Ref. No. AV.15018/18/2011-DG

Date: 27th Feb 2012

REPORT

OF

COMMITTEE OF INQUIRY

ACCIDENT TO BSF (AIR WING) DHRUV HELICOPTER VT-BSH

AT KUNTI VILLAGE, NEAR RANCHI ON 19th Oct 2011

BY

CHAIRMAN

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

MEMBERS

Capt A Bhambhani **Helicopter Pilot**	**Dr. Subir K. Bhaumik** **Scientist G, NAL**	**Sh P K Chattopadhyay** **Jt. DGCA (Retd)**

SECRETARY

Sh Sanit 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 examination of various components. 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		
Sl. No.	Subject	Page

FINAL INVESTIGATION REPORT OF ACCIDENT TO BSF (AIR WING) DHRUV HELICOPTER VT-BSH AT KUNTI VILLAGE, NEAR RANCHI ON 19TH OCTOBER 2011

1	Helicopter		
		Type	Dhruv Helicopter (ALH Wheel Version)
		Nationality	Indian
		Registration	VT-BSH
2	Owner		Border Security Force (Air Wing), Ministry of Home Affairs, Nirman Bhavan, New Delhi
3	Operator		Border Security Force (Air Wing), Ministry of Home Affairs, Nirman Bhavan, New Delhi
4	Pilot – in –Command		Under Rule 160
	Extent of injuries		Fatal
5	Co-Pilot		CPL (H) 470
	Extent of Injuries		Fatal
6	No. of Passengers on board		One
	Extent of Injuries		Fatal
7	Last point of Departure		Birsa Munda Airport, Ranchi
8	Intended landing place		Chaibasa
9	Place of Accident		Kunti Village, near Ranchi. N23°10.492’. E085°25.452’
10	Date & Time of Accident		19th October 2011; 0315 UTC

(All timings in this report are in UTC)

SYNOPSIS

1. BSF Dhruv (ALH) helicopter Regn No VT-BSH departed Ranchi aerodrome for Chaibasa at 0309 UTC on 19th October 2011. The crew had obtained ATC approval to operate under Special VFR as reported visibility at the aerodrome was 1.5 km. Six minutes after take-off at a distance of 10 NM from Ranchi, the helicopter crashed over hilly terrain. It was destroyed due to the impact and post impact fire, killing all three occupants including two crew members. The helicopter had been requisitioned by Central Reserve Police Force. It was being operated by PHHL, a sub-contractor of HAL for Operation & Maintenance of the BSF ALH fleet.

2. The accident occurred during daylight. 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.15018/018/2011-DG dated 28.11.2011 to determine the causes and the contributory factors leading to the accident. The Committee issued a public notification in the leading newspapers of Jharkhand asking public opinion on the cause or circumstances leading to the accident.

3. Investigation revealed that the accident was caused due to loss of Situational Awareness wherein the flight crew got spatially disorientated. As a result, the helicopter went beyond the flight envelope exceeding its structural limits and thereby leading to failure of the rotor system. The Pilot had inadvertently entered clouds while executing a turn to return back to the base for a cautionary landing, due to 'Tail Gear Box Hot' warning. The route weather was marginal. The contributory factors for the accident were inadequacies in IF experience, training/ knowledge of aircraft systems and failure of Cockpit Resource Management. ALH being a recent induction in PHHL, crew's experience on type was limited which hindered effective use of onboard systems for a recovery. HAL's product support to the aircraft operator and monitoring its sub contractor activities were considered inadequate.

4. In view of the above findings, the Committee recommends that PHHL must evolve a comprehensive induction plan for conversion training and consolidation flying of the pilots with no previous experience on multi engine helicopters and IFR operations. HAL should review the conversion training standards for ALH to accommodate pilots from different backgrounds, with mandatory use of simulator. As manufacturer, HAL needs to enhance its support to the operators in terms of maintenance and training.

1. **FACTUAL INFORMATION**

1.1. **History of The Flight**.

1.1.1. Border Security Force (BSF) (Air Wing), Ministry of Home Affairs, New Delhi, the owner and operator of Dhruv helicopter VT-BSH had contracted its operation and maintenance activities to M/s Hindustan Aeronautics Limited (HAL) who further subcontracted these activities to M/s Pawan Hans Helicopters Limited (PHHL), New Delhi.

1.1.2. The helicopter was based at Ranchi to meet operational requirement of Central Reserve Police Force (CRPF) in Jharkhand sector. On 18th October 2011, a sortie was requisitioned to operate Ranchi-Chaibasa-Thalkobad-Trilposi-Ranchi sector on 19th October 2011 at 0245 UTC. The complete itinerary was expected to take approx 3 ½ hrs of flying.

1.1.3. On 19th October 2011, Daily Inspection of the helicopter was carried out by the Aircraft Maintenance Engineer (AME) and it was declared airworthy for the day's flight. The crew filed the Flight Plan at 0230 UTC on 19th October 2011. The plan had been faxed to Flight Information Centre (FIC) Kolkata on previous evening. FIC and ADC clearances were obtained well in time before commencement of the flight. At 0255 UTC, the helicopter requested for start with total of three personnel on board, two operating crew and one technician as passenger. The Air Traffic Control (ATC) informed that the prevailing visibility was 1500 m and all operations under Visual Flight Rules (VFR) had been suspended. The Pilot's request for special VFR flight, thereafter, was acceded to and start-up was approved by ATC. The helicopter took off from Ranchi for Chaibasa at 0309 UTC and was cleared for a direct routing to Chaibasa on radial 150 from RRC VOR at 6000 ft altitude. The helicopter was advised to initially climb and maintain altitude of 4600 ft till 15 NM. At approx 0313 UTC, the Pilot reported to ATC that the helicopter was 6 NM out of Ranchi and climbing, passing through 3700 ft. This was the last communication between the Pilot and the ATC tower. Time 0319 UTC onwards, several attempts were made to contact the helicopter but there was no response. Attempts were also made to establish contact with helicopter VT-BSH through other aircraft in the area but did not succeed. At 0334 UTC, Superintendent of Police, Kunti informed about the crash.

1.1.4. The helicopter had crashed at time 03:15:09 UTC and had been destroyed due to the impact and post impact fire. All three persons on board the helicopter had received fatal injuries.

1.2. **Injuries to Persons**.

Injuries	**Crew**	**Passengers**	**Others**
Fatal	02	01	Nil
Serious	Nil	Nil	Nil
Minor/None	Nil	Nil	Nil

1.3. **Damage to Helicopter.** The helicopter was completely destroyed due impact and post-accident fire.

1.4. **Other Damage.** Trees and the vegetation including paddy crops were damaged due to the crash and post-accident fire.

1.5. **Personnel Information.**

1.5.1. **Pilot-in-Command.**

Age	57 yrs
Licence	R-160
Date of Issue	01 Sep 2008
Valid up to	N/A
Category	N/A
Endorsements as Pilot in Command (PIC)	16th Jul 2009
Date of last Med. Exam	22th Jun 2011
Med. Exam valid up to	21 Dec 2011
FRTO Licence No	N/A
Date of issue	N/A
Valid up to	N/A
IR test done	25th Aug 2011
IR test due	24th Aug 2012

Total flying experience	5925 hrs
Experience on type	294:00 hrs (approx.)
Total flying experience during last 90 days	37:20 hrs
Total flying experience during last 30 days	Nil
Total flying experience during last 07 Days	Nil
Total flying experience during last 24 Hours	Nil

1.5.2. **Co-Pilot.**

Age	53 yrs
Licence	CHPL 470
Date of Issue	13 Aug 1999
Valid up to	13 Aug 2016
Category	CHPL
Endorsements as PIC	06th Sep 2011
Date of last Med. Exam	21st Jun 2011
Med. Exam valid up to	20th Dec 2011
FRTO Licence No	7662
Date of issue	14th Aug 2011
Valid up to	13th Aug 2016
Total flying experience	3340:30 hrs
Experience on type	34:00 hrs
Total flying experience during last 90 days	34:00 hrs
Total flying experience during last 30 days	16 :45 hrs
Total flying experience during last 07 Days	2:30 hrs
Total flying experience during last 24 Hours	Nil

1.6. **Helicopter Information**.

1.6.1. Dhruv (ALH) helicopter designed and manufactured by HAL, is a multi engine helicopter capable of operating in all weather and geographical conditions. More than 100 units of this helicopter in various versions have been manufactured and are being operated mainly by Indian Air Force, Army, Navy, Coast Guard and certain foreign countries. The helicopter is also being widely employed by paramilitary forces in insurgency environment. Since the civil variant was designed recently and is still in developing stage, the experience gathered for commercial operation is limited. Brief details of the helicopter are given below:

1.6.2. Passenger transportation:

Configuration	Pilot	Passenger
High density version	2	14
Standard version	2	9

Maximum takeoff weight 5,500 kg

Engine: 2 Nos.

TURBOMECA ARRIEL TM 333-2B2 turbine engine

Max Continuous power : 2X 568 kW

Take off Power : 2X 640 kW

At Max Take off weight of 5,500 Kg

Maximum speed (Vne)	155 kts /287 km/h
Fast cruise speed	110 kts
Range with standard tank	638 km
Rate of climb at Take off Power	2050 ft/min at Sea Level
Service ceiling	20,000 ft
Hover ceiling IGE	7000 ft at ISA Condition
Hover ceiling OGE	6000 ft at ISA Condition

1.6.3. Details of the Helicopter

Helicopter Regn. No	VT- BSH
Helicopter Model	Dhruv (ALH)
Name of Manufacture	HAL, India
Helicopter Sl. No	DW 63
Certificate of Airworthiness	6031
Date of issue	31.03.2009
Validity	30.03.2014

Certificate of Registration	3922/2
Date of Issue	23.03.2008 initial and 16.09.2009 subsequently.
Total Hrs Since New	483.47Hrs (as on 13.10.2011) before the last flight
Last Major Schedule carried out	100 Hrs inspection/3 Monthly at Air Frame Hrs 449:27 on 7.9.2011
25Hr/01 month inspection	At 472:52 Hrs of Airframe on 01.10.2011
Engine Make and Model	Turbomeca, TM333 - 2B2
Engine Serial No. (LH)	1236
Date of Manufacture	10th December 2008
Engine Serial No. (RH)	1247
Date of Manufacture	23rd January 2009.

Repetitive snag reported in Last 15 days - Nil

Snags reported in last 30 days - Nil

List of Avionics items fitted:

ELT Make and Model	: Smith 503-1.
Check on ELT	: As per Pre flight 'To Arm'.
ELT Battery status	: Expiry due on June 2015
G Switch Part No 503-7	: Expiry on 21/02/2013.
VHF Main	: Chelton; VCS 40 B.
VHF Stand-by	: Chelton; VCS 40 B.
HF Main	: Honeywell; KHF 1050.
ADF	: Chelton; DFS-43-A.
VOR	: VNS41B.
ILS system	: Chelton; VNS41B.
Glide path Recvr.	: Chelton; VNS 41B.
Marker Recvr.	: Chelton; VNS 41B.
ATC Transponder	: Honeywell; MST67A.
Radio Altimeter	: Honeywell KRA405B.
GPS	: Honeywell KLN900.
Weather Radar	: Teleponics; RDR 1400C.
DME Interrogator	: Chelton DMS 44 A
Compass	: DR and RR

1.6.4. Engine power check 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. Scrutiny of Engine log book revealed that recording of Cycles and creep data was irregular. The last Engine power check was carried out on 02nd Oct 2011. The torque and T4 margin have been recorded as given below:

On #1 Engine: 1% and 30°C
On #2 Engine: 0% and 34°C

1.6.5. Record of operation for the last few days was not available as the engineering department had failed to remove the required copy of the Technical Log Book for preservation and the whole Tech Log Book placed in the helicopter was destroyed by the post-crash fire.

1.7. **Meteorological Information.**

1.7.1. The helicopter took off from Ranchi Airport for Chaibasa at 0309 UTC. The meteorology (Met) report issued at Ranchi from 0230 UTC to 0400 UTC on 19th October 2011 is given below:

0230 Wind 340/05 kt, Visibility 1500 m, BR CLD FEW 1500 ft, BKN 10000 ft, T 23, DP 22, QNH 1012 HPA and QFE 937 HPA.

0300 Wind 320/06 kt, Visibility 1500 m, BR CLD SCT 1500 ft, BKN 10000 ft, T 24, DP 22, QNH 1011 HPA and QFE 936 HPA.

0330 Wind 320/06 kt, Visibility 1500 m, BR CLD SCT 1500 ft, BKN 10000 ft, T 24, DP 21, QNH 1012 HPA and QFE 936 HPA.

0400 Wind 320/05 kt, Visibility 1800 m, BR CLD SCT 1500 ft, BKN 10000 ft, T 26, DP 22, QNH 1012 HPA and QFE 936 HPA.

1.7.2. INSAT 3A picture of 0300 UTC is shown in Fig.1. The satellite picture shows presence of a Deep Depression over the Bay of Bengal. Associated low and medium level clouding can be seen over Ranchi and adjoining areas.

1.7.3. The prevailing conditions were well below VMC due to which all the VFR flights had been suspended. The helicopter requested for special VFR permission, which was agreed to by ATC.

1.7.4. The clouding reported by Ranchi Met was 'Few' at 1500 ft. However, the SAR helicopter which flew in the area approx two hours after the accident had reported significant clouding 5 NM out of Ranchi and at the crash site. The Pilot of the SAR helicopter had reported heavy clouding above 1000 ft from approximately 5 NM distance out from Ranchi. For the search and rescue, they had to maintain below 1000 ft AGL. This corroborates the CVR details wherein the Pilot had commented on excessive clouding while climbing through 1500 ft AGL.

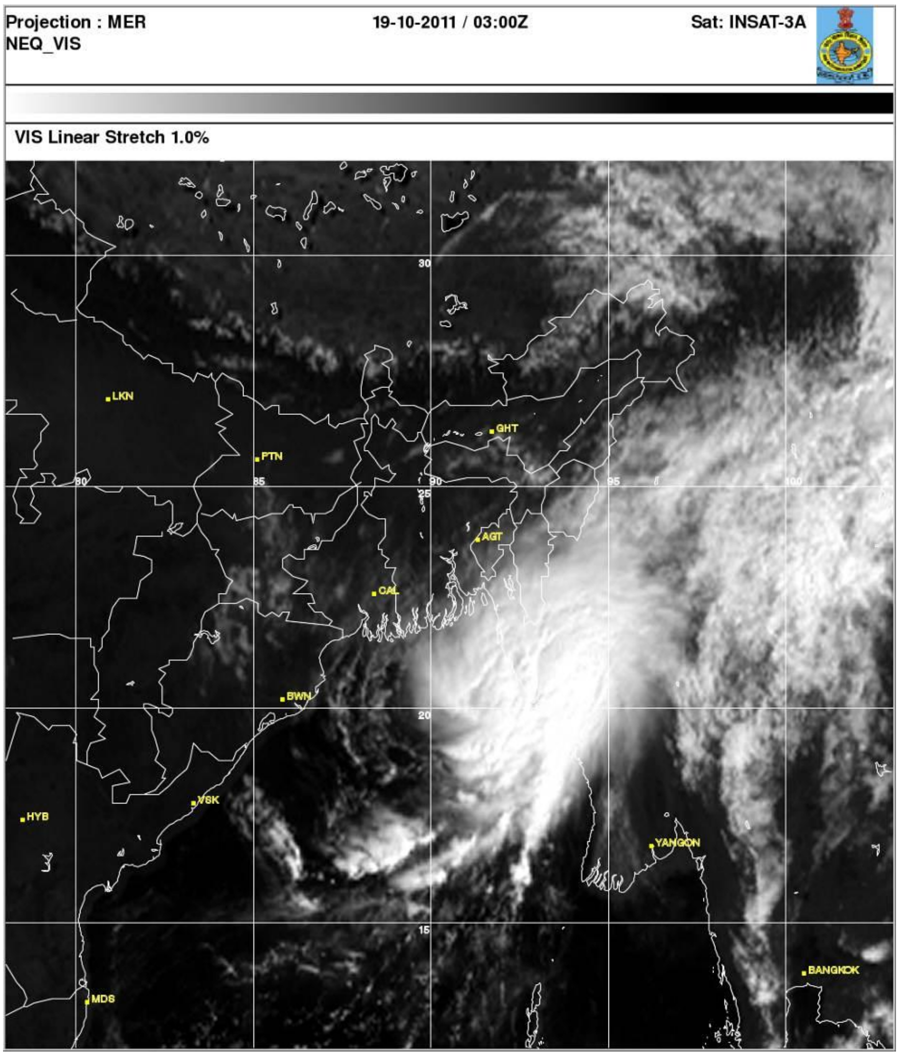

Figure 1 INSAT 3 A picture for Ranchi area of 0300 UTC 19th October 2011

1.8. **Aids to Navigation.**

1.8.1. The helicopter VT-BSH took off from Birsa Munda Airport, Ranchi normally at 0309 UTC. The airport at Ranchi is equipped with following Radio Navigation and Landing Aids:

Sl. No.	Type of Aid installed	Operating Frequency
1.	DVOR	116.9 MHz
2.	VOR DME	1140/1203 MHz
3.	NDB	285 kHz
4.	LLZ 31 (ILS CAT-I)	110.5 MHz
5.	GP31	329.6 MHz
6.	ILS DME (LP)	1066/1003 MHz

1.8.2. The helicopter VT-BSH was equipped with following Navigation Equipment:

ADF	: Chelton; DFS-43-A
VOR	: VNS41B
ILS system	: Chelton; VNS41B.
Glide path Recvr.	: Chelton; VNS 41B
Marker Recvr.	: Chelton; VNS 41B
ATC Transponder	: Honeywell; MST67A
Radio Altimeter	: Honeywell KRA405B
GPS	: Honeywell KLN900
Weather Radar	: Teleponics; RDR 1400C
DME Interrogator	: Chelton DMS 44 A
Compass	: DR and RR

1.9. **Communications**.

1.9.1. The airport at Ranchi is equipped with Very High Frequency (VHF) communication and the VHF working frequency is 118.05 MHz. The channel had recording facilities. The replay of the stored communication revealed that the Pilot was in continuous contact with ATC up to 0313 UTC. There was no response to ATC calls thereafter, even when other departing/arriving aircraft were in two way communication. The ATC tried to contact VT-BSH several times after 0319 UTC but no contact could be established.

1.9.2. The helicopter was equipped with following Communication Equipment:

VHF Main	: Chelton; VCS 40 B
VHF Stand by	: Chelton; VCS 40 B
HF Main	: Honeywell; KHF 1050

1.10. **Aerodrome information.** The helicopter VT-BSH took off normally from Ranchi Airport; also known as Birsa Munda Airport. The airport is fully managed and controlled by Airports Authority of India. Basic details of Ranchi Airport are given below:

Aerodrome Reference Point coordinates	231851.3N 0851915.8E
Elevation/Reference temperature	654.53 m(2148 ft)/38°C
Types of traffic permitted	VFR/IFR
Category for fire fighting	CAT-7 between 0340 UTC to 1410 UTC daily
Runway designation	13 / 31
Strip dimension	2833 x150 m
ATS Air space lateral limits	25 NM; centred at 231901.3N, 0851918.8E NDB “RC”.
Vertical limits	6000 ft MSL
ATS communication facilities	VHF “TWR” & DATIS
Navigation and landing Aids	DVOR, VOR DME, NDB, ILS CAT-I LLZ31, GP 31& ILS DME (LP)

The helicopter crashed while enroute to Chaibasa.

1.11. **Flight Recorders.**

1.11.1. Dhruv helicopter VT-BSH was fitted with Cockpit Voice and Data Recorder Model No. FA2300, Part No. 2316-1501-01. The recording unit was severely damaged externally because of prolonged exposure to fire (refer Fig.2). However, the data captured by the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) was stored and could be recovered.

Figure 2 Recovered FDR/CVR of VT-BSH Helicopter

1.11.2. **CVR Analysis.**

1.11.2.1. The CVR of the helicopter 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 the audio warnings which were recorded and correlating them with the FDR.

1.11.2.2. Information gathered from the CVR recordings is detailed below. The timings referred to in the CVR are FDR timings that are 20 min 44 sec behind UTC.

- Co-Pilot had arrived at the helicopter early to feed the flight plan in GPS. He could feed only one point before Captain's arrival since he was not effectively familiar with its usage.
- Captain asked the Co-Pilot if he has the communication frequency of Kalaikunda. The Co-Pilot did not have the details and referred to relevant document to obtain the same.
- Captain told the Co-Pilot to feed the second way point in the GPS and complete the remaining in air.

- Pre Flight Checks and Checks before/ after Start were not carried out in the prescribed manner.

- The crew asked for Special VFR on being informed that VFR operations had been suspended on account of visibility which was reported as 1500 m. Special VFR was cleared by ATC.

- At time 2:47:17, the Pilot had called out “Why is…Yeh Dekh”. The phrase relates to the Master Warning (MW) that was flashing intermittently during hover from 2:47:05 to 2:47:37 (as per the FDR recording). Main Gear Box Pressure No 1 (MGB Pr #1) Warning was triggering the MW. The flashing was intermittent and was for less than one second duration, each time. Hence, the crew was unable to identify the system activating MW. The crew however, did not try to ascertain the un-serviceability and proceeded with the sortie.

- Power used during the hover was suspected to be marginally higher as made out from crew conversation but the discussion was based on approximation, as power required had most likely not been calculated before the flight. On calculating the Torque (Q) required for hovering from the Flight Manual and comparing the same with FDR recording, it was seen that the actual Q being used at hover was within the limits as given in the Flight Manual.

- At time 2:49:28, the crew tried to engage Air Speed and Heading (Hdg) mode on the Automatic Flight Control System (AFCS) wherein Air Speed mode was engaged with difficulty and the Hdg bug was set to 360 by the Co-Pilot, instead of the required heading of 140. This indicates insufficient knowledge of the Co-Pilot on AFCS and Electronic Flight Instrument System (EFIS) usage.

- At 2:51:29, the Co-Pilot selected the Weather Radar on and at 2:51:45, the Pilot called out “Yahan Clouding Kafi Hai”. These two occurrences indicate en-route clouding. The helicopter was climbing passing through 3500 ft at this time as per the FDR.

- At 02:53:37, the MW came on along with ‘TGB HOT’ on the Centralised Warning Panel (CWP) and the same was observed by the Pilot. The

Co-Pilot calls out action to be taken as ‘Land as soon as possible’ and the technician in the passenger seat also confirms the same. The Pilot decides to turn back to Ranchi, after consulting the Co-Pilot.

- At 2:54:01, the Co-Pilot called out “Direct to VEDX” implying GPS being set for direct navigation to Kalaikunda. This action was flawed and indicates confusion in Co-Pilot’s mind. The helicopter was barely 10 NM out of Ranchi and the Pilot was executing a left turn for returning to Ranchi.

- At 2:54:08, the Audio Warning System (AWS) and Audio Alarm for Torque came on, indicating that the Torque had exceeded 91% on one or both engines.

- From time 2:54:09, the background noise recorded is found to increase due to the increase in helicopter airspeed, which is also corroborated by the FDR data.

- At time 2:54:22, AWS for high rotor warning indicates Nr beyond 106.5%. After first three beeps of this warning, an increase in sound by 6 dB is heard, lasting for 0.7 seconds. Last two beeps of the high rotor warning can also be heard in the background. At time 2:54:25, once again increase in back ground sound by 6 dB is heard which lasts for 0.5 seconds and immediately thereafter, the CVR recording is found to stop at time 2:54:25.5.

- No communication between the Pilots was recorded from time 2:54:01 till the end of recording.

1.11.3. **FDR Analysis.** The FDR of the helicopter records parameters in eight groups. The FDR was analysed to determine the sequence of events during the subject flight. The time stamp recorded in the FDR is of its own clock, which is 20 min 44 sec behind UTC. All timings mentioned below in the FDR analysis are FDR timings.

1.11.3.1. **Recording of AFCS Data**. The data recording was scrutinised and it was found that Gp 7 and Gp 8 parameters, which were supposed to record the AFCS status had not been recording the same. On enquiring, it was revealed that the fault had been observed by HAL during scheduled FDR data review at its facility and was communicated to PHHL through routine reports on FDR analysis. The deficiency, was missed out at PHHL and no corrective action was initiated. HAL also did not initiate any corrective action to rectify the fault either as manufacturer or maintenance contractor. The matter was also not communicated to BSF. Absence of AFCS data impeded the investigation in determining the sequence of actions taken by the Pilot.

1.11.3.2. **Barometric Altitude and Air Speed**. The barometric (baro) altitude, indicated airspeed and true airspeed of the helicopter are detected by Air Data Unit (ADU) 1 & 2 and the data from ADU 1 is transmitted to AHRS 1 & 2 which further transmits the same to the FDR for recording. The Attitude Heading Reference System (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 ADU provided the baro altitude, corresponding to standard QNH setting (1013 mb), which requires to be corrected for the prevailing QNH, and this was 1011 mb at the time of take-off at Ranchi. Hence, the altitude as recorded in the FDR needs to be reduced by 54 ft for getting the altitude of the helicopter. The recording of altitude and the airspeed was satisfactory till time 02:54:16, approx 11 seconds before the end of recording. At time 02:54:16 and 02:54:17 respectively, both the AHRS have recorded anemometer and barometer faults. In addition, lag introduced due to very high rate of descent of the helicopter at that point in time, coupled with excessive pitch and bank attitudes renders the altitude and airspeed recorded in the FDR suspect. The exact error however, could not be quantified. And hence, all references to baro altitude and airspeed in the last phase of flight are approximations.

1.11.3.3. **Warnings and Cautions**. Activation of MW along with a number of critical warnings and status messages are recorded in Gp 3 and Gp 4 of FDR parameters. Once activated, the MW warning remains on until reset by the crew or till such time the parameter causing the activation become normal. The FDR record of MW and other failures/status messages was studied to ascertain the failures that the crew had encountered during the flight.

1.11.3.3.1. **MW Activation at Hover**. MW along with the MGB PR#1 was found to be flashing intermittently from 2:47:05 to 2:47:37 during the hover phase of flight. The activation of MW was observed by the Crew as seen in the CVR recording. The details of MW activation while at hover are given in Table 1:

Table1 Occurrences of MW Activation during Hover Phase

FDR Time	Master Warning	MGB PR#1
02:47:05	ON	
02:47:05	ON	ON
02:47:08		ON
02:47:09	ON	
02:47:14		ON
02:47:14	ON	ON
02:47:15	ON	
02:47:18	ON	
02:47:19	ON	
02:47:22		ON
02:47:23	ON	
02:47:36		ON
02:47:36	ON	

The MW and MGB PR#1 warning (Wx) had been activated on multiple occasions while the helicopter was at hover. In spite of noticing these transient warnings, the crew however, decided to continue with the flight.

1.11.3.3.2. **<u>MW Activation during Terminal Phase</u>**. The flight had been uneventful till 02:53:37 when the Pilot noticed the Master and “TGB Hot" warnings. Since TGB Hot is not a parameter recorded in the FDR, the activation of the MW was linked with TGB Hot through CVR analysis. The record of activation of MW and other failures from time 02:53:37 as recorded in the FDR are given in Table 2.

Table 2 List of Activation Master Warning Activation during Terminal Phase of Flight

FDR Time	**Duration**	**Warnings Recorded in FDR**	**Remarks**
02:53:37	15 sec	Master Warning	Not recorded in FDR. Correlated to TGB HOT Wx through CVR
02:53:52.5	6.5 sec	Master Warning	No Wx recorded in the FDR/CVR
02:54:00	1.5 sec	Master Warning	No Wx recorded in the FDR/CVR
02:54:02	01 sec	Master Warning	No Wx recorded in the FDR/CVR
02:54:05	0.5 sec	Master Warning	No Wx recorded in the FDR/CVR
02:54:08.5	0.5 sec	Master Warning	Correlated to Torque through CVR and

FDR Time	Duration	Warnings Recorded in FDR	Remarks
			FDR
02:54:10	3.5 sec	Master Warning	Related to MCR Wx and MGB Pr#1
		MCR Eng 1 &2	MCR Eng 1 & 2 recorded for 01 second at 02:54:10
		MGB Pr#1	MGB PR#1 recorded for 0.5 second at 02:54:11.5
02:54:21.5	4.5 sec - till end of recording	Master Warning	
		Hi Rotor	Correlated with High Rotor audio of 01 sec duration from FDR and CVR
		HYD 1	Hyd 1 failure recorded from 02:54:24 till end of recording
		HYD 2	Hyd 1 failure recorded from 02:54:23 till end of recording
		MGB PR#1	MGB Pr#1 failure recorded from 02:54:23 till end of recording
		MGBPR#2	MGB Pr#2 failure recorded from 02:54:23 till end of recording
		FLT/ACCR	FLT/ACCR Drv status recorded from 02:54:23 for 01 second
		FREE WHL YL	FREE WHL YL status recorded from 02:54:23 for 01 second
		Manual Radio #1	Manual Radio #1 recorded from 02:54:23 till end of recording

1.11.3.3.3. As can be seen from Table 2, the MW was activated repetitively after TGB Hot warning. Specific reason for its activation, on some of the instances could not be determined, in absence of associated warning in FDR and CVR. Possible causes of the MW activation for these instances are listed below:

- **Failure of AFCS**. This could not be determined, as FDR was not recording AFCS status in Gp 7 and Gp 8.
- **Degradation of AFCS**. Minor degradation in AFCS could also have resulted in the MW activation.
- **TGB Hot Wx.** TGB Hot Wx could have been intermittent that would have activated the MW.

1.11.3.3.4. Repetitive activation of MW, TGB Hot caution and prevailing weather conditions have led to situational overload where in the Pilot’s attention got diverted from the instruments to analysing the failures.

1.11.3.4. **Pilot's Handling of Emergency**.

1.11.3.4.1. In the event of TGB Hot warning coming on, as part of the emergency actions, the Pilot was required to reduce speed to 60-70 kts and land as soon as possible (ASAP). Since the helicopter was only 10 NM out of Ranchi, the crew decided to return back to Ranchi for which the Pilot initiated a turn to the left for returning back to Ranchi at time 2:53:54 with helicopter at 4461 ft and 102 kts. No action was taken to reduce the speed to 60-70 kts. Subsequent events that lasted for 32.5 seconds are appended in succeeding paragraphs and have been divided into three phases for clarity and better understanding

1.11.3.4.2. **Phase I - Commencement of Turn (2:53:54 to 2:54:03).** The Pilot moved the cyclic laterally to the left by 8.7% for initiating a turn and a roll rate was set up. The Pilot maintained the control input for nearly 10 seconds that resulted in continued increase, in left bank, reaching 31° in 9 seconds. The control inputs given for this turn were compared with inputs used in earlier left turn, at the time of departure from the aerodrome. It was observed that only 4% of lateral cyclic input was used for 2 to 3 sec for the earlier turn. Large lateral cyclic input and unchecked roll beyond 30° bank suggest that the Pilot intended to execute a tight turn on limited Attitude Director Indicator (ADI) reference. The Pilot apparently had not completed transition from visual references to instruments. In addition, the MW had got activated thrice during this period (associated failure not recorded in the FDR). This could have been possibly caused by degradation, failure or inadvertent switching off of the AFCS or TGB Hot Wx. Repetitive activation of MW would have diverted Pilot's attention; possibly because of shifting of focus to establish the cause of failure.

1.11.3.4.3. **Phase II - Loss of Orientation (02:54:04 to 02:54:20).** Analysis of the Pilot's actions and consequent effects during this period, revealed the following.

1.11.3.4.3.1. Due to the large lateral cyclic input and unchecked roll, the helicopter had developed a roll rate of 8.9°/sec to the left. After which, the Pilot now tried to reduce the roll rate and the bank angle, by giving right cyclic input of 15.5% in 06 sec. This was however, slow and insufficient to arrest the roll; and the bank, continued to increase, going up to -56.7°. Concurrently, the cyclic was also moved forward by 13% which lowered helicopter's pitch attitude to -21.9°, leading to a high rate of descent. The pilot rapidly raised the collective to arrest the descent, resulting in Main Rotor RPM (N_R) dropping to 95%. This was accompanied by activation of MW and Low Rotor RPM & MCR audio warnings. The Pilot lowered the collective rapidly to 47.7%, to recover the rotor RPM maintaining the lateral position, the cyclic was moved backwards to 57.7%. The rapid lowering of the collective led to continued pitching down to -29°.

1.11.3.4.3.2. In next three seconds (02:54:12 to 02:54:15), the cyclic was once again moved forward to 81% thereby further lowering the nose and resulting in rapid increase in helicopter speed to 140 kts, accompanied by rapid loss of altitude. The Pilot raised the collective to 87%, to arrest the rate of descent. No attempt was, however, made to raise the attitude or take off the bank. From 02:54:16 to 02:54:20, the cyclic was moved rearwards and then forward again, while in the lateral axis the cyclic was once again moved to the left by 7%. Consequent to these inputs, the helicopter continued to roll left and pitch down, reaching extreme pitch down attitude of -74° and bank angle of -105°. The helicopter speed increased rapidly to 172 kts, and the ROD became very high. The helicopter had reached 3083 ft by this time, losing about 1400 ft since commencement of the turn.

1.11.3.4.3.3. The Pilot's actions are indicative of setting in of spatial disorientation during this period, in all probability due to inadvertent entry into clouds during the turn. Reduced visibility conditions such as while flying in clouds greatly increase the risk of spatial disorientation. Spatial disorientation occurs when the pilot develops an incorrect perception of helicopter attitude, altitude or motion relative to the Earth's surface. It results when a pilot's normal visual cues to helicopter attitude are inaccurate, unavailable or inadequately monitored and the pilot, instead, relies on other cues to helicopter attitude that may be misleading. Situational risk factors for spatial disorientation transition between VMC and IMC that require the shifting of visual attention between external visual references and cockpit flight instruments accompanied by high workload. Spatially disoriented pilots are at risk of making inappropriate control inputs that can result in loss of helicopter control.

1.11.3.4.3.4. The control inputs discussed below clearly indicate that the Pilot was disorientated and was not relying on instruments:

- Large control inputs given, especially in forward direction, even though the helicopter was already in a steep nose down attitude.

- Insufficient lateral control input to hold off the bank and to neutralise the roll rate to the left, thereby allowing the helicopter to go into an extremely high bank angle (-105°) condition.

1.11.3.4.4. **Phase III – Loss of Control (02:54:20 to 02:54:25.5).**. Realisation of the steep nose down attitude (-74°) and bank to the left (105°), the Pilot applied large cyclic inputs to the rear and right. The cyclic was moved rearwards by 35.4% and to the right by 22.9% along with raising the collective by 10% (83% to 93%). These large control inputs were applied with helicopter air speed in excess of 170 kts, which is greater than the V_{NE} for the ambient conditions. The effect of these control inputs is discussed in the following paragraphs.

1.11.3.4.4.1. **Main Rotor RPM (N_R) and Longitudinal Acceleration (N_Z)**. As a result of large rearward cyclic input, the helicopter experienced a flare effect wherein the N_R increased to 109.7%. Due to the rearward cyclic application, the longitudinal acceleration (N_Z) as recorded, increased from 1.4 g to 3.3 g. Immediately after the cyclic input to the rear, at time 02:54:22.5, the N_R reduced from 109.7% to 76% in 0.5 sec and continued to wind down, becoming zero, thereafter, in the next one second. This rapid deceleration in N_R implies damage to the rotor system. Max N_Z recorded at time 02:54:22.5 was 4.3 g. Since the N_R at that time was already winding down to below the normal operating range, no control power would have been available to achieve the high value of N_Z. This implies that maximum N_Z would have been reached between the time period of 02:54:22 to 02:54:22.5. The peak value thus would have been higher than 4.3 g but that was not recorded since its occurrence was in the time interval between two samples. In the last 2.5 seconds of recording, the N_Z value is found to go below 1.0 g and further to negative values. This corresponds to the period when the helicopter was partially inverted with max bank angle recorded at -151.2°.

1.11.3.4.4.2. **Aircraft Attitudes and Accelerations**. The effect of large cyclic control application was observed on helicopter pitch and roll rate, and subsequently on the helicopter attitude. Details are given in succeeding paragraphs.

1.11.3.4.4.2.1. **Pitch Rate and Pitch Attitude**. Immediately on application of the cyclic input to the rear, the pitch rate was found to change from 7.9°/sec to 51.1°/sec at time 02:54:22.5. Within the next 0.5 sec, the pitch rate reduced to 32.3°/sec and further reduced to -33.3°/sec over the next 01 sec. As a result of this cyclic input, the pitch attitude initially changed from -74.7° to -31.1°. However, as the pitch rate went negative, the pitch attitude once again reduced to -68.9° and remained in that region till end of recording, although the cyclic position was fully back. This also coincided with the time when the N_R was winding down to zero.

1.11.3.4.4.2.2. **Roll Rate and Bank Angle**. At time 02:54:21.5, the cyclic was moved to $_{right}$ by 15.3%, which resulted in the roll rate changing from -15.4°/sec to 20.2°/sec (change of 35.6°/sec in 1.5 sec) and the bank angle from -102.7° to -32.1°. However, at time 02:54:23, the roll rate was found to change abruptly from 20.2°/sec to - 83.7°/sec (change in roll rate of 100°/sec to the left) in 0.5 sec. Since the N_R during this period was reducing from 109% to 76% (below the normal operating range), there would have been no control power available to generate such a high roll rate.

1.11.3.5. **Mast Moment Indication (MMI).** The MMI recording in the last 05 seconds was studied. It was observed that it had incrementally increased along with the indicated speed. The maximum MMI was recorded immediately after the Pilot applied the cyclic control to the rear. The large cyclic input at high speed would have caused the MMI to exceed beyond the cleared limits.

1.11.3.6. Analysis of the above flight parameters and control inputs, indicate that most probably, the Pilot had regained visual references at a very late stage whereon he had applied large control inputs in an attempt to recover the helicopter. The control application was done at a stage where the helicopter was already beyond its cleared flight envelope. The large application of controls further aggravated the situation, taking the helicopter well beyond its structural limit resulting in damage to the rotor system.

1.11.3.7. **Engine Parameters**. The engine parameters as recorded in the FDR were analysed to check for functioning of the engines. The engine operation had been normal till time 02:54:21.5 where after in the last 04 sec of FDR recording, the N_F, $N_{G,}$ Q and TGT values of both engines were found to wind down. The reason for this could not be ascertained. However, this does not have relevance since the rotor system had already been damaged by this time.

1.11.3.8. **Radio PTT.** The FDR records activation of 'Press to Transmit (PTT)' button of the Pilot as well as Co-Pilot stations. It was observed that the Pilot PTT had been engaged in the last three seconds of data recording indicating that the Pilot had tried to transmit. No voice recording was found in the CVR for the corresponding period, which indicates that the situational load on the Pilot was so high that in spite of trying he was unable to transmit.

1.12. **Wreckage and Impact Information**

1.12.1. The helicopter VT-BSH crashed in a hilly and forested terrain. As per the eyewitness accounts, one blade of the helicopter had separated in air from the helicopter. The same (Green Blade) was found in Mara Buru village, 1.2 km away from the main wreckage site. The main wreckage of the helicopter was lying in a North – South orientation. The damage to the tree tops also indicated that the helicopter was descending in a southerly direction. The tail boom was found to have got separated from fuselage and lying un-burnt along with the tail rotor assembly, tail gear box, tail rotor control rod and drive shaft; all these were lying upside down with the horizontal stabilizer and other accessories. The Integrated Dynamic System (IDS) was found lying by the side of tail boom in un-burnt condition. The fire consumed the complete cabin along with all the accessories. The available evidences indicated that the fuselage impacted with the ground at a high speed in an inverted condition with steep nose down attitude. The impact was on a surface having slope causing the fuel to spill uni-directionally up to a distance of approx 80 ft in the down hill direction, and approx 20 ft in the uphill direction. The spillage of fuel and the subsequent fire, damaged the paddy plantation and the trees in the uphill area. The main wreckage was confined to within 12-15 m except for the main rotor blades, which were found broken and lying away from the wreckage. The distribution of the separated parts with respect to the main wreckage is given below:

Wreckage Positions	**Lat/Long**	**Distances**	**Bearings**
Main Wreckage	23°10.492N 85°25.452E	Reference Point	Reference Point
Wing Stub	23°10.515N 85°25.408E	0.08623 km	299° 37’ 23”
Antenna	23°10.515N 85°25.412E	0.08038 km	302° 01’ 29”
Blue Blade	23°10.489N 85°25.381E	0.1211 km	267° 22’ 06”
Part of MRB L/E	23°10.483N 85°25.385E	0.1154 km	261° 41’ 13”
Red Blade found on tree	23°10.512N 85°27.443E	0.04011 km	337° 31’ 33”
Yellow Blade	23°10.466N 85°25.431E	0.06002 km	216° 35’ 41”
Part of Green Blade	23°10.830N 85°26.077E	1.235 km	059° 31’ 57”

1.12.2. The map of the area showing the distribution of the wreckage is given in Fig.3. Photographs of the main wreckage, rotor blades and other accessories are shown in Fig.3-11.

Figure 3 Satellite view of the area of crash with wreckage distribution

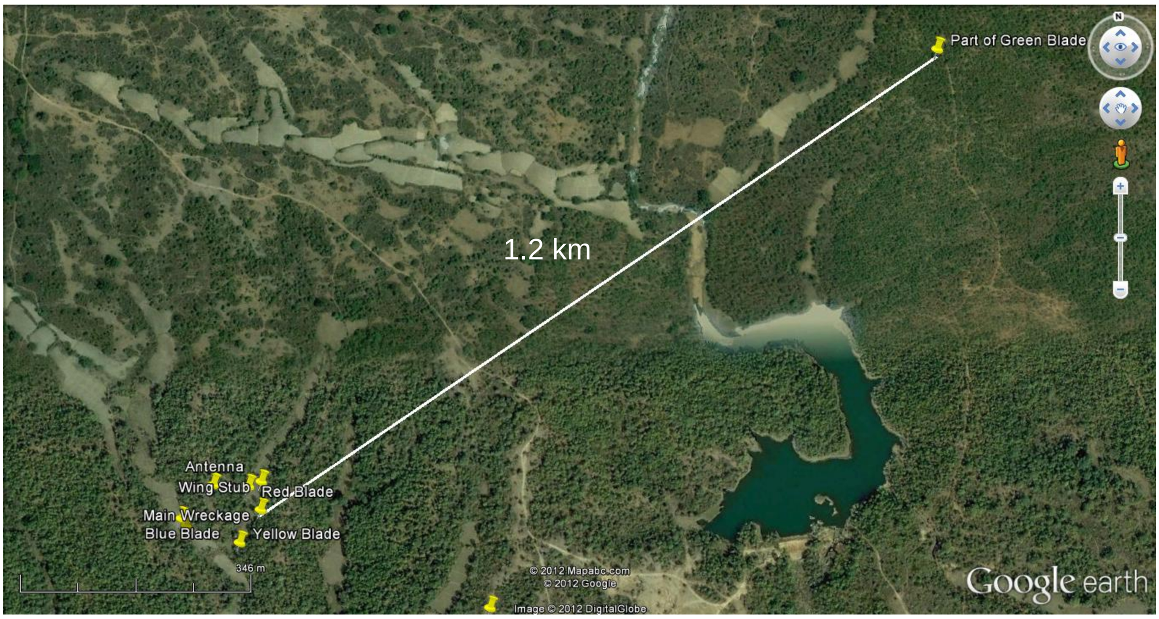

Figure 4 Satellite view of main wreckage and place from where part of green blade was found

Figure 5 View of the main wreckage

Figure 6 View of main wreckage area

Figure 7 View of MRH with Green blade attached and un-burnt tail boom with horizontal stabiliser and tail rotor assembly

Figure 8. Portion of Green Blade recovered from Vill Mara Buru 1.2 km from Main Wreckage

Figure 9 Blue blade found lying in a paddy field at distance of 121 m from the main wreckage

Figure 10 Yellow blade found lying at a distance of 60 m from the main wreckage

Figure 11 Red blade found hanging on the top of a tree

1.13. **Medical and Pathological Information.** The helicopter VT-BSH took off with two operating crew and one passenger on board. Approximately after six minutes of flying, the helicopter crashed. The main fuselage of the helicopter was completely destroyed due to the post crash fire. All the three persons on board the helicopter received fatal injuries due to the impact and subsequent fire. The remains were subjected to post mortem as per the regulatory requirement, which did not reveal any noticeable observations for further investigation.

1.14. **Fire.** There was evidence of post impact fire. The fire was very intense because of spillage of fuel onboard. The fire got extinguished itself after all the burning materials were exhausted.

1.15. **Survival Aspects.** The helicopter VT-BSH took off at 0309 UTC for Chaibasa on direct routing at Radial 150. It was in contact with ATC up to approx 0313 UTC at which time, the Pilot reported its position to ATC as 6 NM outbound Ranchi and passing through 3700 ft in order to climb level 4600 ft. This was the last communication between the Pilot and the ATC tower. At 0319 UTC, the ATC tried to contact the Pilot several times, but did not get any response. The tower relayed to the incoming/overhead traffic for establishing contact with the helicopter VT-BSH, but the effort was not successful. At 0334 UTC, Superintendent of Police, Khuti informed about the crash, but the details could not be gathered immediately because of network failure. The search and rescue operation was initiated, and Govt. of

Jharkhand helicopter was pressed into action for locating the accident site. At 0607 UTC, the crash site was located. The accident took place in a hilly and forested terrain. All the three persons on board the helicopter received fatal injuries due to impact and post accident fire.

1.16. **Tests and Research.** A few parts of the helicopter VT-BSH, recovered from the accident site were sent to HAL, Bangalore for detailed failure analysis under the supervision of Accident Investigation Team members. The salient features of this analysis are summarized below.

1.16.1. **Main Rotor Blades.**

1.16.1.1. Examination did not show any characteristic hit marks on any of the available parts of the Main Rotor Blades (MRB) (refer Fig.12-15). This clearly indicates that all the four MRBs had got separated from the IDS in air and not due to impact with any objects. Three of the four blades, viz., red, blue and yellow blades got separated from the IDS by fracturing the hub plates. In all these cases, the failure of the hub plates were found to be identical such that the top hub plate fractured at the hole position while the bottom hub plate got fractured at the main bolt location.

1.16.1.2. The failure patterns suggest that the fracturing of the hub plates took place under tensile load superimposed with upward bending. Under the loading conditions mentioned above, the top hub plate would have been under compressive load and the main bolt head collar would press against the plate. The concentrated compressive load by the bolt head collar would result in fracturing of a few laminates at this location. Once this failure occurs, the load bearing capacity of the hub plate would reduce, leading to further bending of the plate followed by fracture at the hole position. In contrast, the main bolt hole on the bottom hub plate would be under tensile load and hence, the fracture on this plate is expected to occur across the hole itself. The failure patterns seen on the red, blue and yellow blades substantiate this hypothesis.

1.16.1.3. Examination revealed that the green blade has failed from the transition zone and there was no external damage at this fracture location. There were no evidences to suggest that the blade failure was due to impact with any object. It appears that this blade has failed under aerodynamic loads superimposed with excessive twisting of the blade.

1.16.1.4. Based on the wreckage distribution and the laboratory analysis, it appears that the green blade has failed first in air. Followed by this, the other three blades got separated from the IDS by fracturing the hub plates. The primary reason for the failure of the blades appears to be excessive aerodynamic loads. There were no evidences to suggest that any deficiencies in the blades or blade assemblies were responsible for the failure.

1.16.2. **Tail Rotor Gearbox (TGB)**

1.16.2.1. Examination of the components of the tail rotor gearbox did not show any abnormalities and none of the components showed any signatures of distress. There were no evidences of oil starvation in the TGB. The drag torque measured was found to be normal indicating that there was no heavy torque on the TGB. Therefore, the display "TGB Hot" warning could be because of malfunctioning of temperature sensor or switch or due to problems with the Helicopter wiring.

1.16.2.2. The PI test report submitted by HAL, Lucknow Division indicates that there were no abnormalities in the temperature sensor or switch of the TGB. Therefore, fault in the helicopter wiring could be a possible reason for the "TGB Hot" display during the flight. However, this could not be ascertained unambiguously since the evidences with regard to helicopter wiring were completely destroyed by post accident fire.

INTENTIONALY LEFT BLANK

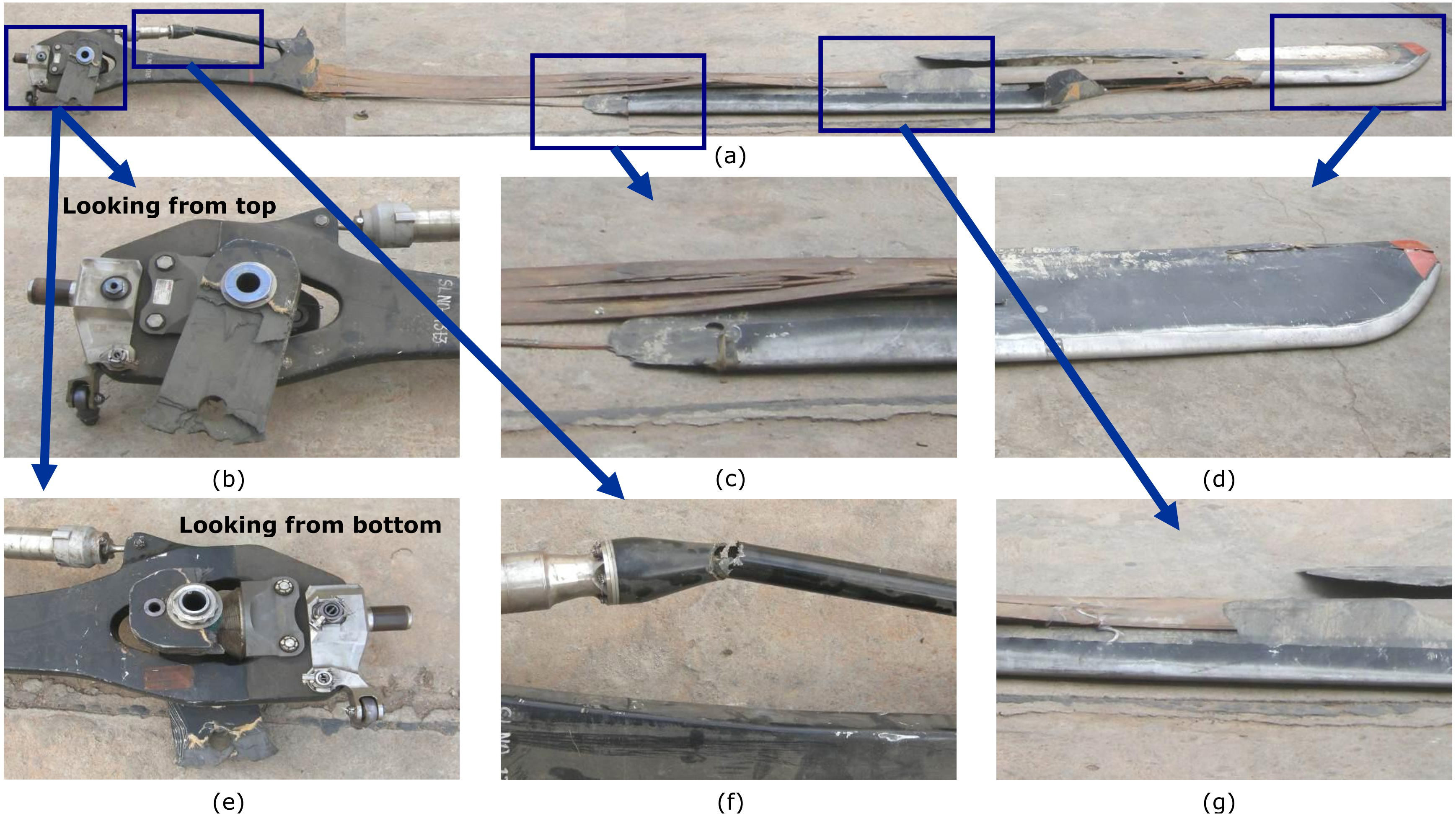

Figure 12 Photographs of the red main rotor blade showing: (a) full blade assembled with available parts, (b) failure pattern in top hub plate, (c) blade spar, (d) tip of the blade with airfoil, (e) failure pattern in bottom hub plate, (f) broken damper rod, and (g) a part of the leading edge of the airfoil retrieved from the wreckage site; note no hit marks on the available parts of the blade

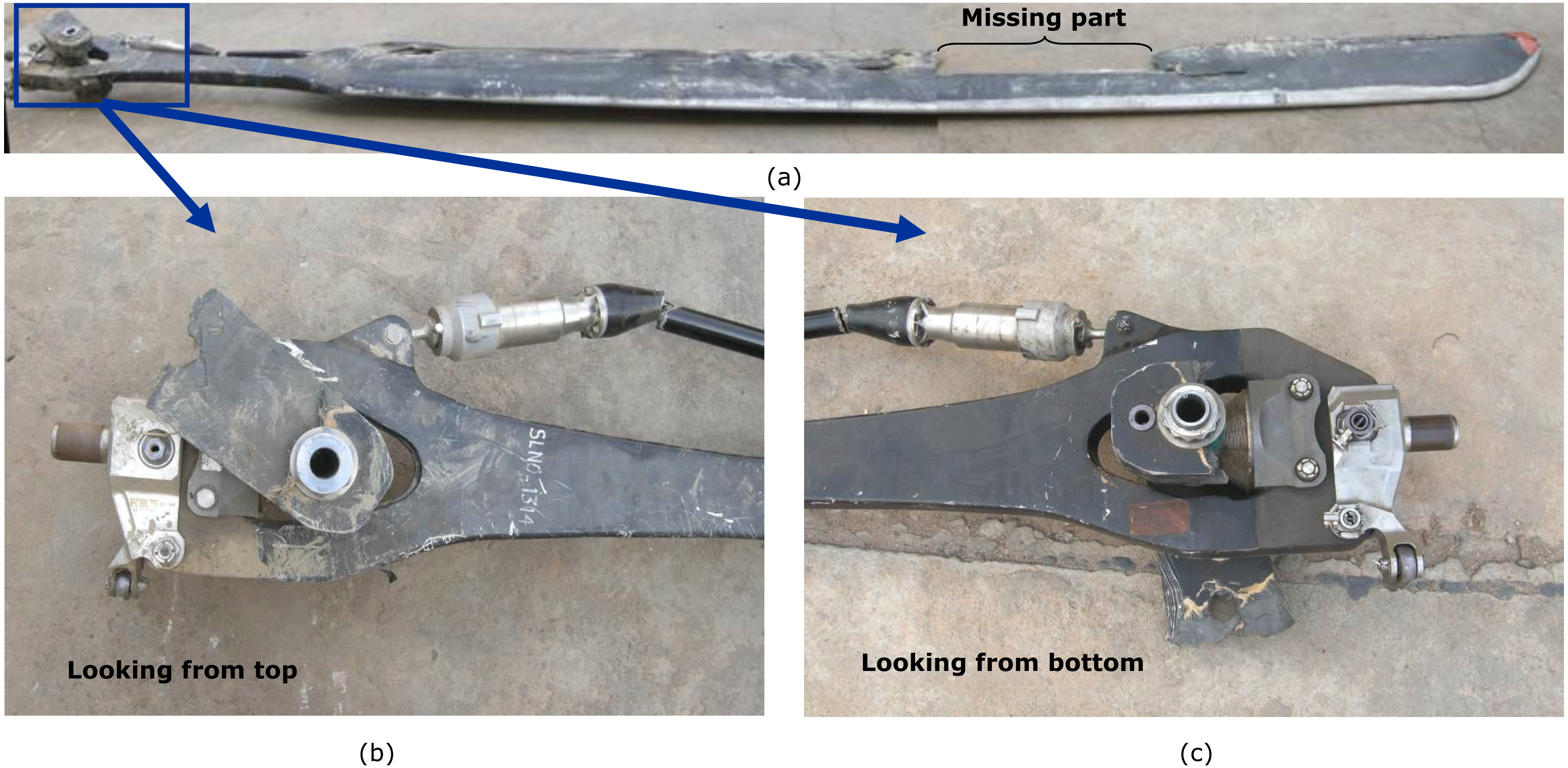

Figure 13 Photographs of the blue MRB showing (a) complete blade as retrieved from the wreckage, (b) failure pattern on the top hub plate, and (c) failure pattern on the bottom hub plate; note the failures of the hub plate to be identical of those shown in case of red MRB (refer Fig.1(b) and (e))

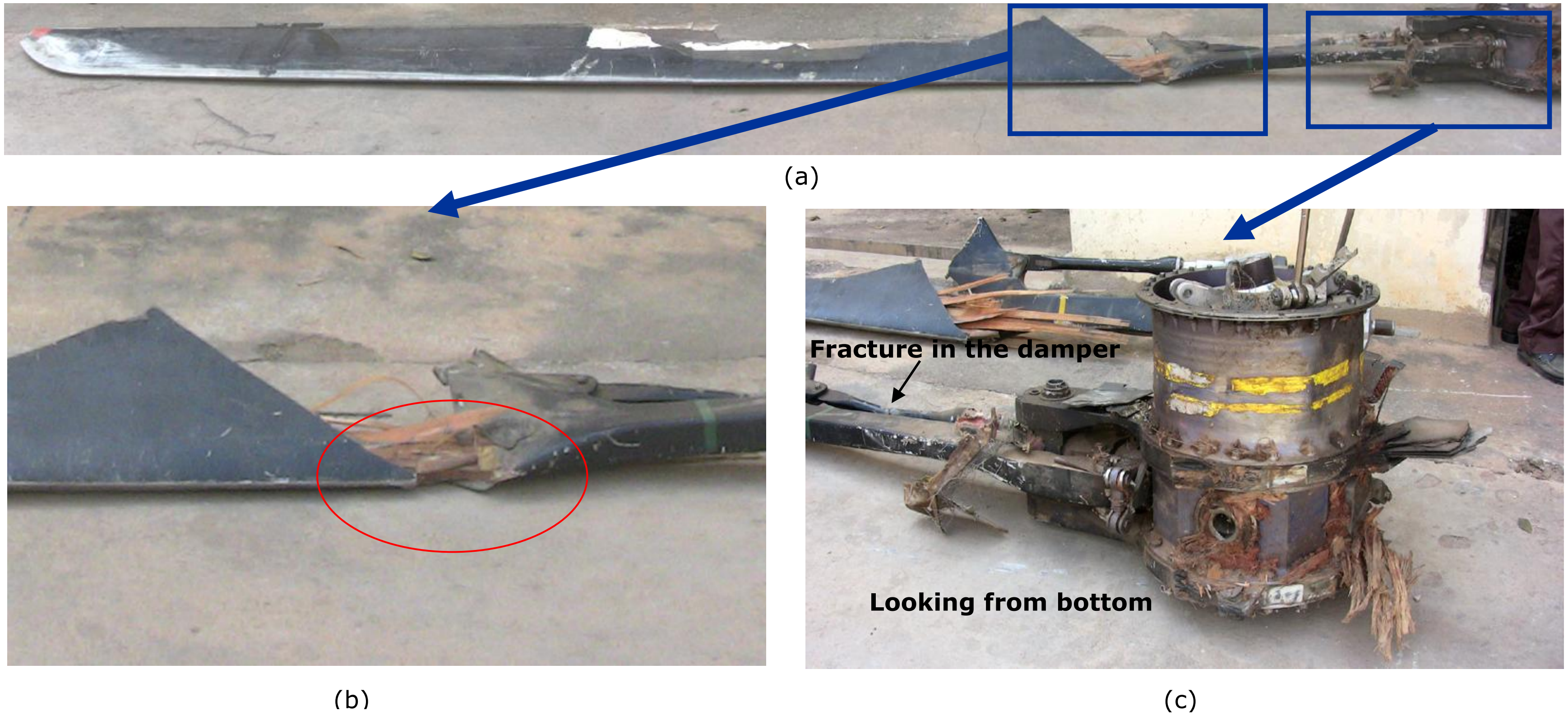

Figure 14 Photographs of the green MRB showing (a) full blade assembled with the available parts, (b) lose-up view of the failure location at the transition zone (encircled); note presence of no hit marks, and (c) IDS with spoon (root) of the blade showing failure location in the damper rod; note buck of the tree picked up during impacting with a tree

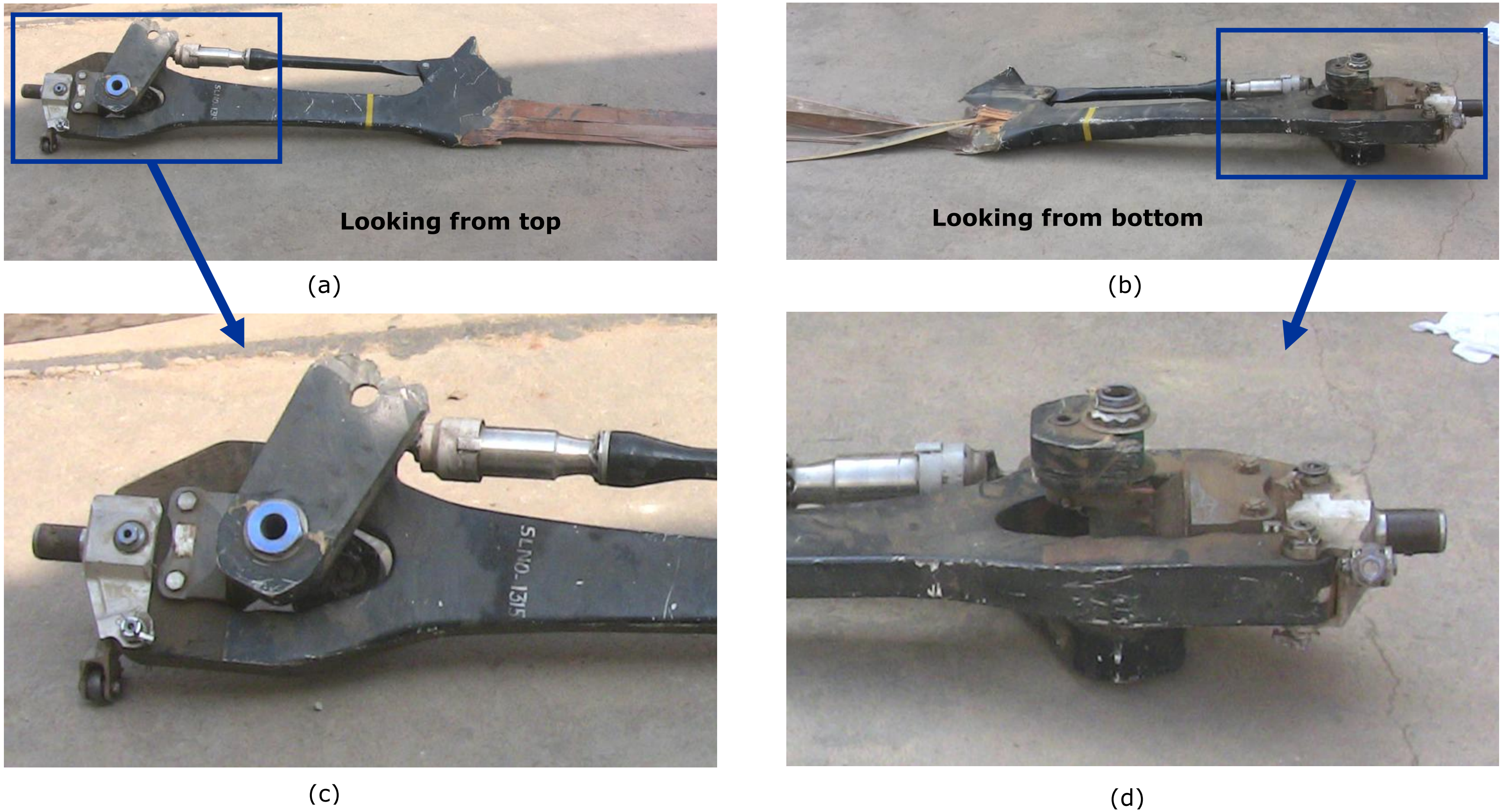

Figure 15 Photographs of the yellow MRB showing (a) and (b) part of the blade with the spoon, and (c) and (d) close-up views showing failure patterns in the top and bottom hub plates respectively; note no failure in the damper rod

1.17. <u>**Organizational and Management Information**</u>

1.17.1. Dhruv helicopter VT-BSH was owned and operated by Border Security Force (Air Wing), Ministry of Home Affairs, New Delhi. BSF had contracted the operation and the maintenance to HAL for two years initially from 25 March 2009. The maintenance and operating contract was further sub-contracted by HAL to PHHL, a Public Sector Undertaking Company. For this purpose, HAL had trained AMEs and in turn, these AMEs had got the relevant Licences/ Approval for certifying the airworthiness of the helicopter. Towards this BSF had set up operating bases at Ranchi, Raipur and Agartala for which PHHL had obtained requisite approval.

1.17.2. The maintenance of the helicopter was carried out by the manufacturer trained and authorized AMEs. The AMEs were positioned at Ranchi for a short period of 4 to 6 weeks on rotation basis. A local Engineer was also positioned in Ranchi, who was qualified on type but employment was limited to 50 Hrs inspection as per PHHL policy. The engineers were working as per their capability and there is no organizational barrier for identifying their mistakes except through audit. Audit was being carried out by Quality Control (QC) department trained auditors on a regular basis. Deliberation with the field engineers revealed that deficiency in AFCS data recording noted by HAL had not been addressed either by HAL or PHHL. A few other observations made on maintenance practices are placed below:

- The engineering audit report carried out by BSF auditor among other things found four Tins of Time expired grease in the Ranchi store.

- The Ranchi store needed immediate renovation, which is yet to be accomplished.

1.17.3. Such issues should have been noted by PHHL auditors and acted upon on priority basis. Also HAL as maintenance contractor has not discharged its duty through audit of its subcontractor, PHHL.

1.17.4. The BSF as an Operator is expected to perform certain roles in accordance with the CAR, which include monitoring of its Operation and Maintenance contractors. In the instant case, certain audits had been carried out but BSF was not persuasive in removing the deficiencies observed. The BSF personnel at its operating bases are from general duty cadre who have no previous exposure to aviation, this hampers monitoring of deficiencies in flying and maintenance activities.

1.18. **Additional Information.** The representative of Bureau of Civil Aviation Security had visited the accident site, to check for possible use of explosives. The use of explosive has been ruled out as per the report submitted by the Bureau.

1.19. **Useful or Effective Investigation Techniques.** Nil

2. ANALYSIS.

2.1. **Flight Planning.** The planning and preparation of the flight along with the support facilities available were studied to see if they had any bearing on the cause of the accident. The plan for the sortie was received by the crew on 18th October 2011 in evening hours, and a flight plan for the same was faxed to Kolkata FIC for obtaining the FIC. Due to the late requisition for use of helicopter, no information was passed on to Ranchi Met for making the route forecast for the next day.

2.1.1. **Weather Briefing.** Ranchi Airport has a Class 'A' Met facility, which maintains current weather observation on 24 hour basis. For the flight undertaken on 19th October 2011, no requirement was placed to Ranchi Met for obtaining any route forecast. The 2nd Pilot had visited Ranchi Met at time 0230 UTC on 19th October 2011 prior to the planned departure wherein he was provided only with the Current Weather of Ranchi. The Met Officer on duty endorsed the same on the flight plan. Considering the presence of a **Deep Depression** over the Bay of Bengal at that time, it was not prudent on part of the crew, to have not asked for a detailed Met briefing before the flight. It is felt that under the circumstances, the crew should have liaised with Ranchi Met Section for obtaining detailed area weather forecast before proceeding for the sortie.

2.1.2. The system of obtaining weather from the destination helipads was also checked. It was found that no trained personnel were available on helipads to provide weather accurate inputs. The crew have been getting generic weather picture of the helipad telephonically from the personnel deployed at the helipad.

2.1.3. **Pre Flight Checks**. The pre-flight checks, pre-start checks and post-start checks were not carried out by the crew in the prescribed manner. The recommended practice has been to use the Flight Reference Cards for the purpose in the challenge response method.

2.1.4. **Navigation Planning**. The crew had received the coordinates for the helipads well in time. However, the 2nd Pilot was unable to feed the same in the GPS due to lack of practice in doing the same.

2.2. **Piloting and Handling of Emergency**. On the day of fateful accident, the helicopter took off for a sortie to Chaibasa, as per programme intimated to the crew on previous evening. On receiving the clearance from Ranchi ATC, the helicopter took off on the designated radial. After having flown for approx 5 min, the Pilot observed illumination of an annunciator light along with the Master Warning. The enunciator indicated that the warning was due to Tail Rotor Gear Box 'Hot' condition. As per Flight Manual emergency check list, this anomaly calls for the following actions to be taken.

- Speed 60 to 70 kts
- Land ASAP

2.2.1. The CVR recording revealed that the crewmembers discussed the course of action to be taken in the event of “TGB Hot” and the second step, i.e., land ASAP was reiterated by both Co-Pilot and the technician at the rear. Latter’s voice was recorded in the CVR. But, there was no mention of speed reduction. It appears that the Flight Manual was not referred to for the required emergency actions.

2.2.2. On deciding to return back to Ranchi Airport, the Pilot initiated a left turn. During this period, the MW was activated on multiple occasions Flight Control parameters recorded in the FDR suggests distraction of the Pilot by these warnings. In addition, Co-Pilot’s flawed action of setting the GPS for ‘Direct Nav’ to Kalaikunda and marginal weather conditions, led to diversion of Pilot’s attention. The Pilot was confronted with a situation for which he was not prepared. The Pilot also has inadvertently entered the clouds wherein he failed to notice the increase in bank angle, eventually resulting in Spatial Disorientation. The Co-Pilot did not try to gain Pilot’s attention on the unusual attitude of the helicopter. The disorientation of the Pilot resulted in the helicopter entering into an unusual steep nose down attitude with bank angle of 105°. With the helicopter close to ground, the Pilot applied abrupt and large control inputs resulting in the helicopter exceeding its structural limits, and thereby causing damage to the main rotor system. The failure of the rotor system was further confirmed through fracture analysis wherein it was established that the separation of the main rotor blades from the IDS was due to prevailing high aerodynamic loads.

2.2.3. **Use of AFCS**. ALH is equipped with a four axis AFCS which has the following modes.

- Stab Mode
- Hdg Hold
- Nav Mode
- Pre Select Altitude
- Altitude Hold
- Vertical Speed Mode
- Localizer and Glide Slope Hold
- Go Around
- Hover Ht Mod

2.2.4. The recommended practice in IMC conditions is to always use the AFCS upper modes for flying the helicopter. During the discussions with HAL flying instructors, it was confirmed that during conversion training of Pilots, the aspect of using the AFCS in IMC conditions had been duly emphasised. However, it was observed that the crew of the ill-fated helicopter had not used the upper modes of the AFCS for returning back to Ranchi in spite of having encountered conditions below VMC. The crew had chosen to fly the helicopter manually although the AFCS was serviceable and available.

2.2.5. **Use of Beep Trim** The flight controls of the helicopter are provided with a Force Trim Release (FTR) and a beep trim button on the cyclic. The FTR button is used for coarse trim while the beep trim is used for fine trimming of the helicopter. The FTR button when depressed removes the spring feel in both lateral and longitudinal axis simultaneously, while the beep trim allows input to be given only in one axis. The recommended practice is to use the beep trim in IMC conditions so that precise control inputs can be given only in one axis, especially, in IMC conditions. From the FDR, it is observed that although the flight conditions were below VMC, the Pilot had chosen to use the FTR instead of using the beep trim to undertake the turn for returning back to Ranchi.

2.3. **Cockpit Resource Management**. From the analysis of the CVR, it was observed that effective CRM was lacking. During the critical phase of flight, when the Pilot was initiating the turn to the left for returning to Ranchi, there was no communication between the crew in the cockpit. The decision to turn back and the presence of technical failure was not transmitted to ATC Ranchi. In IMC conditions, the Co-Pilot should have monitored the flight instruments closely. He also should have warned the Pilot of helicopter bank angle being increased continuously and the helicopter loosing height rapidly. It was observed that the Co-Pilot made no contribution during the most critical phase of the flight. The setting the GPS for direct nav to Kalaikunda by the Co-pilot while the helicopter was returning to Ranchi appears to have a negative impact on Pilot's actions.

2.4. **Human Factors.** To ascertain reasons behind the spatial disorientation and subsequent loss of control, influencing factors such as previous flying experience, quantum of flying, training, and company's management of Pilot assets were studied.

2.4.1. **Flying Experience of Pilots**. The background of Pilot and the Co-Pilot was studied to examine whether or not the same had any bearings on the accident. As per the records, the PIC had total flying experience of 5925 hrs with 294 hrs on ALH, while the Co-Pilot had 3340 hrs of total flying with 34 hrs on ALH. Though the combined experience in the cockpit was adequate, both Pilots did not have previous exposure of IFR operations. They also did not have any previous multi engine experience. Some of the Pilots in this fleet have also had long break in flying prior to their induction in PHHL. The Pilots from older generation single engine helicopter background were invariably seen to lack requisite exposure to modern generation avionics and IFR operations. The inability to feed the Nav Plan in the GPS by the Co-Pilot, and non-utilisation of VOR/GPS along with AFCS upper modes in IMC conditions, indicates that the Pilots were not fully conversant with utilisation of the AFCS and avionics on ALH.

2.4.2. **Flying Conversion Training**. Both Pilots had undergone ALH conversion training, 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 15:00 hrs of flying, including skill test by day and night, was undertaken at HAL by each Pilot. The Captain of the helicopter had undergone conversion training in 2009 and had been cleared to fly as PIC. He had logged 294 hrs on ALH. The Co-Pilot had undergone conversion training in August 2009 and was cleared to fly as Co-Pilot. He had completed 34 hrs on ALH.

2.4.3. **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 ALH, the conversion training is being undertaken by HAL. The training syllabus being followed by HAL is in line with the DGCA CAR. The syllabus was found adequate for Pilots who were current in flying or had previous experience on helicopter equipped with modern generation avionics. However, for Pilots who have had a long break in flying and have had previous experience only on basic helicopter, the syllabus is considered inadequate. Considering the complexity of the modern generation machines, the manufacturer should formulate the syllabus so as to ensure that the Pilots who are undergoing training are confident at the end of the training to handle the helicopter and exploit its full capability. The use of full motion simulators for training of Pilots is authorised by DGCA. Although the simulator for ALH has been available in the country, the training for the PHHL Pilots by HAL continues to be given on the helicopter, because of commercial reasons. The Flying training facility of HAL needs to tailor the syllabus depending on the trainee's previous experience and capability. Also, strict monitoring of the training quality needs to be maintained by HAL and DGCA to ensure that no weak Pilots are passed out.

2.4.4. **<u>IR Training</u>**. The training records for Instrument Rating (IR) were scrutinised and the following observations were made:

2.4.4.1. The Captain had undergone 5 hrs of Instrument Flying (IF) training as required for issue of IR in the year 2009. As per Aircraft Act 1937 for issue of Initial IR, the Pilot needs to be examined by two independent examiners. In case of the Captain, record of only one IR test for initial issue could be found. For the year 2010, no IF training record could be found in the logbook. For the year 2011, the Pilot had logged adequate Actual/Simulated IF.

2.4.4.2. It was observed that Simulated (Sim) IF had been logged in number of revenue sorties where the PIC had logged Sim flying while flying with a 2nd Pilot who was not an Instructor. This is in contravention to the DGCA instructions wherein training flying cannot be conducted with passengers on board.

2.4.4.3. Since the Captain was flying under Rule 160, the above deficiencies seem to have been missed by the regulatory authority.

2.4.5. **<u>Recurrent Training</u>**. DGCA CAR Section 7 Series 'B' Part XIV dated 8th July 2005 lays down the recurrent training requirements for helicopter Pilots. Training records of the Pilots were scrutinised to check if the laid down requirements had been met. The Captain had completed his conversion training in July 2009 and IF training in August 2009 while the Co-Pilot had undergone conversion training in July 2011.

2.4.5.1. **Proficiency and Route Checks**. The crew had undergone Proficiency Checks and Route Check as required. Route Check had only been carried out by Day as no Night Ops were being undertaken.

2.4.5.2. **Instrument Renewal Checks**. The Captain had undergone IR renewal check on 25th August 2012. All checks were being undertaken on the helicopter. No utilisation of the Full Motion Aircraft Simulator available was done.

2.4.5.3. **Night Currency Check**. Though the aircraft is not being utilised for night operations, however, the crew were undertaking 01 hour of night flying every six months to maintain currency.

2.4.5.4. **Ground Training**. No ground refresher training had been carried out.

2.4.5.5. **Simulator Training for IF**. Pilot holding IR Rating are required to undergo 05 hrs of IF training in two years on type specific flight simulator or in case the simulator for the type is not available, the training can be carried out on the type of helicopter. The Captain had completed his conversion training in June 2009 and IF training in August 2009 and was due for Simulator IF training, while the 2nd Pilot was not yet Instrument Rated. Simulator training for IF for the Captain was overdue and had not been undertaken either on the simulator or the aircraft, though the type simulator for ALH was available.

2.4.5.6. **Simulator Training for Critical Emergencies**. Simulator training of 05 hrs for critical emergencies, which cannot be practiced on the aircraft needs to be undertaken once in two years. The crew had not undertaken the same.

2.4.5.7. **CRM and Dangerous Good Training**. Both Pilots had undergone CRM and dangerous Good Training in accordance with CAR.

2.4.5.8. **Emergency and Survival Training**. Emergency and Survival training had been completed by both the pilots as required.

2.4.6. **Quantum of Flying**. It was also observed that the total quantum of flying in the ALH fleet was much lesser as compared to the other fleets of PHHL leading to inadequate opportunities for the Pilots to consolidate. The company has a large number of Pilots with multi engine experience who are proficient in IFR operations. It would be beneficial if some of these Pilots experienced in IFR operations were inducted into the ALH fleet. They could help the Pilots coming from single engine background and not having exposure to IFR operations to consolidate and build up the requisite skills for operating the ALH.

2.4.7. **Flying Linked Pay**. PHHL has a system of emoluments for its pilots wherein the remunerations are as per the quantum of flying undertaken. As mentioned in para 2.4.6, the quantum of flying undertaken by ALH is much lesser as compared to the other fleets operated by PHHL. Hence, ALH pilots' total emoluments are much lesser than other pilots of the Company. In view of this and the harsher operating environment, experienced pilots of PHHL are reluctant to migrate to ALH fleet. The ibid system of remuneration also has another drawback wherein there is tendency to accept unserviceable helicopter or to fly in marginal weather.

2.5. **ELT Operation**. It was observed that though the helicopter is equipped with the Emergency Locator Transmitter (ELT) ELT 503, which has a G switch for activation, the same had not operated in the crashed helicopter. The procedure of arming the ELT and the G switch before take-off was checked. It was found that the Pilots were not checking the ELT status as they were under the impression that the ELT and the G switch was always kept armed. Also, no check for the same was mentioned in the Flight Reference Cards provided by HAL. Flight Manual para 4.8.10 provides the checks to be carried out for arming of ELT and the G switch. The Flight reference card needs to be suitably amended and also, the check for ELT must be included in section 4.1.2 Pre-flight Checks of the Flight Manual.

3. CONCLUSIONS.

3.1. **Findings**.

3.1.1. The helicopter departed Ranchi Aerodrome at 0209 UTC for Chaibasa and was cleared to climb to 4500ft initially. After about six minutes of uneventful flying when the helicopter was at an approx altitude of 4400 ft (2300 ft AGL), the 'TGB Hot' warning came on. The crew discussed required actions and decided to land back at Ranchi. This decision was in order but the stipulated reduction of speed, was missed out, as the checklist was not referred to.

3.1.2. The Pilot commenced a left turn for returning to base wherein excessive control input was given and bank was not done. This led to rapid increase in bank, which was not perceived by the Pilot due to pre-occupation with other cockpit activities and poor visual reference. A sharp turn may have been intended to maintain clear of clouds in the vicinity.

3.1.3. Rapid roll coupled with loss of visual reference led to Spatial Disorientation of the Pilot and consequent loss of control.

3.1.4. Restoration of visual references was significantly delayed as seen from flight parameters and control inputs. On regaining visual reference, the Pilot applied large control inputs, to recover the helicopter in a frantic attempt but the inputs were grossly delayed to such an extent that the helicopter had already gone beyond the cleared flight envelope by then. These unfavourable conditions aggravated the situation further such that the helicopter crossed the structural limits resulting in damage to the rotor system.

3.1.5. Structural failure analysis confirms failure of all Main Rotor Blades in air under excessive aerodynamic loads. The helicopter crashed over hilly terrain and was destroyed due to the impact and post impact fire, killing all personnel on board.

3.1.6. No failure or abnormality was found in any of the TGB component. Thus the cause for the “TGB Hot” caution could not be conclusively established. Possibility of degradation in electrical looming cannot be ruled out.

3.1.7. The flight planning for the flight was found to be inadequate, as available facilities of Ranchi Met were not utilised appropriately.

3.1.8. The destination helipad weather was being provided by untrained personnel.

3.1.9. The BSF personnel at its operating bases had no previous exposure to aviation and hence could undertake only limited monitoring of PHHL activities.

3.1.10. The Cockpit Resource Management by the crew was found to be lacking. Inadequate use of available helicopter resources and Co-Pilot’s inability to render assistance to the pilot in the critical phase of flight aggravated the situation.

3.1.11. The training imparted by the manufacturer to the PHHL pilots was found to be inadequate in view of their lack of previous experience in multi engine, IFR capable helicopter.

3.1.12. Simulator training for IF and Critical emergency training along with the ground refresher had not been undertaken.

3.1.13. Opportunities to the pilots for consolidation were found to be lacking as the quantum of flying undertaken in the ALH fleet was low.

3.1.14. PHHL follows a policy of linking remuneration of the pilots to the quantum of flying and hence, no transfer of experience had taken place from other fleets of PHHL as experienced pilots were unwilling to migrate to ALH.

3.1.15. The supervision of regulatory body for pilots operating under Rule 160 was found to be inadequate. Pilot in the instant case had not completed his second IR test but he continued to utilise the privileges of IR. In spite of no logging of instrument time by the Captain in the year 2010, his IR was renewed.

3.1.16. The flying syllabus being followed for conversion by HAL was as per DGCA CAR without taking into consideration factors such as break in flying, previous experience of pilots and their respective capabilities. HAL needs to ensure that the quantum of training imparted is such that the pilot at the end of training is capable of handling the helicopter competently.

3.1.17. The use of flight simulators needs to be made mandatory so that the pilots can be trained for all emergencies, which cannot be practiced on the actual helicopter. Also they can be given practice in actual IFR flying.

3.1.18. The helicopter FDR was not recording the AFCS status. The fault had been observed by the HAL during the routine analysis of ALH FDR data. The same had been intimated through routine reports to PHHL, who missed the anomaly. No intimation of the same was given to BSF, the owner of the helicopter. HAL as manufacturer and maintenance contractor, did not take any action to rectify the fault.

3.1.19. Low MGB PR#1 enunciator had come on during hover but the crew continued with the flight without analysing the problem.

3.1.20. Helicopter operation record for the recent period could not be recovered as requisite copy of technical log book had not been removed for retention at base.

3.1.21. The ELT had not operated, possibly, as the ELT or the G switch had not been ‘armed’

3.2. **Probable Causes and Contributing Factors.**

3.2.1. The cause of the accident was loss of Situational Awareness wherein the crew got Spatially Disoriented during a turn for returning to base in response to an emergency warning. In the process, the helicopter went beyond the flight envelope exceeding its structural limits and thereby leading to failure of the rotor system.

3.2.2. The contributory factors to the loss of Situational Awareness were:

3.2.2.1. **Spatial Disorientation.** In response to the 'TGB Hot' Warning, the crew was required to reduce speed to 60 to 70 Kts and land as soon as possible. The Pilot initiated a manual turn without using the AFCS upper modes or reducing speed, in flight conditions below VMC. These actions coupled with inadvertent entry into clouds, led to the helicopter reaching steep nose down attitude with bank angle in excess of 90°.

3.2.2.2. **Pilot Training and Experience.** The crew had limited type experience and inadequate exposure to IFR operations. They had also not undergone simulator training for IF or handling of critical emergencies. The crew's knowledge of the helicopter systems was inadequate.

3.2.2.3. **Cockpit Resource Management.** Crew coordination was found lacking during handling of the emergency. The Co-Pilot did not render any assistance during the critical phase of flight. The AFCS and available avionics onboard were not appropriately utilized for negotiating the marginal weather.

3.2.2.4. **Piloting.** The large and sudden control applications by the Pilot at the time when the helicopter was beyond its cleared flight envelope led to exceedance of structural limits and subsequent failure of the rotor system.

3.2.2.5. **Additional Factors**. The situation was compounded by continuous activation of MW during the period.

4. **SAFETY RECOMMENDATIONS:**

4.1. PHHL needs to have a comprehensive induction plan for conversion training and consolidation flying of the pilots with no previous experience on multi engine helicopters and IFR operations.

4.2. Use of simulators should be made mandatory for conversion training on ALH.

4.3. The conversion syllabus for ALH followed by HAL needs to be reviewed to accommodate the pilots from different backgrounds.

4.4. Strict monitoring of the pilot training standards should be exercised by HAL and DGCA.

4.5. Monitoring mechanism of pilots flying under Rule 160 by regulatory authority needs to be reviewed.

4.6. Pilots' remuneration system in vogue at PHHL needs to be reviewed. It should not be linked to quantum of flying.

4.7. HAL needs to be pro-active in providing product support as manufacturer as well as maintenance/operations contractor.

4.8. Comprehensive safety audit should be carried out by trained auditors from different base or Headquarters.

4.9. HAL needs to review the flight manual for ensuring clear instructions for 'arming' of the ELT and G switch.

4.10. To enhance safety of operations, basic training in weather reporting needs to be provided to the personnel deployed at helipads.

4.11. The personnel deployed by BSF at its operating bases need to have aviation orientation for better monitoring of operational and maintenance activities.

(Anil Bhambhani)
Wg Cdr (Retd)
Helicopter Pilot

(Dr S K Bhaumik)
Scientist G
NAL

(PK Chattopadhyay)
Jt. DGCA (Retd)

(GS Cheema)
Air Cmde (Retd)
Chairman
Committee of Inquiry

Glossary

AAI	Airports Authority of India
ACCR	Accessory
ADC	Air Defence Clearance
AFCS	Automatic Flight Control System
AHRS	Attitude Heading Reference System
ALH	Advanced Light Helicopter
AME	Aircraft Maintenance Engineer
ASAP	As soon as possible
ATC	Air Traffic Control
AWS	Audio Warning System
baro	Barometric
BKN	Broken
BR	Mist
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
dB	Decibel
DFDR	Digital Flight Data Recorder
DGCA	Director General of Civil Aviation
DME	Distance Measuring Equipment
DP	Dew Point
EFIS	Electronic Flight Instrument System
ELT	Emergency Locator Transmitter
FDR	Flight Data Recorder
FIC	Flight Information Clearance
FLT	Flight
Ft	Feet
FTR	Force Trim Release
g	Gravitational acceleration
G Switch	Gravity Switch
GP	Glide Path

Gp	Group
GPS	Global Positioning System
HAL	Hindustan Aeronautics Limited
Hdg	Heading
HF	High Frequency
Hi	High
HPA	Hecta Pascal
Hrs.	Hours
HYD	Hydraulic
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
IST	Indian Standard Time
kg	Kilogram
kHz	Kilo Hertz
km/h	Kilometer per hour
kts	Knots
kW	Kilo Watt
LH	Left Hand
LLZ	Localizer
m	Meter
mb	Milli Bar
MCR	Maximum Contingency Rating
Met	Meteorology
MGB	Main Gear Box
MHz	Mega Hertz
MMI	Mast Moment Indicator
MRB	Main Rotor Blade
NDB	Non Directional Beacon
NM	Nautical Miles
N_R	Main Rotor RPM
NSOP	Non Schedule Operators Permit
N_Z	Longitudinal Acceleration
OGE	Out of Ground Effect
PHHL	Pawan Hans Helicopters Limited
PIC	Pilot in Command

Pr	Pressure
PTT	Press to Transmit
Q	Torque
QC	Quality Control
R-160	Rule 160 of Indian Aircraft Rule 1937
RH	Right Hand
RWY	Runway
T	Temperature
TGB	Tail Gear Box
UTC	Universal Coordinated Time
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
Vne	Velocity Never Exceed
VOR	VHF Omni Directional Range
VWS	Voice Warning System
wt	Weight
Wx	Warning
yrs	Years