REPORT ON ACCIDENT TO ANDHRA PRADESH GOVERNMENT BELL 430 HELICOPTER VT-APG AT RUDRAKODU HILLS IN KURNOOL DISTRICT OF ANDHRA PRADESH ON 02.09.2009

a) Helicopter

Type and Model	:	Bell 430
Nationality	:	Indian
Registration	:	VT-APG

b) Owner/Operator	:	Govt. of Andhra Pradesh
c) Date of Accident	:	02.09.2009
d) Time of Accident	:	09:28 IST (Approx.)
e) Last Point of Departure	:	Begumpet Hyderabad
f) Point of Intended Landing	:	Chittoor
g) Geographical Location of Accident	:	At a distance of 26 km from Atamkur **Coordinates**: N 15° 47´04.7¨ E 078° 42´ 40.9¨ Altitude: 1230 ft.
h) Type of Operation	:	General Aviation
i) Phase of Operation	:	Cruise

(All timings in the report are in IST)

SYNOPSIS

On 02.09.2009 Andhra Pradesh Government Bell 430 helicopter, VT-APG met with an accident while operating flight from Begumpet Hyderabad to Chittoor. Initially, there was confusion regarding occurrence of accident. However, later it was confirmed that helicopter had crashed and the wreckage was sighted at 09:20 IST on 3.09.2009 by Indian Air Force helicopter. The accident occurred while the helicopter was on its way to Chittoor in Rudrakodu hills of Nallamalla forest range.

The accident was investigated by Committee of Inquiry appointed under Rule 74 of Aircraft Rules, 1937. As per the obligations under ICAO Annex 13, notification was sent to National Transport Safety Board (NTSB), USA, the State of engine manufacture and Transport Safety Board (TSB), Canada, the State of helicopter manufacture. TSB, Canada and NTSB, USA appointed their accredited representatives and authorized engine manufacturer M/s Rolls Royce and M/s Bell Textron to associate with the investigation of engine, ECU and Wreckage. The CVR data was downloaded at the NTSB facility in USA in presence of the representative of the committee.

The helicopter took off from Begumpet Airport, Hyderabad at 08:38 IST and was cleared for altitude of 5500 ft enroute at a radial of 172˚. It had been encountering clouds from the beginning. At 9:10:50 IST and at a distance of 64 nm the helicopter entered the clouds. As per CVR readout helicopter weather radar was painting red. Last radio contact with Approach Hyderabad was made at 09:12:52 IST and that was the last contact the helicopter had with any ATS units during its flight. The helicopter painted on the radar screen of approach radar Hyderabad up to 9:13 IST and at distance of 79.2 nm from VOHS Airport. Till the helicopter painted on the radar screen it was maintaining an altitude of 5500 ft and ground speed of around 140 kts.

At 9:13:17 IST due to weather they decided to be slightly on the left of the track. Although they cleared the red zone as painted on helicopter weather radar, however they continued to fly through the clouds. At 9:16:31 IST they observed that clouds were more on the right of the track and quantum of clouds were increasing. They decided that after crossing Krishna River they would turn left.

At 09:21:07 IST they encountered the snag of transmission oil pressure. Thereafter they got engaged in finding out the procedure in emergency checklist for the transmission oil pressure and they were not able to find it. 09:27:24 IST onwards, there were repeated callouts from co-pilot to "**Go Around**". The Engine Control Unit(ECU) readout shows that during the last 14 seconds the rate of descent was in excess of ten thousand feet/minute indicating that the helicopter during this period when the co-pilot was giving callouts for go around was encountering very high rate of descent. Thereafter helicopter crashed due to loss of control resulting in high rate of descent in down draught. The helicopter impacted the ground and all occupants on board died due to crash injuries.

1. Factual Information

1.1 History of the Flight

On 02.09.2009 Andhra Pradesh Government Bell 430 Helicopter VT-APG was to operate a flight from Begumpet Airport in Hyderabad to Chittoor for the commitment of the Hon'ble Chief Minister of Andhra Pradesh. There were five persons on board which consisted two crew members, Hon'ble Chief Minister and a two member team accompanying him. The Helicopter took off from Begumpet airport Hyderabad at 08:38 IST and crashed in the Rudrakodu hills of Nallamalla forests range towards South of Begumpet airport on the radial 169° and at a distance of 101 nm at around 09:28hrs IST.

Flight plan was filed with the air traffic control Begumpet airport. As per the flight plan, aircraft was to fly direct to Chittoor at altitude 5500 ft ETA / ETD Chittoor as 09:45 IST/12:00 IST. From Chittoor the helicopter was to proceed to Ankulpattur (ETA/ETD: 12:40/1600 IST) and finally, Ongole (ETA 16:45 IST). The flight was to be conducted under visual flight rules (VFR). However, Instrument Meteorological Conditions (IMC) prevailed at that level enroute and near the accident site. The refueling was to be undertaken at Chittoor. The emergency radio frequency is indicated to be VHF.

On 02.09.09 at 6 am, AME carried out pre-flight inspection as per the pre-flight task card and everything was found satisfactory. Pilot accepted the helicopter as per procedure and the helicopter was positioned at the VIP departure apron. After the positioning, no snag was reported by the crew. 760 lts of fuel was uplifted after fuel sample check. There was 356 lts of fuel already in the tank and the total fuel after uplift was 1116lts. Crew obtained ATC and met briefing at 6:30 IST. During the met briefing they were shown the synoptic charts, satellite picture of 5:30 IST and provided with met folder. The movement was coordinated with Chennai FIC (FIC No. 0033 and ADC No. C523).

Helicopter took off from Begumpet Airport RWY 27 at 8:38 IST. Helicopter was given direct clearance to destination Chittoor at an altitude 5500 ft. It was cleared to take-off from RWY-27, climb on RWY heading to 4600 feet and further in coordination with approach radar. At 08:38:50 IST helicopter was transferred to the Hyderabad approach and it established contact with approach radar at Hyderabad. Approach Radar gave it clearance for climb to 5600 ft. and after reaching 5600 ft. to turn left and set course to Hyderabad (HIA-VOR) due to traffic. At 08:42:16 IST helicopter was at a radial of 172º from HHY (Begumpet) distance 25.6nm and requested to proceed to Chittoor on course 170º and gave ETA Chittor as 10:30 IST. Same was approved by approach Control. At 08:39:41 IST, Approach asked “Confirm destination is Chittoor on Radial 172º”. Helicopter requested that if they could maintain the present course. ATC asked “Report Establish Radial 172º from HHY” which was affirmed by the helicopter.

At 09:03:20 IST, it reported 46 miles maintaining 5600 ft. The helicopter was asked to descent to 5500 at 50 miles. At around 09:02 IST the helicopter contacted Chennai on HF frequency 6655 KHZ and relayed its position along with estimated time of arrival 10:30 IST at Chittoor. HF Radio advised the helicopter to report at 09:30 IST. At 09:07:46 IST and at a distance of 55 NM from VOHY as per CVR readout, there was a callout “altitude 5500, speed 120, ground speed 144, 83” indicating that helicopter was maintaining a speed of 120 kts and 83% collective. Though it had been encountering clouds from the beginning, at 9:10:50 IST and at a distance of 64 nm the helicopter entered the clouds and accordingly the PIC instructed the Co-pilot to keep hand on the collective so as to reduce it, as up draught/down draught may lead to exceedance of torque. As per CVR readout, helicopter weather radar was painting red indicating bad weather ahead. Last radio contact with Approach Hyderabad was made at 09:12:52 IST and that was the last contact the helicopter had with any ATS units during its flight. The helicopter painted on the radar screen of approach radar Hyderabad up to 9:13 IST and at distance of 79.2 nm from VOHS Airport. Till the helicopter painted on the radar screen it was maintaining an altitude of 5500 ft and ground speed of around 140 kts. At 9:13:17 IST due to weather, they decided to be slightly on the left of the track. Although they cleared the red zone as painted on helicopter weather radar, however they continued to fly through the clouds. At 9:16:31 IST they observed that clouds were more on the right of the track and quantum of clouds were increasing. They decided that after crossing Krishna River they would turn to the left. At 09:18 IST there was a call out that both the VORs have gone i.e. the helicopter was out of range from any of the VORs and would be navigating based on the GPS and visual references. At 09:20:11 IST they were abeam Kurnool but were still in clouds. At 09:20:22 IST they were at 86 nm and talked about crossing Krishna River. At this stage they were hopeful of improvement in existing weather as per CVR read out. At 09:20:46 IST they reduced the speed to 40kts.

At 09:21:07 IST they noticed a snag of transmission oil. Thereafter they got engaged in finding out the procedure in emergency checklist for the transmission oil pressure warning. At 09:27:25 IST there was a callout regarding the Autopilot. Probably it had tripped and was reengaged. From 09:27:24 IST there were repeated callouts from co-pilot to "**Go Around**" indicating emergency situation i.e. proximity to the ground. The Engine Control Unit(ECU) readout shows that during the last 14 seconds the rate of descent was in excess of ten thousand feet/minute indicating that helicopter during this period when the co-pilot was giving callouts for "Go Around was encountering very high rate of descent. During this period as per the ECU readout, there was exceedance of Main rotor RPM; power turbine RPM with simultaneous drop in the torque. This is consistent with a rapid lowering of collective. CVR stopped at 09:27:57 IST.

Since there was no report received from either helicopter VT-APG or nearby stations, action was initiated for search and rescue measures at 11:15 IST by Chennai. No Emergency Locator Transmitter (ELT) alert messages from Cospas-Sarsat satellite system was received by Indian Mission Control Center (INMCC), Bangalore on any of the frequency. In the meanwhile sensing the gravity of situation various agencies including Andhra Pradesh State Government initiated action and helicopters from various stations including Indian Air Force bases conducted sorties in search of the missing Helicopter. However the poor weather conditions impeded the search operation. The location of the accident site was established with the help of telecom agencies. Finally after more than 24 hours of search, the wreckage of the helicopter was located in Rudrakodu Hills of Nallamalla forest range at around 26 km from Atamkur by the Indian Air Force helicopter on 3.09.2009 at 09:20 IST on coordinates 15471349N 078426025E.

Thereafter, the dead bodies were recovered by IAF and the units of Special task force of the State.

Examination of the wreckage site revealed that the helicopter had turned by almost ninety degree to the left from its flight path before impact. It had flown through the trees before finally impacting the ground on the slope of a hill at an altitude of 1230 ft., where the surface is rocky. Due to impact, the helicopter had broken in number of pieces and the wreckage was spread over an area of 566 sq m. The helicopter impacted the ground in steep left nose pitch down attitude. Due to this impact and post impact fire the helicopter was destroyed. All on board had died due to injuries.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	3	Nill
Serious	Nil	Nil	Nill
Minor/None	Nil	Nil	

1.3 Damage to Helicopter

Bell 430 Helicopter VT-APG was destroyed due to impact and post impact fire.

1.4 Other Damage

Trees and other vegetation at the accident site were damaged as a result of the accident.

1.5 Personnel information

1.5.1 Pilot-in-Command

1. He was a serving officer of the Indian Air Force and was on deputation to the Government of Andhra Pradesh since 4th Dec. 2006. He received his initial helicopter training at an Indian Air Force training school in Hyderabad, India. During his career with IAF he was qualified as a rotorcraft instructor. The Pilot had accumulated 6204:30 total flight hours, major portion on turbine powered helicopters.

   On completion of ground training and simulator training at manufacturer's facility his conversion training on Bell 430 helicopter was carried out in India by DGCA approved instructor in March 2007. Recurrent simulator training as stipulated was due in the month of June 2009 on completion of 2 years from initial endorsement and was not carried out. Flying hours during training sorties have been reflected as PIC flying in the personal log book. For endorsement on Bell 430 helicopters only one instrument rating test was carried out against the requirement of two Instrument rating tests with two different examiners as per Schedule 2, Section P, Subpara E of Air craft Rules 1937. The instructor who conducted the night flying and instrument flying training has also undertaken Night Skill test and instrument rating test as well. Only day skill test by the training instructor is valid as FOI (H) DGCA was on board as observer as no other examiner on type was available.

License Details:

License type	:	CHPL 714.
CHPL Valid up to	:	17.07.2011
Date of Initial Issue	:	18.07.2006
Date of Endorsement of Bell 430 Helicopter	:	5.06.2007
Date of Birth	:	9.06.1962

Medical Valid up to	:	12.01.2010
FRTO No 9626, valid till	:	17.07.2011.
Instrument Rating No.	:	212
Date of last IR check	:	31.07.2009
PC checks	:	01 September 2009
Helicopter Ratings:		
As PIC	:	Alloutee III/Chetak, Bell 430

Flying Details	:	
Total Flying Experience	:	6204:30 hrs
Total instrument flying	:	424 hrs. IMC: 147 Hrs, Sim 213, Actual 64hrs)
Experience on type	:	PIC: 290:30 hrs. ; co-pilot: 60:10 hrs; Total: 350:40 Hrs
Flying during Last One year	:	Day: PIC 106:20 hrs. ; Co-Pilot: 17:20 Night: PIC 5:45 hrs; Co-Pilot: 00:35 Hrs Sim. 8:00 hrs; ACT 2:15 hrs (Both on helicopter) Total: 129:40 hrs.
Flying during last 6 months	:	20:50 hrs. (excluding the accident flight)
Flying during Last 30 days	:	6:30 hrs.
Flying during last 7 days	:	3:59 hrs.
During last 24 hours	:	2:14 Hrs

2. Previous Involvement in Accidents/Serious Incidents/Incidents

He was not previously involved in any accident or serious incident. However he was involved in following reportable incidents:

- He was involved in an incident on 19.01.2009 while operating flight from Hyderabad to Gulbarga with Hon'ble Dalai Lama on board. Hydraulic pressure of No.2 system was fluctuating and failed to take appropriate action even though he was cautioned by the co-pilot for the same.

- He was involved in the incident of exceedances which are as follows
  i) 7.06.2009 -Torque exceedance
  ii) 24.06.2008- Torque exceedance
  iii) 23.12.2007- Torque exceedance

These exceedances were not reported to regulatory authority.

- The pilot on the earlier occassion had refused to undergo Pre-Flight Medical Examination for consumption of alcohol. This is in violation of Rule 24 of Aircraft Rule.

1.5.2 **Co-Pilot**

He had retired from the Indian Army. He received his initial helicopter training at an Indian Air Force training school in Hyderabad, India.

License Details:

License type	:	CHPL 883
CHPL Valid up to	:	21/07/2013
Date of Initial Issue	:	22/07/2008
Date of Endorsement of Bell 430 Helicopter	:	27/01/2009
Date of Birth	:	12/10/1964
Medical valid upto	:	1.11.2009
Instrument Rating No.	:	268 on Bell 430
Details of last two IR check	:	08 January 2009
PC checks	:	01 September 2009

Helicopter Ratings:

As PIC	:	Alloutee III/Chetak, Bell 430

Flying Details :

Total Flying Experience	:	3272:05 Hrs (Appx)
Experience on type	:	PIC 13:30 Hrs (Appx); co-pilot 83:25hrs; Total: 96:55 Hrs
Flying during Last One year	:	Bell 430, 96:55hrs.
Flying during Last 30 days	:	6:10 hrs

Flying during last 7 days : 2:45 hrs

During last 24 hours : 2:45 Hrs

1.5.3 Scrutiny of Records

- He was previously not involved in any accident/serious incident.
- His second IRT for initial endorsement of instrument rating was carried out on 6.3.2009 by DGCA approved examiner. The examiner commented as "passed and requires more practice."
- Original logbook and licence were not made available to Committee of Inquiry.

1.5.4 Aircraft Maintenance Engineer

The AME is holding Cat RA and JE license. Bell430 Helicopter and Allison 250C-40B was endorsed on his license on 29.10.2007. He was approved as Deputy Quality Manager by CAW Hyderabad for Bell 430 Helicopter VT-APG, on 8.10.2008 till operational and maintenance facilities are taken over by M/s OSS Air management, Mumbai.

1.6 Helicopter Information

1.6.1

Manufacturer	Bell Helicopter Textron
Type	Bell 430
Constructors S.NO.	49049
Year of Manufacturer	1998
Certificate of Airworthiness	2390 (Last issued on 06.12.08 Valid up to 05.12.2010) Date of initial issue : 14.01.1999
Category	Normal
Sub Division	Passenger
Certificate of Registration	2981
Owner	Government of Andhra Pradesh GAD (Poll'C') Andhra Pradesh Secretariat, Hyderabad-500022
Minimum Crew Required	One

Maximum Authorised All Up Weight	4218 KGS	
Last Major Inspection	150 Hrs/3 months inspection carried out at 2944:10 airframe hrs on 29/08/2009	
Last Inspection	Preflight inspection	
Air frame Hrs. Since New	2946:55	
Air frame Hrs. Since last C of A	132 hrs	
Engine	**Left**	**Right**
Manufacturer	Allison	Allison
Type	Allison 250 C40B	Allison 250 C40B
Serial No.	844104	844011
Hours Done Since New	2195 :55	2144:00
TSO	2195 :55	2144:00
Last Inspection Carried Out	Pre-flight	Pre-flight
Last Major Inspection Carried out	150hrs/3M on 29.08.2009 at 2194:40 Engine hrs	150hrs/3M on 29.08.2009 at 2142:00 Engine hrs
Engine hrs since last 300hrs/6M inspection	35:50 hrs	35:50 hrs

1.6.2 Scrutiny of record

- 600hrs/1 year inspection carried out at 2812:20 Airframe Hrs on 29/11/2008.
- Engine S/N: CAE-844104 was removed from helicopter on 01/11/2007 from No. 2 position at 2160:05 hrs and installed on 30/05/2009 at No: 1 position at 2160:05 hrs after repair and modification at the manufacturer facility at Oakland. Reason for removal was not recorded in the logbook. There is no preservation/depreservation entry for the storage period.
- Reason for removal is not given in any of the component removal entries in the logbook.
- Engine log books are not updated as on few occassion they have flown but engine cycle have not been recorded.
- Copies of the journey logbook after 7.08.2009 were not provided. The information in the journey logbook is filled up in duplicate. One copy is to be retained by the office.
- Snag register has not been maintained.

- Scrutiny of the journey log book for last one year did not indicate any snag pertaining to transmission or any repetitive snag. On 07.06.2009, torque had exceedance took place on No.1 engine and it was 105.8% for 1 sec. Inspection carried out as per MM-Chapter 5.

1.6.3 Aircraft Emergency Locator Transmitter (ELT)

ELT Type Pointer 4000-10 and Serial No. 408587 was installed on the helicopter after NRL test on 18/06/2009. After installation, its operation was found to be satisfactory. The certificate of Release to service (CRS) after NRL test and bench check was issued by DGCA approved organisation. The CRS was valid up to 16/06/2010. The ELT battery was replaced with new one P/N 2020 ; the replacement of battery was due on 04/2011.

This type of ELT conforms to TSO –C91A specification. This solid state transmitter operates at emergency frequencies of 121.5 MHz and 243.0 MHz.

1.6.4 Downloading of ECU data

The laptop used for the downloading of the data from ECU and IIDS was in bad state. No exceedance or the engine history data was stored in it after March 2007. Since March 2007 following exceedance have occurred for which laptop has been used for clearing the data from the memory after the rectification.

Date	Exeedance	Exceeded	Time	Remarks
30.04.07	MGT2	827 832.2 825.7 837.7	1 sec-Primary 2Sec-Primary 0 sec-Secondary 3 Sec-Secondary	With in limits IIDS cleared
22.07.07	MR	106.8 106.8	1 sec-Primary 1 sec-Secondary	Checks carried out as per MM-CH-5. Found sat. IIDS cleared.

07.12.07	MQ	102.5 102.0	1 sec-Primary 1 Sec-Secondary	With in limits IIDS cleared
23.12.07	MQ	112.7 112.2	0 sec-Prim 2 Sec-Sec	Checks carried out as per Chap 5 MM. 5 hours of test flight carried out. Found Sat. IIDS cleared.
24.06.08	MQ	109.4 109.4	1 Sec-Primary 1 Sec-Secondary	Checks carried out as per MM-CH-5. Found Sat. IIDS cleared.
07.06.09	No.1 Engine Torque	105.8	1 sec-Primary 1 sec-Secondary	Checks carried out as per MM-Chp-5. Found Sat.

From above it is seen that exceedance have occurred on number of occasions and after inspection/rectification has been carried out, the IIDS has been cleared. For this, the data has to be downloaded on the laptop. However no corresponding data was recovered from the laptop. The organisation is maintaining a register for recording the exceedances. There are no written instructions by quality manager/organisation at that time as not to retain the soft copy. Neither it was ensured by all the Quality managers since then to retain the soft copy of the ECU downloads. The laptop was checked at CFSL, Hyderabad and it was found that only one file in 2007 has been deleted. No file has been deleted thereafter.

As per Flight Manual 31-61PH-Rev2 D/O

(1) FADEC-ECU Inputs

The IIDS interfaces with the FADEC-ECU system through two ARINC 429 high speed (100 kHz) data busses - one from each FADEC-ECU. The IIDS only receives from the FADEC-ECU and does not transmit back to it. The primary purpose of the ARINC 429 data link is to communicate load sharing information, OEI flags and sensor values between engines. This data link also is shared with the IIDS to provide additional engine and control status to the aircrew or to maintenance personnel. As no backup to the ARINC 429 data bus is available, the IIDS treats the data supplied as non-flight critical. The ARINC 429 data bus contains information specific to the FADEC-ECU which is also used by the IIDS and additional data words dedicated to the IIDS. Each block of 24 data words are broadcast once every 24 milliseconds. Each parameter such as N1, MGT, START COUNT, requires one data word. Up to 16 pieces of discrete data can be grouped into one data word for each transmission. For example, the FADEC-ECU could transmit one grouped word containing 16 fault/status bits and twelve data words containing parameter data. The IIDS uses the analog inputs to display Np, Nr and Ng and reverts to the ARINC 429 data bus input upon the loss of the analog inputs. The IIDS uses the ARINC 429 inputs to display MGT and engine torques and reverts to the analog signal inputs upon loss of the ARINC 429 data bus.

(2) Maintenance Bus Inputs/Outputs: The IIDS is capable of interfacing with Ground Maintenance Equipment (such as personal computer) through an RS-232 port to download engine exceedances, IIDS fault code, engine/FADEC-ECU history data and any recorded engine parameters and time logs or to upload engine identification and related information clearing the NVM. Fuel calibration data can also be uploaded/downloaded via the RS-232 port.

1.6.5 General Description

a) Fuselage:

The Model 430 is a single pilot, nine places (optional 10 places), twin engine, intermediate helicopter with a four-bladed main rotor, and a tail rotor that provides directional control. The airframe is a semi-monocoque structure with metal and composite covering and consists of a fuselage, a pair of stub wings, and a tail boom with horizontal and vertical stabilizers. The primary load-carrying structures are the cabin roof and floor assemblies, each containing two main longitudinal beams, and bulkheads joining the two assemblies.

The fuselage consists of forward and aft sections joined at a bulkhead just forward of the wing leading edges. The forward section contains the nose compartment, crew compartment, and passenger/cargo compartment. The aft section contains the fuel cells, baggage compartment, aft avionics compartment, and optional equipment compartment. Stub wings, attached to each side of the aft fuselage, contain the fuel cells and a space for the optional pop-out emergency flotation gear. Cowlings and fairings enclose the roof mounted assemblies: power plant, transmission, transmission suspension system, hydraulic flight controls, and protective firewalls.

The tailboom is a part of the aft end of the fuselage and supports the tail rotor and drive train, vertical fin, horizontal stabilizer, tail rotor guard, and tail skid.

The nose compartment contains a battery, avionics, and other electrical equipment. The nose compartment door is hinged underneath so it can be rotated forward and down for easy access. Two support struts hold the door securely in the open position when pinned to receptacles located at the forward end of the center nose shelf.

The crew compartment or cockpit occupies the forward part of the cabin. The pilot station is on the right side and the copilot and forward passenger station is on the left. An instrument panel extends across the front of the cockpit and is tilted upward slightly for more direct viewing of the instruments. An overhead console is centered on the cockpit roof and a floor mounted pedestal extends from the instrument panel aft between the crew seats.

The pilot and copilot seats are designed for energy attenuation to absorb vertical impact loads in the event of a hard landing. The adjustment handles, located beneath the right side of each seat, can be pulled to adjust the seats 3.5 inches (8.9 centimeters) vertically and 4.5 inches (11.4 centimeters) longitudinally. Each crew seat is equipped with a lap seatbelt and a dual shoulder harness with an inertia reel which locks in the event of a rapid deceleration.

The aft area of the cabin contains a space of 158 cubic feet (4.5 cubic meters) for carrying of passengers. The baggage compartment is located aft of the passenger compartment and has a capacity of 37 cubic feet (1.0 cubic meter). The compartment can carry up to 500 pounds (227 kilograms) of baggage or other cargo. An aft avionics compartment is located aft of the baggage compartment. The compartment is accessible through a removable panel in the aft end of the baggage compartment.

Wings attached to each side of the aft fuselage contain fuel cells with a capacity of 70 U.S. gallons (265 liters) each. A ventral plate is added to the lower surface of each wing for improved aerodynamic stability.

b) POWERPLANT

The power plant consists of two Allison Engine Company Model 250-C40B turboshaft engines and their independent fuel, oil, and air management systems. The engines are mounted side-by-side and drive independently into the transmission. Each engine consists of a single-stage, centrifugal compressor, a single combustion chamber, a two-stage gas producer turbine, and a two-stage power turbine which supplies output power of the engine through the power and accessory gearbox. The engines have separate air intakes, exhaust ducts, fuel systems, oil systems, and controls for simultaneous or independent engine operation and twin engine reliability. A collective pitch position signal, provided by a potentiometer on a collective jackshaft, provides load anticipation for the NP governor. This anticipation initiates acceleration/deceleration after collective position movement prior to actual load change, thus reducing rotor speed droop or over speed condition.

b-1) ENGINE CONTROLS

The engines use a full authority digital electronic control (FADEC) to control, monitor, and limit engine operation while maintaining helicopter rotor speed. The control interface between the helicopter and the engine is both electrical and mechanical. The mechanical interface is the power lever angle (PLA) input from the throttle twist grip to the hydromechanical unit (HMU) on the engine via the cable assembly. The electrical interfaces are hard wired discrete, analog signals, and ARINC 429 and RS-423 digital data busses. In the event of a FADEC failure, engine speed is controlled by the HMU as set by the throttle position. The RS-423 data bus provides maintenance personnel with a data port to down load stored maintenance data. The ARINC 429 data bus is utilized by the FADEC on each engine to compare data for engine load sharing, and to transmit data to the IIDS. In the automatic mode, the FADEC controls the engine power level from cutoff to takeoff power by controlling the NG speed as a function of the PLA. In normal flight operations, the power lever is advanced and maintained at its maximum setting to act as a NG topping governor, while the NP governor establishes the engine power level necessary to match the rotor loads required. In the event of a FADEC failure, the throttle should be rolled back to idle, the ECU MODE switch for the affected engine set to MAN, and the throttle slowly advanced to a power setting slightly less than the good engine. This will allow the engine operating in manual mode to assist the good engine to deliver power to the transmission while it maintains the proper rotor RPM. While operating in the manual mode, all collective inputs should be made slowly, this is to allow the pilot to keep the manually operating engine within normal parameters. When the collective pitch is increased, the NP governor will maintain NP RPM by increasing NG until NG topping limit is achieved. Depending on engine inlet temperature and altitude the NG topping limit will correspond to one of the following limits; engine torque, engine temperature (MGT), NG speed, engine fuel flow, or transmission torque limit, whichever is lower.

b-2) ENGINE OVERSPEED PROTECTION

The FADEC provides over speed protection for both the gas generator (NG) and power turbine (NP). NP over speed limiting is provided by an analog electronic control that is integral to the ECU. Upon activation, 0.01 seconds after detection of 115% NP, the over speed solenoid valve will shut off engine fuel flow. Once the NP speed drops below the over speed threshold (113%) the over speed solenoid opens, fuel is reintroduced and auto relight is activated. The over speed limit control uses two analog speed sensing circuits activated by two NP speed signals. The sensing circuits are independently capable of providing a ground to the over speed solenoid valve. False trips are unlikely since a false trip requires both independent sensing circuits to fail. The NP over speed limiter operates while the FADEC is in either automatic or manual mode, however the auto relight is disabled when the ECU is in the manual mode. The power supply for the NP over speed limiting circuits is independent of the power supply for the remaining FADEC circuits and is supplied by both the helicopter power bus and the engine mounted Permanent Magnet Alternator (PMA) sensors is above 110%. When a NG over speed condition is present, the over speed solenoid is energized and fuel flow is cut off. This condition is cleared when the lowest of the two NG sensors is below 107%. The auto relight is activated and fuel flow is restored to the engine. The failure of one NG sensor will disable the NG over speed protection. An FADEC O/S TEST switch allows testing of the over speed system, to confirm operation of the over speed solenoid valve. The over speed test should be performed after the first flight of the day. The test is successful if the engine shuts down and the amber OVSPD caution message appears on the IIDS.

b-3) AUTO RELIGHT

The FADEC is capable of detecting an engine flameout by measuring an NG deceleration rate greater than the predetermined flameout boundary rate. Without a pilot action, the auto relight sequence is initiated, a fuel flow rate is established and the ignition system is activated. The FADEC will control the MGT and accelerate the engine back to its commanded operation. In the event of an unsuccessful relight, the throttle for the affected engine should be rotated to the full off position. Auto relight is disabled when the ECU is in the manual mode.

b-4) AUTOMATIC ENGINE LOAD SHARING SYSTEM

The FADEC accomplishes automatic engine load sharing by comparing engine torque and/or MGT signals of the two engines via the ARINC 429 data link. Each FADEC contains the control logic to raise the lower powered engine's power level to match the higher engine's power level. Upon loss of the MGT signal, torque signal, or ARINC 429 bus, the load sharing will revert to NG data, which is shared as an analog signal between the engines through the electrical harnesses. The pilot may select either MGT or torque as NG over speed condition is declared primary load sharing data with the FADEC when the lowest of the two NG speed.

c) INTEGRATED INSTRUMENT DISPLAY SYSTEM IIIDS

All engine, transmission, hydraulic. And control indications are displayed on the IIDS along with caution, warning and advisory messages, engine oil temperature and pressure, and transmission oil temperature and pressure. Also included is engine and mast torque (Q/MQ), power, turbine and rotor speed (NP/NR), gas producer speed (NG), end measured gas temperature (MGT) along with hydraulic temperature and pressure. Fuel system data displayed is fuel quantity for both main tanks and total fuel, auxiliary fuel tanks quantity (If Installed), and position of the interconnect valve. All fuel information is displayed blue except to, the last 50 pounds (Ibs) of fuel which will be displayed red. The displays is color coded to show operating parameter with green being used to show normal/continuous operating range yellow for cautionary, and red to, limit/exceeding limit. White digits with no backgrounds are to show normal condition and values (except NG end AMP where green digits are used), yellow digits with no background or black digits with yellow background used to show cautionary displays, and white digits on red background are used to announce warnings. Whenever the primary source of data for a MGT. Q, NP, NR, or NG Parameter is missing or invalid, secondary source will provide backup data for display. When date displayed is from a secondary source (except NG), the word ‘ALT’ will be displayed below the data. If both primary and secondary source are missing or invalid the digital display will revert to dashes, the vertical scale will remain empty, and amber ‘FAIL’ (except NG) will appear below the scale. The IIDS processes and displays information from the engine and systems separately so that a single failure does not cause the complete loss of one parameter for both engines/systems. The IIDS contains two power supplies, two Independent microprocessors and two independent displays. Each power supply has two isolated 28 Vdc inputs from two helicopter sources so that the loss of one power source does not cause the loss of the alternate power source or power altogether. The two processors ensure the loss of one processor does not cause the loss of any information shown on the display, except for fuel quantity, where loss of one processor will cause the loss of its associated fuel sensor, and only the fuel in one side of the fuel system will be displayed. In the event of a failure of one of the displays, pressing the ‘C’ switch under the primary display will cause the composite screen to be shown.

d) TRIPLE TORQUE DISPLAY

Triple torque display, simultaneously torque output of both engines (Q) and torque applied to main rotor mast (MQ). The torque gear of each individual engine regulates oil pressure as a function of engine power delivered. For each engine, this oil pressure is changed into an electrical signal through two pressure transducers which independently send the signal to the FADEC computer and to the IIDS as a backup. in normal operation the torque value Indicated by the IIDS comes from the FADEC computer (ECU). If the signal from the FADEC is lost, the IIDS will display the signal coming directly from the alternate pressure transducer. The IIDS will then display three letters ‘ALT’ at the bottom of the affected gage. When an OEI condition is detected by the IIDS, the scale on the Individual engine torque gage will change to the OEI range: two more red lines will appear Indicating a 2 minute limit and a 30 second Limit. The moving ribbon changes color till the operative range is reached: Green when below the adjacent yellow scale reference; yellow when within twin engine takeoff or OEI range, red if the 30 second limit is exceeded. The digits below the letter (Q) are indicating the actual engine torque produced (In percent) and the background ‘or the digital indication will change color in conjunction with the moving ribbon. For each engine, the area immediately above the letter (Q) is used to display the following Warning and Caution messages: ECU (red with audio) ‘or FADEC failure. ECU (white) ‘or FADEC degraded, A/RLT for automatic relight, SRT ABT, for ‘Start abort’. Whenever an OEI condition is detected by the IIDS, the following caution will appear above the Mast torque: OEI when the engine torque is less than 80.256, CONT OEI when engine torque is between 90.2 and 92.8%, 2 MIN OEI when engine torque is between 92.9 and 105.3% and 30 SEC OEI when engine torque is at 105.4% and above. The OEI caution will not trigger the Master warning/ caution.

e) TRANSMISSION

The transmission is mounted to the cabin roof with a vibration attenuation system. Power from the engines is transmitted from input quills through various stages of reduction gearing to obtain necessary torque and speed for mast and tail rotor drive. A hydraulic pump is mounted on each outboard quill. Freewheeling clutches are incorporated in outboard quills to permit disengagement of either engine in the event of engine failure, while allowing both hydraulic pumps to remain powered.

e-1) TRANSMISSION OIL SYSTEM

The transmission oil system lubricates and cools the transmission. A gear-driven pump and return screen are mounted in the transmission sump case. An oil manifold, located on the left side of the transmission, supports an oil thermostat, oil temperature bulb, oil temperature switch, oil pressure transmitter, oil pressure regulator, and oil filter. Each transmission/engine oil cooler consists of two separate, independent cores welded together. The forward core of each cooler is for the respective engine oil system and the aft core of each cooler is for the transmission oil system. The oil coolers are mounted over ducting aft of the aft engine firewall. Oil in the sump is pumped through an internal line to the manifold and filter. After passing through the filter, oil is routed by a thermostat either to the oil cooler or directly to the pressure regulator, depending on the oil temperature. The oil is then routed to eight jets which spray the oil directly on gears and bearings. A filter bypass valve opens if excessive back pressure develops as a result of extremely cold temperature or a clogged filter.

f) ROTOR SYSTEMS

f-1) MAIN ROTOR

The main rotor is a four bladed, all composite bearing less system. The two yokes bolt directly to the mast flange. A pitch change adapter at the inboard end of yoke section houses an elastomeric shear restraint and two elastomeric dampers. The blades have an integral cuff that fits over the hub yoke and bolts to the pitch change adapter, two more bolts are used to secure the blade to the outer portion of the yoke. The leading edges of the blades are fitted with a stainless steel abrasion strip. The end of the blade is a nickel cap. The stainless strip and nickel cap are used to protect the rotor blade against erosion.

f-2) TAIL ROTOR

The tail rotor is a two-bladed, semi rigid system mounted on the left side of the tail boom. All-metal blades incorporate the spherical pitch change bearings. Rotor flapping is allowed by a delta hinge for stability during hovering and forward flight.

f-3) ROTOR SYSTEM INDICATORS

Rotor system Indicators consist of a triple tachometer, triple torque meter, rotor RPM caution light, rotor RPM audio warning signal, and an O/TRQ caution message on the IIDS.

g) ELECTRICAL SYSTEMS

The electrical system consists of two nonessential, essential, emergency DC busses and two static inverters.

g-1) ELECTRICAL SYSTEM

The DC electrical system is a 28 volt direct current, negative ground system. Power is supplied by two 30 volt, 200 ampere starter generators (derated to 180 ampere), one mounted on each engine, and by a 24 volt, 28 ampere hour nickel-cadmium battery located aft of baggage bay. The electrical power distribution system is composed of two independent subsystems, which can be interconnected in the event of failure of either or both generators. Electrical separation between the subsystems is accomplished with relays, circuit breakers, fuses, and isolation diodes.

Each generator supplies 28 VDC power, controlled by a fault-sensing voltage regulator (Generator Control Unit), to respective DC main bus feeder. Each main bus then distributes power to respective non-essential, essential, and emergency DC busses. Two non-essential busses provide power to all equipment considered non-essential for flight Two essential busses provide power to all equipment considered essential for flight (when either or both generators are operational). Two emergency busses provide power to all equipment considered essential for flight under all generator operating conditions, including dual generator failure. The generators cannot be paralleled and will operate normally at differing ampere loads. Failure of either generator will render its respective non-essential DC bus inoperative; however, both emergency busses and both essential busses are interconnected and will remain powered by the remaining generator. Power can be restored to the affected nonessential DC bus through a bus interconnect relay, which will close upon pressing the BUS INTCON switch in the overhead console. The interconnect relay will be inhibited from closing if the failure is caused by a bus/feeder fault (short circuit). This protects the operating generator from being connected to the faulty system. Also, diodes prevent current flow from the emergency busses and essential busses back to the non-essential busses. In the event of a failure of the second generator, both non-essential and both essential busses will be de-energized. This automatic load shedding feature allows a minimum of 30 minutes flight with both emergency busses powered by the battery only. Battery power can be applied to both non-essential and both essential busses by pressing the BUS INTCON switch. This action closes both the battery relay and interconnect relay, provided there is no bus/feeder fault. Shortened battery life (less than 30 minutes) can be expected in this mode. Pressing the BUS DISCON switch will open both relays to disconnect the battery power from all but the two emergency busses. The essential busses are fault-protected from each other by the ESS BUS PWR circuit breaker. The emergency busses are fault protected from each other by two interconnecting EMER BUS PWR circuit breakers. The non-essential busses are ground fault-protected from the emergency busses and essential busses by fuses. The battery is protected from faults on the emergency feeder circuit to the two emergency busses by the EMER BUS CONT remote controlled circuit breaker (RCCB). Two 250 VA inverters provide the 115 VAC and 26 VAC power required for various navigation and flight control systems. No. I inverter derives its power from ESSENTIAL BUS 1 while No. 2 inverter derives its power from EMERGENCY BUS 2.

g-2) ELECTRICAL SYSTEM PRIMARY CONTROLS

Electrical system primary controls consist of a battery switch, generator switches, inverter switches, bus interconnect and disconnect switches, all located in the overhead console (figure 1-5) and engine start switches and a disengage switch located in the glare shield panel.

g-3) GENERATOR SWITCHES

The GEN 1 and GEN 2 switches open and close the generator field circuits. When either of switches is ON and the output voltage from the respective generator reaches 25 +0.5 VDC, the generator relay will close to energize the DC bus and the appropriate GEN caution message will extinguish. During engine starts using battery power, each GEN switch should be OFF until its respective engine is operating at Idle (61 ±1% NG). After the first engine is started, its generator may be switched on to assist the battery in starting the second engine (generator-assisted start). During engine starts using external power, both GEN switches should remain

OFF until both engines are operating at idle and external power has been disconnected. A RESET function is provided to reset a generator relay which has been tripped due to overvoltage, reverse current, or a ground fault If the malfunction condition persists, the generator relay cannot be reset and further attempts to reset should not be made.

1.6.6 Load & Trim Sheet

The seating arrangement in the passenger cabin was as follows:

1. Passenger No.1 – Left Forward Behind Co-Pilot
2. Passenger No.2 – Right Middle
3. Passenger No.3 – Right Rear

The load and trim sheet is available on the journey logbook (JLB). The current JLB was destroyed during the crash. The organisation has not retained the second copy. Based on the available records load and CG position was calculated and both were found to be within permissible range.

1.7 Meteorological Information

Meteorological briefing for the route VOHY-Chittoor-Ankul Pattru (Nellore Dist)-Ongole was provided to the pilot of the ill-fated helicopter by Aviation Meteorological Services (AMS) Begumpet at 6:30 IST of 2nd September, 09. At the time of briefing METAR 6:10 IST, local forecast of VOHY/VOHS and 100 nm around with validity period 01.09.2009/3:30 IST – 02.09.2009/11:30 IST, with validity TAF of 02.09.09/7:30 IST and TAF for other stations on the route with validity 02.09.09/7:30 IST were provided. Also, en-route synoptic situation were provided along with the flight folder. The flight folder contained upper wind/temperature charts of 050 FL, 100 FL and 140 FL and national significant weather charts.

The pilot was briefed about the presence of CB clouds tops reaching 12 km and shown the 05:30 IST imagery and satellite bulletin based on 01.09.2009 / 17:30 IST.

1.7.1 **Met Report: VOHS**

Time	**:**	**6:40IST**
Wind	:	290/08 KT
Visibility	:	4000 M
Weather	:	FBLRA
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	23˚C
Dew Point	:	23˚C
QNH	:	1007 HPA 2973INS
QFE	:	936 HPA 2764 INS
Trend	:	No Significant

Time	**:**	**7:10 IST**
Wind	:	300/08 KT
Visibility	:	4000 M
Weather	:	FBLRA
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	23˚C
Dew Point	:	23˚C
QNH	:	1008 HPA 2976INS
QFE	:	936 HPA 2764 INS
Trend	:	No Significant

Time	**:**	**7:40 IST**
Wind	:	300/06 KT
Visibility	:	4000 M
Weather	:	FBLRA
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	23˚C
Dew Point	:	23˚C
QNH	:	1008 HPA 2976 INS
QFE	:	936 HPA 2764 INS
Trend	:	No Significant

Time	**:**	**8:10 IST**
Wind	:	300/06 KT
Visibility	:	4000 M
Weather	:	FBLRA
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	23˚C
Dew Point	:	23˚C
QNH	:	1008 HPA 2976 INS
QFE	:	937 HPA 2767 INS
Trend	:	No Significant

Time	**:**	**8:40 IST**
Wind	:	310/08 KT
Visibility	:	4000 M
Weather	:	RERA
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	24˚C
Dew Point	:	23˚C
QNH	:	1009 HPA 2980 INS
QFE	:	937 HPA 2767 INS
Trend	:	No Significant

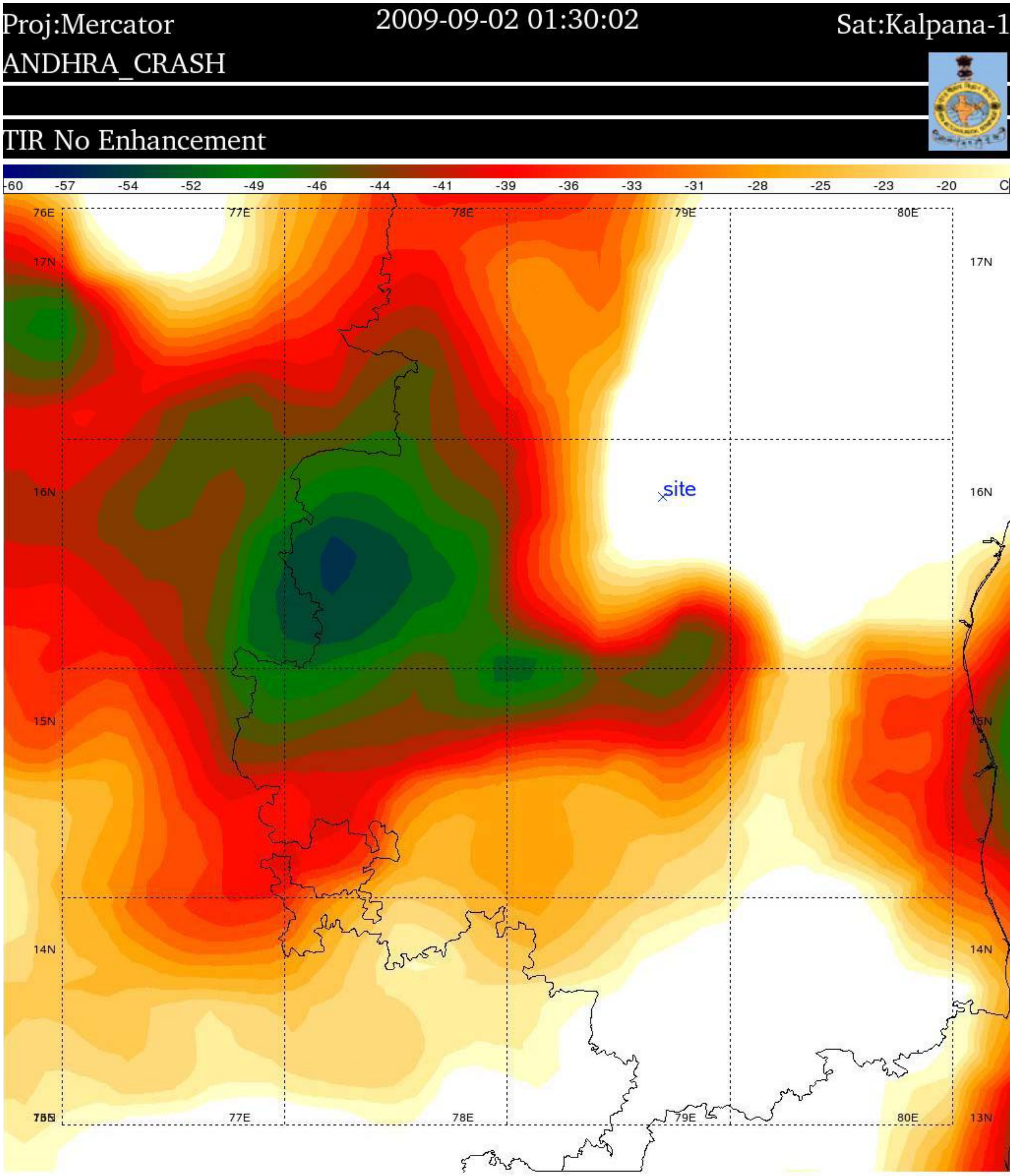
Time	**:**	**9:10 IST**
Wind	:	310/08 KT
Visibility	:	4000 M
Weather	:	RERA
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	24˚C
Dew Point	:	23˚C
QNH	:	1009 HPA 2980 INS
QFE	:	937 HPA 2767 INS
Trend	:	No Significant

Time	**:**	**9:40 IST**
Wind	:	310/06 KT
Visibility	:	4000 M
Weather	:	HZ
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	24˚C
Dew Point	:	23˚C
QNH	:	1009 HPA 2980 INS
QFE	:	937 HPA 2767 INS
Trend	:	No Significant

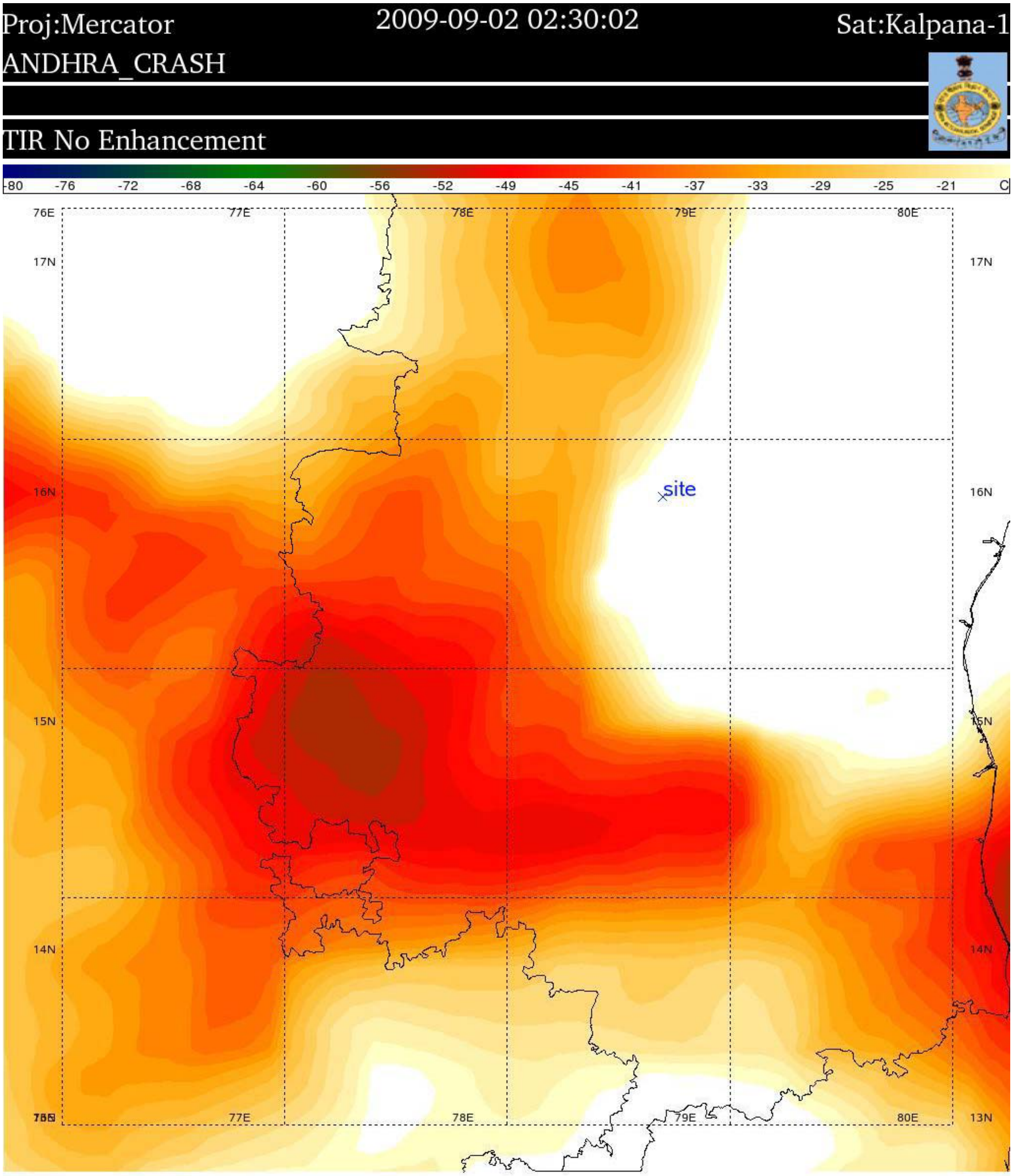
Time	**:**	**10:10 IST**
Wind	:	310/07 KT
Visibility	:	4000 M
Weather	:	HZ
Clouds	:	SCT 1500 FT, SCT 2000 FT, BKN 8000 FT
Temp.	:	25˚C
Dew Point	:	23˚C
QNH	:	1009 HPA 2980 INS
QFE	:	937 HPA 2767 INS
Trend	:	No Significant

1.7.2 **Met Report: VOHY**

Time	**-**	**08:10 IST**
Visibility	-	5000 m.
Winds	-	310/04 kts
Weather	-	HZ
Clouds	-	SCT 1500Ft, OVC 8000 Ft
Temperature	-	24˚C
DEW Point	-	21˚C
QNH	-	1008 HPA
QFE	-	946 HPA
Trend	-	No Significant



Time: 07:00:02 IST



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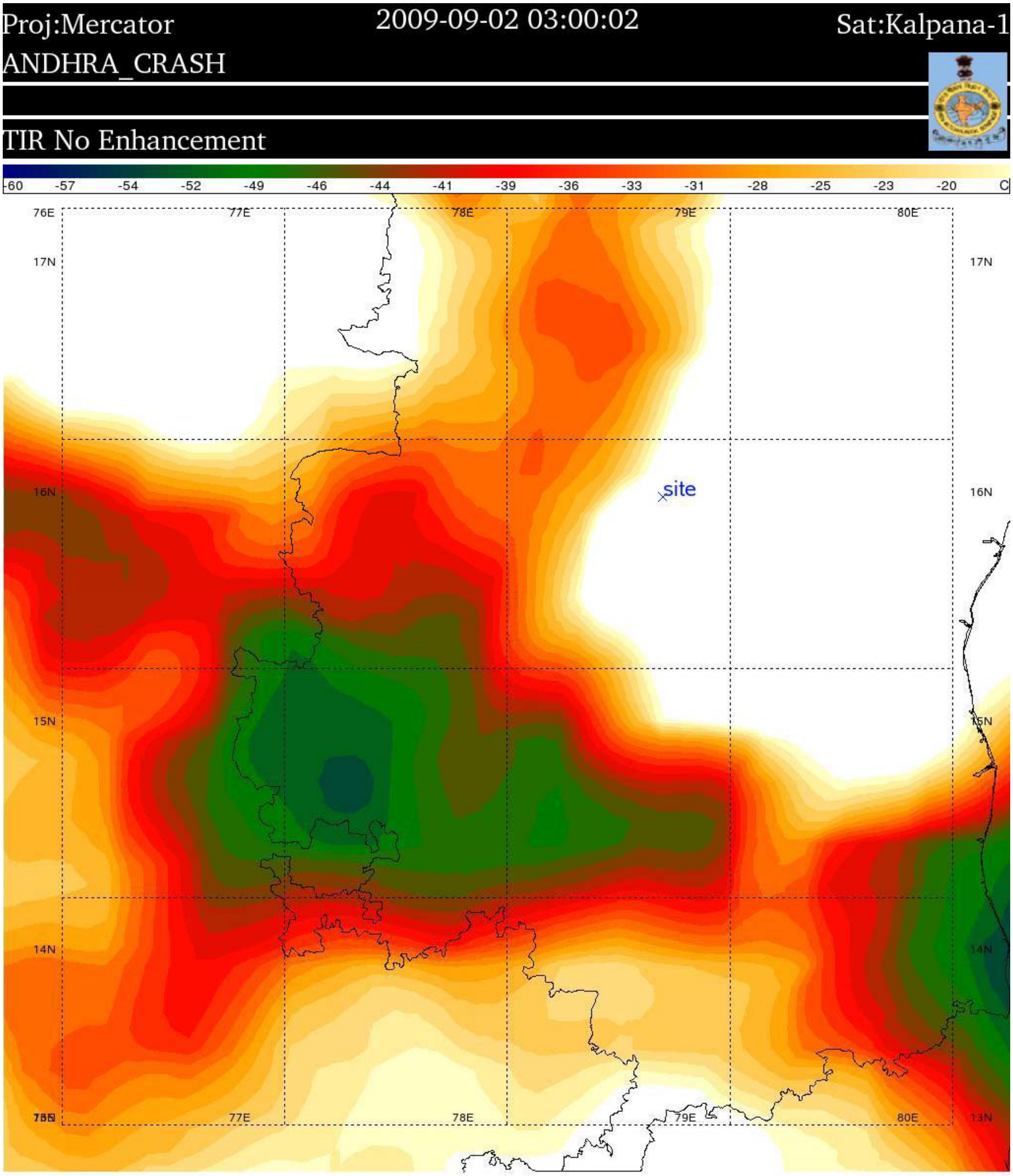

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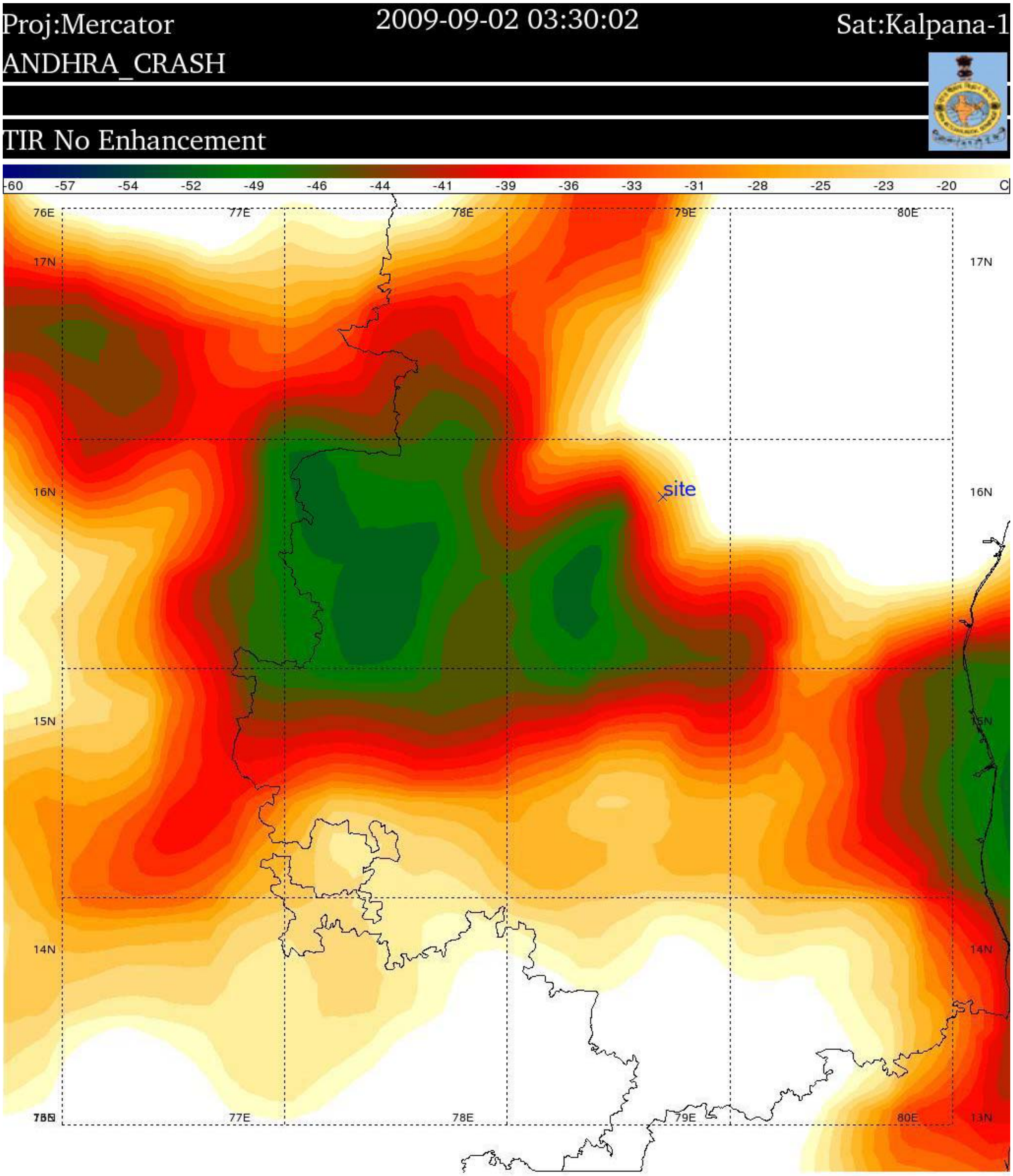
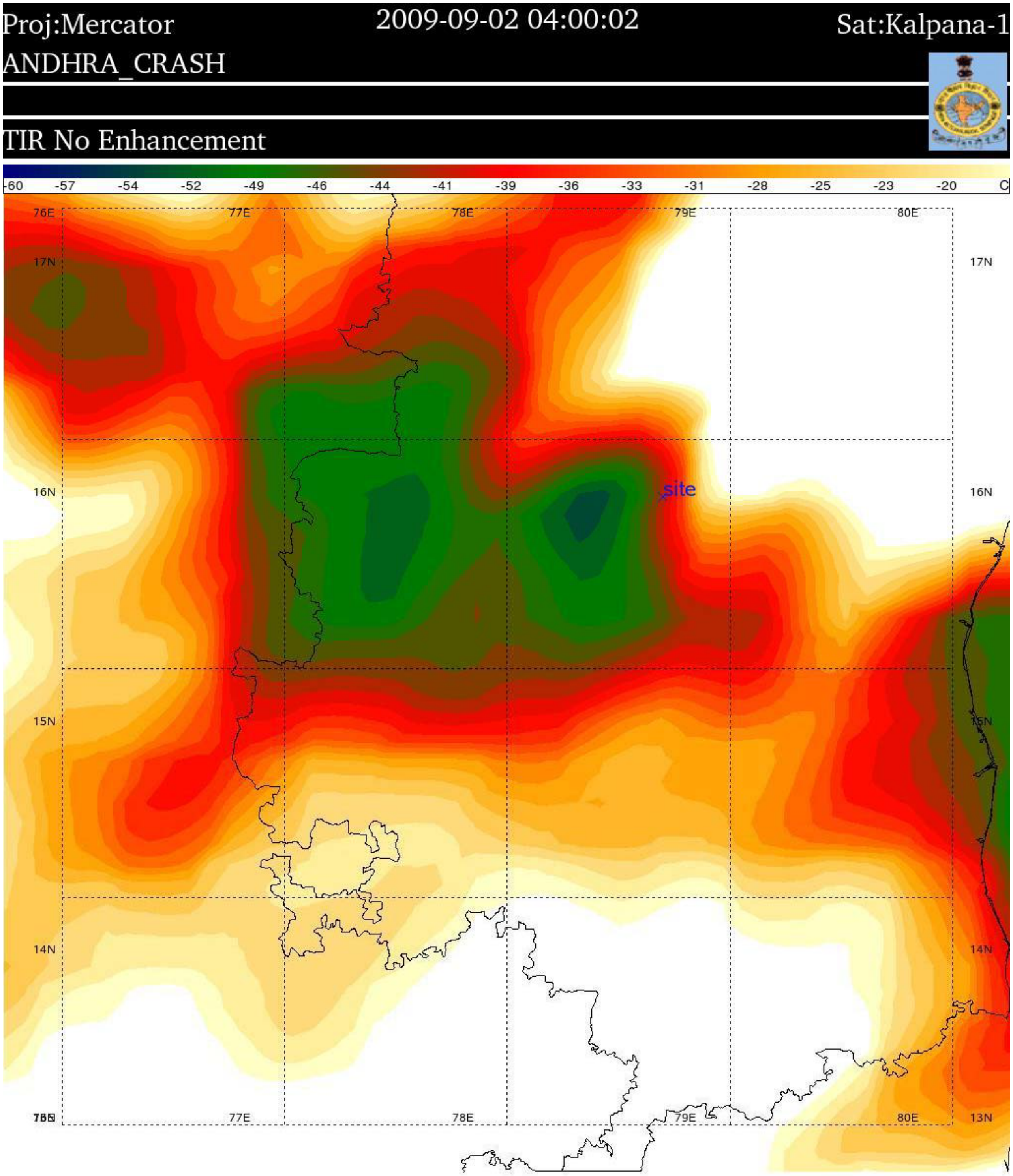


Time: 09:00:02 IST



Time: 09:30:02 IST

1.7.3 **Analysis of the weather Provided by the Indian Meteorological Department.**

Following paras list the interpretation/analysis of the weather situation provided by the Indian Metrological department

1.7.3.1 **Current Weather Observations**

West-northwesterly to northwesterly winds were reported by Begumpet airport from 08:10 IST to 12:10 IST and the speeds were between 04 knots to 09 knots. The visibility reported was 5000 m throughout the period and the weather was haze. 3-4 oktas low clouds were observed with base height 450 m and the sky was overcast with clouds with base height 2400 m.

The METARs of Shamshabad also shows northwesterly wind but slightly stronger, i.e. 06 to 08 knots during the period. Visibility was 4000 m only and rain was observed during the period. Here also, 3-4 oktas of low clouds with base height 450 m and base height 600 m along with 5-7 oktas of clouds with base height 2400 m were present. By 09:10 IST visibility improved to 5000 m in haze but again reduced to 3000 m in rain at 11:40 IST and further to 1500 m in rain at 11:50 IST.

1.7.3.2 **Synopsis observations at Kurnool**

a) 05:30 IST :Wind 02 knots, direction variable overcast sky with 3 okta low clouds with base height 600-999 m, visibility less than 4000 m, weather continuous rain.

b) 08:30 IST :Wind 5 knots from direction 270 degrees, visibility 4000-10000 m, weather slight rain, visibility less than 4000 m, overcast sky with 3 oktas low clouds of base height 600-999 m.

c) 11:30 IST :Wind 5 knots from direction 270 degrees, visibility and cloud amount, height of base of cloud remained the same, but weather was continuous and heavy at the time of observation.

1.7.3.3 **Synopsis situation**

From the observations of 08:30 IST on 2nd September, rain/thunderstorms were observed at most places of Telangana and Kurnool reported 4.5 cm rain. In the forecast valid till 08:30 IST on 4 September, rain/thunderstorm was forecasted for entire Andhra at many places with heavy rain at isolated places. From the 08:30 IST observation on 3rd September it is seen that, rain occurred at many places in Telengana, but Kurnool reported only 0.7 cm rain. There were no synoptic systems present exactly over the accident region, however, the southwest monsoon was active in the neighbouring subdivisions, like Konkan & Goa, Vidarbha, coastal Karnataka, and Kerala on 2nd September. On 3rd September, also, monsoon was active in Konkan & Goa, Madhya Maharashtra and Vidarbha.

1.7.3.4 **Interpretation of the satellite imageries**

06:00 IST Low clouds with embedded weak convection were observed over the accident site. CB tops reaching 16 kms were seen embedded. There were no significant convective clouds over the eastern sector of the site.

06:30 IST: Increase in convection and aerial extension, specially towards southeastern sector of the accident site was observed.

07:00 IST: Further slight increase in convection and aerial extension in southeast sector of the accident site is observed.

08:00 IST: The convection in the southeast sector nearer to the accident site area decreased. In the rest of the areas/sectors cloud clusters remain more or less same.

08:30 IST: Almost same situation persisted as 08:00 UTC.

09:00 IST: There is sudden increase in convection over the site and also the accident site area is fully covered by convective cloud cluster. The maximum increase in convection found over southwest sector.

09:30 IST: The accident site is fully covered by convective cloud cluster and there is further increase in aerial extension of the convective cloud cluster.

1.7.3.5 **The Aviation Forecasts**

a) Local forecast for VOHY/VOHS and 100nm around

In the local forecast valid 02/03:30 IST to 02/11:30 IST, the surface wind was forecast to be 290/10 KT. A reduction of visibility to 3000 m in moderate rain/drizzle or haze was forecast till 08:30 IST. Possible formation of isolated Towering Cumulus or CB clouds with base at 750 meter and top height 9000 meter was also forecasted. Moderate to severe turbulence and icing in CB was forecasted during the period. Warning for light aircraft "WIND SPEED MAY REACH 20 KT IN GUST FROM 270˚ " was also appended to the local forecast.

b) Terminal Aerodrome Forecasts

In the TAF for VOHS and VOHY valid for 02/ 08:30 and 02/ 17:30, 10 knots wind from direction 250˚ was forecasted and the wind was expected to increase to 20 knots in gusts during the forecast period. Also possibility of development of CB clouds and temporary reduction in visibility from 6000 meter to 3000 meter in thunderstorm and light rain was forecasted during 02 /15:30 to 02/ 17:30 IST.

In the TAF for Chittoor, Ongole and Krishnapatnam, the possible formation of CB clouds and temporary reduction in visibility from 6000 meter to 3000 meter in thunderstorm and light rain was forecasted from 07:30 to 14:30 IST.

1.7.3.6 **Analysis of convective stability parameters**

In the analysis of the RS/RW data of nearest available station, Hyderabad, for the 05:30 IST ascent on 02.09.09, at 925 hPa level, the vertical velocity (up-draught) was found to be negative (-7.466577E-01 m/s). But at 900 hPa level other vertical velocity was positive (1.071932 m/s). From next level (850 hPa) vertical velocity was nil. In this analysis only the vertical velocity due to convection was considered. However by 17:30 IST, the magnitude of the vertical velocities increased and high values were seen even up to 113 hPa. The estimated vertical velocity in the lower levels were of the order of 15 m/s. These observations were at a location of about 150 km from the accident site and also taken at 05:30 & 17:30 IST. Hence exact values of up-draught at the site and the time of accident could not be estimated.

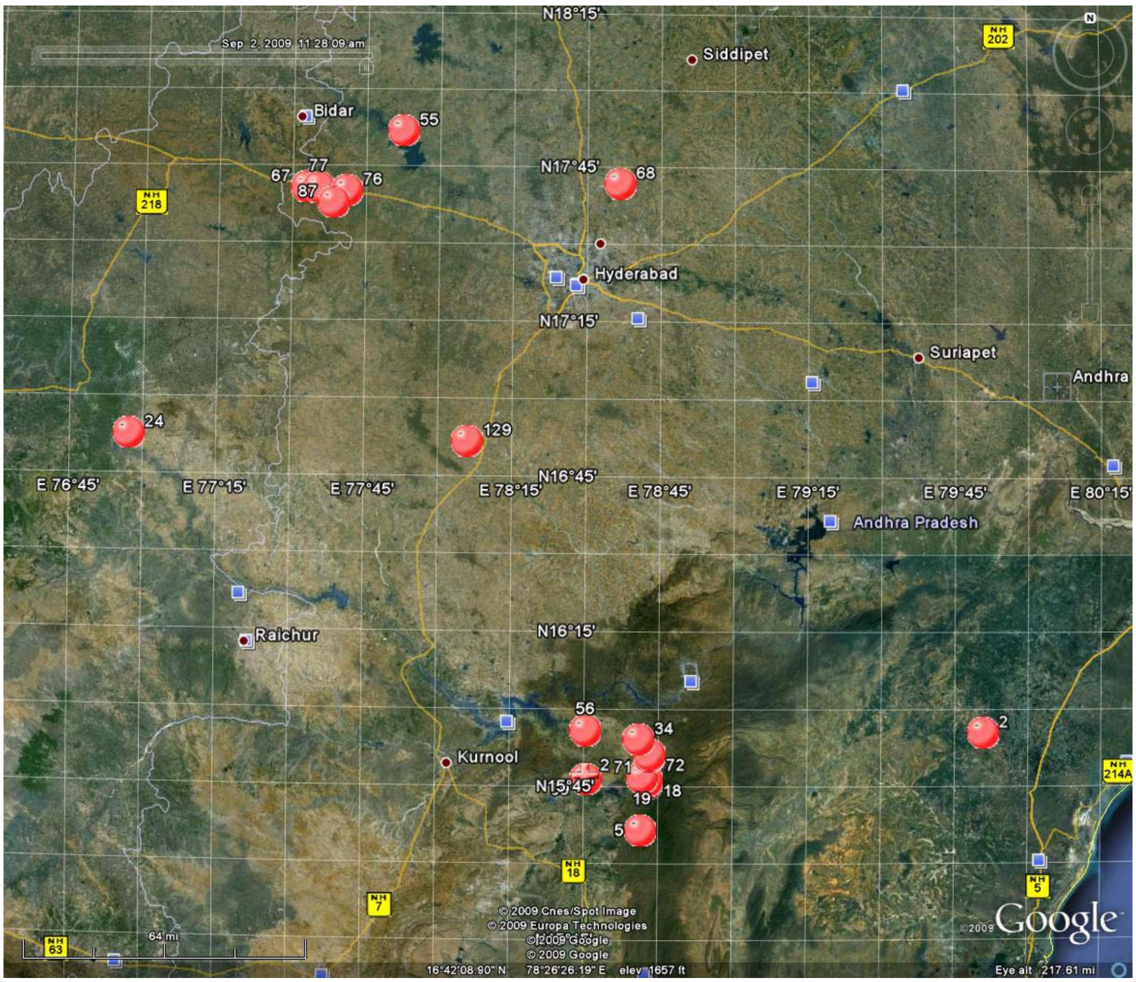
1.7.4 **Eyewitness Account:**

As per the residents of area near the accident site, it was raining heavily in the area and the visibility was also poor.

1.7.5 **Lightning Data:**

M/s India Precision Lightning Network, who have established lightning detection network in India as joint collaboration of M/s Rationale Technologies and TOA system were requested to provide the lighting data for 2.09.2009. The information provided by them states as follows:

“A review of our archived lightning location data reveals a storm center that appears to be in the helicopters path at the time of the disaster which we believe was between 09:30 IST and 10:30 IST**. The first lightning activity that was reported in that area was around 09:00 IST, this data also located lightning at 09:35 IST in the area of the crash site.**”



1.8 Aids to Navigation

Helicopter was out of the range of VOR signal of Begumpet and Shamshabad. The GPS was the only navigation aid available.

1.9 **Communication**

1.9.1 **ATC communication record of Begumpet**

At 8:29:10 IST - Start up was approved for VT-APG and QNH was given as 1008

At 8:34:14 IST - Helicopter was given taxi to holding point "B"

At 8:35:42 IST - VT-APG was given departure instructions "VT-APG cleared to destination Chittoor direct, altitude 5500 feet departure RWY-27 climb RWY heading 4600 feet further with RADAR for departure squawk 2736". At 8:36:27 IST, it was given take-off clearance from RWY 27. Helicopter was airborne at 8:37:57 and at 8:38:05 handed over to approach. Crew copied all the ATC instructions.

1.9.2 **Communication Recording of Approach Radar Shamshabad**

Helicopter came in contact with Approach Radar Hyderabad at 08:38:50 IST. After identification it was given clearance "Runway heading climb to 5600 feet and reaching 5600 feet turn left set course to HIA (VOR-Hyderabad)". The clearance was copied by the helicopter. At 0842:16 IST helicopter was asked to turn left intercept track to Cuddapah. Then it was clarified by the helicopter that the destination was Chittoor. At this point helicopter was on Radial 172˚ from HHY (Begumpet) distance 25.6 miles. Helicopter requested for the radial 170 for Chittoor. This was approved. At 08:45:00 IST Approach asked for the ETA Chittoor. At 08:45:58 IST, the crew gave estimate Chittoor as 10:30 IST. At 08:39:41 IST Approach asked "Confirm destination is Chittoor on Radial 172˚ ". Helicopter asked if they could maintain the present course. ATC asked "Report Established Radial 172˚ from HHY", which was affirmed by the helicopter. At 09:03:20 approach asked helicopter to report at 50 miles from HHY. The helicopter gave the present position as 46 miles maintaining 5600 feet. Approach asked helicopter "Report in contact with Chennai Control 118.9 alternate Chennai Radio." Helicopter affirmed that they were in contact with HF. At

09:03:45 IST helicopter asked “May we maintain 5600 or 5500 feet”. Approach cleared it to descent to 5500 feet at 50 miles. At 09:06:22 IST helicopter confirmed with approach that Chennai area control frequency as 118.9. At 09:12:34 IST helicopter informed the approach that they have contacted the Chennai radio and the next contact is at 09:30 IST. The frequency change was approved and radar services terminated. The last radio contact with Hyderabad approach was made at 09:12:52 IST.

1.9.3 ATC communication record of Chennai

Helicopter contacted Chennai radio at HF frequency 6655KHZ at 08:59:56 IST and passed the information that they are at 5500 feet; estimate Chittoor at 10:30 IST; CM on board; departure clearance issued to them by Begumpet. HF Chennai advised helicopter to make next contact at 09:30 IST.

1.9.4 Radar Recording of Shamshabad

The helicopter was painting on the approach radar Shamshabad up to 79.2 nm from it. The radar recording of Approach Radar Shamshabad was obtained and on its basis the position of helicopter w.r.t. Begumpet was determined as given below:

S.No	Time (IST)	Distance from Begumpet (nm)	Bearing w.r.t. Begumpet (HHY)	Heading (Approx)	Altitude (Ft)	Ground Speed (Kts)	Lat/Long.
1	0838	Airborne from Begumpet	Overhead Begumpet RWY 27	RWY heading	2000	059	172657N 0782655E
2	0844	7.9	245°	172	5600	104	172325N 0782011E
3	0846	9.8	222°	174	5600	136	171938N 0782109E
4	0848	13	206°	171	5600	134	171444N 0782214E
5	0850	15	202°	172	5600	135	171037N 0782255E
6	0852	20.8	191°	163	5600	135	170622N 0782403E

7	0854	24.7	186°	163	5600	138	170218N 0782538E
8	0856	28.8	182°	161	5600	137	165746N 0782716E
9	0858	33.3	179°	161	5600	140	165324N 0782858E
10	0900	38.2	176°	161	5600	143	164822N 0783041E
11	0902	43.3	175°	161	5600	143	164319N 0783240E
12	0904	47.4	174°	162	5600	143	163950N 0783403E
13	0906	51.9	173°	171	5600	142	163521N 0783502E
14	0908	56.7	173°	174	5500	145	163029N 0783545E
15	0910	61.4	173°	173	5500	141	162553N 0783633E
16	0912	66	173°	170	550	143	162116N 0783722E
17	0913	69.2	173°	173	5500	144	161752N 0783741E

1.9.5 **Correlation of Radar Plot and Radio Communication**

1.10 **Aerodrome information**

1.10.1 Hyderabad airport is located 7 kms. from Hyderabad Railway Station. The ARP coordinates of Hyderabad Airport are 172711.2N 0782729.1E and elevation is 531.3 meters. IFR/VFR types of traffic are permitted with 24 hours operation. The airport has DGCA licence No. AL/Public/011.

1.10.2 **Meteorological Services**

It has class-I Met Office with 24 hours of service. The trends are issued from 05:40 to 21:40 IST every 30 minutes and 16:40 to 23:40 IST hourly. Hyderabad ATS units are also provided with the information.

1.10.3 **Diversion Helipads**

Within close proximity of accident site, the diversion helipad could be Atamkur to the right of the flight path. Approximately six minutes before the helicopter encountered transmission oil snag, the diversionary helipads available were Achempet, Kurnool and Atamkur. Achempet was on the track while other two were to the right of the track.

1.10.4 **Search and Rescue Services**

The Search and Rescue Service in India is organized by the Airports Authority of India in collaboration with the Ministry of Defence, which has the responsibility for making the necessary resources available. Airports Authority of India has prepared a manual for search and rescue operation. The relevant extract for the manual for organizing search and rescue are as follows:

Head of SAR Services Chennai

The General Manager (Aerodromes) Airports Authority of India, Chennai Airport is the head of the Search and Rescue Services of Southern Region.

Agencies involved in SAR operations

Various other departments of the Central and State Governments viz. Railways, P&T, All India Radio Police and District Collectors/Magistrates etc., Municipal and Local Bodies, Airline Operators, Flying Clubs, Professional Pilots, Mercantile Marine, Port Trusts and Armed Forces are available for Search and Rescue missions as and when required.

Delimitation of the Area of Responsibility

The SAR area of Chennai Search and Rescue Region is the area contained within the boundaries of Chennai Flight Information Region. The coordinates of Chennai Flight Information is as follows:

1800N 7600E to 1800N 8100E to 1630N 8300E to 1400N 9200E to 1330N 9425E to 0600N 9425E to 0600N 9200E to 1000 N 8000E to 0600N 7800E to 0600N 7200E to 1500N 7200E to 1500N 7600E to 1800N 7600E

RCC Chennai – Functions

The RCC Chennai is responsible for promoting efficient organization of SAR Services and co-ordinating conduct of SAR operations within Chennai SRR. RCC is responsible for drawing up a detailed plan for the conduct of SAR in its area, which includes the –

(a) Organisation of the quickest possible means of communication in the area and with adjacent areas, for exchange of search and rescue information;

(b) Organisation of rescue units and designation of alerting posts;

(c) Coordination with services and organizations likely to be useful;

(d) Responsibilities of personnel assigned to search and rescue;

(e) Location, call signs, hours of watch and frequencies of radio stations maintaining watch for the purposes;

(f) Manner in which search and rescue is to be conducted;

(g) Actions planned jointly with adjacent Rescue Coordination Centers

(h) Any special provisions necessary or incidental to the conduct of search and rescue.

Information regarding State of Emergency of an Aircraft

An ATS Unit may generally become aware that an aircraft is in a state of emergency in one or more of the following ways:

a) Report to that effect by the aircraft itself.
b) Failure of an aircraft to report position or to respond to calls either from the ground or from other aircraft.
c) Failure to appear on radar when normally it should have appeared or sudden disappearance from radar screen.
d) Emergency indications on ADS and Secondary Surveillance Radar (SSR).

   The following SSR Code will be applicable relating to the nature of an emergency as below:

   State of Emergency: Mode A Code 7700

   Two-way communication lost: Mode A Code 7600

   Unlawful interference: Mode A Code 7500
e) Reports by Pilots of other aircraft or ships at sea.
f) Reports from Airline Operators who may have received the information on their Company channels.
g) Reports from members of public.
h) Alert messages received via Satellites relayed by INMCC Bangalore.

Declaration of Emergency

Notification of emergency : Without prejudice to any other circumstance that may render such notification advisable ATS Units shall notify RCC Chennai immediately, that an aircraft is considered to be in a state of emergency.

Phases of Emergency

a) Uncertainty Phase

i) When no communication has been received from an aircraft within a period of 30 minutes after the time, a communication should have been received or from the time an unsuccessful attempt to establish communication with such aircraft was first made, whichever is earlier or when

ii) An aircraft fails to arrive within 30 minutes of the estimated time of arrival last notified to or estimated by Air Traffic Services Unit, whichever is the later except when no doubt exists as to the safety of the aircraft and its occupants.

b) Alert Phase

i) Following the uncertainty phase, subsequent attempts to establish communication with the aircraft or enquiries to other relevant sources have failed to reveal any news of the aircraft, or when

ii) An aircraft has been cleared to land and fails to land within five minutes of the estimated time of landing and communication has not been re-established with the aircraft' or when

iii) An aircraft is known or believed to be the subject of unlawful interference.

c) Distress Phase

Following the alert phase further unsuccessful attempts to establish communication with the aircraft and more widespread unsuccessful enquiries point to the probability that the aircraft is in distress.

Initiation of Action

On receiving information that an aircraft is in a state of emergency, the FIC Coordinator should initiate action immediately.

Aircraft whose position is unknown

In the event that an emergency phase is declared in respect of an aircraft whose position is unknown and may be in Chennai or any other SRR the following will apply:

If RCC Chennai is notified of an emergency phase and it is unaware of other centers taking appropriate action, RCC Chennai will assume responsibility for initiation of suitable action in accordance with these procedures and confer with neighboring RCCs to designate an RCC to assume responsibility in this regard.

Actions during Emergency Phase

Actions to be taken when aircraft enters into uncertainty phase:

i) The flight of the aircraft involved shall be plotted on a chart by FIC in order to determine the probable future positions of the aircraft at its maximum range of action from its last known position. The flight of the aircraft known to be in the vicinity of the aircraft involved should also be plotted to determine the maximum endurance.
ii) When FIC decides that an aircraft is in a state of emergency, it shall, as soon as possible inform other aircraft known to be in the vicinity of the aircraft involved, the nature of the emergency. At the discretion of the RCC other SAR units and RCCs may be alerted.

Alert Phase

SAR action is normally initiated when the state of emergency enters the Alert Phase. The GM (aero) besides informing all concerned Chennai at his discretion will keep the Chairman, AAI (NAD), New Delhi informed through Member (O) and ED(ATM).

i) Send ALERFA message to concerned neighboring FICs, destination, alternate and other Aerodromes on the route where the aircraft could have landed.
ii) Plot the progress of the flight in Chennai FIR, its point of entry, route followed, last position known or reported for further action.
iii) If the overdue aircraft is over the land, informs the Duty Officer, IAF, Tambaram to relay message to Officer Commanding to keep the search aircraft on standby.
iv) Maintain watch on frequencies on which the aircraft was last working and do blind weather broadcast for the destination and alternate aerodromes, if the weather condition at Chennai is below minima, if the destination of the involved aircraft is Chennai.
v) Inform Met Officer to send to FIC in plain language route forecast etc., for the route involved up to destination and alternate aerodromes.

1.11 Flight Recorders

The helicopter is equipped with CVR but not DFDR (neither it is required to be equipped with DFDR). The CVR was recovered in damaged condition. It was decoded at NTSB facility at Washington D.C in presence of representative of committee of inquiry.

Salient Points from the CVR transcript are as under:

The Flying Crew was well aware of inclement weather enroute as the same was discussed, visually observed and interpreted the weather Radar picture throughout the flight.

* The Crew was in contact with Hyderabad approach on VHF frequency till they were asked to change over to Chennai control after establishing the contact with Chennai on HF frequency.

* The Crew was not sure about Chennai frequency and was debating among themselves about the Chennai frequency given to them by Hyderabad approach which shows poor flight planning.

* The PIC was well aware of the repercussions of bad weather and instructed the Co-Pilot to keep his hand under the collective to safe guard against exceedance of Torque and up and down draughts and turbulence.

* The Crew noticed transmission pressure display on IIDS and failed to correlate with other indication associated with it. They wanted to refer the emergency encountered with the help of emergency checklist but could not locate the emergency either in the emergency checklist or in the Flight Manual.

* The CVR transcript shows that they were expecting some improvement in weather conditions after crossing Krishna River which was flowing at right angle to the flight path in hilly region.

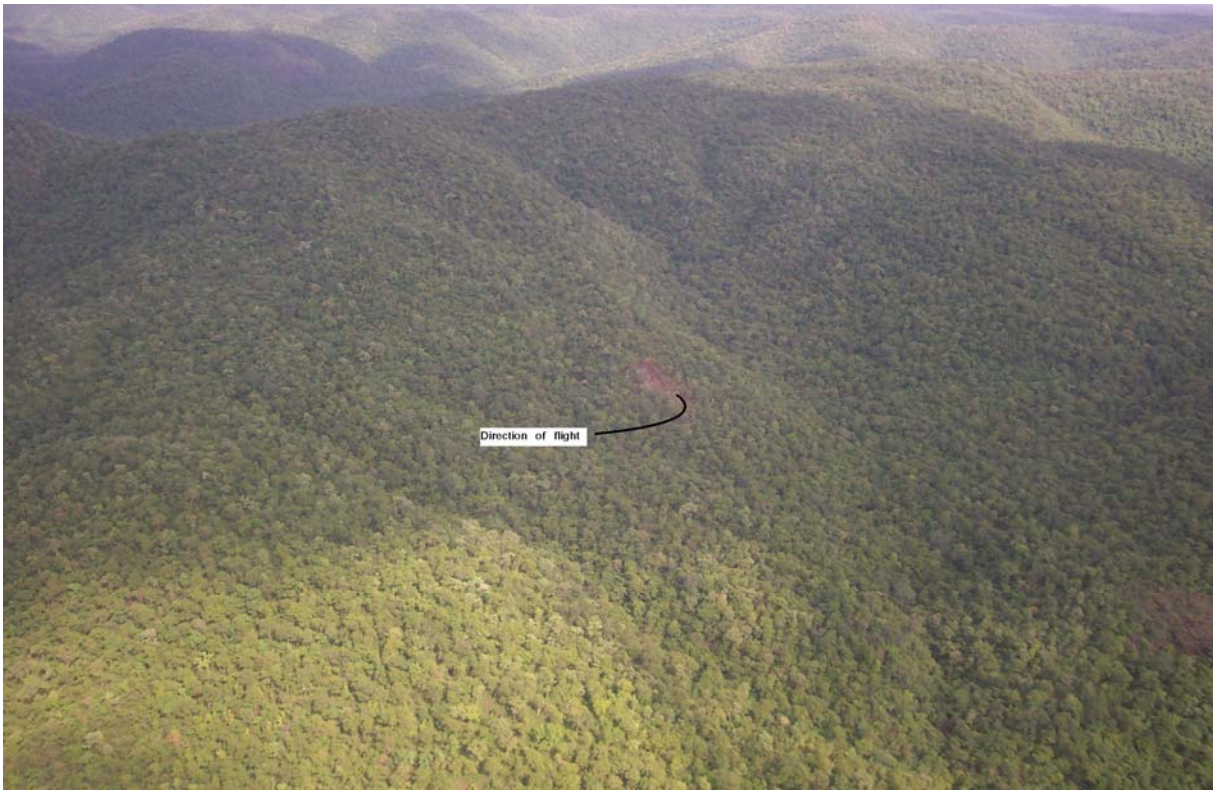
* The Crew got so engrossed with the emergency and lost situational awareness of extreme bad weather ahead.

* There were repeated warnings from Co-pilot to **Go Around** due to close proximity of ground which he may have realized either with the help of Radio altimeter or may have sighted the obstruction momentarily, the PIC failed to react to the situation.

* The CVR transcript shows that there was poor CRM amongst the Crew at any given stage of flying.

1.12 **Wreckage and Impact Information**

Accident site is approximately 26 km from Atamakur in the dense forest. The coordinates of the accident site are N 15° 47´04.7”, E 078° 42´40.9¨.Accident site is at the slope of a hill. The surface is rocky. Due to impact the helicopter had broken in number of pieces. The wreckage was spread over an area of 566 sq m. Helicopter approached the accident site in steep left bank.



Aerial View of Accident Site

At approximately 63 meters before the final resting point of main wreckage, the lower portion of the helicopter chopped off the tip of a tree around 40 feet in height. There after it moved forward in the same direction while losing the height and at 48 meters before main wreckage, the main rotor hit four trees almost in a row, on left, right and the body of the helicopter impacted trees in the middle, this is indicated by the damage on the trees. Portion of main rotor blades were recovered near them. From the central tree at approximately 6 meters in the forward direction the helicopter impacted the ground. The helicopter impacted the ground in steep left nose pitch down attitude. After the impact the tail rotor assembly along with vertical fin and a portion of tail boom separated and went towards right side. The PIC body along with the wire loom, portion of instrument panel, few instruments, torn floor mat with structural part, broken control sticks, and right cockpit door separated and were observed on the left of the path. At 22 m. before the main wreckage the helicopter passed through two trees. The right horizontal tail surface struck the tree on the right and this portion of the tail boom separated from the helicopter. The Copilot body was further on the left along with the frame of the seat. At 15m from this point, Left wing upper portion, burnt VIP seat, and "passenger no.1" body was recovered. The back of the body bore signs of fire burn. The right wing upper portion with soot deposit was recovered 15 m to the right of main wreckage. The helicopter moved forward, its parts progressively separated and finally came to rest after impacting a group of trees and caught fire. The main wreckage was resting on left side and turned by 90˚ to the direction of motion.

No aircraft part was recovered before the tree where the initial impact was made. Ground marks of fire/soot were observed from 22 m before the main wreckage on the tree and the stones. Marks of the fire were observed on the leading edge of the one tail rotor blade, left horizontal stabilizer, lower portion of tail boom on the left and floor mat located near the horizontal stabilizer. Detailed wreckage diagram is given as appendix 'A'.

View of the site with direction of flight

1.12.1 Fuselage

a. Fuselage was broken in to number of pieces and spread along the direction of the motion. Due to impact the nose compartment had shattered, the avionic components, electrical components, radar and CVR housed in it were scattered near the point of initial impact with the ground. All the units were damaged/stripped open. A portion of the right side of the cockpit along with the instrument panel had separated initially. Both the seats in the cockpit were shattered. Left side crew seat belt was buckled on the body and attached to the frame. The cockpit doors and frames were broken and bent. Left cockpit door was recovered with the lock in engaged mode. The right cockpit door was bent outward. Control sticks of both sides were bent and broken, top panel of the cockpit was located at the main wreckage position along with overhead electrical console, center pedestal in damaged condition and bore fire damage/soot deposit. All the passenger seats frames were shattered. Passenger door of the right side with the glass and upper portion of the window frame broken and baggage compartment door in the locked condition was recovered. Soot deposits were observed on the rear panel of the baggage compartment. The fuselage fuel tank, auxiliary fuel tank were ripped open. Fuel tank rear spar with a portion of ribs attached, partially burnt bladders, fuel filler neck along with fuselage panel were recovered. Fire damage was seen on the spar. The warping and burning of the skin had taken place. The portion of skin on right side was missing.

b. **Following items were recovered** :
Pilot seat frames, Co-pilot seat frame, DR Compass, Altimeters, Artificial Horizon, Vertical speed indicators, Airspeed indicators, Overhead control panel, EFIS displays. Avionics units

c. Position of switches and CB's
CB's for "PED LIGHT","ATT2", "HDG2", ENG1 ANTI ICE","INST FLT", "ESS2 PWR","AUX FUEL TANK", "BAG SMOKE DET", "IIDS 1&2" ,"VHF COMM1", "FIRE EXTG BTL1", "FIRE EXTG BTL2", "FADEC

1&2", "BUS INCON", "GEN2 FIELD", "GEN1 FIELD" were observed to be out.

Switches	**Position**
TEMP CONT	Middle
WSHLD WIPER	HIGH
ENG1 (FADEC)	AUTO MODE
ENG2 (FADEC)	MAN MODE
ENG2 (FIRE)	ARM

d. Cockpit Instrument Readings

Instrument	**Reading**
Air Speed Indicator (Left)	Out of Scale
Air Speed Indicator (Right)	160 kts
Vertical Speed Indicator (descent)	3500 ft/min
Helicopter Clock	09:29
Altimeter	
Pressure Setting	1007.5 MB
Altitude	1230 feet

1.12.2 **Stubwing :**

Both the left and the right stubwings had shattered. Upper skin panel of both the stubwings were recovered. They showed the sign of axial load with bent line near the step portion. Soot deposits were seen on the right wing upper panel and it was recovered around 50 feet from the main wreckage towards its right. The forward and the bottom portions were missing. The spar in continuation of the fuselage tank was available on both left and right side.

1.12.3 **Landing Gear**

Skids assembly was broken into pieces. The cross tubes and the skids had separated.

1.12.4 **Engines**

Both the engines were recovered at the site of main wreckage. They were located in their housing on top of fuselage. Right engine had extensive fire damage. The accessory gearbox casing was completely burnt and starter generator had shattered. Oil and transmission cooler along with the blower had separated. No debris was seen in the inlet and exhaust of both the engines.

1.12.5 **Main Transmission**

The main transmission was located at its position on the top of the fuselage. The right input drive quill adapter had separated from the transmission. All the mounts were intact. Tail rotor quill and the rotor brake assembly were intact.

1.12.6 **Main Rotor**

Main rotor assembly was intact. Only $1/4^{th}$ of the blade length was available. The blades displayed significant leading edge damage, with middle portion and trailing edge of the composite blades shattered. The damage observed to the main rotor blades was consistent with the blades impacting with power being applied.

1.12.7 Tail Boom Assembly

Tail boom assembly had separated at the fuselage attaching frame viz. frame 388. It was split into two portions with one portion from frame 388 to just aft of horizontal tail surface. The tail boom sustained impact damage along each side, as did the horizontal stabilizer. Both the stabilizers attached to the tail boom. No deformation seen in the inner segment of the stabilizer. All the screws at the attachment bracket intact.

The left portion of the boom near the bottom, at buckled skin near frame 388 and underside of left elevator had soot deposit/fire damage. The skin of left elevator near the tip had ruptured though that portion of skin along with fin was still attached. The stabilizer on right side had damage on the leading edge.

The tail rotor gearbox case was fractured and separated into two (2) pieces. The fracture of the case separated the gearbox at the drive gears and, the tail rotor assembly (and outer portion of the case) separated from the tail boom on impact. The case flanges were fractured around the mating attachment bolts. There was no visible damage to the internal gears. The tail rotor assembly displayed substantial impact damage, consistent with impact with rotational energy present in the tail rotor system. The tail rotor blades displayed both impact and fire damage. Vertical fin was attached to the fuselage and had impact damage and a rectangular cut on near the top leading edge.

1.12.8 Examination of the Wreckage in the Hangar

The wreckage of the helicopter was relocated to A. P. Government facility, Hyderabad, for the purpose of post-accident examination. A partial rebuilding of various sectors was undertaken for detailed analysis

1.12.8.1 Examination of the Fuselage and Tail Boom

Forward fairing, Transmission cowling, air inlet cowling, upper engine cowling and fairing was missing/split into fragments. Roof of the cockpit had spilt in three parts viz. Cockpit roof, Transmission deck and engine web. Fuselage shell consisting of frames and longitudinal members had shattered. Tail boom had separated at fuselage attaching frame.

Transmission deck: both the hydraulic modules were intact. All the four manifold intact, all the hydraulic lines are connected. Three front and three rear Bell crank attachments separated.

Transmission Deck

Engine Web

Left Top Panel of the No.1 Engine: Decolouration and bluish marks seen near the exhaust and forward portion on the RHS. On the inner side completely covered with the soot. Burning of surface seen in patches and white deposit were seen near the exhaust.

Bottom Portion of the No.1 Engine: Warping of the surface seen in damage condition due to fire. Metallic hose burnt. Bluish and brown marks observed.

No.2 Engine Bottom Panel: The surface colour is brown and bluish. White material deposit, thick soot deposit and charring of the metal on the front side out board. Lower panel cover, bluish and brown marks at leading edge. Bottom surface warping seen.

Right Side Aft Panel: Side portion heavy soot deposits are seen. A large portion of the grill was burnt.

Exhaust Panel: Top portion, decolouration, bluish and brown marks observed. White deposits were seen in the direction of flow in the exhaust. Inner side soot deposit and white deposit seen, bluish and brown patches observed.

Rear Panel: Showed sign of fire damage/soot deposit. On the top, mesh is intact. On the left side a portion of wire mesh is burnt. The portion shows fire damage, discoloration and soot deposit.

Fire Wall Front Side: Sign of fire damage observed and deformed due to impact. Metal puddle is seen on RHS flowing downward. The fire wall material is shattered and burnt.

Fuselage RHS: Cargo door fully recovered. Door is in locked position and separated from the fuselage. Passenger door glass with frame separated.

Doors on Right Side

Fuselage LHS: Passenger door was not located/shattered in to fragments. Fuselage portion from station 340 to 388 had separated from the fuselage and indicated severe fire damage.

Aft fuselage portion with fire damage

Tail Boom

Tail Boom: Separated at fuselage attachment to the tail boom. The first frame is damaged and about ¼ portion is missing. All the eight longerons attached, however, broken at attachment point due bending. The impact was from the left bottom. Soot deposit, decolouration and burning of the paint seen on the left bottom portion. Elsewhere in the left side soot deposit seen. Tail boom fractured at tail boom frame No.10. No fire damage and separation occurred due to bending and rupture. End portion of the frame No.10 has impacted. All fasteners of the drive shaft upper panel were intact. No fire damage or soot deposit seen.

Vertical Fin: Entire length of the vertical fin recovered near the root end trailing edge there is impact causing compression cord wise and in vertical direction. On the left side near leading edge there is a rectangular cut 5cm x 2cm. Leading edge ripped open about 12'inch leading edge impact and flattened. TGB housing attached along with portion of tail drive shaft. TGB mounting is in place. TGB separated from the housing. No fire damage observed.

Tail Gear Box: Casing broken. Pitch change link broken from airframe attachment. Input rod from the cockpit broken. However, the linkages are intact. No fire damage.

Tail Rotor Blade: Tail rotor blade separated from the gear box. Both the blades attached to the hub. No damage in the leading edge. Blade S/N A-1895 intact with impact damages. No fire damage. Blade S/N A-1892 only leading edge available, a portion of honeycomb near the root end available. Ripped open at the trailing edge and has fire damage / soot deposit. Leading edge also indicate signature of high temp. Bulbs of the paint were formed.

Tail Drive Shaft: All the four segments of the tail drive shaft recovered. No.1 segment separated on the MGB side due to tear and torsion. Several scoring marks observed on the shaft. At the rear end the Thomas coupling is intact. None of the fasteners are adrift. Splines are satisfactory. No.2 Segment came out from the spline. The inner splines are intact. Near the forward portion soot deposit and brown colouration is due to high temperature. On the rear, the shaft was ruptured. Splines are satisfactory and the coupling is attached. Third segment intact, attached at both ends and tail boom. No.4 Segment Split in two pieces. On the front end the coupling attached. Inner splines were found intact.

Tail boom and Tail rotor drive Shaft

Wire locking and other fasteners available. No fire damage. Rear portion attached to the TGB. Coupling is intact and free to rotate.

Left Stabilizer: Auxiliary fin detached along with a portion of stabilizer. Leading Edge slat is intact. Compression is due to impact from the tip towards the root. On the top surface soot deposit and burning of the paint observed in the out board portion. Soot deposit seen on the inner surface of the stabilizer skin. Entire bottom surface shows soot deposit, burning of paint and discoloration.

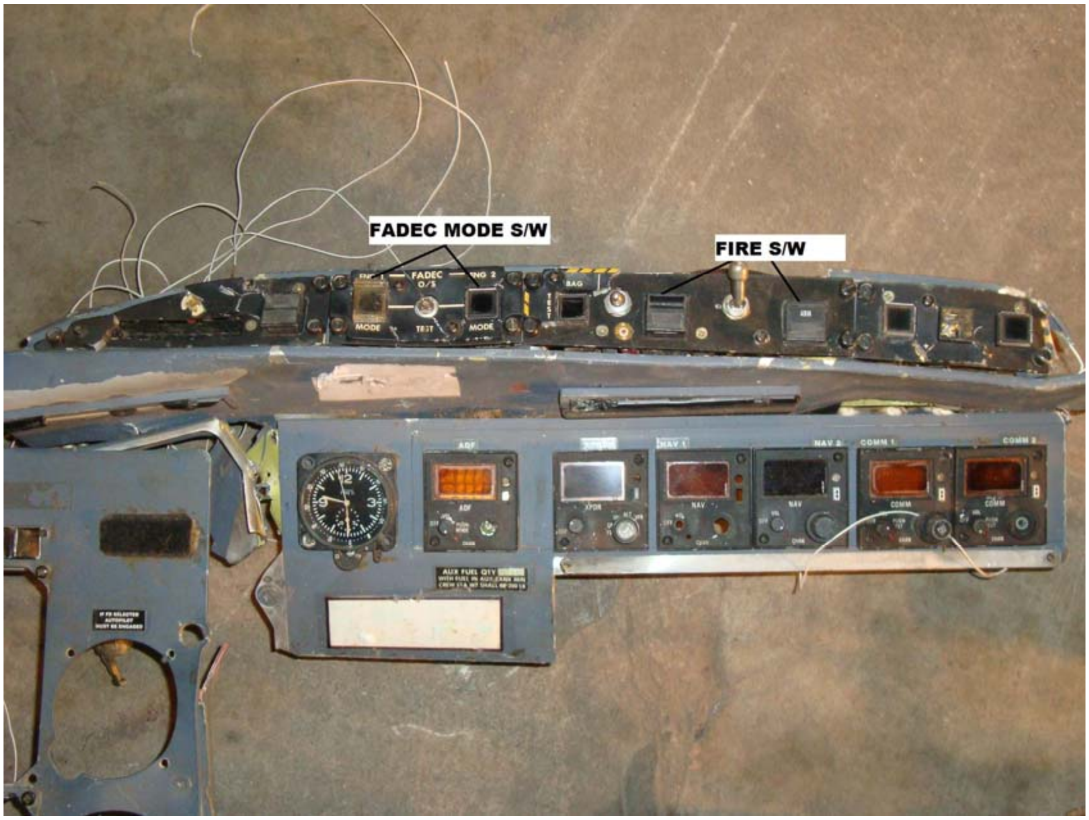
Right Stabilizer: Attached with the tail boom. Auxiliary fin attached. Bottom portion of the auxiliary fin bent due to impact. Leading edge slat impacted at the out board portion of the leading edge. Compression is due to hit with the tree. All fasteners of drive shaft upper panel were intact. No fire damage and soot deposit seen.

1.12.8.2 Examination of the Cockpit

The roof panel of the fuselage is deformed and bent inward due to impact from the front and left side. It is covered with soot. Only a portion frame of left and right cockpit door and frame was recovered. The forward edge of the right door is battered and bent outward in the forward direction. The lower portion of the frame is also bent in the forward direction. The left door is pushed in the backward direction. The frame is also buckled. Scissor assembly is damaged and separated. The damage pattern indicates forward and vertical impact on the left side and vertical impact on the right side.

Cockpit doors with Upper Portion

The glare shield panel indicates that the No.2 engine fire was armed. No.1 engine was in FADEC auto mode while No.2 engine was FADEC manual mode.



Glare Shield Panel

1.12.8.3 **Examination of the landing gear**

Almost all the elements of the landing gear were recovered and arranged as per the layout and following observations were made:

- Skid gear separated from the fuselage at the attachment points.
- Forward Cross tube on the left side was flattened and attachment to the skid was served and twisted backward.
- Left Skid had served near attachment at forward cross tube and aft cross tube and broken into three pieces.
- Right Skid was broken into five pieces.
- Aft cross tube support beam shifted towards the left.

Damage to the landing gear indicates that heavy impact was felt on the left side in the vertical and longitudinal direction which cased the flattening and twisting backward of the forward cross tube on the left side.

1.12.8.4 Examination of the fuel tanks

Available parts of the fuel tanks were assembled and following observation were made:-

Only upper portion of the both wings were available. Soot deposits were seen on the underside of upper panel of the right stubwing. The panels had impact marks/penetration on the leading edge. Rear spar of both the stubwing tanks were in position though deformed. Flexible tanks had separated and torn in pieces and found in partially burnt condition. On the left side flexible tank attaching bolt were dislodged with elongation of the bolt holes inward.

Left wing fairing separated at the bolt line. Holes failed in the inward direction. Central fuel tank rear spar was available and showed signs of severe burns on the right side. Main tank and auxiliary fuel caps were recovered. Auxiliary fuel tank was totally burnt. Both sides of wing tip fairings have shattered in pieces.

1.13 **Medical and Pathological Information**

1.13.1 The post-mortem examination of crew and passengers was carried out by the Forensic Science Department of Kurnool Medical College. The examination revealed that the clothes of all the bodies were torn and stained with blood, mud, pieces of vegetations, electric wires, seat belts and glass were found embedded in the muscular tissues/viscera. The facial features were intact and identifiable but the skulls were crushed, with the cranial cavity exposed and brain tissues either oozing out or missing. The limbs were fractured or separated. The abdominal and thoracic cavities were exposed. Most of these injuries were anti-mortem. Fire injuries were observed on occupants seated on left side. The cause of death has been given to be shock and hemorrhage resulting from multiple injuries.

1.13.2 The postmortem reports were referred to DMS (CA) for his opinion. As per opinion expressed by him on the reports in respect of crew/passengers suggest the following:

- Severe decelerative stress leading to multiple fractures/bony injuries indicating very high speed impact.
- Post crash fire for a short duration due to extensive fuel spill – Flash burns.

1.14 Fire

Soot deposit/fire damage was observed on the left side aft of left wing. The fire damage/soot deposit followed the air pattern. The soot deposit was not in the upward direction. These parts had separated subsequently along the direction of motion before the helicopter wreckage finally came to rest. Fuselage portion aft of the baggage compartment had severe burns and warping of the skin. Bodies of the passengers which were thrown out had fire injuries on the back. This indicates the fire was triggered either during impact with the trees or after the first impact with the ground, the fire was of moderate intensity and of short duration. Also there were no signs of fire during the flight like metal spattering along the flight direction or brooming.

Fired Squib

Therefore fire appears to have been triggered in the baggage compartment which houses auxiliary fuel tank. Externally it caused fire damage soot deposit on the area of the helicopter behind it. Inside the cabin fire traveled from aft to the forward. At the place the wreckage finally rested huge fire took place on the right side which caused fire damage to the right engine and other helicopter parts. Examination one of the fire bottle indicated that both of its squibs have been fired. At the glare shield panel No.2 engine fire system was observed to be armed.

1.15 **Survival Aspects**

Postmortem report shows that the deaths were caused due to shock and hemorrhage resulting from multiple injuries resulting from high decelerative stress/ impact forces involved. Due to the impact the fuselage shell and the landing gear of the helicopter split into many pieces which caused the bodies to be thrown out and exposed to the high impact forces. Accident was not survivable.

The helicopter was last painted on Hyderabad (VOHS) Radar at 09:13 IST at 79NM from Hyderabad. The helicopter was advised by the HF Chennai to call Chennai Radio at 09:30 IST and also passed the information to FIC Chennai.

At 10:50 IST, the duty officer Chennai FIC contacted Tirupati ATC for any information regarding this helicopter. The INCERFA (uncertainty phase) action was initiated at 11: 15 IST. At 12:08 IST calls were made to helicopter on the all available frequencies by the Manager (Com). On the request of the State Government, Indian Air Force deployed helicopters for search and rescue operations. At 13:40 IST the DRO Kurnool informed on being called that two Air force helicopters had departed for search and rescue operation. Both the helicopters flew on a radial of 183˚ and to 103 NM from Hyderabad and returned back due to bad weather. Helicopter of other agencies, manpower from State Police Force and other security agencies were used for search and rescue operations. Signals from the ELT was also not available, therefore, the precise coordinates of the accident site could not be ascertained. With the help of Telecom Department, the location of accident site was established.

On 3.9.2009 at 09:10 IST information was received by WSO, Hyderabad ATC that an Air Force helicopter has sighted the wreckage and ground parties are proceeding to the site. Finally the wreckage of helicopter was located after more than 24 hours of search. At 12:01 IST information was received by WSO, Hyderabad ATC confirming the death of all five passengers. At 17:10 IST message was received by WSO, Hyderabad ATC that three helicopters have departed from the crash site to Begumpet with the dead bodies. At 19:20 IST search and rescue operation was terminated by GM(Aero)-Chennai.

1.16 Tests and Research

1.16.1 Forensic Report

Forensic Examination of the samples collected from the site was carried out at Andhra Pradesh Forensic Science Laboratories, Hyderabad. In their report, they have ruled out the presence of explosive substances, their residues and inflammable hydrocarbons.

1.16.2 Metallurgical Examination

1.16.2.1 Metallurgical examination of No.1 Engine accessory gear box housing and electrical harnesses of No.1 generator was carried out at Defense Metallurgical Research Laboratory Hyderabad using Scanning Electron Microscope (SEM). The fracture surface of larger sample revealed globular deposits over large areas. The area clear from such deposits predominantly revealed an intergranular fracture having secondary intergranular cracks. The fracture surface of the smaller sample also showed globular deposits before cleaning. After cleaning the fracture surface revealed predominantly an intergranular fracture.

In order to simulate an impact loading condition, a small piece of the gear box housing was cut and broken using impact load. On examining this sample under SEM an essentially intergranular fracture was revealed over the entire fracture surface. A bunch of wires from a few broken strands of all the three generator cable were cleaned and examined under SEM. The broken ends showed relatively brittle failure without much deformation. At higher magnification the fractured ends of the wires revealed dimpled rupture.

Metallographic Examination

Sections near the failed region and away from it were prepared for metallographic examination. On etching with picral the samples revealed equiaxed grains of magnesium solid solution and intergranular precipitates of a second phase in both the samples.

Chemical Analysis

The accessory gear box housing and the powder collected from the burnt surface were analysed by wet chemical method and Electron Probe Micro Analyser (EPMA). The result revealed the presence of rear earth, zinc, zirconium and magnesium. On analyzing the surface deposit powder by EPMA, results revealed the presence of Mg, Zn, O and C. X-Ray mapping of the matrix and grain boundary phase showed the presence of Mg, RE, Zr and Zn along the grain boundary.

Hardness

Hardness was measured on the sample cut from accessory gear box housing at 5 kg load and the average Vickers hardness was found to be 60 HV.

Conclusion

SEM fractography revealed intergranular fracture features. This mode of cracking/ fracture can occur under Stress Corrosion Cracking (SCC) or due to impact overload in magnesium based alloys. Since the second phase comprising of Mg-RE-Zn along grain boundaries resists crack propagation by SCC the fracture mode in this alloy due to SCC is predominantly transgranular with branching. As this kind of evidences were not observed in the present case, SCC as the cause of failure can be ruled out.

Further to eliminate SCC as the cause of failure the material was subjected to impact load under laboratory condition, which showed that the material fractures in intergranular mode.

The Mg-RE-Zn phase forming along the grain boundaries is a massive brittle phase that reduces the ductility of this alloy, although the alloy exhibits very good strength and castability. Under the condition of impact overload the alloy fractures in an intergranular mode as the easy path of crack propagation is along the brittle grain boundary phase. The mode of failure has also been confirmed by simulated laboratory test.

It is, therefore, **reasonable to infer that the component had failed by impact overloading** at the damaged area as evidenced by intergranular fracture in SEM fractography. The adherence of some deposits on the fracture surface were found to be due to burning of the portion after breakage as it was found to contain oxides of magnesium and zinc.

The broken ends of the wires did not show any deformation which confirmed that the failure was due to a sudden pull rather a slow tensile pull. The ends of the wires did also not show presence of any melted and resolidified globules ruling out the possibility of sparking leading to the breakage cables. Hence it is inferred that the breakage of the generator cable was due to overload at high strain rate condition as evidenced by SEM fractography.

1.16.2.2 National Aeronautics Laboratory had carried out general examination of the wreckage to establish the cause of failure. Based on the evidences and physical examination of various items/components, it was concluded that there was no failure in the flight control system components in air. The failure in these components was instantaneous and would have occurred during impact of the helicopter on ground. There were no signatures of explosive damage on any of the components of the helicopter. The conclusion was arrived based on physical inspection of the wreckage and examinations carried out in the laboratory.

1.16.2.3 **Tear Down Inspection of Transmission**

CVR indicated that in the later part of the flight crew experienced transmission pressure snag. To confirm snag of the transmission; possible gear degradation teardown inspection of the transmission was carried out.

History and related Data:

Part No.	:	430-040-003-109
Part Serial No.	:	A-55
TSN	:	2949 hrs.

External Condition

The swash plate and controls were attached to the mast. The left side input pinion had fractured from the transmission assembly due to overload fracture of the case.

Left Aft View of Transmission

Examination on Dis assembly:

The mast and controls were removed from the transmission exposing the mast lower end. The top case was removed, which exposed the planetary carrier and ring gear. Gear teeth of on a typical planet gear, planetary ring gear and upper teeth of the sun gear were in good condition. Teeth on the collector gear and on the right side input pinion were in good condition.

Conclusion:

The transmission gears were in good condition. No evidence of degradation due to lack of oil pressure which was observed. The gears in the transmission were capable of smooth transmission of power.

Planetary Carriers and Gears

Upper Portion of Sun Gear

1.16.3 **Temperature, Pressure Sensor/switch and Pressure regulator of Transmission**

Following components were tested in M/s Pawan Hans Electrical Instrument Lab:

a) Pressure Switch Part No.214-040-806-3, S.No.11686 was found to be operating normally.

b) Pressure Regulator Part No. 206-040-088-00 – The pressure regulator opened at approx. 40 PSI letting the oil flow from t he circumferential outlet.

c) Fuel Oil Pressure Transmitter Part No.IPT-20RTI-1000-100G, S.No.7113-2-969 was found to be operating normally.

d) Oil Temperature Switch Part No. 214-040-805, S.No.73168 found to be operating normally and opened in the tolerance of 2˚ centigrade.

e) Thermal Switch Part No.102-00002, S.No. 70407 The contacts are open circuit at 150 centigrade and closed 105 centigrade

1.16.4 **Inspection of Transmission and engine Oil Cooler**

The transmission and engine oil cooler was cut open to check for any abnormality in the oil cooler. However, there was no sign of blockage, fire and any other abnormality which could be associated with the transmission oil cooler.

1.16.5 **Boroscope Inspection of No.1 Engine**

Boroscope inspection of No.1 engine was carried out by M/s Rolls Royce representative at Hyderabad. Following are the findings:

- The engine had experienced obvious signs of heavy impact and fire.
- All engine mount struts had been fractured in apparent overload.
- All evidence of fire is consistent with post-impact fire. There was no evidence of in flight fire.
- Both the N1 and N2 rotor systems were locked and could not be turned by hand.
- The fuel system had been compromised by fire; no sample was available.
- All engine accessories were heavily damaged by impact and fire.
- The upper and lower chip detectors were not removed.
- The engine CEFA assembly was melted by fire, exposing the filter elements. No contamination was visible on these elements.
- The fuel nozzle was removed and inspected; it had begun to rust but was otherwise normal.
- Boroscope inspection of the compressor revealed no obvious internal failings of the compressor wheel. The compressor had been exposed to fire and was sooted as far as the boroscope equipment could reach. The compressor intake (#1 bearing support strut) had sustained minor impact damage.
- Boroscope inspection of the combustor section (via the fuel spray nozzle port) revealed no obvious signs of failure or combustion anomalies. The combustor contained a significant amount of what appeared to be finely shredded vegetative matter. There was no metal spatter or other evidence of compressor failure.
- Boroscope inspection of the turbine section revealed no obvious signs of damage to either the (#4 turbine wheel or nozzle, nor the #1 turbine wheel or nozzle).

1.16.6 Download of Data from Engine Electronic Control Unit

ECU data from the No.2 engine FADEC system was downloaded at Hyderabad by Rolls Royce representative and examined by Rolls-Royce engineers in Indianapolis. Due to damage to the No.1 engine FADEC system it was downloaded at M/s Goodrich Facility at Connecticut. The No.2 engine FADEC was again downloaded and was functionally tested for Standard Acceptance Testing Process, no test anomalies were recognized during this process. Available evidences revealed both engines appeared to be operating normally until impact. No hard faults were recorded on either engine.

The sequence of events leading to accident is as follows:-

Time 0 to 3.6 seconds

Both engine and FADEC were operating normally. There is increase in ambient pressure indicating drop in altitude of 500 to 850 ft. Both the throttles are in ‘fly’ position collective pitch on No.1 engine is 32% and No.2 at 34%. Both FADEC controlled engine in auto mode. No.1 engine two minutes OEI event had been detected.

Time 3.6 to 8.4 seconds

Collective pitch is reduced from 24 to 18% on No.1 engine and 24 to 20% on No.2 engine. Correspondingly there is reduction in fuel flow, engine power, torque and an MGT. Ambient pressure climbs indicating drop of approximately 1200 ft. on No.1 FADEC and 650 on No.2 FADEC.

Time 8.4 to 10.8 seconds

Collective pitch is increased (18 to 24 % No1, and 20 to 24% on No2). However the rotor speed continues to climb to 108%. The power turbine speed follows rotor speed to 104% before turning back to 100%. Ambient pressure climbs indicating drop in altitude of approximately 600 ft. on No.1 FADEC and 1100 ft. on No.2 FADEC.

Time 10.8 to 12.0 seconds

Both collective pitch setting was rapidly increased from 22 to 44% and then lower to 8%. As a result the speed of the unloaded power turbine climbs to 108% on both engines. Rotor speed continues to increase to 111% on both despite torque of 2%. Ambient pressure climbs from 13.33 to 13.52 PSI on No.1 and 13.7 to 13.75 on No.2 indicating additional drop in altitude of approx. 400 ft. and 50 ft. respectively.

From the above as recorded by FADEC No.1 cumulatively over 12 seconds ambient pressure increased by 1.29 seconds psia indicating that altitude decreased by approx. 2800 ft. to 2200 ft PA. This equates a descent rate of approx. 14,000 ft./min. Similarly, FADEC No.2 indicates corresponding increase of ambient pressure by 1.31 psia indicating that altitude decreased by approx. 2850 ft. to 1650 ft PA. This equates to a descent rate of approx. 237 ft./sec or 14,200 ft./min

The ECU data indicated that on No.1 engine, two minutes OEI event had occurred. The event lasted for 14.208 seconds and was due to MGT exceeding the two minute OEI limit of 1468ºF for more that 12 seconds continuously. The cumulative MGT exceedance is recorded for 44.256 seconds. The data also indicates that during the event, torque exceeded its two minute OEI limit of 102.5% for 4.224 seconds. Because the event data is recorded in NVM and restored to RAM at ECU power-up, it is possible that the event occurred during a previous flight. Had an MGT run limit exceedance occurred during the final flight, it is expected that an MGT run limit exceedance fault (MGTRLmTOut) would have been recorded in the last engine run fault, accumulated fault and timestamped fault areas of NVM Fault recorder. Therefore it is concluded that the exceedance occurred during a previous flight and the exceedance fault records were manually cleared from the accumulated and time stamped fault areas of NVM using the maintenance terminal during the previous maintenance action. **It would have resulted in an advisory indication to the pilot,**

displayed as a white '1M/OEI' on the IIDS prior to and during the final flight.

1.16.7 Engine Tear Down Inspection

Further to the boroscope inspection of No.1 engine performed by M/s Rolls Royce representative, tear down inspection of power plant was performed at the facilities of A.P. Government at Begumpet Airport. The engines displayed no indications of any pre-impact anomalies or distress that would have precluded normal engine operation prior to impact. Both the engines were running when the impact took place. The salient observations made during the strip examination are as follows:

Note: -**All positional references are in relation to view from aft looking forward. Upstream and downstream references are in relation to gas path flow from the compressor inlet to exhaust.**

SUMMARY OF FINDINGS

- Both the left and right engines displayed severe impact and fire damage.
- There were no indications of any pre-impact distress or operational dysfunction to any of the engine components examined.
- No.2 engine showed more appreciable sign of circumferential rub in the turbine section and damage to the leading edges of the compressor vanes.

1.16.7.1 LEFT ENGINE (No.1) EXAMINATION.

i **External Condition**

The engine was recovered in the engine housing. It exhibited impact damage and fire damage. The compressor intake had fire damaged.

View from the front

a. Two compressor support struts had sustained frontal impact damage. No.1 lubrication line was intact. None of the compressor blades exhibited impact or foreign object damage. Diffuser vent pipe in place no rupture seen. Discharge tube was in place and no rupture seen. Main Drive Shaft was broken. AGB housing is burnt and broken on the forward bottom right side. N2 pickup is bent though in place. N1 pickup was in place.

b. **Accessory Gear Box**

Top surface covered with soot and discoloration observed. Filter was satisfactory and no pop out was observed. Breather was in place. HMU was intact and in place and lever was free to move.

c. **Exhaust Duct:** Displayed moderate compressional deformation.

d. MGT harnesses were all intact. 6 &7 and No. 8 bearing lube line in place. The spray face of the fuel spray nozzle exhibited light carbon buildup and had begin to rust. Majority of the fuel line to FSN was consumed by fire. The Combined Engine Filter Assembly (CEFA) had melted by fire exposing the fuel filter element.

ii. **DISASSEMBLY OBSERVATION**

a. **Combustion Chamber**

Liner displayed no sign of operational distress. Inlet vanes were in satisfactory condition. No elongation or crack seen in primary, secondary, tertiary holes. No distress, crack or metal deposit seen on the flame tube.

Combustion Chamber

b. **Accessory Gear Box**

Cooler shaft drive adopter shows sign of overheating and soot deposits. The half burnt "O" ring was available on the shaft.

HMU SNO JGAMT 0539: Potentiometer burnt and charred. FADEC cable burnt. Output line to fuel nozzle was satisfactory. Splined drive was satisfactory. Electrical connection intact with burn marks. At the mating surface of pump and metering unit burn mark, fusion and charring observed. Heat shield burnt and frayed.

Starter Generator: Soot deposit seen on mounting pad. Insulation of the electric harness was burnt and few electric harnesses were snapped and showed formation of metallic bulb or deposit of molten metal at the broken end.

Electric Harness GEN. 1

Burnt oil deposits seen inside the accessory box casing and gears. No mechanical failure observed in the gearbox.

c. **Turbine:**

No.2 Stage: No damage/operational distress seen on the guide vanes and rotor blades or scoring on the shroud. Free to rotate. No cocking observed in No 6&7 bearing. Burnt oil seen in the hub. All four thermocouples were in satisfactory condition.

No.3 Stage: No damage/operational distress seen on the guide vanes and rotor blades. Turbine shroud displayed light circumferential scoring from 3ºclock position to 9°clock due to radial contact with blade tips. Turbine was free to rotate.

No.4 Stage: No damage/operational distress seen on the guide vanes and rotor blades. Burning marks were seen on the tip of two blades. Aluminum drops were seen on tip of one blade. No.8 bearing nozzle was clean

d. **Centrifugal Compressor**

Inlet is clean except for ingestion of smoke and dust. Diffuser discharge tubes are clean. Compressor rear was clean, no pitting or burn marks observed.

No 2 bearing free to rotate. On outer surface soot deposit and little charring observed

2½ bearing impression and burning observed on the inner race.

1.16.7.2 RIGHT ENGINE (No.2)

i External Condition

The engine was recovered in the engine housing. It exhibited impact and fire damage. The compressor intake was also damaged in fire.

In the compressor, damage was observed on the leading edge of seven blades from 12° clock position to 9° clock position which was apparently due to ingestion of foreign objects. No.1 lubrication line was intact. Main Driveshaft was intact. Diffuser vent pipe in place no rupture seen. Discharge tube was in place and no rupture was seen.

a. Accessory Gear Box

Casing of Accessory gearbox was consumed in fire. Drive train had separated. Discoloration soot deposit and white deposits were observed on gears and shaft. Heat shield burnt and warping observed.

Starter Generator: Disintegrated

b. **Exhaust Duct:** Displayed moderate compressional deformation and white deposit on the inner surface.

c. MGT harnesses were all intact. 6 &7 and No. 8 bearing lube line in place. The spray face of the fuel spray nozzle was clean. Majority of the fuel line to Fuel Spray Nozzle was consumed by fire.

ii **DIS-ASSEMBLY OBSERVATION**

Dis-assembled view of Engine No.2

a. **Combustion Chamber**

Liner displayed no sign of operational distress. Inlet vanes were in satisfactory condition. No elongation or crack seen in primary, secondary, tertiary holes. No distress, crack or metal deposit seen on the flame tube.

b. **Turbine:**

No.2 Stage: Blade impression seen on the turbine shroud. No damage seen on guide vanes and rotor blades. Free to rotate. No cocking observed in No 6&7 bearing. Burnt oil seen in the hub. All four thermocouples were in satisfactory condition.

No.3 Stage: No damage/operational distress seen on the guide vanes and rotor blades. Turbine shroud displayed circumferential scoring. Scoring was seen on the outer ring of the blades. No.3 NGV - scoring was seen on the trailing edge of outer rim.

c. **No.4 Bearing Housing**: Fused and molten metal seen. Power Turbine Output shaft was stiff to rotate. Splines were in satisfactory condition. Spur adapter gear shaft showed discoloration and sign of over temperature.

d. **Centrifugal Compressor**

Inlet was clean except for ingestion of smoke and dust. Diffuser discharge tubes were cleaned. Compressor rear was clean, no pitting or burn marks observed. No 2 bearing jammed. Splines of the shaft were in satisfactory condition. 2½ bearing jammed.

1.16.8 Tear Down Inspection of No.1 Generator

Generator was recovered in damaged condition. Fan cover dented and without terminal block, external terminal leads broken, shunt and equalizing terminal wires without insulation. This unit was examined at the PHHL facility and it was concluded as follows:-

With present condition it is difficult to visualize the exact cause of overheat. However, heavy current has passed through the generator. Due to this current, heat was generated. Extreme heat has discoloured armature conductors. Heat was transferred to terminal block through main terminal conductor. Sleeving of field and equalizing terminal were melted due to heat at terminal block. There was no fire or smoke indication. No melting metal pieces were found. Overheat indication was visible.

1.16.9 Fuel Sample Report

A sample of fuel of the same batch as was used on the helicopter was obtained and subjected to full specification test at the Fuel Lab at Hyderabad. As per the examination, report received there was no abnormality in the sample and it passed all the specification tests.

1.16.10 Acoustic Analysis Helicopter

The CVR recording were analysed by M/s Bell Helicopters and the following observation has been made-

The recording is of sufficient quality to identify several characteristic frequency of 430 model.

A mid to high frequency broad band noise characteristic is observed near the end of the recordings.

Communication between pilot and co-pilot seem to increase in urgency during the last 30 seconds of the recording.

No urgent communication prior to last 30 seconds of recording.

No anomalous discrete frequency characteristic of model 430 are observed other than the possible over-speed event near the abrupt end.

There is a warning/advisory signal observed for both the crew members during the last approximately 5 seconds of the recordings.

1.17 Organizational and Management Information

Organizational Set-up

On 31.03.2006 the Government of Andhra Pradesh have promoted the A.P. Aviation Corporation Limited a Public Limited company with the following objectives:

1. To develop Aviation Sector in Andhra Pradesh.
2. To promote and run Aviation Training Academy for imparting training to Pilots, Airhostess and other Aviation Support functions.
3. To acquire, operate and maintain Helicopters/Aircrafts.
4. To collect rentals from the hiring parties like General Administration, Police, Tourism Departments, other Governments, Private & Corporate Parties.
5. Commercial utilization of available test equipment etc. of the corporation.

In order to activate the working of corporation a regular Managing Director was appointed. Shri K.V. Brahmananda Reddy, IRAS Officer was the first Managing Director in addition to his duties of OSD in Transport Road &Building (TR&B) Department.

In November 2007, the helicopter wing which was under the administrative control of General Administration Department, Government of A.P. was transferred to Infrastructure & Investment department. But the budget of helicopter wing was operated by the General Administration department.

In 2007, a purchase committee was appointed by the Government with the Cabinet Secretary as Chairman and other senior officers like Director General of Police, Special Chief Secretary Finance, Additional DGP (Intelligence), Principal Secretary (TR&B) as Members for the purchase of new Helicopter.

The APACL was given the budget only during the year 2008-09 onwards. In June 2008, Shri G. Kishan, IAS was posted as full time Managing Director of the A.P. Aviation Corporation till 24th February, 2009.

In last week of Feb 2009 Shri K.V. Brahmananda Reddy was posted as Managing Director of APACL in addition to his duties as Special Secretary, Infrastructure & Investment Department.

System of Maintenance and Operation:

The organisation changed its name to APACL. However it continues to hold organisation approval in the name The Aviation Division, Helicopter Wing (GAD). It is holding approval in Category “C”.

(1)To carryout and certify inspections up to 600hrs/1 year inspection schedule on Bell 430 Helicopter fitted with Allison 250-C-40C engines and its associated systems.

(2) To carryout charging and capacity test of Ni-Cd batteries installed on Bell 430 Helicopter.

The approval of the organisation was valid up to 31.12.2009. As per the QC cum Assurance Manual, Maintenance organisation will be headed by Quality Control Manager assisted by Deputy QCM and AME. .The Organisation entered in to contract with M/s OSS management services to provide maintenance for the Bell 430 helicopter along with AW-139 helicopter. After the contract materialized, M/s OSS expressed its inability to take care of the maintenance of Bell 430 helicopter. Therefore the organisation partially revived its maintenance setup for the Bell 430 Helicopter. Prior to the contract, the Helicopter wing had three AMEs, and the supporting staff. However post contract it was left with only one AME who also performed the duties of the Dy. Quality Control Manager.

The operation wing is headed by Chief Pilot/Pilot Coordinator/Chief operating officer. For the operation of the Bell 430 helicopter, one pilot was taken on contract from M/s OSS Management services. Earlier the other two pilots were in the employment of the State Government on deputation basis from Indian Air Force. Though at all time organisation had licensed crew, however no attempt was made to revise the operation manual of the organisation in view of the new Civil Aviation Requirements and the changes in the operational policy of the organisation. The operations manual was made in 2004 and thereafter never got revised. Organisation has not prescribed any minimum flying experience requirements in the operation manual before permitting a newly endorsed crew on Bell 430 helicopter to fly as PIC. The organisation discouraged its pilots to undergo mandatory recurrent simulator training.

Record reveals that earlier two pilots who were on deputation were engaged in the act of one up manship and despite the adverse entries, were able to prolong their stay in the organisation beyond the permitted deputation period. They were able to influence the highest decision making levels in the State. They were also involved in various procurements without adequate knowledge about the subject. Even selection of AMEs for the training on new helicopter was not appropriate as the AMEs with the State were overlooked. This did not promote a healthy culture in the organisation.

The MD, APACL centrally co-ordinates all aspects to ensure maintenance and operation requirements. The release of Helicopter for flying task is the sole responsibility of the concerned helicopter engineer. Thereafter, the

Helicopter is accepted by the captain of the Helicopter, after satisfying himself that helicopter meets all stipulated standards and flightworthiness. The helicopter launch for the sortie is at the sole discretion of the PIC having met all required standards as prescribed.

Planning of the Flight

A brief of established events/procedures leading to helicopter launch on 02.09.2009 is as under:-

- **At 11:00 hrs on 31.08.2009**

  APACL had received a fax message pertaining to the tour programme of Hon'ble Chief Minister for 2nd and 3rd September, 2009.

- **At 11:30 hrs on 31.08.2009**

  The tour programme was communicated to the pilots, Maintenance Wing (Hangar). The Aircraft Maintenance Engineer of Bell-430 Helicopter confirmed that Helicopter is fit for flight and got valid Certificate of Release to Service (CRS). The CRS for Radio equipment including ELT, CVR etc. were valid up to 05.12.2009.

- **On 01.09.2009**, Capt. Bhatia, the Pilot-In-Command carried out proficiency check of Capt. Reddy, Co-Pilot on Bell-430 Helicopter, VT-APG as permitted by DGCA vide letter No.AV.22019/05/08-FID, dated 21.08.09. The duration of the flight was 1:15 hrs.

- **At 05:00 hrs on 02.09.2009**, the maintenance staff arrived at the hangar and carried out pre-flight inspection as per the approved schedule by Aircraft Maintenance Engineer (holding a valid licence).

- **At 06:15 hrs**, the doctor completed pre-flight medical examination of the pilots. The Pilot-in-command (PIC) had accepted the Helicopter from Aircraft Maintenance Engineer (AME). The helicopter was positioned at Old Airport (Begumpet) for VIP flight. The duration of flight was 10 minutes.

- **At 06:30 hrs**, the helicopter was positioned at Begumpet Airport (VVIP point) for Bomb Detection & Disposal Squad (BDDS) checks by the security wing of the police as the schedule departure was at 07:30 hrs.

- The Pilot-in-command obtained clearance from ATC by filing a flight plan. They personally obtained Meteorological briefing and obtained a copy of the same. There was no practice of preparing a passenger manifest**.**

- **At about 08:30 hrs**, the helicopter took off with three passengers.

- **On 01.09.2009**, APACL had informed the District Collectors of Chittoor, Nellore & Prakasham to provide the weather conditions to the Pilots.

- **Post Accident Actions by the organisation**
  No documented procedure has been established for post accident action.

Regulatory Oversight

The DGCA performs the oversight on the operators through the regional offices. The Air Worthiness Directorate office in the regions carries out regular surveillances and spot check on the operator. The office of Controller of Airworthiness, Hyderabad had carried out inspection and report rendered to DGCA, Hqrs. The Air Safety Directorate regional office is responsible for the investigation of occurrence, incidents that are reported to the office.

Though the Controller of Airworthiness had carried out several inspections of the AP Govt. however the discontinuation of not keeping a soft copy or hard copy pertaining to ECU download of VT-APG helicopter had gone unnoticed. The fact that tool (LAPTOP) used for ECU download had got damaged and degraded was also not noticed and reported.

Management of Investigation:

The investigation of the crash to Bell 430, VT-APG was ordered by Govt. of India under the Rule 74 under the Aircraft Rules, 1937, by appointing the committee of Inquiry. The team comprising of DGCA official was dispatched on 03/09/2009 to Hyderabad from Mumbai and Delhi. The Search and Rescue operation was undertaken by the Air Force and the inputs taken were initially from the district administration and police department.

The DGCA officials had by then already examined the ATC radar images and were aware the last known position of the helicopter on the Monopulse Secondary Surveillance Radar (MSSR) screen.

The officials were not able to reach to the site of accident as the Air Force helicopters were engaged in recovery of the bodies and transporting it to Kurnool. The District Magistrate was requested to get the investigation team flown through a Air Force Helicopter to the accident site however no helicopter could be made available.

The police team from the district had reached the spot and recovered the CVR and few other documents which were subsequently handed over to CB-CID, State of AP. These documents got further transferred to CBI.

The CBI was also investigating the helicopter accident simultaneously, had many queries on the technical issues for their investigation and the same could not be answered as the technical investigation was at initial stage.

The multiple agencies carrying out investigation definitely does not augur well as the investigation for the technical aspect requires thorough study of various shop level investigation of various components and items of equipment.

- **Release of Information to Media:**

During the course of investigation it was observed that many media agencies and the aggrieved families wanted to seek the information on the progress of investigation. As the matter of international practice adopted all over the developed nation it is essential to brief the stakeholder by giving a press release or brief on the progress of accident investigation. However, in the absence of directives on the issue to the Committee such briefings were not conducted.

1.18 **Additional information**

Nil

1.19 **Useful and Effective Investigation Techniques**

Nil

2.0 ANALYSIS

2.1 Airworthiness of Helicopter

2.1.1 **Maintenance of Helicopter**

The Certificate of Airworthiness of the helicopter was current and valid. Periodicity of all scheduled maintenance task were maintained. As per the available records no snag was reported during the C of A inspection. The organisation did not maintain any snag register to allow analysis of the defects.

Para 08,Section II, Chapter 2 of QC cum Assurance Manual requires that" a separate 'Snag Register' for each helicopter shall be maintained where all defects and rectification actions as recorded in flight report Book & additional work sheet shall be reproduced"

The action of the maintenance organisation was in violation of the procedure specified in the Quality Control manual.

Review of journey log book did not indicate repetitive snags. Power assurance check was carried out regularly and engine parameters were being recorded. Review of power assurance check did not indicate any abnormality. Journey logbook only up to 7th August 2009 was provided. Engine S/N: CAE-844104 was removed from helicopter on 01/11/2007 from No. 2 position at 2160:05 hrs and installed on 30/05/2009 at No: 1 position at 2160:05 hrs after repair and modification at the manufacturer facility at Oakland. Reason for removal was not recorded in the logbook. There is no preservation/de-preservation entry for the storage period. Reason for removal of any other component is not recorded. This indicates casual attitude of the maintenance personnel.

As per the Quality Control cum Assurance manual of the organisation, "*The QA manager should be free from all certification duties so that his decisions are not influenced by production/certification consideration*". In this organisation only one AME was performing the job of certifying staff, QCM and Quality assurance personnel. The organisation had once engaged outside personnel for the audit. The report submitted by him did not mention any deficiency despite many deficiencies as mentioned above. Therefore quality assurance function of the organisation was not performed as per the laid down practices/ directives.

2.1.2 **Download of FADEC Data**

The data from the ECU was downloaded at M/s Goodrich facilities, USA. ECU data indicated that the engine No 1 was operated over the MGT run limit of 1435 F for 44.256 seconds. The peak MGT recorded during the exceedance time is 1487.8 F. because the exceedance time is cumulative, it is possible that there was more than one exceedance event, although an event must persist for more than 12 seconds before the exceedance time i.e., including the 12 second is recorded. Had an MGT run limit exceedance occurred during the final flight, it is expected that an MGT run limit exceedance fault (MGTRLmTOut) would have been recorded in the last engine run fault, accumulated fault and timestamped fault areas of NVM Fault recorder. Therefore it is concluded that the exceedance occurred during a previous flight and the exceedance fault records were manually cleared from the accumulated and time stamped fault areas of NVM using the maintenance terminal during the previous maintenance action.

A ‘Two minutes OEI’ event had been detected on No.1 engine. The event lasted for 14.208 seconds and was due to MGT exceeding the two minute OEI limit of 1468ºF (for more than 12 seconds continuously). The cumulative MGT exceedance is recorded for 44.256 seconds. The data also indicates that during the event, torque exceeded its two minute OEI limit of 102.5% for 4.224 seconds. Because the event data is recorded in NVM and restored to RAM at ECU power-up, it is possible that the event occurred during a previous flight.

However the exceedance did not have the timestamped information. Therefore it was not known that at what stage the exceedance had occurred. If exceedance is not erased after necessary rectification action/inspection, it continues to be indicated on the IIDS screen. M/s Goodrich has opined that “**it would have resulted in an advisory indication to the pilot, displayed as a white ‘1 M/OEI’ on the IIDS prior to and during the final flight.”** As per section 3 emergency / malfunctions of document BHT-430-FM-1 “the maintenance action is required prior to next flight, if this advisory is indicated”. This implies that before operation of flight the advisory should have been seen by the AME during the preflight check and also by the pilot before undertaking the flight.

The AME has stated that at no stage this exceedance was seen on IIDS either during the preflight inspection on 02.09.2009 or before it. The engine was installed on this helicopter after rectification action at the manufacturer facility and they returned the engine after clearing all the defects. Further 150hrs/3 month inspection schedule was carried out on 28.08.2009. During that inspection snag/exceedance if any had to be cleared. Thereafter the helicopter flew on 1.09.2009. The helicopter on 02.09.2009 was released with this exceedance.

The organisation has maintained neither the soft copy nor the printout of ECU downloads of the exceedance data after March 2007. However, organisation has been maintaining a register for recording the exceedances. All the exceedances recorded were examined and only exceedance of the torque was observed on No.1 engine in June 2009. However none of recorded exceedance matched the exceedance observed during the post accident ECU down load. Therefore the exceedance had occurred during the training/positioning flight on 1.09.2009 / 2.09.2009. This is lapse on the part of the crew and on the part of AME that with advisory of No.1 OEI, AME released the helicopter for the flight and the crew operated the flight.

No written instruction exists for departure from the practice of retaining soft copy. The reason advanced by the AME was poor state of the laptop and the past practices. As per the manufacturer requirements, any laptop meeting their specification for the hardware can be used and the software is available online. It is apparent that replacement action for the laptop and software was delayed due to unsettled organisation and lack of knowledge in handling the laptop for downloading the data and removing the exceedances after the rectification action.

2.1.3 Serviceability of Engine

Examination of the wreckage revealed that there was soot deposit/fire damage on the left side of helicopter aft of the baggage compartment. Soot deposit was also seen on the stones and the trees. The passengers sitting in the left portion of the helicopter also had fire injuries in the back of the body. Also there was fire at the place where helicopter wreckage finally rested. There was substantial fire due to which accessory gear box of the right engine was burned /destroyed in the fire. Other helicopter parts at the main wreckage location also sustained fire damage. Further the glare shield panel indicated No.2 engine in manual mode and No.2 fire system in armed position. One of the fire extinguishers which were intact was dismantled and on inspection it was revealed that it had been fired. CVR readout of the last phase also suggested that the helicopter was losing height and same was corroborated by the ECU readout which indicated a very high rate of descent during last 14 seconds. Therefore strip investigation of the engines were carried out to determine there serviceability. ECU readout of both the FADECs indicated in the pre-incidence phase the engine parameters viz. Torque, MGT, Power turbine RPM to be normal. This indicated that the performance of both the engines before the accident was satisfactory.

The boroscope inspection of the No.1 engine was carried out by the expert from the manufacturer and also tear down inspection of both the engines were carried out. These inspections did not reveal of any abnormality in the compressor, turbine and combustion chambers. This indicates that there was no engine fire or any engine related abnormality. Visual inspection of the electric harness of the No.1 generator revealed that few of the cut wires had globules/ molten metal deposit at the cut end. To confirm whether any short circuit/arcing had taken place or not, the harnesses were subjected to metallurgical examination. Metallurgical examination revealed that the failure was due to high tensile stress and did not reveal of the electrical fire. It indicates that the generator was working when the electric harness snapped. Further the No.1 generator was also examined. It indicated electrical overheating and not fire. Thus it indicates that both the engines were producing power before the impact and there was no engine failure.

2.1.4 Serviceability of Transmission Gear Box

As per the CVR readout at 09:21:07 IST the crew encountered the snag of transmission oil. For taking appropriate action they reviewed the checklist and the flight manual for transmission oil pressure. Therefore to identify any failure which led to snag encountered by the crew the teardown inspection of the rotor transmission gearbox was carried out. The transmission gears were found to be in good condition. No evidence of degradation due to lack of oil pressure was observed. No sign of overheating was observed. The gears in the transmission were capable of smooth transmission of power. Further to identify the reported snag transmission oil pressure and temperature sensors; pressure and temperature switches and pressure regulator were subjected to the bench check at the M/s PHHL facility in Mumbai and manufacturers facility in Texas, USA. However no discrepancy was noticed. Therefore the cause of the observed snag could not be established. The crew also did not collaborate with other identifications of emergency i.e. caution warning light as evident from CVR readout.

2.1.5 As per CAR Section 2 Series F Part V, *the Certificate of Airworthiness of an aircraft shall be deemed to be suspended when an aircraft ceases or fails to conform with condition stipulated in the Type Certificate or C of A, airworthiness requirements in respect of operation, maintenance, modification, repair, replacement, overhaul, process or inspection applicable to that aircraft, or*

2.1 is modified or repaired otherwise than in accordance with approved procedure, or

2.2 suffers major/substantial damage (which requires replacement or extensive repair of any major component), or

2.3 develop a major defect which would affect the safety of the aircraft or its occupants in subsequent flights.

It appears from the available evidences that on 02.09.2009 the helicopter was released with the exceedance of MGT and use of OEI on no.1 engine. Thus the helicopter was probably not airworthy when it was released for flight on 02.09.2009 even though it was not a contributory factor to the accident.

2.1.6 **Why ELT failed to transmit?**

It was established that ELT was installed on the helicopter and was serviceable. However, ELT had 121.5 MHZ and 243 MHZ as operating frequencies. As per CAR of Section 2, Series O Part V and ICAO's recommendations in Annex 10, all ELT must have three frequencies including 406 MHZ as operating frequencies. This requirement is effective from 01 January 2005, however, was not implemented by APACL on this helicopter. This issue needs to be addressed by the Regulatory Authority.

Unless signals are transmitted at 406 MHZ, it is not possible to initiate satellite based search operation to pin point the location of the accident, aircraft/helicopter. The ELT got detached and had fire damage. Even if it had transmitted the signals, being at location out of VHF coverage, ATC would not have picked up the distress call.

In view of failure of ELT to transmit distress signals in a number of previous accidents, installation and suitability of ELT location needs immediate examination. An alternate system of flight following needs to be examined and installed for prompt search and rescue in case of accident.

2.2 **Weather**

Local forecast for VOHY/VOHS and 100nm around valid 02/03:30 IST to 02/11:30 IST indicated the surface wind to be 290/10 KT. A reduction of visibility to 3000 m in moderate rain/drizzle or haze till 08:30 IST. Possible formation of isolated Towering Cumulus or CB clouds with base at 750 meters and top height 9000 meters was also forecast. Moderate to severe turbulence and icing in CB was forecast during the period. Warning for light aircraft "WIND SPEED MAY REACH 20 KT IN GUST FROM 270° " was also appended to the local forecast.

In the TAF for Chittoor, Ongole and Krishnapatnam, the possible formation of CB clouds and temporary reduction in visibility from 6000 meters to 3000 meters in thunderstorm and light rain was forecast, from 07:30 to 14:30 IST.

Synoptic observations for the Kurnool for the period for 08:30 IST and 11:30 IST was slight rain, overcast sky with 3 oktas low clouds of base height 600-999 m.

Satellite imagery of 09:00 IST indicated a sudden increase in convection over the site and also the accident site area to be fully covered by convective cloud cluster. The maximum increase in convection was over southwest sector. Satellite imagery of 09:30 IST indicated accident site was fully covered by convective cloud cluster and there was further increase in aerial extension of the convective cloud cluster.

From the observations of 08:30 IST on 2nd September, rain/thunderstorms were observed at most places of Telangana and Kurnool reported 4.5 cm of rain. There were no synoptic systems present exactly over the accident region, however, the southwest monsoon was active in the neighbouring subdivisions, like Konkan & Goa, Vidarbha, coastal Karnataka, and Kerala on 2nd September 2009.

As per the lightning data, the storm center was located in the path of helicopter and lightning activity was reported in the area comprising the accident site at about 09:00 hrs IST and 09:35 IST.

As per the residents of area near the accident site, it was raining heavily in the area and the visibility was also poor.

As per the CVR readout, they were encountering clouds almost from the beginning of flight. At 9:10:50 IST and at a distance of 64 nm the helicopter entered the clouds and accordingly the PIC instructed the co-pilot to keep hand on the collective so as to reduce it, as down draught may lead to exceedance of the torque. The Helicopter weather radar was painting red which shows heavy rain or CB clouds. At 9:13:17 IST due weather, they decided to be slightly on the left of the track. Although they cleared the red zone as painted on their weather radar, however they continued to fly through the clouds. At 9:16:31 IST they observed that clouds were more on the right of the track and quantum of clouds were increasing. They decided that after crossing Krishna River they would turn left. At 09:20:11 IST they reported abeam Kurnool but were still in clouds. At 09:20:22 IST, they were at 86 nm and probably crossing Krishna River. From 09:27:24 IST there were repeated callouts from co-pilot to "**Go Around**" thus indicating of some problem. The Engine Control Unit (ECU) readout shows that during the last 14 seconds the rate of descent was in excess of ten thousand feet/minute indicating that helicopter during this period when the co-pilot was giving callouts for go around was encountering very high rate of descent. During this period as per the ECU readout there was exceedance of Main rotor RPM, power turbine RPM with simultaneous drop in the collective.

From the above it is apparent that they were flying through the clouds and anticipated up draught/down draught. Finally at the accident site they experienced sudden sink. At that point of time (09:30 IST) as per the satellite imagery, accident site was fully covered by convective cloud cluster and there was further increase in aerial extension of the convective clouds accompanied with heavy rain and lightning.

As per Text on Aviation Meteorology by K.M. Wickson, Airlife Publishing Ltd. England, "In thunderstorms or CB substantial shafts of air may be encountered, with no warning, which can be moving either vertically up or down. Such shafts may be virtually side by side, and the shear will then be very marked and violent". It further states that "Cumulonimbus-Thunderstorms mature stage is reached when there is precipitation. By this time, the ice crystals have formed together with large concentrations of water droplets, resulting in precipitation. This will cause down currents which may reach speeds of 2000 ft to 3000 ft per minute. The up currents increasing at this stage to some 6000 ft/minute. These vertical movements cause turbulence *inside the cloud. The cloud top will be close to tropopause height and in low latitudes this can be in excess of 50,000 ft".*

Thus it is apparent that at the accident site severe down draught existed and was encountered by the helicopter. This is corroborated by high rate of sink encountered by the helicopter and heavy precipitation in form of heavy rain.

2.3 **Conduct of the Flight**

2.3.1 **Crew Qualification and proficiency**

Both the crew held valid license and were qualified on type. Their ratings were current. The PIC had a total flying experience of 6204:30 hrs out of which 350:40 Hrs were on Bell 430 helicopter.

- Air safety Circular 2 of 1981, Para 3.2 regarding carriage of VIPs in private/State Government owned aircraft states :-

3.3.2When operation is by Helicopter:

3.3.2.1 The Pilot –in –Command should be in possession of a current commercial Helicopter Pilots Licence.

3.3.2.2 The pilot should have a minimum of 500 hrs. experience as Pilot-in-command on Helicopters, including 10 hrs. of night flying and not less than 75 hrs., as Pilot-in-command, on type of helicopter t o be flown.

3.3.2.3 The pilot should have a minimum of 30 hrs. experience as PIC on Helicopters in the last 6 months including 5 hrs. on the type helicopter in the last 30 days, immediately preceding the date of intended flight.

NOTES:

(ii) Whenever practicable, an additional pilot may be carried possessing current CHPL and IR rating.

Both the crew met all the requirements of the above air safety circulars on the date of the flight. However following were the discrepancies regarding license of PIC:-

- For the Endorsement on Bell 430 helicopters only one instrument rating test was carried out against the requirement of two Instrument rating tests with two different examiners for as per Schedule 2, Section P, Subpara E of Aircraft Rules 1937.
- Flying hours during training sorties have been reflected as PIC flying in the personal log book whereas it should be in Training Column.
- The instructor who conducted the night flying and instrument flying training has also undertaken night skill test and instrument rating test as well. Only day skill test by the training instructor was carried out with FOI (H) DGCA on board as observer.

This indicates lack of knowledge/disregards to the rules by the PIC and supervisory staff. The above two discrepancies also went unnoticed during the check by the then Instructor/examiner and endorsement on his licence by the licensing authority.

- CAR Section 7 Series B, Part XIV, Para 2.2b (ii) requires

Simulator Training for critical emergencies:

At least 5 hours of mandatory practice of critical emergencies in simulator such as engine failure, system failure, tail rotor failure etc. which cannot be practiced or simulated in actual flying shall be carried out by a pilot on specific type of flight simulator once in two years. The satisfactory simulator test report shall be submitted to the Directorate General of Civil Aviation along with application for renewal of pilot licence.

Recurrent simulator training became due for PIC in the month of June 2009 on completion of two years from the date of endorsement viz. 5.06.2007 and was not carried out. This is non-compliance of Civil Aviation Requirements.

2.3.2 Flight Planning

Crew obtained the Meteorological briefing for the route VOHY-Chittoor-Ankul Pattru (Nellore Dist)-Ongole from Aviation Meteorological Services (AMS) Begumpet at 06:30 IST on 2nd September, 2009. The pilot was briefed about the presence of CB clouds tops reaching 12 km and showed the 05:30 IST imagery and satellite bulletin based on 01.09.2009 / 17:30 IST. In the local forecast and for 100 nm around VOHY/VOHS valid 02/03:30 IST to 02/11:30 IST, the surface wind was forecast to be 290/10 KT. A reduction of visibility to 3000 m in moderate rain/drizzle or haze was forecast till 08:30 IST. Possible formation of isolated Towering Cumulus or CB clouds with base at 750 meter and top height 9000 meter was also forecast. Moderate to severe turbulence and icing in CB was forecast during the period. In the TAF for Chittoor, Ongole and Krishnapatnam, the possible formation of CB clouds and temporary reduction in visibility from 6000 meter to 3000 meter in thunderstorm and light rain was forecasted from 07:30 to 14:30 IST. Thus the crew was aware of the existence of the CB clouds with top reaching 12KM, in the route to be flown. However they did not review the subsequent satellite pictures before the preparation of departure at 08.29 IST. Subsequent satellite pictures revealed as follows:-

- 06:30 IST: Increase in convection and aerial extension, specially towards southeastern sector of the accident site was observed.

- 07:00 IST: Further slight increase in convection and aerial extension in southeast sector of the accident site is observed.

- 08:00 IST: The convection in the southeast sector nearer to the accident site area decreased. In the rest of the areas/sectors cloud clusters remain more or less same.

CAR section 4 Series E Part I Para 3.6.2.4 states that

Weather deterioration below the VMC. When it becomes evident that flight in VMC in accordance with its current flight plan will not be practicable, a VFR flight operated as a controlled flight shall:

a) Request an amended clearance enabling the aircraft to continue in VMC to destination or to an alternative aerodrome, or to leave the airspace within which an ATC clearance is required; or

b) If no clearance in accordance with a) can be obtained, continue to operate in VMC and notify the appropriate ATC unit of the action being taken either to leave the airspace concerned or to land at the nearest suitable aerodrome; or

c) If operated within a control zone, request authorization to operate as a special VFR flight; or

d) Request clearance to operate in accordance with the instrument flight rules.

Crew was aware of the poor weather conditions on the route and before departure did not again review the weather situation. They choose to fly in Instrument meteorological conditions whereas the flight was to be conducted as per the visual flight rules. As seen from the CVR readout they were encountering clouds almost from the beginning. At 9:10:50 IST and at a distance of 64 nm the helicopter entered the clouds. Subsequently also they were flying in the clouds. **At this stage they should have decided either to divert to nearby location or return back to Hyderabad** (sufficient fuel was available for the same).

Accidents that occurs in reduced visibility conditions after a pilot has attempted VFR flight into IMC are much more likely to be fatal than accidents that occur in Visual Meteorological Conditions (VMC) for various reasons which also includes spatial disorientation and getting into unusual altitude. During past three years approximately half of helicopter accidents in India occurred in IMC and all such accidents have been fatal. None of the pilots in these fatal accidents in those conditions had activated an IFR flight plan.

2.3.3 Adherence to Procedures

Crew copied all the instructions given by the Air traffic control. However at 09:03:20 IST approach asked helicopter to “Report in contact with Chennai Control 118.9 alternate Chennai Radio.” There was confusion among the crew regarding the Chennai control VHF frequency. Although they finally verified it with Hyderabad control.

At 09:21:07 IST they encountered the snag of transmission oil. The co-pilot was bestowed with the task of locating the procedure in emergency checklist for the transmission pressure fault. The co-pilot reviewed the checklist and flight manual but was not able to locate the emergency procedure in the checklist appropriate for the snag encountered. Thus almost six minutes of the vital time was consumed in locating the emergency procedure in order to take appropriate actions and both pilots were so much engrossed in it that they lost situational awareness.

2.3.4 Spatial Disorientation

Reduced visibility conditions, dark night VMC, or combining VMC & IMC also greatly increase the risk of spatial disorientation. Spatial disorientation occurs when a pilot develops an incorrect perception of aircraft attitude, altitude or motion relative to the Earth’s surface. It results when a pilot’s normal visual cues to aircraft attitude are inaccurate, unavailable or inadequately monitored and the pilot, instead, relies on other cues to aircraft attitude that may be misleading.

These cues are provided by the motion-sensing vestibular organs in each inner ear. The sensory organs of the inner ear detect angular accelerations in the pitch, yaw and roll axes, as well as gravity and linear accelerations. The vestibular system provides useful sensory information under conditions of self-locomotion on the ground but provides misleading sensations in the flight environment. Vestibular sensations are easily ignored when pilots have a clear view of the horizon, but they become compelling illusions when external visual references are not available. Instrument-rated pilots are taught to ignore misleading vestibular sensations in favour of the visual cues from flight instrumentation when operating in IMC. However, even experienced, instrument-rated pilots can experience episodes of spatial disorientation in reduced visibility conditions. Situational risk factors for spatial disorientation include false surface planes created by sloping clouds or terrain, transitions between VMC and IMC that require the shifting of visual attention between external visual references and cockpit flight instruments, sustained turns and high workload. Spatially disoriented pilots are at risk of making inappropriate control inputs that can result in loss of aircraft control.

The aircraft was flying through the clouds and there is great possibility of spatial disorientation. During last few minutes of the flight they had encountered a technical snag and they got engrossed in it. These two factors may have lead to loss of situational awareness. Therefore when the helicopter entered areas of high convective activity and the down draught was encountered there was loss of control and helicopter impacted the ground.

2.4 Management Issues and System of Maintenance & Operation

On 31.03.2006 the Government of Andhra Pradesh promoted the A.P. Aviation Corporation Limited (a Public Limited company) with objectives of developing aviation sector in Andhra Pradesh by setting of training academy, acquiring aircraft and helicopters to serve the commitments of various departments of the state government and private parties. Accordingly it appointed full time Managing Director. However during this period the managing director was changed three times and no system had been evolved for coordinated working of the organisation.

The organisation changed its name to APACL. However it continues to hold organisation approval in the name The Aviation Division, Helicopter Wing (GAD). It is holding approval in Category "C". The approval of the organisation is valid up to 31.12.2009. As per the QC cum Assurance Manual, Maintenance organisation will be headed by Quality Control Manager assisted by Deputy QCM and AME. .The Organisation entered in to contract with M/s OSS management services to provide maintenance for the Bell 430 helicopter along with AW-139 helicopter. After the contract materialized, M/s OSS expressed its inability to take care of the maintenance of Bell 430 helicopter. Apparently no careful assessment of service provider was carried out before entering into the contract.

Thereafter the organisation partially revived its maintenance setup for the Bell 430 Helicopter. Prior to the contract the Helicopter wing had three AMEs, and the supporting staff. However post contract it was left with only one AME who also performed the duties of the Dy. Quality Control Manager (QCM). There was no approved QCM. This put all the responsibilities on the AME and his working was not supervised / cross-checked for any deviation from the standard maintenance practices.

The operation wing is headed by Chief Pilot/Pilot Coordinator/Chief operating officer. For the operation of the Bell 430 one pilot was taken under contract from M/s OSS Management services. Earlier the other two pilots were in the employment of the State Government on deputation basis from the Indian Air Force. Though at all time organisation had licensed crew, however no attempt was made to revise the operation manual of the organisation in line with new Civil Aviation Requirements and the changes in the operational policy of the organisation. The operations manual was made in 2004 and never revised thereafter. Organisation has not prescribed any minimum flying experience requirements in the operation manual before permitting a newly endorsed crew on Bell 430 helicopter to fly as PIC. Records reveal that organization did not encourage its pilots to undergo recurrent simulator training. Many of the reportable incidents / snags were not reported to regulatory authorities.

Record reveals that earlier both the pilots on deputation from Indian Air Force were engaged in the act of one up manship and despite the adverse entries, were able to prolong their stay in the organisation beyond the permitted deputation period. They were able to influence the decision making process even at the highest level in the State. They were also involved in various procurements and also like helicopter procurements without adequate knowledge about the subject. Even selection of AMEs for the training on new helicopter was not appropriate as the AMEs under state were overlooked.

This did not promote a healthy culture in the organisation and indicates lack of involvement and poor knowledge of personnel in-charge of State Aviation set up.

2.5 What was the Source of Fire and how did it Start?

Soot deposit/fire damage was observed on the left side aft of left wing. The fire damage/soot deposit followed the air pattern. The soot deposit was not in the upward direction. These parts had separated sequentially along the direction of motion before the helicopter wreckage finally came to rest. Fuselage portion aft of the baggage compartment had severe burns and warping of the skin. Blistering of the paint on the leading edge was observed on one of the blades of the tail rotor. Bodies of the passengers which were thrown out also had fire injuries on the back.

The auxiliary fuel tank was found disintegrated and burnt. Fire damage was also observed on the aft spar of the central tank. Baggage compartment houses auxiliary fuel tank. Externally the fire damage soot deposit has been caused on left side on the area of the helicopter behind it. Inside the cabin fire traveled from aft to the forward. At the place where the wreckage finally rested, huge fire took place on the right side which caused fire damage to the right engine and other helicopter parts. Examination of one of the fire bottle indicated that both of its squibs have been fired. At the glare shield panel No.2 engine fire system was observed to be armed and No.2 engine was observed to be in manual mode. However, there were no signs of fire during the flight like metal spattering on the surface along the flight direction or brooming, same is corroborated by the intensity of fire.

Due to the fuel consumption pattern the auxiliary fuel tank was first to be emptied. Therefore it may have been containing fuel vapours. Due to the impact, the fuel tank might have got damaged leading to the release of the fuel vapours which might have caught fire.

This indicates the fire was triggered either during impact with the trees or after the first impact with the ground from the baggage compartment. In-flight fire can safely be ruled out.

2.6 Was any explosive device detonated?

Wreckage examination was carried out at the site of the accident to look out for evidence to determine if any explosion had taken place on board at the accident flight. Wreckage did not reveal damage due to splinters nor the splinters were observed. Curling of metal on edges of broken parts was absent. No damage due to impact of high pressure gases was observed. Seat cushion were recovered and examined in details to find out if there were embedded splinters or associated damages. However, nothing was observed.

Post mortem report has not recorded any impact of/embedded splinters in soft tissues of dead bodies nor there is evidence of affect of high pressure waves on lungs, etc.

Opinion on the issue was taken from NAL, Bangalore who also ruled out the possibility of any explosive material in the wreckage.

2.7 Sequence of Events

On 02.09.2009 Andhra Pradesh Government Bell 430 Helicopter VT-APG was to operate a flight from Begumpet Airport in Hyderabad to Chittoor for the commitment of the Hon'ble Chief Minister. There were five persons on board which consisted two crew members, Hon'ble Chief Minister and a two member team accompanying him.

Flight plan was filed with the air traffic control at Begumpet airport. As per the flight plan, helicopter was to fly direct to Chittoor at altitude 5500 ft. ETA / ETD Chittoor as 09:45 IST/12:00 IST. From Chittoor the helicopter was to proceed to Ankulpattur (ETA/ETD: 12:40/16:00 IST) and finally, Ongole (ETA 16:45 IST). The flight was to be conducted under visual flight rules (VFR). However, Instrument Meteorological Conditions (IMC) prevailed at that level enroute and near the accident site.

The helicopter was positioned at the VIP departure apron. After the positioning, no snag was reported by the crew. Crew obtained ATC and met briefing at 06:30 IST. During the met briefing they were shown the synoptic charts, satellite picture of 05:30 IST and provided with met folder. As per the met briefing CB cells with height up to 12 km were present on the route to be flown. The crew did not obtain any subsequent update of the weather. The movement was coordinated with Chennai FIC (FIC No. 0033 and ADC No. C523).

The helicopter took off from Begumpet Airport RWY 27 at 08:38 IST. Helicopter was given direct clearance to destination Chittoor at enroute altitude 5500 ft. It was cleared to take-off from RWY-27, climb on RWY heading to 4600 feet and further in coordination with approach radar. At 08:38:50 IST helicopter was transferred to the Hyderabad approach and it established contact with approach radar at Hyderabad. Approach Radar gave it clearance for climb to 5600 ft. and after reaching 5600 ft. to turn left and set course to Hyderabad (VOHS) due to traffic. At 08:42:16 IST helicopter was at a radial of 172˚ from HHY distance 25.6 nm and requested to proceed to Chittoor on course 170˚ and gave ETA Chittor as 10:30 IST. Same was approved by approach Control. At 08:39:41 IST, Approach asked "Confirm destination is Chittoor on Radial 172˚ ". Helicopter requested that if they could maintain the present course. ATC asked "Report Establish Radial 172˚ from HHY" which was affirmed by the helicopter.

At 09:03:20 IST, it reported 46 miles maintaining 5600 ft. It was asked to descent to 5500 at 50 miles. At around 09:02 IST the helicopter contacted Chennai on HF frequency 6655 KHZ and relayed its position along with estimated time of arrival 10:30 IST at Chittoor. HF Chennai advised the helicopter to report at 09:30 IST. At 09:07:46 IST and distance of 55 NM from VOHY as per CVR readout there was a callout "altitude 5500, speed 120, ground speed 144, 83" indicating that helicopter was maintaining a speed of 120 kts and 83% collective. It was encountering clouds from the beginning. At 9:10:50 IST and at a distance of 64 nm the helicopter entered the clouds and accordingly the PIC instructed the co-pilot to keep hand on the collective so as to reduce it, as draughts may lead to exceedance of the torque. As per CVR readout helicopter weather radar was painting red. Last radio contact with Approach Hyderabad was made at 09:12:52 IST and that was the last contact the helicopter had with any ATS units during its flight. The helicopter painted on the radar screen of approach radar Hyderabad up to 9:13 IST and at distance of 79.2 nm from VOHS Airport. At 9:13:17 IST due to weather, they decided to be slightly on the left of the track. Although they cleared the red zone as painted on their weather radar, however they continued to fly through the clouds. Till the helicopter painted on the radar screen of approach control, it was maintaining an altitude of 5500 ft and ground speed of around 140 kts. At 09:18 IST there was a call out that both the VORs have gone i.e. the helicopter was out of range from any of the VORs and would be navigating based on the GPS and visual references. At 09:20:11 IST as per CVR they reported abeam Kurnool whereas they were slightly short of abeam Kurnool and were still in clouds. **Despite being constantly in clouds they never thought it fit to turn back to Hyderabad or divert.** At 09:20:22 IST, they were at 86 nm and had crossed Krishna River. At this stage they were hopeful of some improvement in the weather ahead. At 09:20:46 IST there was a callout to reduce the speed. Subsequently there was inter-crew talk that whether any thing will happen below 40kts.

At 09:21:07 IST they encountered the snag of transmission oil. Thereafter they got engaged in finding out the procedure in the checklist for the transmission oil pressure but were not able to find it. At 09:27: 25 IST there was a callout regarding the Autopilot. Probably it had tripped and was re-engaged. The autopilot would trip if the speed falls below 50 kts. Thus it appears they had reduced the speed to 40 kts. They were flying in Instrument metrological condition. The snag of transmission oil occupied their attention till the helicopter impacted the ground and apparently they lost focus of weather conditions. From 09:27:24 IST there were repeated callouts from co-pilot to "**Go Around**" thereby indicating of some problem might be close vicinity of hill feature. The Engine Control Unit (ECU) readout shows that during the last 14 seconds the rate of descent was probably in excess of ten thousand feet/minute indicating that helicopter during this period when the co-pilot was giving callouts for go around was encountering very high rate of descent. During this period as per the ECU readout there was exceedance of Main rotor RPM, power turbine RPM with simultaneous drop in the torque. This is consistent with a rapid lowering of collective. As mentioned in Para 2.2 apparently a severe downdraught existed and was encountered by the helicopter at the accident site which caused sudden loss of height of the helicopter and it impacted the hills. This is corroborated by the reading of (-) 3500 ft/min on vertical speed indicator and speed of more than 150 kts on the airspeed indicator. No procedure has been prescribed by M/s Bell helicopters to negotiate the severe down draught or the flight through turbulence. CAA, UK recommends following action when caught in a down draught.

"Widely varying conditions make it difficult to detail specific actions to take if the aircraft encounters a powerful down draught. In general, however, the following action should be taken: -

(a) Apply full power.

(b) Fly at best ROC/angle of climb speed depending upon the proximity to obstruction.

(c) Turn away from the feature causing the down-drought, while selecting a downhill route towards a clear area.

(d) Closely monitor IAS, but disregard high ground speed.

(e) Regain height in the ascending air on lifting slope.

The down-draught will reduce in severity somewhere in the valley bottom. The following actions should be taken in case the aircraft is likely to be forced into ground.

(a) Maintain full power and climbing speed.

(b) Turn into wind.

(c) Jettison load, if possible.

(d) Choose a landing site, which is as flat as possible — if the ground is sloping, head up the slope if possible.

As far as possible a touchdown should be avoided and an escape route should be followed away from further down-droughts."

Inspection of the wreckage site revealed that helicopter had turned left of its flight path by 90 degrees before impacting the hill. At 9:16:31 IST they observed that clouds were more on the right of the track and quantum of clouds were increasing. They decided that after crossing Krishna River they would turn to the left. It appears that they turned left as a part of procedure to get out of the severe downdraught or while they were turning left as decided, they encountered the down draught. However there is no call out for turning left and damage pattern of the helicopter suggests that the helicopter impacted the ground in severe left bank. Thus it is apparent that the helicopter turned left as part of procedure to get out of the down draught. However the loss of height was so rapid that it was forced into ground.

2.8 Search and Rescue- was the Operation Coordinated ?

The Search and Rescue Service in India is organized by the Airports Authority of India in collaboration with the Ministry of Defence, local administrative setup, Indian Air force and other agencies who have means to help in search and rescue operation. Since the helicopter was in the FIR boundary of Chennai FIC. Therefore it was the responsibility of the RCC Chennai to initiate different phases which constitute this operation. The helicopter was advised by the HF controller to call Chennai Radio at 09:30 IST and also passed the information to Chennai FIC.

Uncertainty Phase

As per the uncertainty phase when no communication has been received from an aircraft with in a period of thirty minutes after

- *When no communication has been received from an aircraft within a period of 30 minutes after the time, a communication should have been received or from the time an unsuccessful attempt to establish communication with such aircraft was first made, whichever is earlier or when*
- *An aircraft fails to arrive within 30 minutes of the estimated time of arrival last notified to or estimated by Air Traffic Services Unit,*

whichever is the later except when no doubt exists as to the safety of the aircraft and its occupants.

Alert Phase

- *Following the uncertainty phase, subsequent attempts to establish communication with the aircraft or enquiries to other relevant sources have failed to reveal any news of the aircraft, or when*
- *An aircraft has been cleared to land and fails to land within five minutes of the estimated time of landing and communication has not been re-established with the aircraft' or when*
- *An aircraft is known or believed to be the subject of unlawful interference.*

As per above Chennai ATC was to call the helicopter with in 30 minutes after a communication was to be received i.e. by 10:00 IST. However, no call was made on HF. Accordingly the alert phase should have been initiated at 10:00 IST. It is a practice with the ATC to call the aircraft landing at uncontrolled airfield if no communication has been received within the 30 minutes after the estimated landing time. Accordingly only at 10:50 IST, the duty officer FIC contacted Tirupati ATC for any information regarding this helicopter. The INCERFA (uncertainty phase) action was initiated at 11:15 IST. At 12:08 IST calls were made to helicopter on the all available frequencies by the Manager (Com). On the request of the State Government, Indian Air Force deployed helicopters for search and rescue operations. At 13:40 IST the DRO Kurnool informed on being called by RCC Chennai that two Air Force helicopters had departed for search and rescue operation. Apparently the helicopters were dispatched without any coordination and briefing with RCC Chennai. Both the helicopters went on radial 183º and upto 103 NM from Hyderabad and returned back due to bad weather. Aircraft of other agencies, manpower from State Police Force and other security agencies were used for search and rescue operations. Signals from the ELT were also not available, therefore, the precise coordinates of the accident site could not be ascertained. With the help of Telecom agencies, the location of accident site was established and finally the wreckage of helicopter was located after a lapse of more than 24 hours of search.

The RCC Chennai was to draw a plan based upon the last location of the helicopter as available to the air traffic services with input from the Meteorological experts and other agencies who were to carry out search and rescue operations, inform duty officer, IAF Tambaram to relay message to Officer Commanding to keep search aircraft on standby. However, the available data reveals that RCC Chennai failed to perform the assigned functions. All the agencies acted independently of RCC Chennai and it was merely reduced to obtaining information about the activities and passing on the information to different agencies. The CAR section 4 series ‘C’ Part-I and ICAO Annex.12 lays down the requirement for establishment of search and rescue centre and conduct of search and rescue operation. Examination of the system revealed that the RCC set up is not as per the requirements as above. The Rescue Coordination Centre (RCC) is being manned only by one DGM(SAR) who besides this function is bestowed with other duties and has a sketchy set up. Therefore, the search and rescue patterns were not developed by RCC Chennai. After the termination of the operation no evaluation of search and rescue operation was carried out.

There are no structured exercises conducted to evaluate the effectiveness of the system. The above requirements demands that search and rescue plan for a particular region should be developed with all other agencies who would participate or lend support during such exigencies. A review of search and rescue manual indicated that it is merely repetition of requirements as stated in the CAR and ICAO Annex.12 and no plan has been developed in coordination with other agencies. Further, no mutual coordination meetings are held.

Due to the above stated reasons, search and rescue operation has failed to yield result in a desired fashion and time limit, time and again.

3. CONCLUSION

3.1 Findings:

3.1.1 Certificate of Airworthiness of the helicopter was current and valid.

3.1.2 The organisation did not maintain any snag register to allow analysis of the defects. The action of the maintenance organisation was in violation of the procedure specified in the QC manual.

3.1.3 Engine S/N: CAE-844104 was removed from helicopter on 01/11/2007 from No.2 position at 2160:05 hrs and installed on 30/05/2009 at No: 1 position. Reason for removal was not recorded in the logbook. There is no preservation/de-preservation entry for the storage period. Reason for removal of any other component is also not recorded. This indicates casual attitude of the maintenance personnel.

3.1.4 In APACL only one AME is performing the job of certifying staff, QCM and Quality assurance personnel. The organisation once engaged outside personnel for the audit. The report submitted by him did not mention any deficiency despite many deficiencies as mentioned above. Therefore quality assurance function of the organisation was not performed as per the laid down practices/ directives.

3.1.5 ECU data indicated that on No.1 engine during some previous flight two minutes OEI event had occurred. The event lasted for 14.208 seconds and was due to MGT exceeding the limit of 1468ºF for more than 12 seconds continuously. The cumulative MGT exceedance is recorded for 44.256 seconds. The data also indicates that during the event, torque exceeded its two minute OEI limit of 102.5% for 4.224 seconds. "it would have resulted in an advisory indication to the pilot, displayed as a white '1 M/OEI' on the IIDS prior to and during the final flight." This requires maintenance action prior to release for the next flight. AME and flight crew ignored this advisory before operation of the flight on 2.09.2009. Thus the helicopter was probably not airworthy when it was released for flight on 02.09.2009 even though it was not a contributory factor to the accident.

3.1.6 Both engines were operating normally and capable of producing power at the time of impact.

3.1.7 The Main Gear Box, gears were found to be in good condition. No evidence of degradation due to lack of oil pressure was observed. No sign of overheating was observed. The gears in the transmission were capable of smooth transmission of power. Observed snag could not be established.

3.1.8 The installed ELT had 121.5 MHZ and 243 MHZ as operating frequencies. As per CAR of Section 2, Series O Part V and ICAO's recommendations in Annex 10, all ELT must have three frequencies including 406 MHZ as operating frequencies. This requirement is effective from 01 January 2005, however, was not implemented by APACL on this helicopter.

3.1.9 At the accident site severe down draught existed and was encountered by the helicopter.

3.1.10 Both the crew held valid license and were qualified on type. Their ratings were current. They met the requirements of Air safety Circular 2 of 1981, Para 3.2 regarding carriage of VIPs.

3.1.11 Following were the discrepancies regarding license of Pilot –In-Command:-

- For the Endorsement on Bell 430 helicopters only one instrument rating test was carried out against the requirement of two Instrument rating tests with two different examiners for as per Schedule 2, Section P, Subpara E of Aircraft Rules 1937.
- Flying hours during training sorties have been reflected as PIC flying in the personal log book whereas it should be in Training Column.
- The instructor who conducted the night flying and instrument flying training has also undertaken night skill test and instrument rating test as well. Only day skill test by the training instructor was carried out with FOI (H) DGCA on board as observer.

This indicates lack of knowledge/disregard to the rules by the PIC and supervisory staff. The above discrepancies also went unnoticed during the check by Instructor/examiner and endorsement process on his license.

3.1.12 Recurrent simulator training for PIC became due in the month of June 2009 on completion of two years from the date of endorsement viz. 5.06.2007 and was not carried out. This is non-compliance of Civil Aviation Requirements. The organization also did not encourage its pilots to undergo recurrent simulator training.

3.1.13 Crew was aware of the poor weather conditions on the route and before departure did not again review the weather situation The Crew continued to proceed ahead inspite of inclement weather which was continuously aggravating and was becoming more and more difficult to negotiate**.** The Co-pilot also did not advise the PIC to return back or divert to nearest location.

3.1.14 The crew encountered a snag of transmission oil pressure prior to the accident. Crew got engrossed in locating the appropriate procedure in emergency checklist for the snag. They were not aware about immediate actions, co-relating the visual indications and cautions of the emergency.

3.1.15 Fire was triggered either during impact with the trees or after the first impact with the ground from the baggage compartment. There was no in-flight fire.

3.1.16 ECU data is consistent with a lowering of collective and rapid descent during the last 14 seconds of the flight.

3.1.17 At 9:10:50 IST and at a distance of 64 nm the helicopter entered the clouds and remained in IMC through out the flight although it was cleared under visual flight rules.

3.1.18 Mixing-up of VFR & IFR is a dangerous situation where chances of disorientation are very high.

3.1.19 Helicopter experienced turbulence and the Captain reduced the speed below 40 knots resulting in tripping of auto pilot, which was re-engaged by co-pilot.

3.1.20 The crew got so engrossed with the observed snag and neglected the weather ahead and experienced severe down draught; sudden loss of height and impacted the ground.

3.1.21 Inspite of repeated callouts from Co-pilot during the last 14 seconds to “Go Around”, the Pilot-in-command could not act apparently due to incapacitation.

3.1.22 M/s APACL had decided to handover the O & M of Bell 430 helicopter to M/s OSS and in view of this decision reduced the strength of personnel maintaining the helicopter. However for the reasons best known continued O & M themselves with inadequate manpower which also did not possess requisite professionalism.

3.1.23 There is lack of procedure for flight in turbulent weather conditions.

3.1.24 RCC Chennai failed to perform its assigned functions as per the manual. All the agencies involved in search and rescue operation, acted independently of RCC Chennai and it was merely reduced to obtaining information about the activities and passing on the information to different agencies. No assessment of search and rescue operation was carried out after its termination. There are no structured exercises conducted to evaluate the effectiveness of the system. The relevant requirements demands that search and rescue plan for a particular region should be developed with all other agencies that would participate or lend support during such exigencies. However no plan has been developed in coordination with other agencies and no mutual coordination meetings are held.

3.2 Probable cause:

Accident occurred due to loss of control resulting in uncontrolled descent in the terrain at a very high rate of descent due to entry into severe downdraught

Contributory Factors:

1) Crew noticed a snag and was engrossed for more than vital six minutes before the impact in searching for relevant information in the emergency checklist and the Flight Manual. This distracted their attention from the prevailing weather conditions which led to loss of situational awareness.

2) The Crew was flying in Instrument Meteorological Conditions (IMC) whereas the flight plan was cleared for VFR flying.

3) They had no intention either to divert or return back to base.

4. SAFETY RECOMMENDATIONS

4.1.1 Regulatory Authority/IMD may reemphasize the benefit of taking latest weather briefings including satellite bulletins to all the pilots in aviation. In case of any delay in planned departure by more than half an hour, updated weather re-briefing be made mandatory for the helicopter pilots. Regulatory Authority may like to issue modified instructions accordingly.

4.1.2 IMD may consider setting up automatic weather observatories on priority in remote areas to provide **instantaneous weather information** to aviation personnel with wider coverage over India. This will help more updated weather briefing leading to improvement in safety of operations.

At present weather parameters are observed at meteorological observatories located at many places. After collation of observations like temperature, humidity, wind pattern at different levels, a forecast is prepared. There is time delay / lag when the actual parameters are collated and a forecast is prepared (Usually it takes 3 to 6 hours). Many times it is observed that actual weather significantly differs from the forecasted. Obviously due to continuous and fast changing wind pattern, temperature and humidity conditions, thus seriously affecting the helicopter operations in far flung and remote stations like Kedarnathji, Nallamalla forests and North East region of India. Therefore, there is a need to have a system that could provide almost actual weather scenario to flight planners / captain of the helicopter without any delay.

It is understood that Indian Meteorological Department is planning to establish many automatic weather stations located in critical areas where mapping of meteorological parameters are not only difficult but critical due to terrain and undulating surface. The automatic weather stations which are specially designed to observe local meteorological data, analyse and process without conventional delays (as is now) and transmits it online to the flight planners which could also be sent to the pilots through SMS on the cell phone for safe conduct of flight.

4.2 Need for Satellite based flight following system

There is a need to implement an effective flight following system based on satcom technologies. The system should be capable of transmitting the actual position of the helicopter enroute at regular intervals. A study group may be formed to assess various technologies available for the flight following systems and recommend adoption in a time bound manner. This will also facilitate the operator to monitor the movement of their helicopters at any given time during its operation.

4.3 Regulatory Issues

4.3.1 It was noticed that on earlier occasions MD, APACL / the pilots were summoned by DGCA for certain complaints / regulatory violations and were given caution/counseling. The violations committed by the licensed personnel should be viewed seriously and action be initiated under enforcement policy.

4.3.2 Compendium of all the helicopters related CARs and publication on the Website (without further / cross references) be considered.

4.3.3 DGCA may also consider conduction of appraisal/update courses on relevant provisions/CARs for helicopter operators.

4.3.4 In the present case it was seen that one time authorization was given for the Proficiency check of co-pilot. In the training flight of 1.9.2009 on Bell 430 helicopter i.e. just one day prior to the accident, the proficiency check of co-pilot was undertaken by the PIC. There is a need of sufficient independence and professional checks in this area.

4.3.5 The system of one time instructor /examiner authorization of flight crew by the DGCA for carrying out various recurrent checks/trainings should be dispensed with and number of check pilots, instructors and examiners be increased in all the streams of helicopters to look after this aspect. The system of awarding open ended authorization to AME to function as Quality Manager should also be stopped.

4.3.6 All the state government aviation setups should be audited in view of the aircraft being utilized by the state VIP/VVIPs. The organizational capability as per the provisions of applicable CAR should be established. In case of any deficiency / lack of capability, DGCA, Hqrs may advise outsourcing of Operations & Maintenance.

4.3.7 Experience of the crew rostered for the VIP/VVIP flights should have acceptable level of gradient in their respective experience and be as follows-

- The PIC should have the substantial twin engine experience while joining State Aviation setup and should undergo rigorous instrument flying training either on simulator or on type.

- The regulatory authority may quantify the flying experience requirement while joining and thereafter also in respect of PIC and Copilot.

4.3.8 The district administration should give a certificate about the suitability of temporary helipad as per the stipulation of CAR. The same should be issued by the officer of level not less than District Revenue Officer and also the officer coordinating the movement should provide the weather conditions prevailing at the destination helipad from the meteorological dept. and also from nearby aerodrome to operations head of the state government aviation division.

4.3.9 Various States operating helicopters be advised to review their standard operating procedures (SOPs) to ensure that as far as possible the VIP sorties be avoided over dense forests / difficult hilly terrains where SAR / emergent landings become difficult in case of any eventuality. Designate areas where search & rescue is difficult be identified and listed separately. The standard operating procedures of the States be periodically reviewed at least once in a year so as to incorporate the various advancements in SAR related infrastructure.

4.3.10 The requirement regarding recurrent trainings including simulators should be strictly enforced. Enforcement action be incorporated in the existing CARs for non-compliance of the same.

4.4 APACL functioning

4.4.1 The performance and capability of various MDs of APACL who headed the organization definitely lacked the knowledge of aviation related issues. This resulted into certain issues not being undertaken and certain actions not being initiated due to lack of their professional knowledge/sufficient tenure. It is proposed that a separate technical audit on the functioning of APACL be conducted. It will be better if appropriate qualification requirement (QR) for senior officials like MD/CEO are laid down. CEO / Head of Operations should have adequate knowledge / experience of regulatory, O&M and other aeronautical issues.

The lapses by the AME concerned also need to be addressed suitably by the Regulatory Agencies.

4.4.2 The Committee while examining the technical cause of the present accident also briefly reviewed the reasons of non-availability of AW-139 helicopter (procured by the APACL one year back). It was found that the helicopter was not serviceable on that day and that is why Bell 430 was assigned the flight. The procurement, contract administration and O&M of AW-139 helicopter seem to lack professionalism. It is recommended that an independent audit be conducted to look into the manner in which this helicopter was selected & procured, the processes involved in training, selections and the contract administration of present O&M services. The circumstances leading to the extension of two years period to a five years plus period in case of the then Chief Operating Officer Capt. Jagan Manthena and also his role into the above aspects need a thorough examination by the State.

4.5 Search and Rescue Operations

4.5.1 At present the responsibility of SAR coordination rests with AAI. However it was noticed that no exclusive manpower / infrastructure is put in place. In the present case, there was obvious lack of reporting / coordination among various agencies. The role of AAI got reduced only to gather flight / SAR operations information. AAI may like to take appropriate action to strengthen the mechanism of search and rescue in the country with active participation of other agencies.

4.5.2 It is recommended that an exclusive national Search & Rescue (SAR) Board for on land / onshore search be formed to effectively handle the SAR needs in future.

4.5.3 In the instant case, it was found that the ELT itself was not conforming with the relevant regulations of the DGCA. It was not equipped with 406 MHZ frequencies and therefore no questions being captured by any satellite communication system. It is recommended that DGCA may conduct a one time audit on all the ELTs fitted helicopters in India.

4.6 **Setting up of National Helicopter Academy**

India today has 268 helicopters operated by 62 operators. While top five operators account for 71 helicopters. Most of the operators are confined to operate 1 to 3 helicopters only. Such small operators neither have capacity nor capability to :

- Update knowledge on Civil Aviation Requirements, circulars and rules issued by the competent authority from time to time.
- Operate under the stipulations of CAR-145 for maintenance
- Post induction training for pilots, AMEs and Technicians
- Have self audit/safety management system in true sense.
- Have their own safety/QC set up.

It is recommended that a National Helicopter Academy be formed to provide support to small operators on the above aspects on chargeable basis. This academy also be entrusted with the job of periodical third party audits prior to mandatory audit by DGCA.

Till such academy is in place, leading helicopter operators in the country can be entrusted with this task with adequate initial funding by the Government. It is also recommended that O&M setups in the States should be independent of the administrative control of the State Govt. and should be entrusted with large/capable helicopter operators.

4.7 Deputation Norms for Defence Pilots to States

4.7.1 The Government may lay out clear cut policy regarding the tenure of deputation of Defence Pilots to the State Governments Civil Aviation set up which should be strictly enforced.

4.7.2 Since all the State Governments utilize twin engine helicopters for VIP flying, the pilots inducted to State Government on deputation, should be qualified on twin engine helicopter having adequate PIC flying experience during preceding one year.

4.7.3 The CRM and Regulations/CAR training should be made mandatory for the entire Defence Pilots who seek employment in the civil aviation sector.

4.8 Courses on VIP flying

The Committee in the present case could not find any evidence / indication wherein VIP interfered/influenced the flight planning / progression. However, it is felt that suitable short duration courses may be designed wherein the pilots / AMEs and the VIPs themselves could be reoriented on the capabilities and limitations of the helicopters. Some advisory on this are normally issued by the DGCA / Voluntary organizations during the time of general elections. Structured courses on such aspects may help in safe conduction of VIP flying.

4.9 Enhanced Role for Ministry of Civil Aviation and DGCA in Helicopter Operations by States/PSUs

4.9.1 DGCA today is the regulatory agency for helicopter flying in the country. It is also the repository of various statistics/data/operator capability and compliance related statistics.

4.9.2 Committee has observed that in some cases Bidders/service providers submit incorrect data about their flying experience/crew proficiency etc which state/PSU set up are not in a position to verify. Many state owned PSU's frame their own requirements / qualifications in isolation to DGCA regulations. Many States /MHA funded acquisition/wet lease contracts also contain specifications which may be contrary to DGCA stipulations/safety practices.

4.9.3 It is proposed that a representative from DGCA/nominated by Ministry of Civil Aviation be invariably co-opted/associated for deciding contract conditions/ specifications/verifying technical claims of bidders in case of acquisitions/wet lease of State PSU's/MHA funded helicopter operations for various states in India.

4.10 Media Briefing

In future any committee of Enquiry if formed may be empowered for selective briefings to the Media and other stake holders as deemed fit during the progress of investigation.

4.11 Some points to ponder in the larger interests of Helicopter flying in the country.

During the course of investigation the committee also deliberated on the various issues faced by helicopter industry in India and the country's requirement for efficient, secure and safe helicopter operations.

4.11.1 Memories are fresh of last two accidents (EC135 -14 July 2007 and Bell 430-03 August 2008) and the present accident of Bell 430 helicopter. Some of the common factors in all these accidents were :

- The helicopters involved were of third generation twin engine helicopters that had the capability to negotiate through weather since they were IFR certified and had weather radar.
- Piloted by experienced pilots
- Flights were under VFR/Special VFR
- At the time of take off, enroute weather was bad
- Accidents occurred in flight while negotiating weather
- Loss of visual reference was evident in these cases
- Pilots had the option to abort their flights and return to departure airport or make a precautionary landing in any of clear patch enroute but for some reason they did not do so.

Inspite of helicopters having requisite capabilities and crew experience, the pilots could not negotiate through weather. The missions ended in failure.

Could it be due to lack of basic decision making capabilities or skills, or a combination of both? Could it be due to lack of adequate training or non availability of simulator based training facilities or all the factors combined?

There is a need to review the following:

- Adequacy of recurrent /refresher training related to instrument flying
- Manner in which proficiency checks and IR tests are conducted
- Since the VFR flights do not have the benefit of proper communication, surveillance and real time information in uncontrolled airspace, could the use of mobile on helicopter flying be allowed?
- The process leading to the endorsement of instrument rating by enhanced use of synthetic, simulator based training and by conduction of higher training hours on IFR certified helicopters.

- Could Special VFR capsules which are today being conducted for only unrated pilots, be made mandatory for all CHPL/ALTP (H) holding pilots? Could the industry capacity for such training be further expanded by nominating one or two more organizations in addition to the present courses done by RWSI?

4.11.2 The fixed wing flying today is considered safer than the helicopter flying (a general perception). A lot of investment has gone into the ground communication set up and also the space monitoring set up. Inspite of its tough operational environment helicopter industry does not have the same level of infrastructure funding as the fixed wing / schedule airline operations.

The first civil helicopter flight in India took place in the year 1953. However, since then no investment has gone into the creation of infrastructure suitable for helicopter flying in the country. It is the time that civil aviation authorities may take measures for enhancing the VHF range by means of VHF repeater stations or by raising the height of VHF transmission towers. Other systems such as automated dependent surveillance broadcast (ADSB) may also be considered and be funded by the Government.

4.11.3 Some Bigger Issues:

a) We are one of the fastest growing economies in the world. A population of 106 crores plus which is spread over 28 States, 7 Union Territories and 618 districts. We aspire to be the third largest economy of the world with 14.3% share of global economy by the year 2015 and plan to emerge as the **“third pole of economy in the world”**.

b) 59% of India’s land area is under threat from moderate to severe seismic hazards, over 40 million hectares area prone to floods, a long coastline of approximately 8041 km. exposed to nearly 10% of worlds tropical cyclones, 6,36,394 cases of unnatural accidents during 2007, 13 of 28 states having serious problems of law and order issues.

c) Traditionally, Indian Air Force in our country does the yeoman services of search and rescue support. Whether it is the disaster management to States like Bihar, Maharashtra, Rajasthan, J&K or the helicopter crashes. (Like the present one, where IAF was quick to respond) IAF also plays a significant role in the emergency medical services (EMS) needs.

The Committee briefly examined as to how various developed countries handle their EMS, disaster management, search and rescue assignments. For India the most suitable helicopter model to handle these issues emerges as under:

- All the 618 districts in the country be provided with requisite funding for creation of helipads. One Helicopter can be assigned to each district commissioners to help district administration in governance / EMS / search and rescue support. Earmarking 8-10 helicopters specifically to handle law and order issues for priority States may be considered. The fund for procurement be centrally provided by Ministry of Home Affairs (MHA) and O&M be handed over to an independent agency for effective serviceability / availability.
- AAI may be provided by requisite funding for investment into latest helicopter operations support and maintenance systems including night landing facilities at smaller airports.
- The Police Depts. of eight mega cities of the country be allowed to have helicopter fleet on the model of New York Police Department.
- Every State be funded by Central Government to maintain 2-3 helicopters to be used by them in case of medical or law and order emergencies. If such helicopters are available with the States, the same could have been used for the efficient search and rescue operations.
- All Navratanas and other bigger PSUs allocate 0.75% of their distributable profits for corporate social responsibility (CSR) into the areas of their locations. It is proposed that at least 30% of their CSR

allocations be pooled together under aegis of SCOPE and such funds be utilized for positioning the helicopters in remote / isolated places in the country so as to serve the emergent need of SAR /EMS /Law and Order.

4.11.4 As discussed above, **India needs more helicopters however, general public perception is that helicopters flying is unsafe and is meant only for VIP's and bigwigs of society.**

In order to boost the public confidence in helicopter operations and ensure safe flying, It is proposed that a working group may be formed to formulate a **National Helicopter Policy** wherein the roles for all the important stakeholders viz. Ministry of Civil Aviation, DGCA, helicopter operators, 3rd party inspectors/trainers, pilots, Aircraft Maintenance Engineers and state Governments be defined. A funding option by Central Government for creating a central pool for creation of helicopters resources, simulators, SAR resources and other relevant institutions may also be considered under such National Policy.

(Sanjay K. Bramhane)	(Maneesh Kumar)	(Capt. Irshad Ahmed)
Member	**Member Secretary**	**Member**

(R.K. Tyagi)
Chairman

6. Acknowledgement

6.1 The Government of India appointed me as the Chairman of an Enquiry Committee constituted to investigate the accident to Andhra Pradesh Bell 430 helicopter VT-APG on 02 September 2009 vide Notification no. AV. 15013/003/2009-DG dated 03 September 2009. Captain Irshad Ahmed and Shri Sanjay Bramhane were appointed as Members and Shri Maneesh Kumar as Member Secretary. The magnitude of the task was immense and challenging, however, the help, assistance and cooperation by all concerned made it possible to complete the Enquiry within a short time.

6.2 On behalf of the Committee I would like to express our gratitude to Shri Praful Patel, Hon'ble Minister of Civil Aviation and Shri M. Nambiar, Secretary, Civil Aviation for reposing faith and confidence in the capacity and capability of the Members of the Committee for conduction of this Enquiry of national importance in a professional manner and thereby assignment of this Task to this Team.

6.3 I convey thanks to Dr. S.N.A. Zaidi, Director General of Civil Aviation for providing all assistance and enabling support to the Committee. Our special thanks to Shri AK Chopra, Jt. Director General, DGCA for his guidance and professional support at all the stages from the commencement of this Enquiry. Shri R.P. Sahi, Jt.Director General, Shri Raju, Director Air Safety, Shri Chinnadurai, DDG of DGCA also provided valuable help from time to time. The discussions with Dr. J.K. Shrivastava on deputation to DGCA from Indian Air Force were also of immense help.

6.4 Before proceeding further, I must place on record my appreciation and gratitude to the two Committee Members without whose assistance, advice and cooperation, I would not have been able to complete the Enquiry. Shri Bramhane's technical and professional competency is, of course well known. His

mature judgment and sagacity were of additional value. Capt. Irshad Ahmed was useful not only in matters related to civil aviation's rules and regulations but was also great source of information and expertise on helicopter operations because of his extensive previous experience. His vast knowledge and experience of flying and also on weather related aspects were of great help.

6.5 Shri Maneesh Kumar, Member Secretary had the onerous task of setting up the office for the Committee's work at Delhi. He was also the custodian of all the documents and depositions obtained by the Committee of Enquiry. His investigative skills developed through a long process of various investigations and specific investigation courses were of immense help in the present investigation. His professional advice and assistance played a great role in the preparation of the final report.

6.6 I would like to place on record the help and contribution made by Shri Sanjeev Razdan, DGM (Engg) of Pawan Hans Helicopters Limited for being continuously associated and providing engineering support and understanding on the matters of relevance for the conduction of this Enquiry.

6.7 We are grateful to the District Administration Team of Kurnool headed by Shri Mukesh Kumar Meena and also the officials of APACL for facilitating the visits to the site and ensuring the smooth arrangements for investigation during the visit of the Committee to Andhra Pradesh. We are also thankful to the Chief Secretary and the Secretary (Infrastructure) of AP Government for the enabling support and help.

6.8 During the course of investigation, the Committee took the technical help of foreign agencies like NTSB, M/s. Bell Helicopters, M/s. Rolls Royce and M/s. Goodrich, USA. I would like to place on record our thanks and appreciation for their positive role in investigation. Shri BS Singhdeo who represents Bell Helicopters in India also deserves a special mention and thanks.

6.9 We are thankful for the excellent help and support provided by the Indian Meteorological Department (IMD) headed by AVM Ajit Tyagi. We are thankful to Shri Raju Shukla of India Precision Lightning Network, New Delhi for providing technical help in assessing the electric charge scenario behavior of the clouds on the site of the accident on 2.9.2009.

6.10 We are especially thankful to Air Marshal P.K. Barbora, Vice Chief of Air Staff for directing the IAF inputs in the conduction of the present Enquiry. The Airports Authority of India led by Shri V.P. Aggarwal, Chairman, AAI provided all the requisite help in ATC records at Hyderabad and Chennai and also about the search & rescue initiatives taken by AAI at Chennai.

6.11 We are grateful to Defence Metallurgical Research Laboratory (DMRL), Hyderabad and National Aeronautics Laboratories (NAL), Bangalore for help in conduction of various metallurgical tests and fracture analysis.

6.12 In addition to the present Committee of Enquiry, the Government had instituted various other investigations into the same accident. One of these is the investigation by the Central Bureau of Investigation with Shri Nageshwar Rao, DIG as the Investigating officer. We are thankful for informal interactions and help provided by him for certain examinations through CFSL and other investigative details which helped this Committee to undertake better examination of evidences.

6.13 Most of the report writing and discussions were held at the office of Pawan Hans Helicopters Ltd. New Delhi for prolonged working hours, especially on holidays and Sundays. I am thankful to all the officers and staff of PHHL/DGCA for their valuable support into enabling of the working of the Committee.

I place on record the valuable help by Ms. Raakhee Kharbanda, Ms. Meenakshi Kamra, Shri Sanjay Gogia and Shri Pradeep Kumar for secretarial help into preparation of this Report. We are also thankful to Shri Hari Singh and Shri Alok who used to drive us down in early mornings' hours and also in late hours in the foggy winters of Delhi during this period.

Our appreciations to the Administration team led by Shri H.S. Kashyap for making sure the administrative arrangements including meals during the long sitting hours of the Committee.

6.14 I thank all those who offered valuable suggestions/inputs for the investigations. We are also indebted to various helicopters professionals in the country with the specific mention of AVM R. Sridharan, President, Rotary Wing Society of India for their technical inputs/support from time to time.

(R.K. TYAGI)

Chairman of Enquiry Committee

Date : 14.01.2010

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AGB	Accessory Gear Box
ADC	Air Defense Clearance
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
TWR	Air Traffic Control Tower
ATS	Air Traffic Service
ATPL	Air Transport Pilot Licence
AME	Aircraft Maintenance Engineer
AAI	Airport Authority of India
APACL	Andhra Pradesh Aviation Corporation Ltd.
BDDS	Bomb Detection and Disposal Squad
CB	Cumulonimbus Clouds
CVR	Cockpit Voice Recorder
CEFA	Combined Engine Filter Assembly
CPL	Commercial Pilot Licence
CAW	Controller of Air Worthiness, O/o DGCA
P2	Co-Pilot
CRM	Crew Resource Management
EFIS	Electronic Flight Instrumentation System
ELT	Emergency Locator Transmitter
ECU	Engine Electronic Control Unit
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FADEC	Full Authority Digital Electronic Control
FBLRA	Feeble Rain
FIC	Flight Information Center
VOHY	Hyderabad Airport (Begumpet)
HF	High Frequency (for communication)
HHY	VOR Begumpet Airport
HIA	VOR Shamshabad Airport
HMU	Hydro Mechanical Unit
HPa	A Unit for measuring pressure
HZ	Haze
IMD	Indian Meteorological Department
IRAS	Indian Railways Administrative Services
IST	Indian Standard Time
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IAL	Instrument Approach to Land Procedure
IIDS	Integrated Instrument Display System
MDS	Main Drive Shaft
MGB	Main Gear Box
MGT	Mean Gas Temperature

MSSR	Monopulse Secondary Surveillance Radar
NVM	Non Volatile Memory
NGV	Nozzle Guide Vane
OSD	Officer on Special Duty
OEI	One Engine Inoperative
PHHL	Pawan Hans Helicopters Ltd
PMA	Permanent Magnet Alternator
PIC	Pilot-in-Command
PLA	Power lever Angle
PTO	Power Turbine Output
QNH	Pressure Setting to Indicate Elevation
QC	Quality Control
QCM	Quality Control Manger
RAM	Random Access Memory
RCC	Rescue Coordination Center
RERA	Recent Rain
RPM	Revolution Per Minute
R/W	Runway
SHP	Shaft Horse Power
VOHS	Shamshabad Airport
SAR	Search and Rescue
SKC	Sky Clear
SRR	Search and Rescue Region
TAF	Terminal Area Forecast
TSN	Time Since New
TSO	Time Since Overhaul
VHF	Very High Frequency
VOR	VHF Omni Range (Navigational Aid)
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions