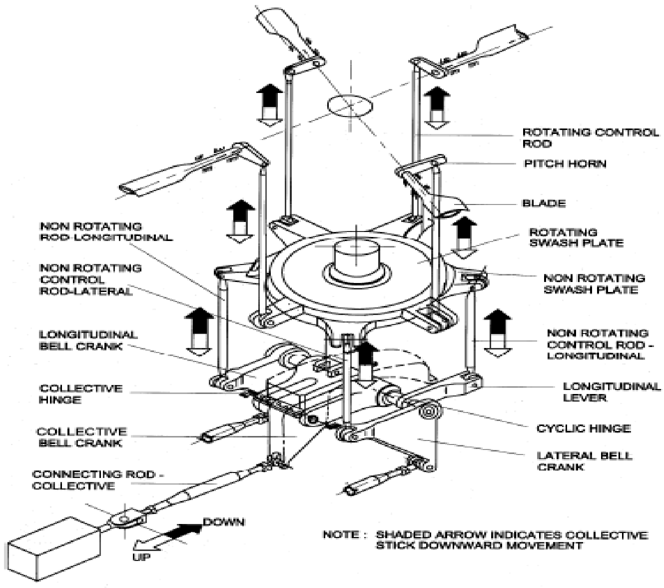


Fig. No. 7 Collective Control Channel

1.12.4 In addition following inspections were carried out:-

- All hydraulic lines checked and found satisfactory except at station #11 where the tubes were found damaged.
- All gear box chip detectors were checked and small metal particle noticed at left hand MGB chip detector.
- Flexible drive shaft connecting the MGB and engine checked and found satisfactory.
- Tail rotor blade attachments checked and found satisfactory and it was noticed that the pitch links are not wire locked at both the ends.
- Engine manual control lever found in complete aft position (shut off position).
- Fuel transfer pump switches were in off mode.
- Fuel cock switches were also in ‘close’ mode.
- LH engine shaft was not rotating however, RH engine shaft was rotating freely.

1.13 Medical and Pathological Information

1.13.1 Pre-flight medicals of the pilots were carried out. Breath analyser test was not carried out. Blood samples of both the crew members drawn after the accident were analysed in the forensic laboratory and no abnormality was observed.

1.13.2 The helicopter impacted the ground in an upright position, during uncontrolled descent from OGE hover. Impact was reduced to 4.8 g in the cockpit from an absolute 'G' value of 16.9. The occupants were injured to varying extent. Co-pilot and one of the maintenance crew had to be extricated by the recue team.

1.14 Fire.

There was no fire damage.

1.15 Survival Aspect

1.15.1 At 12:27 IST, immediately after crash, Duty Officer Tower pressed the fire bell and informed fire station. Co-pilot along and one maintenance crew had to be extricated out of helicopter by crash crew. All the persons on board were evacuated and taken to hospital by AAI.

1.15.2 The helicopter structure has limited the crash 'g' load factors felt by the occupants. Absolute 'g' load factor has been below 20 g as revealed from intactness of heavy mass items' attachments designed to withstand this load. The landing gear is envisaged to have absorbed impact energy to its full capacity of 4g and then deformed and failed. The accident was survivable

1.16 Tests and Research

1.16.1 Lab Tests

- **AFCC**

Part Number: 416-0027-201 Serial No.: 308

Part Number: 416-0027-201 Serial No.: 304

Both AFCC were tested at HAL Aerospace and no defect was observed.

- **AHRS**

Part Number: 420-00332-450 Serial No.: 2051

Part Number: 420-00332-450 Serial No.: 2387

Both AHRS were tested at HAL and no defect was observed.

- **CPA**

Part Number: 34 LL 3C 502 W03 290 Serial No.: 308

Resistance checks were carried on CPA as per QAP. Found satisfactory.

- **Encoding Altimeter**

Part Number: 3H67.32.35F.05.1CW Serial No.: 1035881

Encoding Altimeter was tested at HAL and no defect was observed.

- **Altimeter**

Part Number: 3A63-32.35F.051.0W Serial No.: 1035864

Altimeter was tested at HAL and no defect was observed.

- **ADU Sensor**

ADU Pt No C 17115 Serial No: 241 & 243 were tested at HAL. Static leak was found marginally higher than the acceptable limit in ADU 1 (Sl No 241) wherein altitude tolerance was 55 to 71 ft. ADU 2 (Serial No 243) test results were satisfactory.

- **Fuel Sample Report Fuel** sample was drawn from tank & the two engines and were tested in DGCA Labs. The samples passed the specification tests.
- **Oil Sample Report** Oil Samples were drawn from both the engines, IDS RH side, IDS Centre sump, AGB, IGB, TGB and were tested in DGCA Labs. The samples passed the specification tests.

1.16.2 Validation Flight

1.16.2.1 Dhruv VT-BSM positioned at Ranchi base was nominated for further validation of H.HT usage. The helicopter was configured to obtain IGE & OGE torque values close to the calculated values for VT-BSN on the fateful flight. Accordingly, AUW was planned for prevailing pressure altitude and temperature conditions to get, Q (Q1+Q2) between 130% & 144%.

1.16.2.2 Climb was initiated to achieve OGE hover and in the first attempt, H.HT could not be engaged. The AFCS PCU displayed 'NO GO' as RH was greater than the operating limit of 380 ft. It engaged successfully at 280 ft in the subsequent attempt. During second attempt, a climb was initiated and H.HT was engaged successfully at 280 ft, however, it went off at 330 ft. In the third attempt, sequence of events validated the H.HT design philosophy. It was noted that H.HT went off un-commanded at 395 ft with following additional indications:

- AFCS light flickered
- MW started flashing
- “C>: light flashed on ANP

1.16.2.3. Following was also observed while establishing the OGE hover:

- There being no cockpit instrument to aid position keeping during high OGE hover, good skill levels were required to maintain steadiness in position & height, with H.HT mode inoperative.
- VSI was tending to flicker and was less dependable.

1.16.3 Simulation

1.16.3.1 Using the DFDR data and conditions under which Dhruv VT BSN met with the accident on 15 Jan 12 at Raipur, simulation of flight events were carried in DGCA approved level D Full Flight Simulator (FFS) for Dhruv at HATSOFF Training Pvt Ltd on 13 July 12.

1.16.3.2 Flight Conditions were as tabulated follows:

SL	PARAMETER	VALUE
1	LOCATION	RAIPUR (ON VISUAL DATA BASE)
2	HEIGHT	830 FT AGL ON RADIO ALTIMETER
3	AUW	5200 KG
4	OAT	30 Deg C
5	FLIGHT STATE	HOVER

1.16.3.3 From a steady hover with collective at 72 % at 830 ft on the radio altimeter (RA), Collective Pitch (Dtheta) was lowered to 61% to obtain ROD of 1200 ft/min within first 10 sec, to replicate FDR data conditions. At this stage (630 ft RH), collective was raised partially to 72 % (as if to arrest the ROD), to replicate FDR conditions. In response, the helicopter began to experience random roll and pitch, and the ROD increased instead of decreasing, reaching a value of nearly 2500 ft/min. From the symptoms, it was evident that the helicopter model was experiencing a classic ‘Vortex Ring’ phenomenon. Further, at 160 ft on RA, the collective was raised rapidly and fully, as seen in the FDR. This did not help in reducing or controlling the ROD and the helicopter impacted the ground thereafter. The simulation was repeated another time, with same results.

1.16.3.4 A third simulation was done to assess whether the helicopter would recover from an incipient Vortex Ring state, if the recommended actions of first building up forward speed and then raising collective were followed. To assess this, after obtaining ROD of 1200 ft/min, at 630 ft, the collective was retained at its position instead of raising collective as was in the FDR data, and helicopter nose was lowered to build up forward speed. After attaining a speed of 30 Kts, the collective was slowly raised to control the ROD. The helicopter ROD began to reduce and it recovered to level flight at a RA height of 350 ft approx.

1.16.4 Load Analysis of the failed Structure

- The 'g' (Nz) recorded by DFDR was **16.9 g** and 'g' in cockpit was recorded as **4.8 g**. The live space in the cock pit and cabin has been maintained. No fuel leakage and fire was reported.
- To determine the value of the load factor sustained by the helicopter during the impact, load analysis of the failed structure using the design and test data from HAL was carried out.
- Failure of the structure indicated that the stub wing and landing gear absorbed the major impact and ruptured. The sub floor structure was found more or less intact except for local damages
- Based on the analysis it was concluded that the 'g' factor felt at VT- BSN stub wing structure >10.23g.
- The VT-BSN structure has limited the crash **'g'** load factors felt by the occupants below' **20g'** as it is evident from intactness of mass items attachment and collapse of stub wing.
- The crash energy transferred to the sub floor was limited due to detachment of landing gear and nearby controlled deformation of subfloor thus maintained the intactness of the seat attachments and space around the occupants. Hence occupants have survived.

1.17 Organizational and Management Information

1.17.1 Dhruv helicopter VT-BSN was owned and operated by BSF Air Wing that had been established in the year 1969. BSF is maintaining and operating fixed and rotary wing aircraft. Out of the rotary wing inventory, Dhruv helicopters are civil registered and are contracted to HAL for operations and maintenance. These helicopters are further sub-contracted to PHHL for O&M activities and for that purpose, HAL had trained AMEs who in turn had obtained relevant Licences/ Approval for certifying airworthiness of the helicopter. BSF had set up bases at Ranchi, Raipur and Agartala for facilitating operational and maintenance support. PHHL is a Public Sector Undertaking with its Corporate Office located in NOIDA, Uttar Pradesh. It was initially incorporated as the Helicopter Corporation of India in October 1985, with an objective of providing helicopter support services to the oil sector for its off-shore exploration operations, services in remote areas and charter services for promotion of tourism.

1.17.2 CAR M permits contacting of tasks associated with continuing airworthiness to a continuing airworthiness management organisation approved in accordance with Section A, Subpart G of CAR-M. However there is no regulation in force for contracting the operations activities.

M/s PHHL is CAR 145 approved maintenance organisation. It has approval to carry out the maintenance. Its scope of approval includes maintenance on Dhruv helicopter fitted with Turbomeca TM333-2B2 Engine, up to and including 250 Airframe Hrs/ 300 Engine Hrs. Inspection Schedule

1.17.3 VT-BSN helicopter was based at Raipur Airport to meet operational requirement of Central Reserve Police Force in Chhattisgarh sector. The Flight Crew and AMEs were being positioned in Raipur for 4 to 6 weeks, on rotation basis. Internal audit was being carried out by Quality Control from PHHL, in addition to external audit.

1.17.4 This was the second accident in BSF owned Dhruv fleet within a period of three months. VT-BSH had crashed near Ranchi on 19th October 2011. This helicopter was also being operated and maintained by PHHL as the sub-contractor of HAL.

1.17.5 There are presently a total of 26 pilots operating Dhruv helicopter in PHHL. Out of these only 09 pilots have had previous multi-engine helicopter experience.

1.18 Additional information

1.18.1 There is a significant difference in flight parameters recounted by the Flight Crew and those obtained from Flight Recorder. This may be due to confusion because of rapidity of events. The inputs provided are therefore, not considered reliable in entirety.

1.18.2 Vortex Ring Phenomenon

1.18.2.1 Definition often considered as the equivalent of the fixed-wing stall, Vortex Ring is a condition of powered flight where the helicopter “settles” into its own downwash. Consequently, the Rate of Descent (ROD) will increase dramatically (typically, at least two to three times the ROD before entering Vortex Ring) for the same power setting.

1.18.2.2 Conditions for Vortex Ring Vortex Ring is likely to occur when descending in

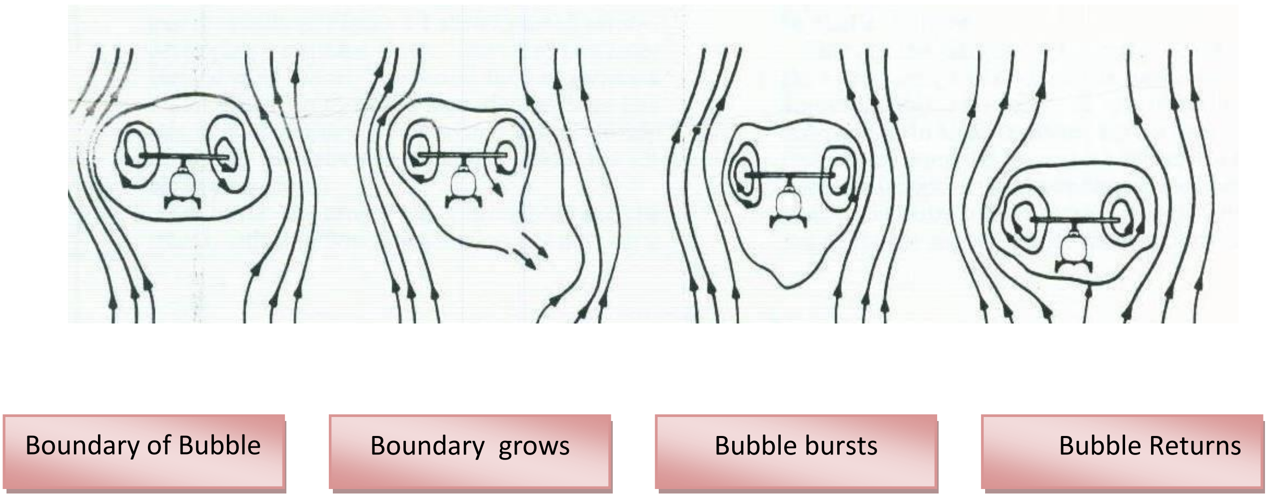


Fig No 4: Vortex Ring flow conditions

powered flight at airspeed below 30 Knots with a Rate of Descent (ROD) close to the main rotor “downwash velocity”. Downwash velocity or induced velocity is defined as the airspeed of the airflow drawn down through the rotor disc. The induced velocity is a function of the helicopter type and gross weight. For example, a helicopter with four bladed rotor with a diameter of 13.2 m and a weight of 5400-5500 kg at OAT of 25ºC would result in an induced velocity of 13-14 m/s. Therefore, although Vortex Ring State is shown to be dependant on the helicopter type and weight, a commonly accepted unsafe ROD is considered to be in excess of 500ft/min (~2.6m/sec).

1.18.2.3 Characteristics

- Besides the unsteadiness, one of the most unusual characteristics of the vortex ring is the high power required to maintain rotor thrust. Pilots call it "Power settling" based on their observation that in some cases the helicopter keeps coming down even though full engine power is being used. Not only does the power required increase in the vortex ring state, but so does the collective pitch-apparently due to local blade stall during flow fluctuations. The range between **750 and 2300 ft/ min** (4 m/sec to 12 m/sec) for a typical helicopter is the power settling condition. The situation may become a problem with a heavily loaded helicopter on a hot day when power available is low.
- Fig 4 is a sequence of events based on interpretation of the smoke movies. According to this concept, the rotor is continuously pumping air into a big bubble under the rotor .This bubble fills up and bursts every second or two, causing large-scale disturbances in the surrounding flow field. The bubble appears to erupt from one side and then another so that not only does the rotor thrust vary, but the rotor flaps erratically in pitch and roll-requiring prompt pilot action.

- As the helicopter descends with power in this state, The Pilot may attempt to arrest the rate of descent by application of increased collective but this tends to increase the rate of descent still further. If on the other hand the Pilot lowers the collective lever the thrust is reduced and the helicopter also increases its rate of descent.

1.18.2.4 Recovery Action It may be taken by cyclic and/or collective application. However, depending on the rotor system, cyclic input alone could be insufficient to modify the helicopter attitude to gain airspeed. It is also possible to recover from Vortex Ring by reducing the collective to minimum pitch. However, the loss of height during recovery by collective pitch reduction is greater than the corresponding loss of height by cyclic input, which is the result of the ROD in autorotation at low airspeed being very high. Therefore, the following recovery actions should be initiated at the incipient stage to minimise the loss of height:

- Apply a positive forward cyclic input to achieve an accelerative attitude to gain airspeed

- If an accelerative attitude cannot be reached, decrease collective pitch to enter autorotation and then apply forward cyclic, as required to increase airspeed.

1.18.2.5 Vortex Ring avoidance Since the recovery actions will entail a considerable loss of height, it is imperative to avoid Vortex Ring especially when close to the ground. Therefore, a ROD in excess of 500 ft/min (~2.6m/sec) at airspeed of less than 30 Knots whilst in powered flight should be avoided. Therefore, the following operations should be conducted with great care:

- Steep approaches
- Hover Out of Ground Effect (HOGE)
- Low speed autorotation recovery
- Downwind quick stops
- Aerial photography
- Downwind approaches

1.18.2.6 Training and Crew Proficiency Crew proficiency and appropriate training helps avoidance of flight regimes prone to vortex ring. Realisation of onset of the condition and timely recovery action is essential for a safe recovery from the condition. Indications and recovery actions as given in flight manual/ FRC need to be well understood by the operating crew.

1.18.2.7 Effect of Vortex Ring

- Vibrations as vortices break away at the blade tips
- Less responsive (sluggish) pitch & roll controls as a result of the unstable airflow constantly modifying the thrust and moment of control. Fluctuations in power requirement (torque) as the large changes in drag cause thrust variations.
- Abnormally high ROD as vortex develops can be in excess of 3000ft/min (~15 m/sec).

1.19 Useful or Effective Investigation Techniques

Nil

2. ANALYSIS

2.1 Airworthiness of Helicopter

2.1.1 Maintenance of the Helicopter: The Certificate of Airworthiness of the helicopter was current and valid. Periodicity of all scheduled maintenance tasks was maintained. The helicopter was under the maintenance of an approved maintenance organisation. AME who carried out Daily Inspection on the day of accident is appropriately licensed for the maintenance of this type of helicopter. He did not observe any snag or abnormality during his inspection. Engine power assurance check was being carried out at intervals specified by the manufacturer i.e. at 25 hrs and no anomaly was observed.

2.1.2 System/Component Failure: The helicopter had snag related to tail rotor and main rotor on numerous occasions and they were rectified as per the procedure. TR imbalance was also reported twice within a span of one month after major inspection of 250 hrs on 16.11.2011. On being referred, HAL recommended re-painting of TR blades to address paint peel off that was opined to have been caused by sand/dust in the operating environment. Painting of the blades was carried out under the supervision of HAL engineer, holding authorization for the scope of work issued by QM HAL. TR assembly was installed after painting and rigging check was carried out on TR flight controls. Helicopter was offered for dynamic balancing of TR on 15th January 2012, comprising ground and flight regimes.

- No snag or abnormality was observed by the AME during his pre-flight inspection. After satisfactory check in the ground regime the helicopter was released for vibration assessment in the flight regime. After about four minutes of the flight the helicopter entered into uncontrolled and rapid descent and thus impacted the ground.
- After the accident detailed inspection of helicopter and its system was carried and no defect was observed, damages observed were post impact.
- To assess the any failure related to the power system, the ECU data from the ECU of both the engines was downloaded and no discrepancy was observed. DFDR data also did not indicate any engine related discrepancies.

- Integrity of the transmission system was checked and found satisfactory.
- To assess any defect related to Auto flight control system (AFCC) which could have led to possible loss of control, both the AFCC were checked at the facility of HAL at Bangalore. No discrepancy was observed.
- During the descent, collective pitch lever was vigorously used by the crew to arrest the rapid rate of descent. However the descent could not be arrested. To obviate malfunction/failure of the CPA, the component was checked at the HAL facility and no discrepancy was observed.
- The helicopter was maintained as per the approved maintenance programme. No snag was reported before the accidental flight.

Thus it can be safely concluded that the helicopter was in airworthy condition to undertake the flight.

2.2 Flight Planning

Planning and preparation of the flight were examined for its bearing on the accident. Flight Crew had filed the Flight Plan with Raipur ATC. A short briefing was carried out on the purpose of check as brought by the AME. The same was however, not exhaustive, as observed from the intercom transcript. Lack of clarity on height to be maintained during the hover check is evident and reflects inadequate planning. Co-pilot's hesitation in being assertive suggests inadequate briefing.

2.3 Meteorological Briefing

There was no significant weather and metrological conditions do not have any bearing on the accident.

2.4 Checks & Procedures

Pre-flight checks, pre-start checks and post start checks were not carried out by the Flight Crew, in the prescribed manner. The recommended practice has been to use the Flight Reference Card in the challenge response method.

2.5 Piloting and Handling of Emergency

2.5.1 On the day of accident, the helicopter was checked for vibrations on ground and then flown for OGE hover check. The helicopter was ‘Picked Up’ and power used was read out by the PIC, without stabilising the hover. Collective setting being greater than the IGE requirement, the helicopter continued to gain height. Further increment resulted in appreciable increase in Q (22.12 % in excess of OGE hover requirement) and ROC (438 ft/ min). Higher power settings were maintained, despite Co-pilot’s advisories on height attained from 90 ft onwards and H.HT mode was engaged at 105 ft, without stabilising the helicopter. In the duration that AFCS could stabilize and bring the helicopter to the reference height, it had exceeded permissible deviation of 30 ft, resulting in un-commanded disengagement of H.HT. Consequent illumination of AFCS annuciator and MW light was seen but the situation was not comprehended. No effort was made to analyse the cause and the PIC perceived it as AFCS malfunction. The helicopter continued to climb thereafter until Co-pilot’s next advisory. Further ascend was stopped for about half minute but was resumed thereafter, during the ensuing spot turn. The turn was intended to assess winds, to align the helicopter into wind for minimizing vibrations. The turn was unnecessary as winds could have been assessed on EHSI with wind vector indication.

2.5.2 OGE hover in this helicopter variant is carried out visually and requires alertness to appreciate vertical movement, especially at higher heights. H.HT reduces the work load and its disengagement worsened the situation. Execution of a spot turn added to the pilot’s work load. The pilot remained focused in position keeping and missed out on height maintenance, revealing inappropriate scanning of flight instruments.

2.5.3 Near continuous gain in height reveals inadequate co-relation of power utilization vis-à-vis calculation based requirement for IGE as well as OGE hover.

2.5.4 Pilot’s initial attempt for descent did not consummate as the helicopter had been in a state of climb and reduction in power settings was not sufficient for commencing a descent. After waiting for about six seconds, he lowered the Collective further. Reduction was excessive and the helicopter began to descend rapidly, resulting in ingress into Vortex Ring regime. The crew displayed poor Situational Awareness in not appreciating high ROD in low power setting descent at zero forward speed. Onset of the Vortex Ring was not recognized, thus requisite action could not be initiated. Dhruv FRC (checklist) mentions following indications and recovery actions for Vortex Ring:

- **Indications**
  - Uncontrolled vertical descent at speed close to zero.
  - Increase in vibrations with random pitching and rolling.
- **Actions**
  - Collective: Maintain approximately at hover setting.
  - Cyclic: Forward to lower attitude by 10 deg to 15 deg.
  - As speed builds to 60 KIAS: Raise attitude and arrest descent.

2.6 Cockpit Resource Management

2.6.1 CVR analyses reveals lack of effective CRM. The Co-pilot did not assist the pilot during the initial hover but had tried to render assistance in establishing the hover by calling out heights from 90 ft onwards up to the intended hover height of 105 ft RH. Later, he had urged the pilot to stop (the climb) at 215 ft and again informed the pilot of the height at 500 ft. The Co-pilot however lacked the requisite assertiveness.

2.6.2 The PIC had continued with the sortie profile without attempting to analyse or discuss the cause for activation of MW light. This was despite AME's availability on board. on Dhruv.

2.6.3 During the descent, the Co-pilot did not caution the PIC of high descent rate and hazards associated with such a condition. This was despite the fact that there was no adverse Trans-Cockpit Authority Gradient (TAG). The two pilots had comparable number of flying hours and in addition, the Co-pilot was qualified Captain on type and had also flown modern generation helicopter (Bell 407), prior to Dhruv conversion.

2.7 Human Factors

2.7.1 To ascertain latent influencing factors such as previous flying experience, quantum of flying and training; company's management of pilot assets were studied.

2.7.2 Flying Experience of Pilots

2.7.2.1 The aviation background of the two pilots was studied for bearing on the accident. Like majority of other pilots employed in Dhruv fleet of PHHL, these two also did not possess previous multi engine experience. Some of them had significant break in flying prior to their induction in PHHL. Most pilots from older vintage single engine helicopter background lacked requisite exposure to modern generation avionics and IFR operations.

2.7.2.2 The VT-BSN pilots had not comprehended H.HT disengagement which indicates that they were not fully conversant with limitations of AFCS utilization in Dhruv helicopter.

2.7.3 Flying Conversion Training Both pilots had undergone Dhruv conversion which included ground and flying training at HAL Bangalore. The training was conducted in accordance with DGCA CAR Section 7- Flight Crew Standards Training and Licensing Series 'B' Part X dated 28th June 2005. A total of 15 hrs of flying, including skill test by day and night, was flown at HAL by each pilot. The PIC had completed flying training on 15 October 2009 and was cleared by the company fly as PIC on 10 October 2011 after having flown 220:55 hrs on type. The Co-pilot had completed flying training on 04 May 2010 and was endorsed as PIC on Dhruv (ALH) on 18 May 2010. However, he was not yet cleared to fly as PIC by the company. The documented policy vide Training Manual of PHHL, for release of a co-pilot into PIC duties is a "minimum of 500 Hrs on type for pilots with less than 2500 Hrs on helicopters". However, Dhruv pilots are considered for independent Captaincy after a minimum of 100 Hrs of co-pilot flying. Performance is monitored by supervisors and if required they are cleared after more hours. Constraints of limited flying availability on Dhruv fleet necessitated the reduction.

2.7.4 Multi-Engine Cockpit Philosophy The crew did not conform with mandatory requirement of "Challenge & Response" philosophy of carrying out checks and procedures throughout the duration of the flight. Non – standard phraseology was used in cockpit call-outs.

2.7.5 Conversion Training Syllabus DGCA vide CAR Section 7- Flight Crew Standards Training and Licensing Series 'B' Part X dated 28th June 2005 has laid down the training syllabus to be followed while converting from one type of helicopter to another. For Dhruv, the conversion training is being undertaken by HAL. The training syllabus being followed by HAL is in consonance with the DGCA CAR. The syllabus was found adequate for pilots who were current in flying or had previous experience on aircraft equipped with modern generation avionics. However, for pilots who have had a long break in flying and have had previous experience only on basic aircraft, the syllabus is considered inadequate. Considering the complexity of modern generation machines, associated systems and its avionic integration, the manufacturer should formulate a syllabus to cater for different backgrounds, experiences and also ensure that the pilots, on completion of training are confident to handle the helicopter and exploit its capability. The use of full motion simulators for training of pilots is a mandatory requirement wide afore mentioned CAR. Although the simulator for Dhruv has been available in the country, training for PHHL pilots by HAL was only on the helicopter, for commercial considerations. Never the less, Simulator Flying Training is now being undertaken. The flying training facility of HAL needs to tailor the syllabus depending on trainee's previous experience and capability. Also, strict monitoring of training and consolidation needs to be maintained by HAL and PHHL to identify and address shortfalls on case to case basis.

2.7.6 Training Records The training records were scrutinised and observations are covered in succeeding paragraphs.

2.7.6.1 Recurrent Training DGCA CAR Section 7 Series 'B' Part XIV dated 8th July 2005 postulates recurrent training requirements for helicopter pilots. Training records of the pilots were scrutinised to check for compliance. The Captain had completed his conversion training on 15th October 2009. Whilst records of Competency Checks were presented for perusal, certificates/records in respect of air crew having undergone CRM

& Dangerous Goods as also ground classes could not be submitted to the Committee.

2.7.6.2 Night Currency Check Since the PIC is not Instrument Rated, he has not being undertaking night flying to maintain currency. Scrutiny of his personal flying log book, however, revealed that night flying of 30 minutes duration had been logged as PIC, on 26 September 2011.

2.7.6.3 Simulator Training for Critical Emergencies Critical emergencies, which cannot be practiced on the helicopter need to be undertaken once in two years on full flight simulators for 05 Hrs. The crew however had not undertaken the same.

2.7.6.4 Quantum of Flying It was also observed that the total quantum of flying in the Dhruv fleet was much lesser compared to other fleets of PHHL resulting in inadequate opportunities for inexperienced pilots to consolidate.

3 CONCLUSIONS

3.1 Findings

3.1.1 On 15 January 2012, Dhruv helicopter VT-BSN undertook a flight from Raipur aerodrome for Vibrex Check at 0653 UTC after filing a VFR flight plan. The exercise entailed checking of TR vibrations in OGE hover and forward flight regimes. The PIC initiated a hover and continued uninterrupted ascent for OGE hover. At about 105 ft, he engaged H.HT hold which went “OFF’ un-commanded. This was indicated by illumination of AFCS annuciator on CWP, followed by activation of MW caption. The helicopter continued to ascend and it attained an approximate height of 800 ft AGL. A descent was initiated thereafter, to get down for establishing forward flight. Excessive lowering of Collective Pitch during vertical descent led to high ROD and onset of Vortex Ring condition. Collective Pitch was raised to arrest the sink which led to intensification of vortices and further increase in sink rate. Subsequent reduction in power did not help in reducing or controlling the sink. The helicopter continued to lose height rapidly and as the ground came closer, the PIC raised the Collective to maximum possible extent. The helicopter impacted ground at 06:57 UTC. It bounced upwards after the initial impact and settled back on the runway after rotating approximately 360 degrees.

3.1.2 Crash services were promptly activated and occupants were evacuated.

3.1.3 There was no fire.

3.1.4 No failure or abnormality was found in any of the helicopter systems.

3.1.5 Flight Crews’ speculated malfunction of AFCS or PCA is ruled out.

3.1.6 Inadequate systems’ knowledge and previous vibration history contributed in obscuring Flight Crews’ Situational Awareness and misjudgement of the emergency.

3.1.7 Flight planning for the flight was inadequate.

3.1.8 The CRM was sub-optimal. Lack of all-inclusive utilisation of available aircraft resources and limited contribution by Co-pilot during critical phase of flight precipitated the emergent situation.

3.1.9 Training imparted by the manufacturer was found inadequate considering PIC's lack of previous experience in multi engine/ IFR capable helicopter.

3.1.10 The pilots were not scheduled for simulator training by the company despite availability of type simulator since May 2010.

3.1.11 Opportunities accorded to pilots for consolidation were found to be lacking as the quantum of flying undertaken by Dhruv fleet had been low.

3.1.12 Flying syllabus followed for conversion by HAL was as per DGCA CAR. The conversion and consolidation training is found inadequate in the instant case considering break in flying, previous experience and individual capabilities. Substantial number of pilots with only single engine helicopter and limited IFR exposure were inducted in the company.

3.2 Probable Causes and Contributing Factors

The accident is attributed to loss of Situational Awareness by the PIC wherein he allowed the helicopter to enter Vortex Ring state during vertical descent. High rate of descent in low power settings had led to onset of the phenomenon. The Flight Crew failed to recognize the condition, therefore, stipulated recovery actions were not initiated. Instead, the PIC attempted to arrest the descent by raising Collective lever which aggravated the situation. Crew's fixation to vibrations' history of this helicopter and other speculated failures contributed towards misjudgement of the situation. Limited experience on type and inadequate knowledge of the helicopter systems also contributed towards the accident.

4 RECOMMENDATIONS

4.1 Flight simulators training/assessment as specified by the regulator needs to be complied.

4.2 HAL should review and customise training syllabus for Dhruv helicopter taking into consideration previous experience and capability of under conversion pilots. This may be over and above Regulator's training requirement.

4.3 PHHL needs to evolve a credible system for enhancement of CRM.

4.4 Information necessary for Flight Crew such as automatic disengagement of Hover Height (H.HT) hold due to Excessive Deviation needs to be incorporated in Flight Manual.

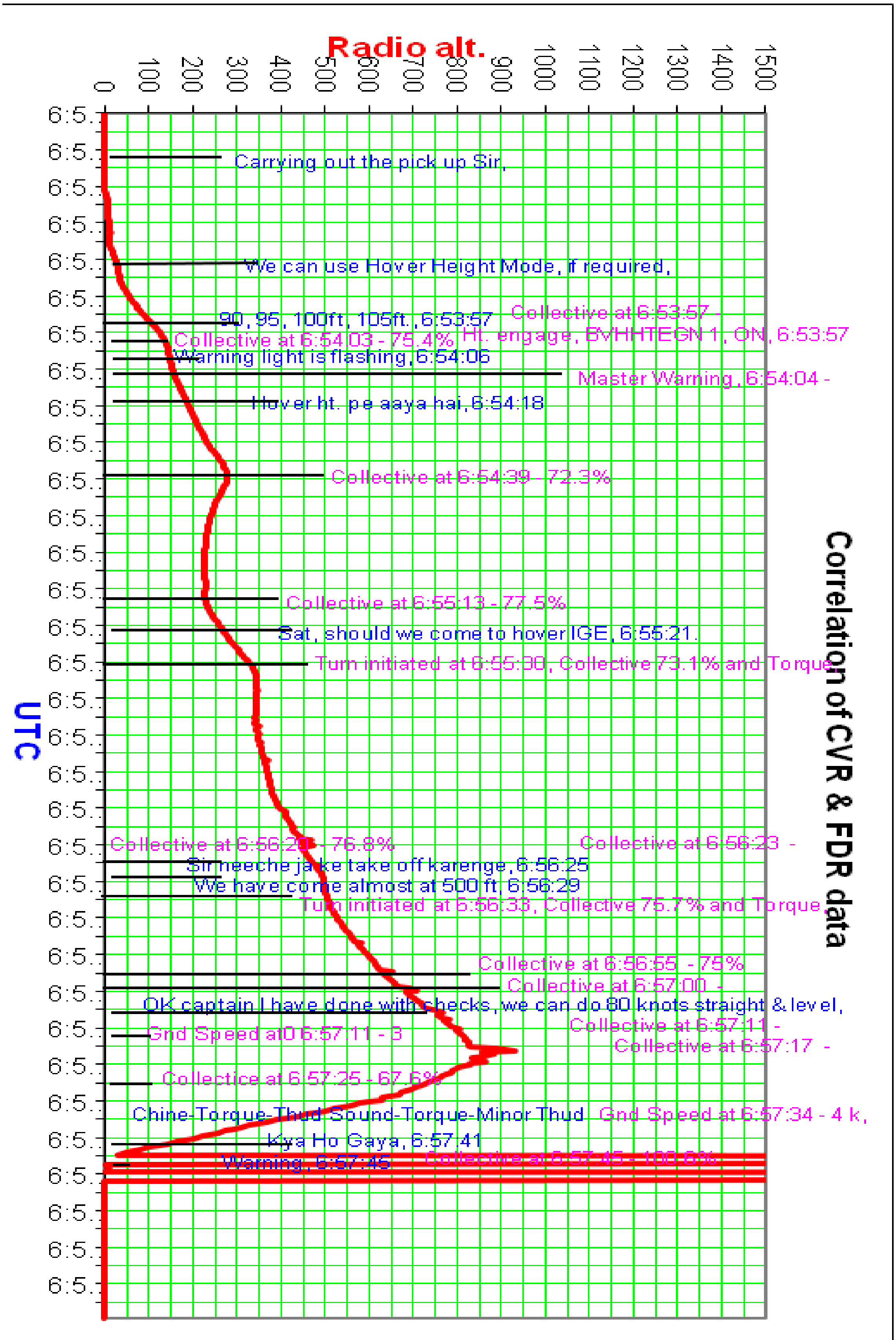
(Capt Sheelpriya Verma)
Helicopter Pilot
MEMBER

(Sh. Maneesh Kumar)
DDAS, O/o DGCA
MEMBER SECRETARY

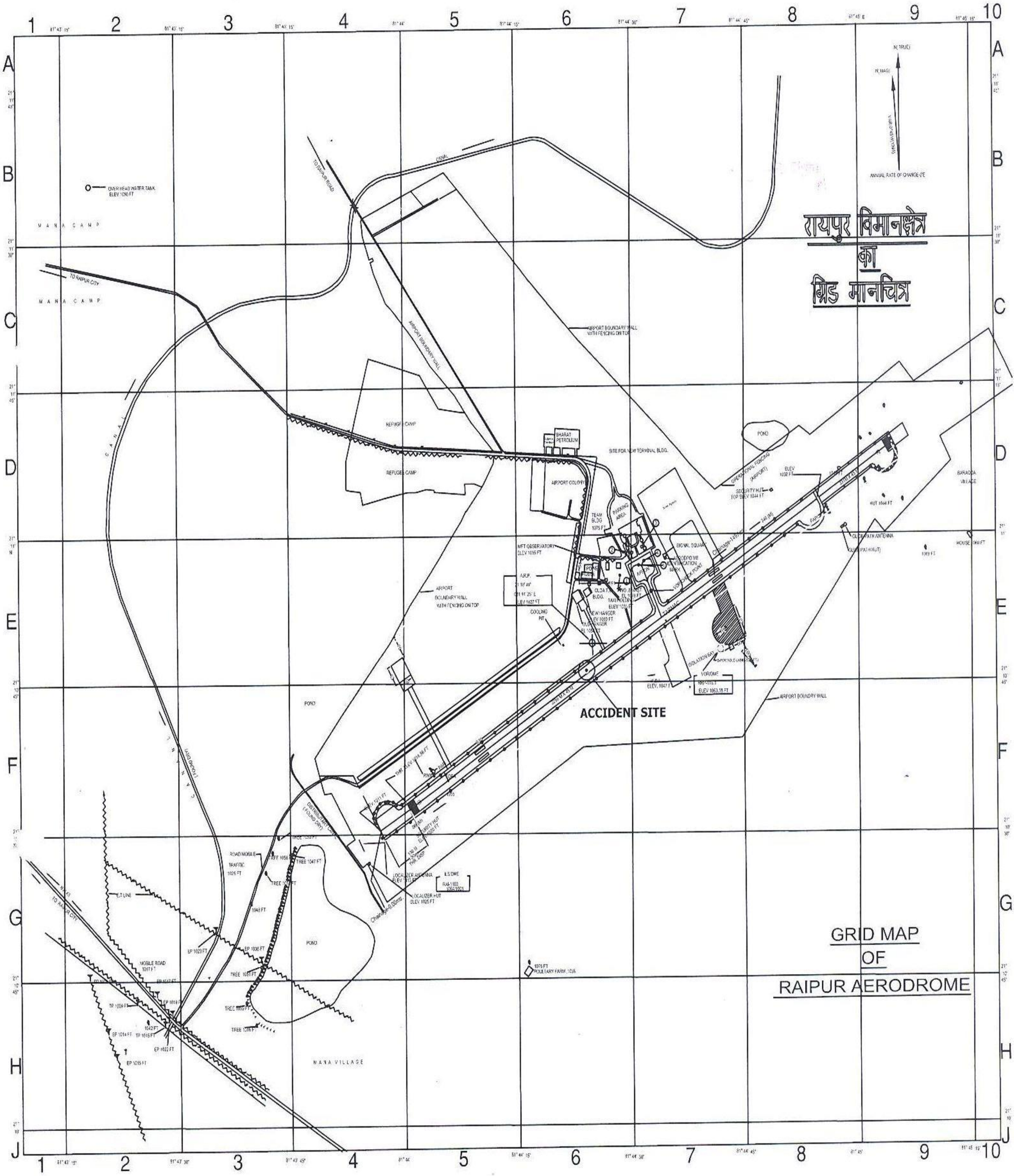
{Air Cmde G S Cheema (Retd)}
AVSM, VSM & Bar
CHAIRMAN

Date: 22 April 2013
Place: New Delhi

APPENDIX - 1


Radio alt.
Correlation of CVR & FDR data
UTC
Carrying out the pick up Sir,
We can use Hover Height Mode, if required,
90, 95, 100ft, 105ft., 6:53:57
Collective at 6:53:57 -
Ht. engage, BVHHTEGN 1, ON, 6:53:57
Collective at 6:54:03 - 75.4%
Warning light is flashing, 6:54:06
Master Warning, 6:54:04 -
Hover ht. pe aaya hai, 6:54:18
Collective at 6:54:39 - 72.3%
Collective at 6:55:13 - 77.5%
Sat, should we come to hover IGE, 6:55:21.
Turn initiated at 6:55:30, Collective 73.1% and Torque
Collective at 6:56:23 -
Sir neeche ja ke take off karenge, 6:56:25
We have come almost at 500 ft, 6:56:29
Turn initiated at 6:56:33, Collective 75.7% and Torque
Collective at 6:56:55 - 75%
Collective at 6:57:00 -
OK captain I have done with checks, we can do 80 knots straight & level,
Collective at 6:57:11 -
Gnd Speed at0 6:57:11 - 3
Collective at 6:57:17 -
Collectice at 6:57:25 - 67.6%
Chine-Torque-Thud Sound-Torque-Minor Thud
Gnd Speed at 6:57:34 - 4 k,
Kya Ho Gaya, 6:57:41
Warning, 6:57:45

APPENDIX - 2



रायपुर विमानक्षेत्र
का
ग्रिड मानचित्र
GRID MAP
OF
RAIPUR AERODROME
ACCIDENT SITE
MANA CAMP
MANA VILLAGE
REFUGEE CAMP
AIRPORT COLONY
BHARAT PETROLIUM
SITE FOR NEW TERMINAL BLDG.
AIRPORT BOUNDARY WALL WITH FENCING ON TOP
AIRPORT BOUNDRY WALL
TO RAIPUR CITY
POND
CANAL

GLOSSARY

AAI	Airports Authority of India
ACCR	Accessory
AFCS	Automatic Flight Control System
AHRS	Attitude Heading Reference System
ALH	Advanced Light Helicopter
AME	Aircraft Maintenance Engineer
ATC	Air Traffic Control
AWS	Audio Warning System
baro	Barometric
BSF	Border Security Force
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
C.G	Centre of Gravity
CAR	Civil Aviation Requirement
CHPL	Commercial Helicopter Pilot License
CRM	Cockpit Resource Management
CRPF	Central Reserve Police Force
CVR	Cockpit Voice Recorder
CWP	Centralised Warning Panel
DFDR	Digital Flight Data Recorder
DGCA	Director General of Civil Aviation
DME	Distance Measuring Equipment
EECU	Electronic Engine Control Unit
EFIS	Electronic Flight Instrument System
ELT	Emergency Locator Transmitter
FADEC	Full Authority Electronic Engine Control Unit
FDR	Flight Data Recorder
Ft	Feet
Ft/ min	Feet per minute
g	Gravitational acceleration
Gp	Group
GPS	Global Positioning System
HAL	Hindustan Aeronautics Limited
Hdg	Heading
HF	High Frequency
Hi	High
hPA	Hecta Pascal
Hrs.	Hours
IDS	Integrated Dynamics System
IF	Instrument Flying
IFR	Instrument Flight Rules
IGE	In Ground Effect
ILS	Instrument Landing System

IMC	Instrument Meteorological Conditions
IR	Instrument Rating
kg	Kilogram
kHz	Kilo Hertz
km/h	Kilometre per hour
kts	Knots
kW	Kilo Watt
LH	Left Hand
LLZ	Localizer
m	Meter
mb	Millibar
MCR	Maximum Contingency Rating
Met	Meteorology
MGB	Main Gear Box
MHz	Mega Hertz
MMI	Mast Moment Indicator
MRB	Main Rotor Blade
MW	Master Warning
NDB	Non Directional Beacon
NM	Nautical Miles
NR	Main Rotor RPM
NSOP	Non Schedule Operators Permit
NZ	Longitudinal Acceleration
OGE	Out of Ground Effect
PHHL	Pawan Hans Helicopters Limited
PIC	Pilot in Command
Pr	Pressure
Q	Torque
QC	Quality Control
R-160	Rule 160 of the Aircraft Rule 1937
RWY	Runway
T	Temperature
TR	Tail Rotor
TGB	Tail Gear Box
UTC	Universal Coordinated Time
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omni Directional Range
VWS	Voice Warning System
wt	Weight
Wx	Warning
Yrs	Years