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FINAL REPORT ON ACCIDENT TO GOVT. OF MAHARASHTRA SIKORSKY S-76C++ HELICOPTER VT- CMM AT NILANGA, LATUR ON 25/05/2017

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Foreword

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 3 of Aircraft (Investigation of Accidents and Incidents), Rules 2012, the sole objective of the investigation of an accident shall be the prevention of accidents and incidents and not apportion blame or liability.

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts and laboratory examination of various components. Consequently, the use of this report for any purpose other than for the prevention of future accidents or incidents could lead to erroneous interpretations.

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FINAL REPORT ON ACCIDENT TO GOVT. OF MAHARASHTRA SIKORSKY S-76C++ HELICOPTER VT- CMM AT NILANGA, LATUR ON 25/05/2017

1.	Aircraft Type	:	Sikorsky S76 C++
	Nationality	:	INDIAN
	Registration	:	VT – CMM
2.	Owner	:	Government of Maharashtra.
3.	Operator	:	Government of Maharashtra.
4.	Pilot – in –Command	:	CHPL holder on type
	Extent of injuries	:	Nil
5.	First Officer	:	CHPL Holder on type
	Extent of injuries	:	Nil
6.	Place of Incident	:	Nilanga, District Latur
7.	Geographical Co-Ordinates	:	18º07’34”N, 76º44’57”E
8.	Date & Time of Incident	:	25th May 2017, 0625 UTC
9.	Last point of Departure	:	Nilanga, District Latur
10.	Point of intended landing	:	Raj Bhawan, Mumbai
11.	Type of operation	:	Non Schedule Operation
12.	Crew on Board	:	02
13.	Passengers on Board	:	04
14.	Phase of operation	:	Take off
15.	Type of accident	:	Crash landing after hitting Electrical High Tension Cables

(ALL TIMINGS IN THE REPORT ARE IN UTC)

SUMMARY

Government of Maharashtra Sikorsky S76C++ Helicopter, VT-CMM was detailed for a flight to fly Hon'able Chief Minister from Nilanga, Latur to Raj Bhawan, Mumbai on 25th May 2017.The helicopter was scheduled for a flight from a temporary landing ground in Nilanga, Latur to Raj Bhawan, Mumbai.

After boarding of the passengers, the helicopter was started up for flight at around 0620 UTC. The helicopter lifted into hover and turned to approximately 90 degrees to its left to initiate take-off into the winds. The PIC commenced a slow vertical lift-off and the helicopter hovered out of ground effect (OGE) at about 25 feet and thereafter gained height to 39 feet approx. Thereafter the PIC moved forward in the North-West direction to clear the obstacles. However as it hovered out of ground effect to proceed for the take-off the rotor RPM started decaying and the helicopter continuously began to descend in height. The PIC realising that, retracted landing gear and pitched up the helicopter nose, to clear the high tension power cables. However, in the process the helicopter belly hit the high tension cables and lost the yaw control and the helicopter turned right. Subsequently, the main rotor blades hit through a tree and also the roof of a truck and sheared off. The tail rotor blades also hit the roof of a hut and sheared off. Thereafter the helicopter crash landed and settled on the ground between the truck and the hut. All six occupants escaped the helicopter safely with no injuries. There was no fire.

Occurrence was classified as Accident as per the Aircraft (Investigation of Accident and Incidents) Rules, 2012. Committee of Inquiry was appointed by Ministry of Civil Aviation vide its notification Ref AV.15013/9/2017-DG appointing Mr. Alvice Xavear Joseph, Deputy Director, AAIB as Chairman, and Mr. Jasbir Singh Larhga, Assistant Director, AAIB and Capt Irshad Ahmed as Member.

Initial notification of the occurrence was sent to ICAO, National Transport Safety Board (NTSB), USA and Bureau d'Enquêtes et d'Analyses (BEA), France on 26th May 2017 as per requirement of ICAO Annex 13. Mr. Philippe Roblin, BEA Investigator was appointed as the accredited representative, by BEA, France and Mr. Josh Cawthra, was appointed as accredited representative by NTSB, USA under ICAO Annex 13.

1. FACTUAL INFORMATION

1.1 History of the flight:

Government of Maharashtra Sikorsky S76C++ Helicopter, VT-CMM was detailed for a flight with Hon'able Chief Minister on board for 24th & 25th May 2017. As per the programme, the scheduled flight was from Raj Bhavan to Sangola, Mandrup, Latur, Nilanga and back to Raj Bhavan. The helicopter departed Raj Bhawan, Mumbai on morning of 24th May 2017 at 0330 UTC and after an uneventful flight through Sangola and Mandrup, the helicopter finally landed for night halt at Latur on 24th May 2017 at 11:35 UTC. The helicopter was involved in an accident on 25th May 2017 during the flight from Nilanga, Latur to Raj Bhawan, Mumbai. There were four passengers and two crew members onboard the helicopter at the time of accident. Both the pilots were duly qualified to operate the subject flight.

On 25th May 2017, as per the programme the Hon'able Chief Minister's flight was scheduled from Nilinga at around 0600 UTC. Both the crew after undergoing the preflight medical examination and carrying out the preflight helicopter checks took off from Latur for Nilanga at 0515 UTC. Prior to landing at Nilanga the crew observed that the landing ground appeared to be even and firm however it was not cemented. The ground flags and on board instrument indicated northerly winds. The presence of obstacles around the temporary landing ground was also observed by the PIC during landing. The helicopter landed at 0535UTC. The helicopter was parked facing east to facilitate easy boarding of passengers.

The crew after landing at Nilanga secured the helicopter and thereafter prepared the load and trim sheet for the onward flight to Raj Bhavan and Mumbai, considering the prevailing weather conditions and taking standard weights for passengers and approximate weight for the passenger luggage. The helicopter carried about 1700 Lbs of fuel, which was enough to complete the flight. The All up weight (AUW) for the flight calculated by the crew was

10891 Lbs. Thereafter both the crew left for the guest house for refreshment as the departure of the Chief Minister was slightly delayed from schedule.

Prior to boarding of the passengers, the crew carried out their briefing, and it was decided that after pickup they will turn into northerly direction and initiate a take-off from a high hover. The PIC also briefed the co-pilot to call out when Rotor RPM (Nr) reaches 102%. After the boarding of the passengers the helicopter was started up for the flight at around 0620 UTC. The temperature at the time of departure was around 40 degrees with visibility fair and variable winds of 3 to 5 knots from northerly direction. As the helicopter picked up and came to hover the commander turned heading towards northerly direction, and thereafter hovered out of ground effect to proceed for the take-off.

The PIC had stated that after few seconds into hover when the helicopter was around the edge of the helipad, co-pilot called out rotor RPM 102%. This was acknowledged by PIC and he continued to apply power to gain height and also moved forward to cross the obstacle (High tension wires) for take-off. Even though the crew applied more collective the rotor RPM kept decaying. The helicopter did not gain height even after the application of extra power. During this time the helicopter had crossed the barricaded area and was engulfed by the dust which was kicked up due to strong rotor downwash caused by the main rotor, this further obscured the vision of the crew.

As the helicopter was transiting in the process of take-off with max collective, the co-pilot called out, close proximity of cables and rotor RPM drop at 93%. The helicopter started sinking instead of climbing to cross over the obstacles. The PIC realising this acknowledge the co-pilot call and immediately called for raising the undercarriage to avoid entanglement with high tension cables. However, in the process the helicopter belly hit the high tension cables and helicopter lost the yaw control and turned right. Subsequently, the main rotor blades hit through a tree and also the roof of a truck and sheared off. The tail rotor blades also hit the roof of a hut and sheared off. Thereafter the helicopter crash landed and settled on the ground between truck and a hut.

After the accident, both the crew switched off engines by operating the fuel shut off levers, pulling T handles and switching off the battery. The crew thereafter evacuated the helicopter and also assisted the passengers in evacuation. There was no fire.

1.2 Injuries to persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	Nil	Nil	Nil
SERIOUS	Nil	Nil	Nil
MINOR	Nil	Nil	Nil

1.3 Damage to Aircraft :

The Helicopter suffered substantial damage during the accident. Damage assessment was carried out onsite and later detailed damage assessment was carried out at Mumbai. The damages to the helicopter are categorised into two parts i.e External Damages observed onsite and Internal Damages observed during detailed investigation at Mumbai.

(A) External Damage observed at the wreckage site

1. All the four main rotor blades had sheared off from its root attachment after the impact with the tree and roof of the parked truck.

Fig:1- Main Fuselage

2. All pitch link rods for the main rotor blades were broken.

3. All the four tail rotor blades damaged after its impact with the house structure.

Fig:2 – Tail Portion

4. Horizontal Stabilizer (LH) was damaged at tip and punctured on upper surface.

5. The helicopter Vertical Fin was damaged at trailing edge and bottom portion.

6. A part of tree stock was found trapped at root of horizontal stabilizer

Fig:3 – Starboard Engine Power Turbine casing

7. The starboard engine Power turbine casing had burst open with local thermal damage in the surrounding area.

8. Belly of tail boom had multiple dents
9. LH engine cowl was damaged
10. LH Passenger window was broken.
11. LH Cargo door was damaged.

Fig:4 – Damaged Plexi window

12. Co-pilot window plexi was broken.
13. Pilot and Co-pilot wind shield were broken.

(B) Damages observed during detailed internal inspection

Helicopter Airframe:

The airframe was primarily intact. Nose frame was fractured and buckled just below the windshield on the left side, aft of the left electronics compartment access panel, through the second chin bubble at about fuselage station (STA) 60.

Fig:5 - Nose frame

Nose frame had damages on the right side aft of the right electronics access panel. The mounting brackets of the LRUs in the right side electronics bay were fractured.

Fig:6 – RH side electronics access panel

The left hand windshield was cracked but in place. The under-deck was buckled from STA 40 to 93. The aft right side pilot's second chin window was fractured at STA 70.

Fig:7 – LH Nose section

The right side pilot's door and door frame were buckled near the hinge at about fuselage station (STA) 120 but the door still operated. The window in the right side door was cracked. The cockpit canopy and right windshield were intact.

Fig:8 – RH Nose Section

The number 1 engine inlet cowl and aft engine cowl showed impact damage and there was a vertical tear bisecting the registration number. A rod belonging to the lorry that was hit during the impact sequence pierced the left side.

Fig:9 – LH Engine cowl

Both the left and right sides of the tail cone were buckled just aft of the tail cone access panel and at STA 390. The horizontal stabilizer was still attached but fractured on the left attachment point. The left hand anti-collision light was broken. The vertical stabilizer fairing was fractured near the tail gearbox.

Fig:10 – Damaged Tail Section

Rotor Blades

Fig:11 – Rotor Head

Three Main Rotor blades fractured at the spindle and one blade fractured at the blade cuff. The Red MRB was fractured at the spindle in the lag direction. The Blue MRB was fractured at the spindle in the lag direction about 45°. The

Yellow MRB was fractured at the spindle in the lag direction. The Black MRB was fractured at blade station BS 0 (cuff) in the lag direction.

All four tail rotor blades (TRB) were damaged during the mishap due to impact with the wires. Two blades separated at the blade root leaving only 4 inches of broom straw; A third blade was fractured just aft of the spar. The fourth blade remained attached from root to tip but was significantly damaged on the blade surface and trailing edge.

Fig:12 – Tail Rotor Head

Transmissions and Driveshafts

a) **Main Gearbox (MGB):**

The main gearbox remained attached to the airframe. All four mounting feet and all eight mounting bolts were intact. Mechanical continuity was confirmed by rotating the inputs and MRH and observing corresponding motions.

Fig:13 - Main gearbox attachment

Both engine input driveshafts drove the main rotor head and freewheeled and the tail take-off freewheeled. The #2 input shaft was fully intact. The #1 input shaft showed traces of contact with the flexible couplings indicating misalignment.

b) **Tail Rotor Drive shafts (TRDS):**

All TRDS, including the vertical pylon driveshaft, were intact and connected. The pylon drive shaft was slightly buckled at its midpoint. The driveshaft showed no witness marks. The flexible couplings exhibited some misalignment.

c) **Intermediate Gearbox (IGB):**

The IGB remained in its proper location in the tail pylon. The input and output flexible couplings were intact. IGB continuity was confirmed through limited rotation of the MGB.

d) **Tail Rotor Gearbox (TGB):**

The TGB remained in the tail pylon. The TGB fairing was impact damaged on the lower facing side. The TGB housing was cracked at the input and output mating surface. Continuity was confirmed to the TGB through limited rotation of the MGB.

Flight Control Systems – Hydraulic/Mechanical

The flight control system remained intact. There was continuity from the cockpit controls to the mixing unit to the main rotor forward, lateral and aft servos. Tail rotor pedal continuity to the tail rotor servo was confirmed. Three of the four pitch change links were fractured.

Flight Control System – Electrical

The cyclic, collective and yaw controls were examined for evidence of malfunctions or pre-impact failures. Electrical continuity was not confirmed for DAFCS trim and SAS servos. No physical system anomalies were noted.

Flight Instrumentation

The instrument panel was intact. Most instruments were glass multifunction display units. The standby airspeed indicator showed 0 KIAS. The standby altimeter showed current altitude and the Kollsman window was set at 1011 Mb. The standby gyro showed 45° right bank and 70° pitch up. The **G/S**, **NAV** and **OFF** flags were in view.

<u>Propulsion</u>

Engines: All engine mounting bolts were intact. Both engines were attached to the helicopter by the front and rear supports.

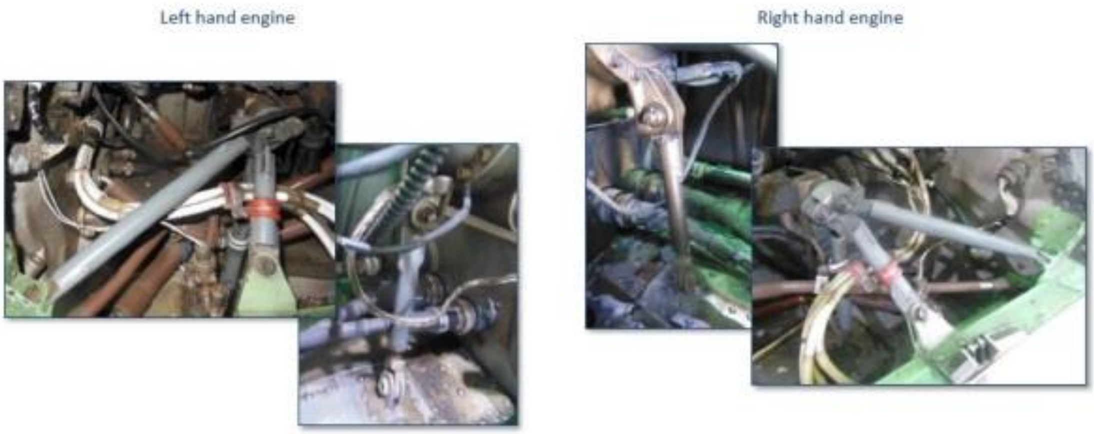

Fig:14 – Engine mountings

The engine cowling revealed impact damage to its left hand side. A rod belonging to the lorry that was hit during the crash had pierced and penetrated the cowling's left flank. The inside of the cowling was unremarkable with light heat stains (the RH one being slightly larger) in the vicinity of the engines' turbines.

Fig:15 – Engine cowling

Both air intakes were fitted with sand filters which showed the presence of dust and small debris of vegetation. The RH filter was in good condition. The

LH filter was damaged during the sequence of the accident, leaving gaps that could allow debris to penetrate into the main air path.

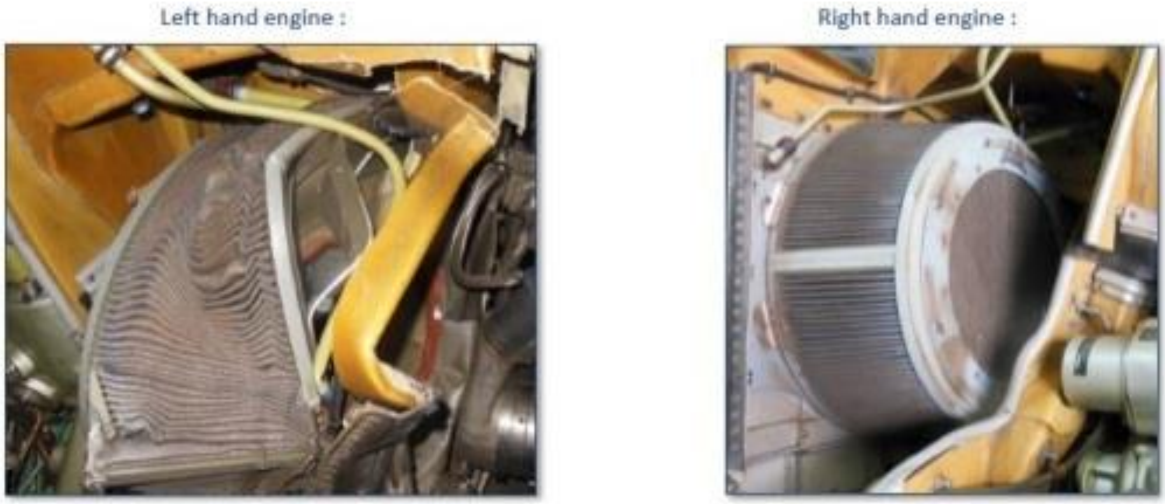

Fig:16 – Air Intake Filters

The drive shafts were in place on both sides. The LH shaft showed circular traces of contact with static parts and a slightly warped flexible coupling indicative of light misalignment between the engine and the Main Gearbox as a consequence of the accident. The RH shaft did not exhibit any remarkable findings.

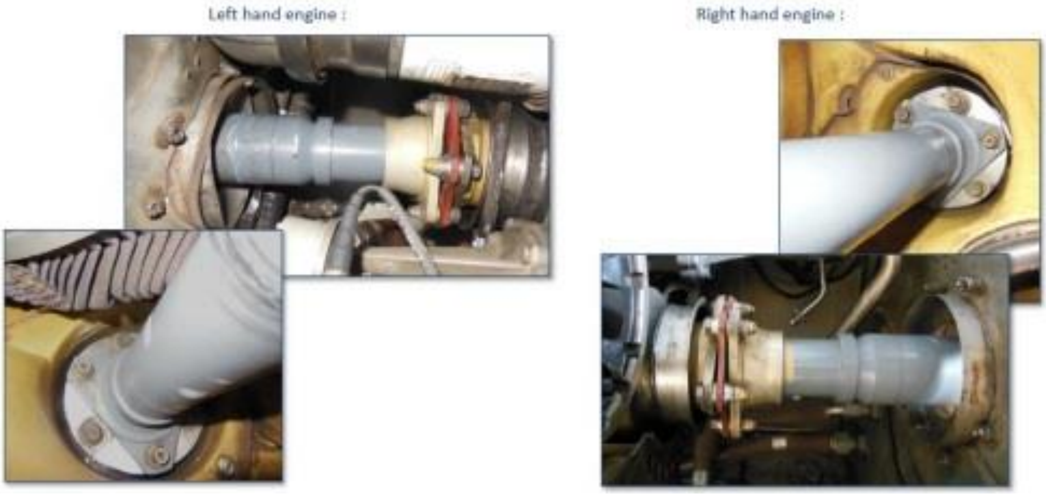

Fig:17 – Drive Shafts

For both engines, the oil and fuel supply lines were in place and tightly connected to their respective engines. Both main fuel tanks remained intact. No fuel leakage was reported at the accident site. The helicopter was defueled in situ. The helicopter had almost a full load of fuel on board at the time of the event.

Engine Controls: The throttle quadrant was intact. Both engine speed selectors were in **OFF** (fully aft). Both fuel selectors were in **OFF**. Both T-handles were in the **AFT** position.

1.4 Other damage: The Helicopter tail boom hit a hut causing its roof and wall to collapse on the occupants.

Fig:18 – Hut hit by tail boom

- The helicopter had hit a 11KV Electrical Cable, resulting in snapping of the cable. The cable had to be repaired to restore electricity supply.

Fig:19 – 11 KV Electricity Transmission line

- The Main Rotor of the Helicopter had hit a tree and a truck parked nearby. The cabin of the truck was damaged by the impact of rotorblades and a steel railing from the truck got entangled in the main rotor blade.

Fig:20 – Truck hit by Main Rotor

1.5 Personnel information

1.5.1 Pilot – in – Command

AGE	:	48 Years
License	:	CHPL Holder
Category	:	Helicopter – Multi Engine
Validity of License	:	21.03.2021
Endorsements as PIC	:	Chetak, Dauphin N3 & Sikorsky S76C++
Med. Exam	:	Valid at the time of accident
FRTO License Validity	:	21.03.2021
Total flying experience	:	6002:10 Hrs
Experience on type	:	993:30 Hrs
Experience as PIC on type	:	558:00 Hrs

Total flying experience during last 365 days :

Total flying experience during last 180 days: 42:30 Hrs

Total flying experience during last 30 days : 12:30 Hrs

Total flying experience during last 07 Days : 02:45 Hrs

Total flying experience during last 24 Hours : 02:45 Hrs

1.5.2 Co-Pilot

AGE	:	27 Years
License	:	CHPL Holder
Category	:	Helicopter – Multi Engine
Validity	:	13.02.2021
Endorsements as PIC	:	Aloutte III, Sikorsky S76C++
Med. Exam	:	Valid at the time of accident
Total flying experience	:	2948:10 Hrs
Experience on type	:	352:10 Hrs

Total flying experience during last 365 days : 219:20 Hrs

Total flying experience during last 180 days : 156:05 Hrs

Total flying experience during last 30 days : 42:05 Hrs

Total flying experience during last 07 Days : 04:35 Hrs

Total flying experience during last 24 Hours : 02:45 Hrs

Both the operating crew were not involved in any serious incident/ accident in past. Both the operating crew were current in all training and had adequate rest as per the Flight Duty Time Limitations (FDTL) requirement prior to operating the incident flight.

1.6 Aircraft Information:

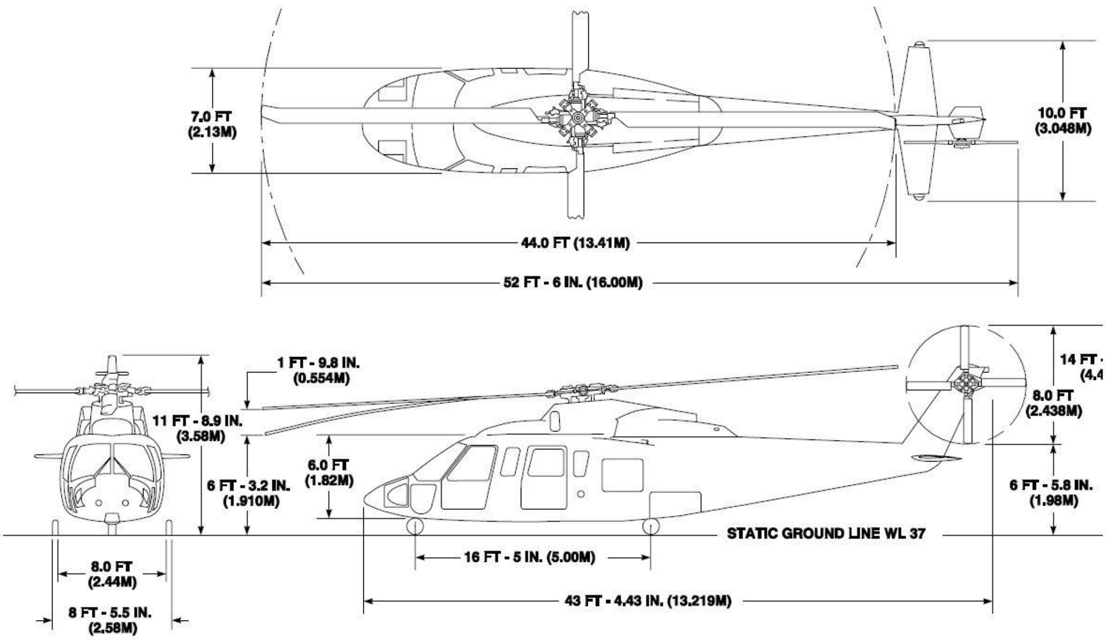

Fig:21 – Helicopter schematic diagram

Sikorsky S 76C++ helicopter is a twin engine helicopter manufactured by Sikorsky Aircraft Corporation. The helicopter is certified in transport category, for day operation under VFR. The maximum operating altitude of this helicopter is 15000 feet density altitude and maximum take-off weight is 11700 Lbs. Helicopter length is 43 feet and width is 10 feet, height of this helicopter is 11 feet. The helicopter is approved in the "Transport" category under sub category Passenger.

ENGINES:

Arriel 2S2 engine is installed on SIKORSKY S 76 C ++. This engine is a turboshaft engine with a single-stage axial compressor, a single-stage centrifugal compressor, an annular combustion chamber, a single stage high pressure turbine, a single stage power turbine, and a reduction gearbox with a nominal output at 6409 rpm.

The ignition system is one of low tension, high energy, and includes two high-energy generators, two injectors and two igniters. Engine start is via an electrovalve. The schematic diagram of the engine is given below.

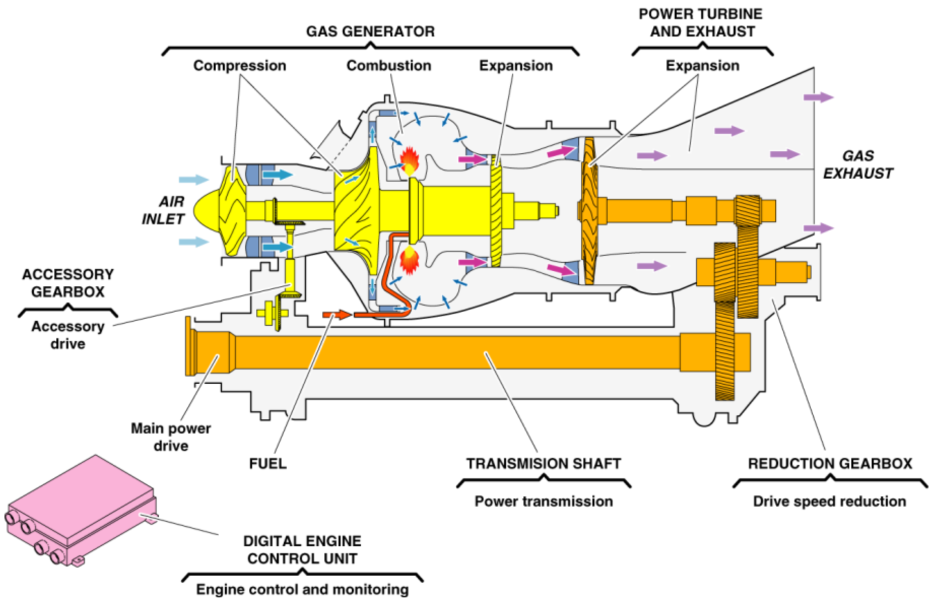

Fig:22 Arriel 2S2 Engine Schematic

The Engine is subdivided into five modules. The modules are

Modules	Description
Module M01	Transmission Shaft and accessory gear box
Module M02	Axial Compressor
Module M03	Gas Generator
Module M04	Power Turbine
Module M05	Reduction Gear Box

The modular construction of the engines is given below.

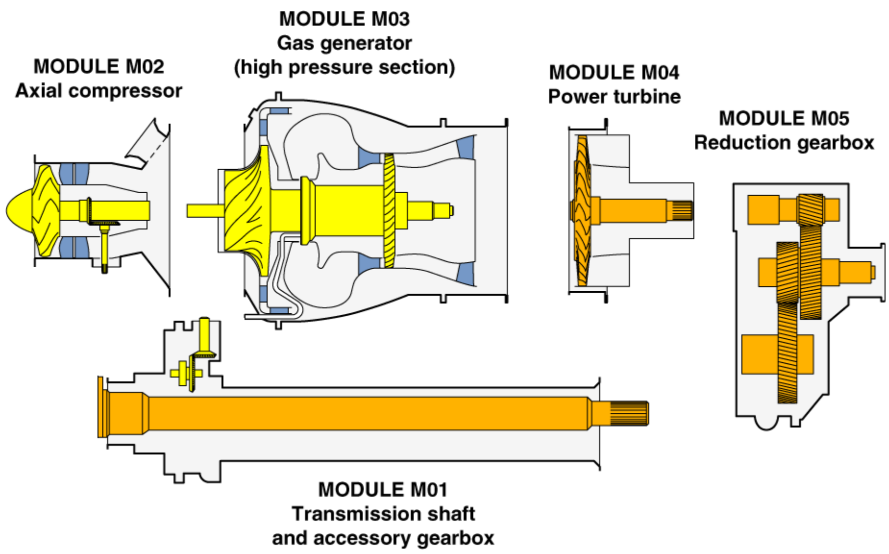

Fig:23 - Engine Modules

The engine is equipped with an Electronic and a Mechanical system to avoid Power Turbine Disk Burst due to over speeding. In case of Electronic System, upon detection of Power Turbine over speed the fuel will cut off. This system shuts down the engine upon detection of a Power Turbine speed that reaches approximately 122%. By design, its activation on one engine leads to de-activation on the other one (cross-inhibition concept). In case of any circumstance, where both the engines simultaneously go into over speed, the first engine to reach the over speed detection threshold will be shut-down by the Electronic System and Electronic System is de-activated on the other engine and it will then require mechanical system.

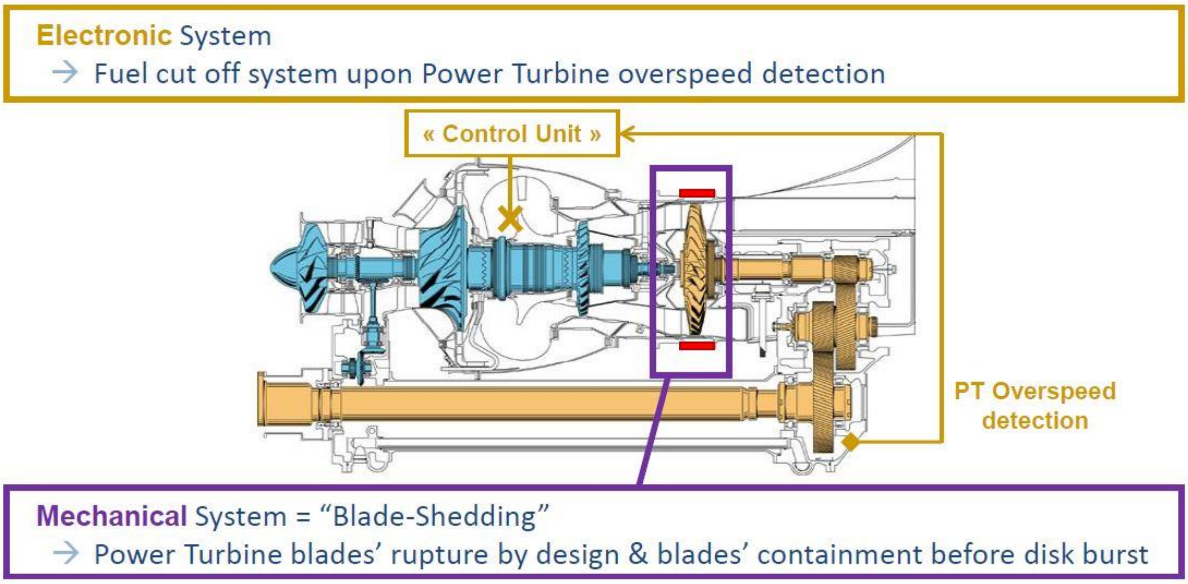

Fig:24 – Engine over speed protection

In Mechanical system the disk bursting is prevented by blade shedding, i.e all power turbine blades will shed at a given over speed and will be contained by a protective casing. Blade shedding speed, by design, is set below disc burst speed with safety margins.

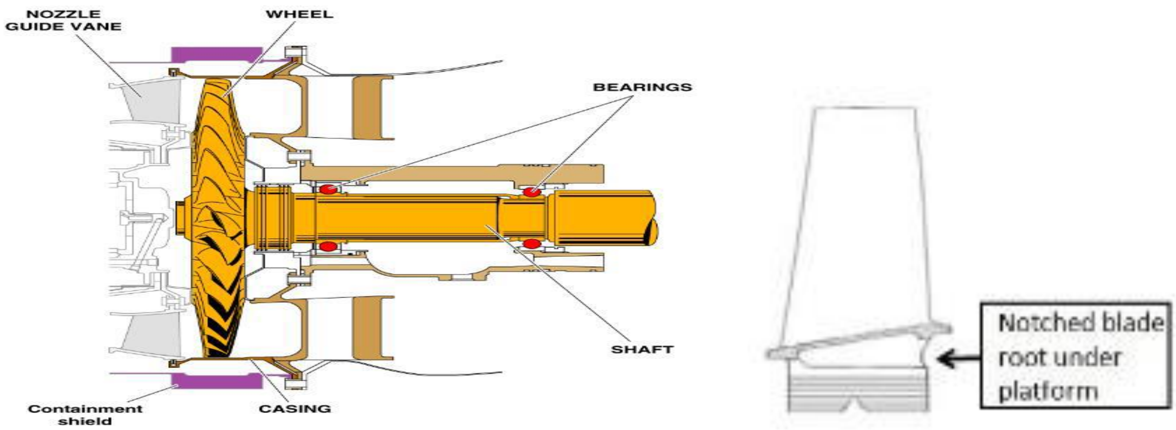

Fig:25 – Engine over speed protection

If a Power Turbine speed reaches approximately 150%, then the turbine blades will liberate at the notch to prevent an over-speed of the turbine disk which would rupture at approximately 170%. The released blades debris are then contained by the surrounding shield ring. The energy released by the sudden shedding of the blades followed by the containment of the debris generally leads to the deformation of the surrounding shield. Power Turbine speed ranges are described in the figure below.

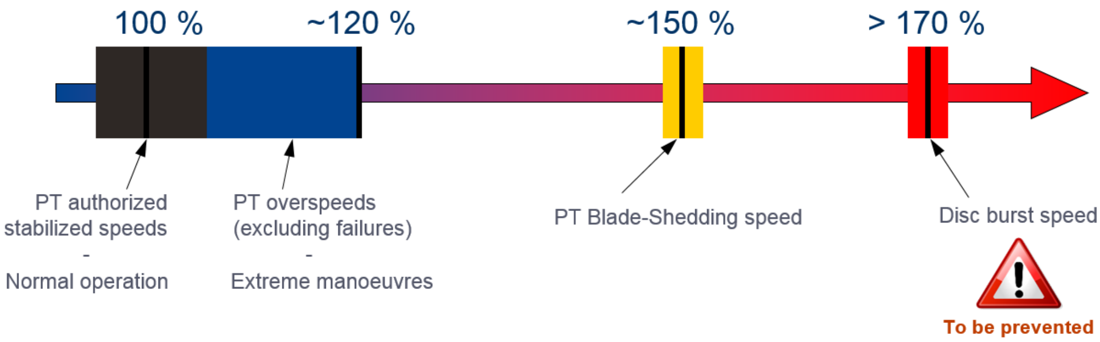

Fig:26 – Engine over speed protection

Sikorsky S 76C++ helicopter VT-CMM S/N 760815 has been manufactured in the year 2011. The helicopter is owned operated by M/s Govt of Maharashtra. Certificate of Registration No 4277 was issued on 26.12.2011 under Category 'A'.

The certificate of Airworthiness Number 6386 was issued under normal category sub-division passenger issued by DGCA on 26.12.2011 and specifying minimum crew as one. ARC Ref No. CMM/6386/ARC5TH/2016/270 and was valid up to 04.12.2017. The helicopter was flown with Aeromobile Licence No. A-041/WRLO-12 and valid up to 31.10.2019. This helicopter was operated under operator's permit No. AV.14015/29/2010-AT-1 and is valid up to 26.11.2018. This Sikorsky S 76C++ helicopter VT-CMM has logged 1265:10 A/F Hrs as on 25th May 2017.

The Sikorsky S 76 C++ helicopter and its Engine are being maintained under continuous maintenance as per maintenance program consisting of calendar period based maintenance and Flying Hours / Cycles based maintenance as per maintenance program approved by DGCA.

Accordingly the last major inspection 03 yearly inspection was carried out at 1204:20 A/F Hrs. on 12.04.2017. Subsequently all lower inspections, after last flight inspection and pre-flight checks were carried out as and when due before the accident. The last inspection carried out on helicopter was 300Hrs/06 month's inspection on 22.04.2017. Last PDR raised was "During shut down at ground idle no 2 generator caution illuminated" on 29.04.2017. Rectification carried out by replacing generator no 2 with serviceable unit.

ENGINE

The Sikorsky S 76C++ helicopter is fitted with two Arriel 2S2 engines manufactured by Turbomeca. VT-CMM was fitted with Engines S/N 42419 TEC (LH) AND 42420 TEC (RH). This Engine had logged with 1265:10 Engine Hrs and 311.9 N1, 987.4 N2 (LH) AND 255.0 N1, 736.6 N2 (RH) cycles respectively as on 25th May 2017. The last major inspection (600 hrs Inspection on engines) was carried out on 09.02.2017 at 1165:00 Engine Hours. The Last inspection 30 Hrs. on Engine carried out on 22/05/2017 at 1261:35 Engine Hours. The engines were not due for Overhaul. As per AMM Engines undergoes chemical compressor wash every 20 Hrs and Engine Power assurance check is carried thereafter. The last power assurance check was carried out at 11 hrs before the accident flight. The Engine Power Check records for the previous 5 months of operation were analysed and found to be within limits

The helicopter was last weighed on 11.11.2016 at Juhu, Mumbai and the weight schedule was recomputed on 11.11.2016 and duly approved by O/o DDG (WR), DGCA. As per the approved weight schedule the Empty weight is 8068.21 Lbs. Maximum Fuel capacity is 1064.4 Ltrs. Maximum permissible load with 2 Pilot, Fuel and Oil tank full is 1372.62 Lbs. Empty weight CG is 530.99 CM (209.05 INCHES) aft of the Datum. There has not been any major modification affecting weight & balance since last weighing hence next weighing was due on 11.11.2021.

All the concerned Airworthiness Directive, Service Bulletins, DGCA Mandatory Modification on this helicopter and its engine have been complied with as & when due.

Turn Around Inspections are carried out by the operator as per approved Turn Around Inspection schedules and all the higher inspection includes checks/inspection as per the manufacturer's guidelines as specified in "PRE" (Maintenance Program).

The last fuel microbiological test was carried out on 08.12.2016 at Indian Oil Corporation Ltd.'s DGCA approved facility and the colony count was within acceptable limits.

1.7 Meteorological information

Helicopter operated from a temporary landing ground at Nilanga where no meteorological facilities were available. As per requirement of temporary landing grounds, flags were installed to provide wind direction to pilots.

The nearest airport where the met facility is available is at Latur which was 40 NM from Nilanga. Temperature recording for the day of accident was obtained by the committee, from one of the weather facility near Nilanga. As per the report the temperature at 0630UTC was 41.1 C^{o}. The time of accident was 0635 UTC.

As per the DFDR the OAT reading was 39°C. For the purpose of investigation external temperature of 40°C was considered.

However at the time of wreckage investigation at the accident site, the last temperature recorded on the physical gauge was 45 C^{o} which corroborates with the temperature recorded on DFDR at the time of impact with the ground.

1.8 Aids to navigation

Other than the flags to indicate wind direction and speed, there was no Nav Aid facility available at the accident site.

1.9 Communications:

Since the fight was from an uncontrolled temporary helipad, hence no ATC was available. The two way communication between the crew was satisfactory.

1.10 Aerodrome information

The helicopter operated from a temporary landing ground at Nilanga prepared by the district authorities at a school ground.

DGCA has issued CAR Section 4, Series B, Part II specifying the minimum safety requirements for temporary helicopter landing ground. The requirements for Touchdown and Lift Off Area(TLOF), Final Approach and Take Off area(FATO) and Safety Area are prescribed in the said CARs and shown in the figure below.

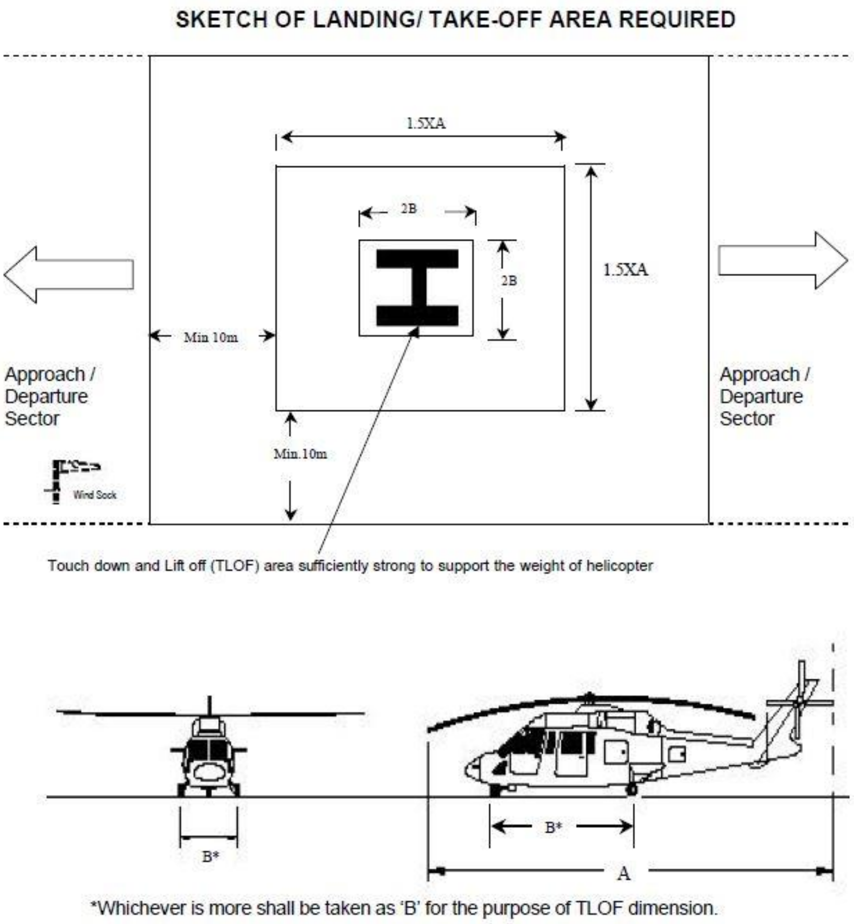

Fig:27 – TLOF, FATO and Safety Area

The minimum required dimension for TLOF, FATO and Safety Area to operate S76 C++ helicopter as per the requirement of CAR comes out to be 10M X 10M, 19.8 M X 19.8 M and 39.8 M X 39.8 M respectively. Actual area available for TLOF, FATO and Safety area at Nilanga was 15 mts X 15 mts, 30 mts X 30 mts and 75 mts X 75 mts respectively.

The helipad was prepared in an open ground measuring 118.6 mts X 110 mts where, an area measuring 75 mts X 75 mts was barricaded for the helipad. The elevation of the helipad is approximately 2000 feet and the geographical co-ordinates are 18º07’34”N and 76º44’57”E.

The temporary landing ground is surrounded by high tension 11 KV electricity cables on three sides and high trees and building on one side. The electricity poles of 10m height (33 ft) carrying the 11 KV electricity cables are located at a distance of 64 mts from the centre of helipad in east direction and in the west direction electricity poles of 10m height carrying the 11 KV electricity cables are located at a distance of 68 mts from centre.

Fig:28 – Layout of the temporary landing ground.

The distance of poles carrying High Tension (HT) cable in the north direction is around 70 mts from centre. On the southern direction the building is located at a distance of approximately 65 mts from the helipad centre. Apart from these there were street light pole of 9 metres in the northern and western direction on the edge on the ground.

Further as per the para 4.6 of CAR Section 4, Series B, Part II, *“An Approach and Take-off climb surface in an inclined plane sloping upwards (8%) from the end of the safety area and centered on a line passing through the centre of the FATO, should be available for a distance of at least 245 meters.”*

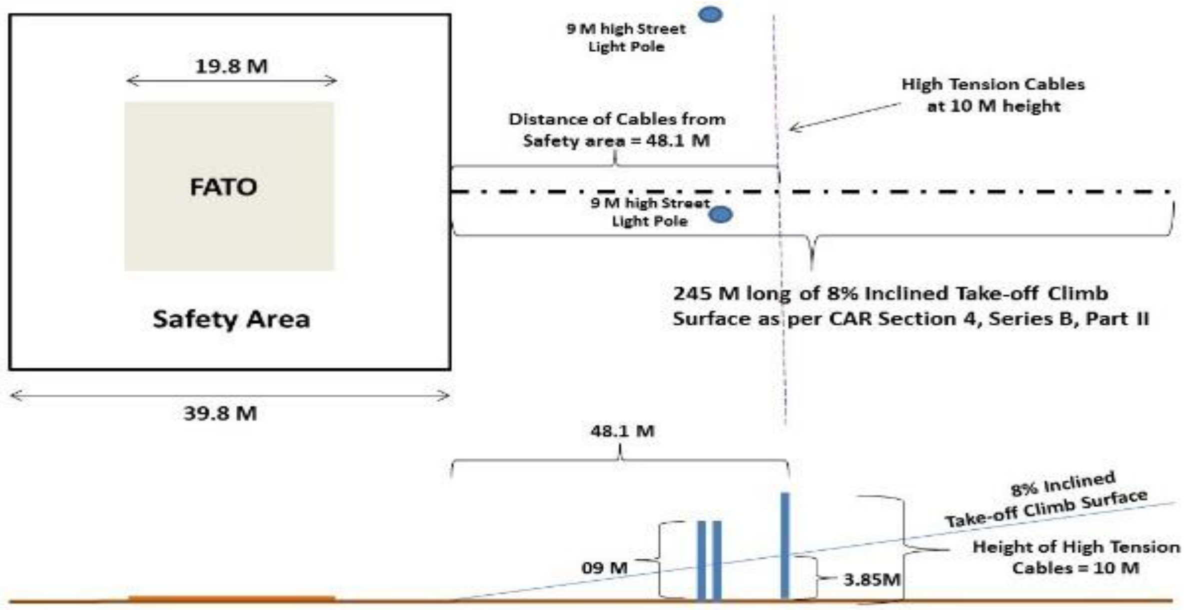

Fig:29 – Obstruction around the FATO

The top and side view of the temporary landing ground is shown in the figure above. The High Tension Wires and the poles carrying them were in the take-off climb path by at least 6.15 mts.

CAR Section 4, Series B, Part II, also states following requirement for fire fighting at temporary landing areas.

“At least one 12 kg powder (DCP) fire extinguisher shall be available at the landing/ take-off area, clearly marked and situated so that it can be used quickly in case of fire. A first aid box shall be placed within easy reach and

clearly marked. The box shall be maintained in accordance with the instructions and its contents shall be supplemented whenever used."

District administration had arranged Fire Tenders and necessary fire fighting equipment at the site as per the requirements.

The CAR Section 8, Series O, Part IV defines hostile environment

(a) a safe forced landing cannot be accomplished because the surface and surrounding environment are inadequate; or

(b) the helicopter occupants cannot be adequately protected from the elements; or

(c) search and rescue response/capability is not provided consistent with anticipated exposure; or

(d) there is an unacceptable risk of endangering persons or property on the ground;

as a hostile environment.

A hostile environment within an area which is substantially used for residential, commercial or recreational purposes is defined as Congested Hostile Environment.

The temporary landing ground used at Nilanga for the purpose of accident flight can be described as a Congested Hostile Area as per the CAR.

1.11 Flight recorders:

The helicopter was equipped with a Universal solid state combination CVR/FDR (CVFDR) with following details.

Part No	**:**	**1605-01-01**
Sr No	**:**	**0236**

The CVR was downloaded by the Committee at DGCA facility. The DFDR was downloaded at NTSB, USA for detail analysis

The transcript of the CVR is given in the table below.

Time(CVR)	**Event**	
01h50min48	PIC	Noise of engine running up
01h52min32	SV_Public Address announcements to passenger (on pilots track only)	
01h52min37	PIC	Oh ... okay(Checklist Started)
01h53min04	PIC	Okay, take-off field… 90° to the left and then I order the heading
01h53min36	PIC	Anything below 100, (mid and) 102 call up
01h53min39	Co-Pilot	Yes
01h53min41	Co-Pilot	97, 98 Sir
01h53min47	Co-Pilot	97..now…98
01h53min56	Co-Pilot	One zero six
01h53min59	Co-Pilot	One zero five
01h54min00	Co-Pilot	One zero four, one zero three, One zero two
01h54min03	Co-Pilot	Sir wires
01h54min04	PIC	Yeah
01h54min05	Co-Pilot	One zero two, one zero ...Sir Lamp Post…..
01h54min08	PIC	Yeah, yeah
01h54min10	Co-Pilot	Wires.
01h54min12	Co-Pilot	93
01h54min12	PIC	Landing gear up
01h54min14	Co-Pilot	Wires Sir
01h54min16	PIC	Yeah yeah yeah
01h54min17	Co-Pilot	Pop or bang noise / sound produced by the lightning strike generated by the contact of the helicopter with the electrical cable
01h54min19	Noise similar to the blade impacting some obstacle 01h54min21 Noise of the helicopter impact with the ground	
01h54min23	Warning sound triggered	
1h54min28	TAWS SV: "Be alert terrain inop"	
01h54min35	Helicopter's Electrical power shut Off	
02h02min43	End of CVR	

The DFDR was downloaded at the Recorders Lab of National Transport Safety Bureau, USA and data analysis was carried out. The parameter for the accident flight were analysed in graphical representation below.

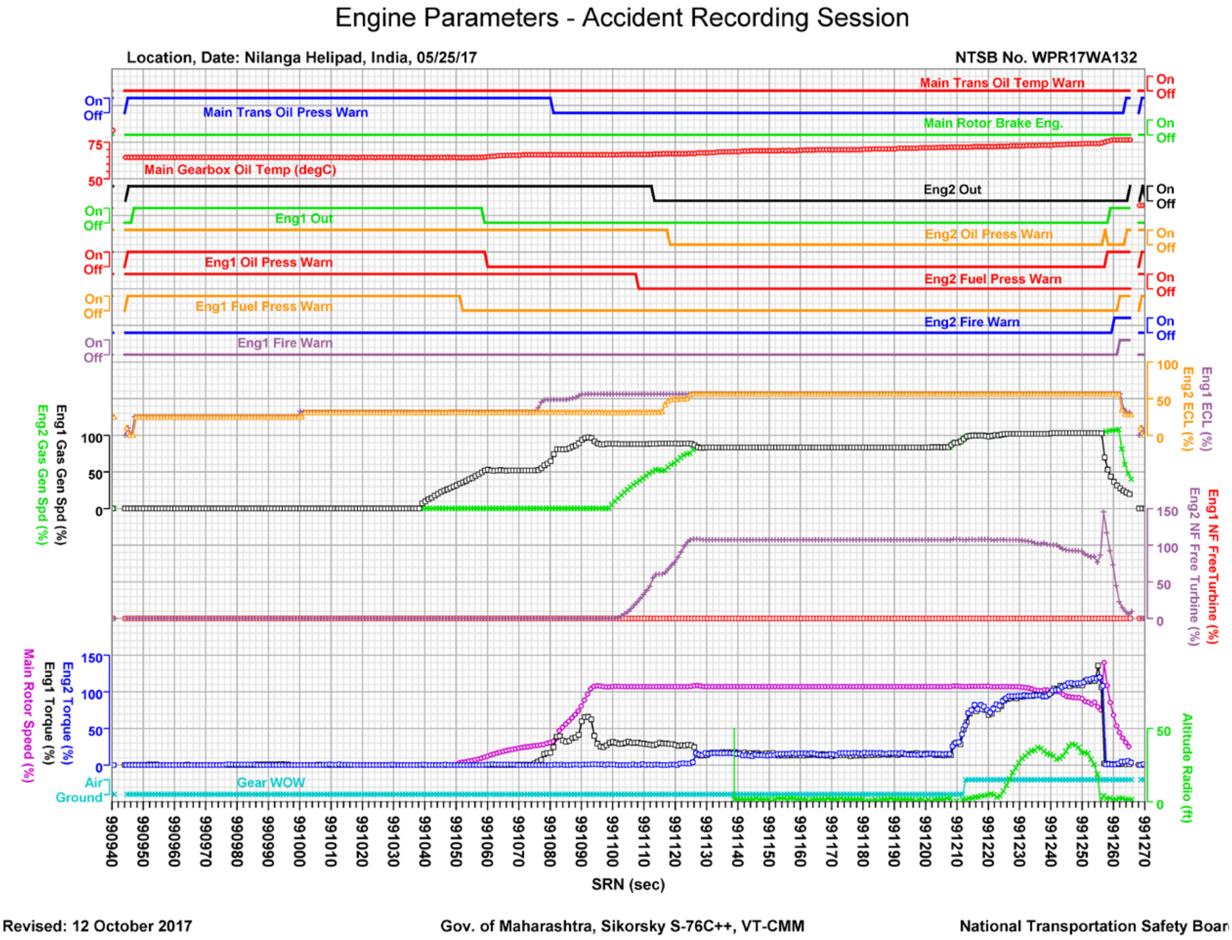

Fig:30 – DFDR readout

1. During the take-off phase, while the helicopter was still in the ground effect (up to ~20ft), the main rotor speed was regulated to 107 % by the engines (as per design).

2. Approximately 13 seconds after lift-off, the crew attempted to climb applying collective pitch and some aft cyclic.

3. As the helicopter came out of the ground effect (above ~20ft), the main rotor speed as well as the free turbine speed decreased. Engine gas generator speed and torque values increased as the pilot increased demand on the collective pitch control lever for increasing power until it reached its stop position.

4. As the Rotor RPM started decreasing, the helicopter began to descend from approximately 39 feet radio height that it gained initially.

5. After the collision with the ground, both engines went into overspeed: the torque suddenly decreased when the main rotor blades broke.

7. Engine #1 was stopped by the ECU (Engine Control Unit) through the overspeed protection function, and, subsequently, this protection was deactivated on engine #2 (as per design).

8. Thus, engine #2 suffered blade shedding as the RPM spiralled to about 148%..

9. During the take-off phase, the analysis of the engines parameters didn't show any discrepancy of the propulsion system.

10. No warning linked to the engines operations was triggered before the impact.

1.12 Wreckage and impact information:

The helicopter after take-off climbed to a height of around 39 feet before descending down and impacted ground 96 mts away from the temporary helipad in the northerly direction. The onsite investigation and detailed wreckage examination of the helicopter was carried at the accident site. Subsequently the helicopter was transported to Mumbai and was again re-examined for the damage along with the team from the manufacturer of both the helicopter and the engines.

The salient findings of the wreckage examination are as below.

After examining the helicopter at the accident site and videos available from the social media, following sequence was derived.

1. The helicopter was parked with its nose in the easterly direction.
2. After lift-off the helicopter turned left by around 130 degrees to the left in to the northerly direction to continue the flight into the wind.
3. A thick dust bowl was developed with the rotor down wash, which affected the crew's visibility.
4. The helicopter continued the flight in the northerly direction maintaining an altitude of around 39 feet, however it was not able to sustain the flight and the helicopter started descending.
5. During the take-off process, PIC was warned by Co-pilot of the high tension cables in the flight direction.
6. The pilot anticipating that he may hit the high tension cables retracted the Landing Gears and pitched up the helicopter, to clear the obstacle. However,

the belly of the helicopter hit the cables and caused it to snap, and the helicopter yawed to the right.

Fig:31 - Burn marks on belly

7. Subsequently, the main rotor blade hit the tree and blades disintegrated.

8. The helicopter there after crash landed and settled on the ground between truck and the hut.

Fig:32 – Truck hit by main rotor

9. Some portion of the helicopter main rotor blades got entangled with the truck and ripped the roof of the truck.

10. The tail boom of the helicopter hit a temporary house and damaged it and also injuring its occupants.

11. The one end of the snapped cable hit one of the person standing close to the accident side and injured him.

12. There was no fire after the helicopter impacted various obstacles before settling on the ground.

Fig:33 – Final resting position of helicopter

13 Helicopter sustained substantial damage in the process.

1.13 Medical and pathological Information:

The crew had undergone the pre-flight medical examination breath analyser alcohol check prior to operating flight from Latur to Nilanga, which was negative. After the accident both the cockpit crew were examined physically by the doctors, however post-accident breath analyser check for alcohol was not carried out.

1.14 Fire:

There was no post impact fire.

1.15 Survival aspects:

As the helicopter started sinking the main rotor blade hit the trees and a parked truck and sheared off. The helicopter thereafter crash landed with its tail hitting a hut. The ground impact was within the design impact criteria and human G-load tolerance. All the six occupants including the crew evacuated the helicopter without any injuries.

1.16 Tests and research

1.16.1 Digital Engine Control Unit (DECU) of both the engines were removed from the accident helicopter and sent to BEA in order to be de-soldered and downloaded. Their analysis was made by the BEA with assistance of the manufacturer Safran Helicopter Engines (SHE)

<u>Findings of DECU examination</u>

The accident flight duration (between the last power up and the lightning noise) recorded in the CVFDR was around 308 seconds. The duration of the last recorded flight in both ECU was consistent with the duration of accident flight recorded in the CVFDR. First failure blocks were recorded 307 seconds after power up.

All the recorded data were consistent. Each ECU recorded a high number of failures related to various independent chains and occurring within a short period of time. These failures include a failure related to the collective pitch anticipator potentiometer position. According to BEA and Safran Helicopter Engines experience, the failure of collective pitch anticipator potentiometer is one of the first failures recorded in the sequence of failures following an impact with the ground.

The parameters associated to the first failure context recorded have the following values (both ECU thus both engines):

- gas generator speed (N1) close to 103%

- free turbine speed (N2) close to 85%

- torque close to 105%

In the same time frame, the torque value dropped to 0%. These values were consistent with a helicopter taking-off out of the limits of the engine performance followed by a torque decrease, consistent with the main rotor break. It is highly probable that the failures recorded in both ECU occurred during the accident sequence.

1.16.2 Examination of Engines

The engine manufacturer experts had dismantled both the engines to determine the internal failures, if any and also to co-relate the physical condition of the engine with the DFDR recording.

LH Engine

The module 1 was in good condition. The output power drive rotated with the rotation of the Power Turbine thus confirming the continuity of the reduction gearbox gear chain.

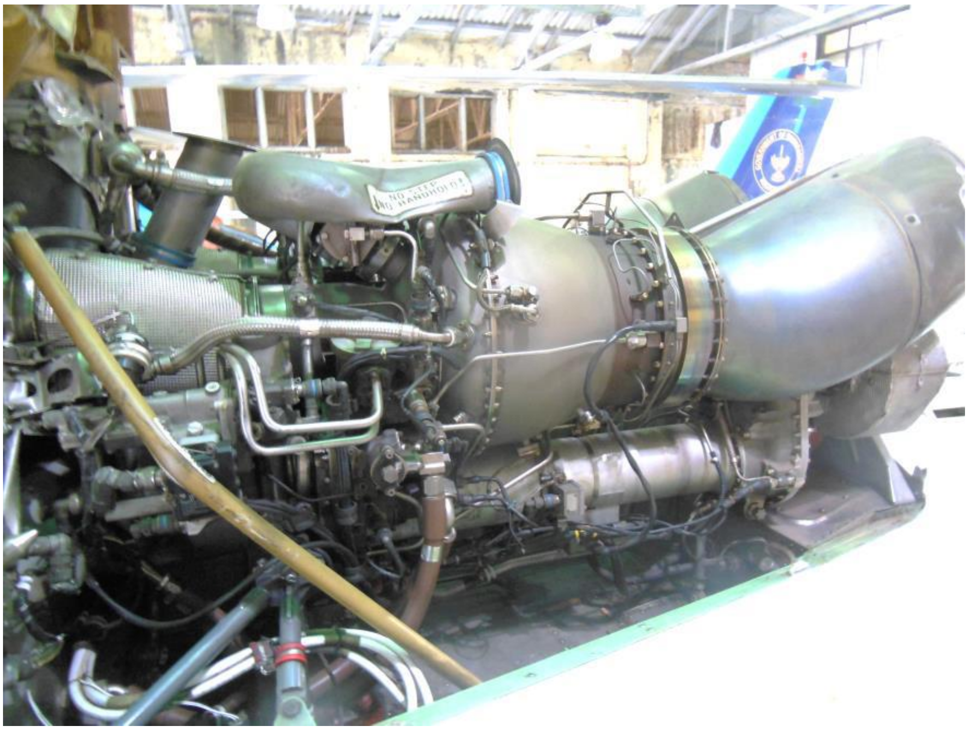

Fig:34 – LH Engine

Five fixing screws (out of 11) were sheared and were found on the engine bay floor along with their associated dowels indicating excessive lateral or vertical load at the time of impact.

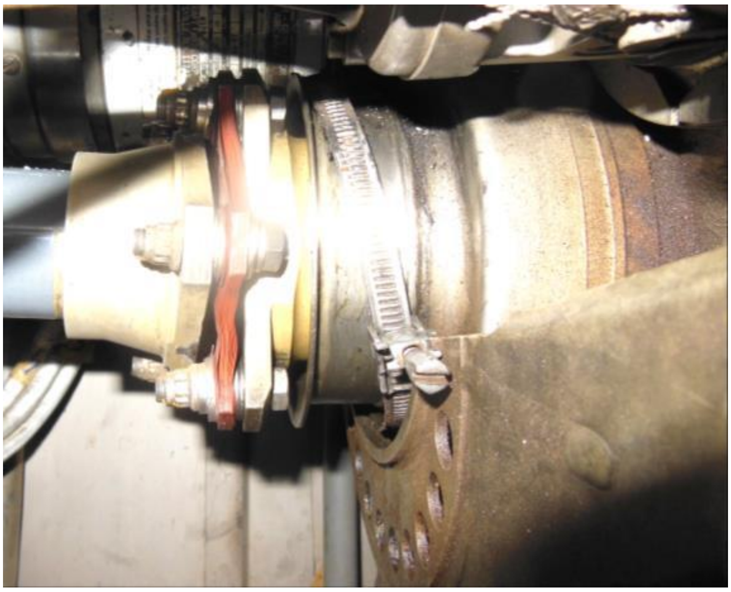

Fig:35 – LH Engine Module 1

The casing of module 2 axial compressor was in good condition. The axial compressor exhibited significant FOD damage and deep scoring on the shroud indicating the ingestion of hard FOD. The numerous deep impacts affecting all the blades indicate that the engine was rotating at the time of the ingestion. The penetration of the FOD was made possible by the openings in the damaged LH barrier filter. As a consequence of the FOD ingestion, the Gas Generator could not be rotated by hand at the time of the examination.

Fig:36 – LH Engine Module 2 – Axial Compressor

The boroscopic inspection showed FOD damage to the leading edges of the centrifugal impeller's blades. The base of the air path showed scoring marks left by hard FOD. The centrifugal diffuser's vanes were in good condition. The ingested FOD did not leave any splatter on the vanes.

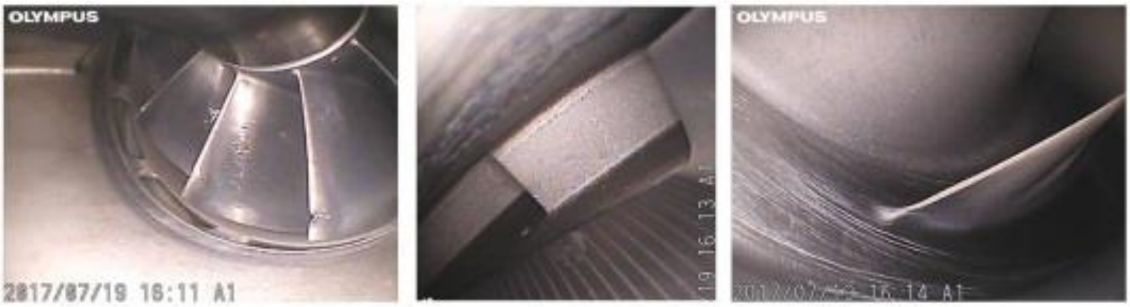

Fig:37 – LH engine Module 2 – Centrifugal Compressor

Both the impeller's blades and the diffuser's vanes showed sharp straight leading edges without any visible erosion. The numerous impacts affecting the blades indicate that the engine was rotating at the moment of the ingestion of the hard FOD.

The module 3 was in good condition. The boroscopic inspection of the combustion chamber showed no abnormality.

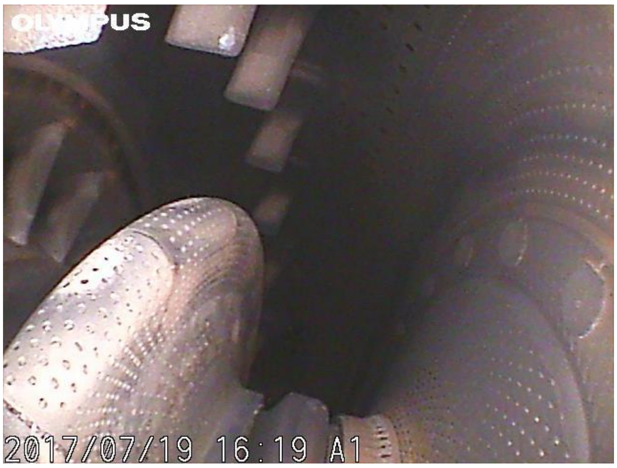

Fig:38 – LH Engine Module 3 – Combustion Chamber

The boroscopic inspection of the Nozzle Guide Vane (NGV) showed that the leading edges and the pressure sides of the trailing edges were covered with metallic deposits. These deposits affected all the vanes similarly. The deposit of the pressure sides of the trailing edges appeared as made of lightly melted metal that had solidified into a plate, and could be detached with light rubbing.

The HP turbine blades too exhibited the presence of solidified metal around their tips with metal spread on the shroud. The blades’ leading and top edges appeared in good condition without erosion nor corrosion.

Fig:39 LH engine Module 3 – HP Turbine

The solidified metal deposits were of ingested FOD which melted due to flame in combustion chamber. These findings indicate that the engine was running at the moment of ingesting FOD’s made of metals with a fusion temperature close to that existing in the established flame inside the combustion chamber

- Module 4 (Power Turbine)

The module 4 was in good condition. The examination of the Power Turbine wheel showed no abnormality or any visible impacts or traces of blade top rubbing.

Fig:40- LH engine Module 4 – Power Turbine

The blades were clear of deposits, thus indicating that the FOD that deposited on the HP turbine did not have time to migrate to the Power Turbine. This indicates that the FOD ingestion must have occurred very shortly before the engine shut-down.

The Power Turbine could be rotated by hand. The rotation was smooth and without noise. The manual rotation of the Power Turbine wheel drove the Rotor head and, through the residual friction of the free wheel assembly, also drove the RH engine's drive shaft thus confirming the integrity of the whole power drive chain from the Power Turbine to the Rotor head.

The module 5 was in good condition and rotated smoothly. It was separated from the Power Turbine module in order to reveal the splined drive nut on the drive gear's shaft. This nut transfers the torque delivered by the Power Turbine through the muff coupling to the reduction gearbox's gear train. Its position on the shaft is marked during the assembly process.

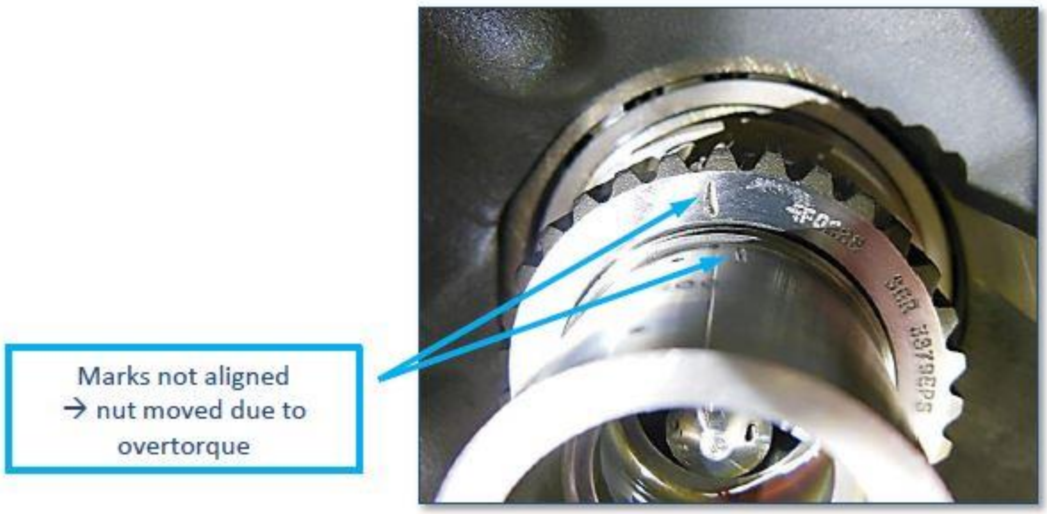

Fig:41 – Misalignment in drive nut

Should the rotation of the reduction gearbox's output shaft be impeded during engine Reduction Gearbox Schematic operation, then the torque applied by the Power Turbine on the nut will increase.

The drive nut’s close examination revealed that the marks had moved by over 2mm indicating over torque caused by due to impediment to reduction gear box caused by rotor blades hitting obstacles during accident.

The LH engine and cowling exhibited signs of impacts on the front LH side where the helicopter hit a parked lorry during the crash. Damage to the engine’s front LH side occurred as a consequence of the accident and shortly before engine shut-down. The front support’s fixings indicated excessive lateral or vertical load at the time of impact.

The LH air intake barrier filter was damaged during the accident, leaving gaps that could allow debris to penetrate into the main air path. The compressor and the turbine exhibited significant damage consistent with the ingestion of hard metallic FOD. The findings in the HP turbine indicate that the engine was running at the moment of ingesting those FOD’s made of metals with a fusion temperature close to that existing inside the combustion chamber with an established flame. Their solidification in the HP turbine and their absence in the Power Turbine indicate that the ingestion occurred shortly before the engine shut-down.

The engine was attached to the helicopter and exhibited signs of impacts on its front LH side in the vicinity of the parked lorry’s rod that was found incrusted in the cowling.

RH Engine

The engine was attached to the helicopter and could be examined. The module 1 was in good condition with no particular findings to report. The output power drive shaft could be rotated smoothly manually when the engine was removed from the helicopter and separated from reduction gearbox.

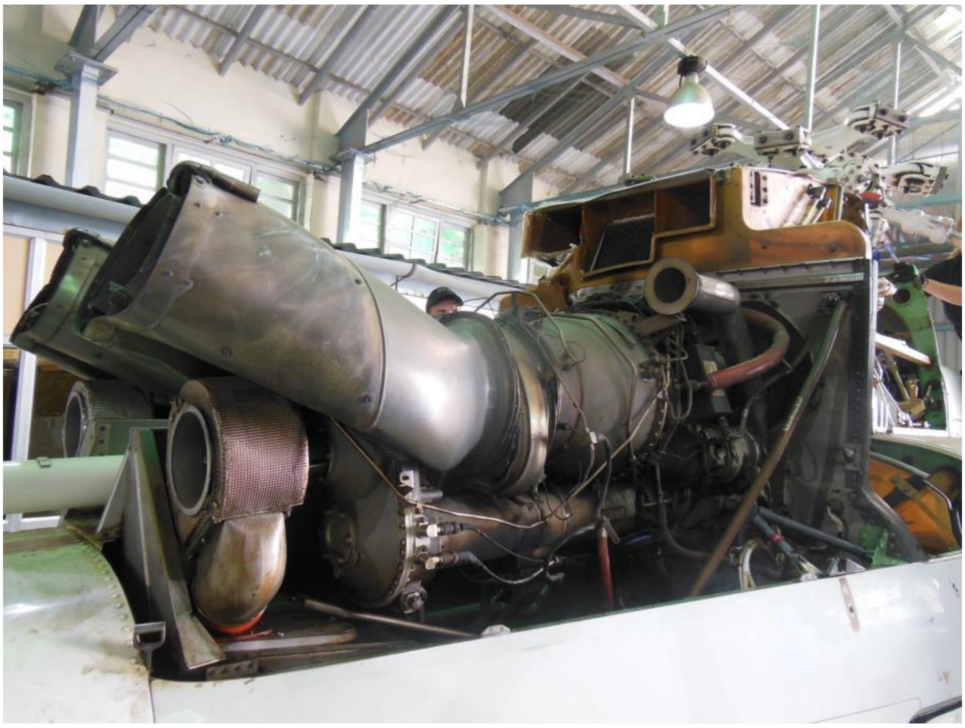

Fig:42 – RH Engine

Two fixing screws (out of 11) were sheared and were found at the bottom of the front support along with their associated dowels thus indicating excessive lateral or vertical load at the time of impact.

Fig:43 - RH engine Module 1

- Module 2 (Axial Compressor)

The module 2 was in good condition with no particular findings to report. The Gas Generator was blocked initially. It could be unlocked manually and its rotation was smooth without noise although with some resistance.

Fig:44 - RH engine Module 2 – Axial Compressor

The examination of the axial compressor showed FOD impacts on the leading edges of all the blades and several small impact marks on the shroud. Considering that the air intake was covered with a barrier filter, the origin of the FOD ingestion cannot be explained. There was blade tip rubbing in the 4 0'Clock position. There was no visible erosion on the blades.

- Module 2 (Centrifugal Compressor)

The boroscopic inspection showed light FOD damage to the leading edges of some of the centrifugal impeller's blades (bottom left photo). Both the impeller's blades and the diffuser's vanes showed sharp straight leading edges without any significant erosion.

Fig:45 - RH engine Module – Centrifugal Compressor

The centrifugal diffuser's vanes were in good condition and exhibited the presence of metallic splatter possibly caused by soft FOD and/or soft abradable coating being scrapped off the centrifugal impeller's cover whilst the engine was running during the accident and/or the Power Turbine blade-shedding.

- Module 3 (Combustion chamber)

The module 3 was in good condition with no particular findings to report. The boroscopic inspection of the combustion chamber showed that it was in good condition with no findings to report.

Fig:46 - RH engine Module 3 – Combustion Chamber

- Module 3 (HP Turbine)

The boroscopic inspection of the Nozzle Guide Vane (NGV) showed that the vanes' leading edges were evenly covered with metallic splatter which are consistent with the compressor's condition. These deposits affected all the vanes similarly (bottom left photo).

Fig:47 - RH engine Module 3 – HP Turbine

The HP turbine blades' leading and top edges appeared in good condition without erosion nor corrosion (top right photo). The blades also exhibited the presence of metal splatter on their leading edges. All the blades were similarly affected. By experience, such splatter indicates that the engine was running with an established flame inside the combustion chamber at the moment of ingesting soft metal FOD’s.

Several blades were oily and partially covered with semi coked oil. Their numbers matched an oily area under the rear bearing chamber as well as a coked oil deposit on the bottom of the main air path downstream of the HP turbine (bottom right photo). The oily nature of the deposits indicates that some oil escaped from the rear bearing chamber after the engine shut-down when temperatures fell below oil coking temperatures (< 400°C).

- Module 4 (Power Turbine)

The module 4 exhibited a deformed casing and several of the screws used to fix it to module 3 were ruptured and had fallen on the engine deck. The examination of the Power Turbine wheel revealed that all the blades had come off.

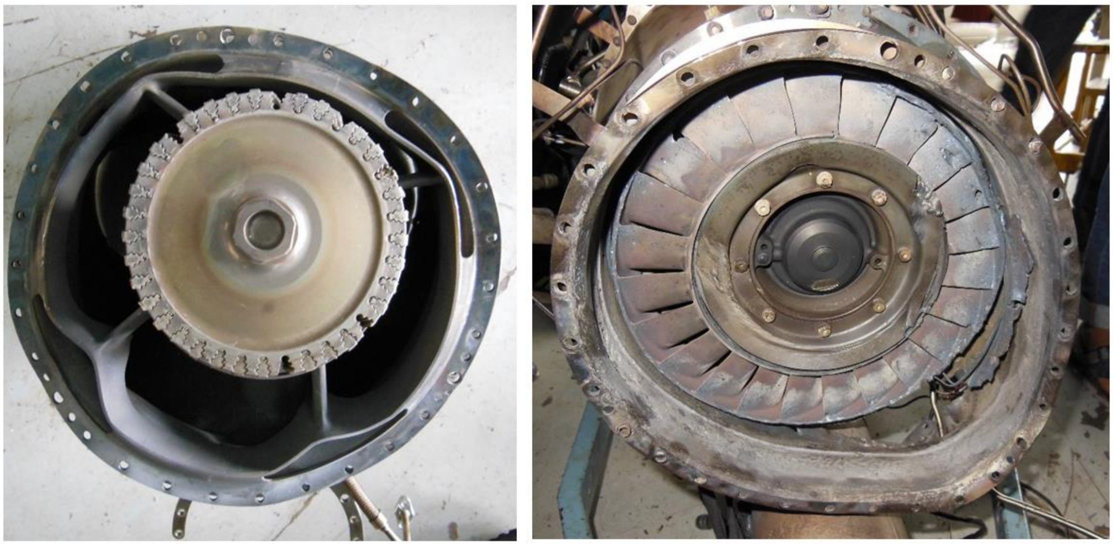

Fig:48 - RH engine Module – Power Turbine

These findings are consistent with the Power Turbine “Blade-Shedding” feature which indicates that the engine was delivering power at the moment of the accident. Due to the cross-inhibition concept, the other engine went into over speed as well and was shut-down by the Electronic System.

- Module 4 (Power Turbine) – (continued)

The module 4 was separated from the rest of the engine. The Power Turbine wheel which appeared initially seized could be freed and rotated by hand albeit with some friction and light rubbing noises.

- Module 5 (Reduction Gearbox)

The module 5 was separated from the engine. A section of the casing used to centre it on the back of the module 4 was broken due to the forces released during the blade-shedding. The shafts could be rotated and a sticking point could be felt during the rotation.

Once the module was separated, the splined drive nut on the drive gear’s shaft could be examined. This nut transfers the torque delivered by the Power Turbine through the muff coupling to the reduction gearbox’s gear train. Its position on the shaft is marked during the assembly process. Should the rotation of the reduction gearbox’s output shaft be impeded during engine operation, then the torque applied by the Power Turbine on the nut will increase. During an accident, this may lead to an over torque capable to rotate the nut on its shaft.

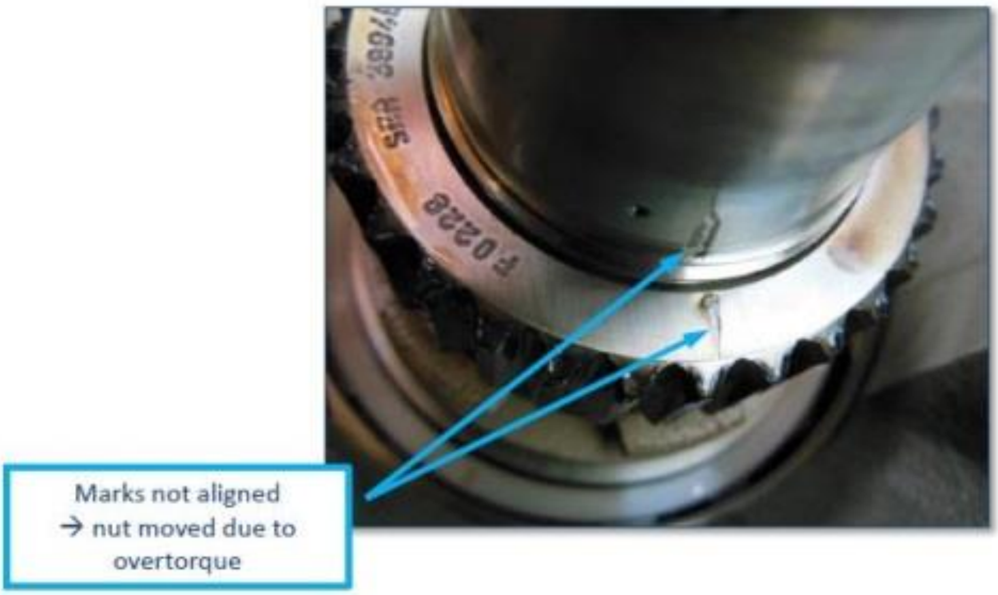

Fig:49 - RH engine Drive Nut

The drive nut’s close examination revealed that the marks had moved by approximately 1mm. Consequently, the engine was delivering power at the time of impact. The engine experienced a Power Turbine “Blade-Shedding”.

The Gas Generator could rotate smoothly without noise but with some resistance due to light rubbing probably as a consequence of the blade-shedding that distorted the rear of the engine.

The RH air intake barrier filter was in good condition. However, the compressor showed light FOD impacts that could not be explained. However, no debris were found in the combustion chamber which was in good condition and the HP turbine blades did not exhibit any hard FOD impacts.

Splatter in the compressor and in the HP turbine indicated that soft FOD and/or soft abradable coating scrapped off the centrifugal impeller’s cover were ingested whilst the engine was running with an established flame inside the combustion chamber. It could have occurred during the accident and/or during the Power Turbine blade-shedding.

Some harnesses exhibited limited local thermal damage following the blade-shedding. The power drive chain (Power Turbine, reduction gearbox and output power drive shaft) could be rotated manually. Some rubbing was felt during the manual rotation of the Power Turbine and a sticking point was felt during the rotation of the reduction gearbox. These findings are consistent with the forces released during the blade-shedding.

The front support’s fixings indicated excessive lateral or vertical load at the time of impact.

<u>Check of the power transmission chain :</u>

The manual rotation of the Power Turbine wheel drove the Rotor head and, through the residual friction of the free wheel assembly, also drove the RH engine’s drive shaft (this check was performed after the RH engine had been removed). The checks on both engines coupled with this check showed the integrity of the whole power drive chain from both Power Turbines to the Rotor head.

Both engines were delivering power during and after the crash and it can be reasonably assumed that they took the MGB and main rotor head (without its blades) into overspeed. The overspeed led to the LH engine shut-down by the overspeed detection Electronic system and to a Power Turbine "blade-shedding" on the RH engine.

1.16.3 Fuel and Oil Samples

The fuel and oil samples were drawn from the accident helicopter and sent to the test laboratory for examination. The same was found satisfactory.

1.17 Organisation and Management information:

Govt of Maharashtra Aviation Wing was incorporated in 1954. Govt of Maharashtra operates under State Govt Operations Permit, which was valid up to Nov 2018 and its aircraft are registered in Government (private) category. As per Air Operator Permit they have a fleet of 03 aircrafts i.e 02 helicopters (Sikorsky S76++ and Dauphin N3) and one fixed wing, Citation 560XLS.

Govt of Maharashtra Aviation Wing fulfils the flying commitments of State VIPs and other State Officials. The Aviation Wing is headed by an officer of rank of Principal Secretary of Maharashtra Govt, who is supported by a Joint Secretary Administration and Director Aviation, who is also a flying pilot. Total of 05 pilots are employed by the Govt of Maharashtra i.e 02 on fix wing and 03 on helicopter.

1.18 Additional Information

1.18.1 Helicopter Performance

As per the Load and Trim sheet of the helicopter, the pilot had calculated the max AUW as 10891Lbs. The actual weight of the passengers and baggage was not taken into account by the PIC. The investigation at the site revealed that there were 06 bags, four for the passengers and 02 for the cockpit crew, catering for the overnight stay of the occupants and documents of Hon'ble CM. Since the baggage could not be weighed after the accident, it is estimated that on an average each bag would have weighed 10Kg/22Lbs on the lower side. This would amount to a total luggage weight of 132 Lbs approximately.

In addition 160 Lbs of other items were found in the cargo, which were not accounted in the load and trim sheet. The computed minimum AUW of the helicopter was at least 11183 Lbs.

The performance of the helicopter varies with change in elevation and temperature conditions. The elevation of Nilanga is approximately 2000 feet AMSL.

As per the Flight Manual, for OAT of 40 degrees and 2000feet AMSL the maximum AUW for the helicopter to hover out of ground effect was limited to 10400Lbs approximately, and for 05feet wheel height the same was limited to 11700 Lbs.

1.18.2 Regulatory requirements for Helicopter Operations.

The requirement for commercial helicopter operations in India is governed by the CAR Section 8 Series O, Part IV.

As per the CAR, helicopters with a passenger seating configuration of more than 19,or helicopters operating to or from a heliport or landing site in a congested hostile environment are require to be operating in Performance Class 1.

As per the CAR for operations in performance Class 1 during take-off and climb phase *"the helicopter shall be able, in the event of the failure of the critical engine being recognized at or before the take-off decision point, to discontinue the take-off and stop within the rejected take-off area available, or, in the event of the failure of the critical engine being recognized at or after the take-off decision point, to continue the take-off, clearing all obstacles along the* *flight path by an adequate margin until the helicopter is in a position to safely continue the flight"* to an appropriate landing area.

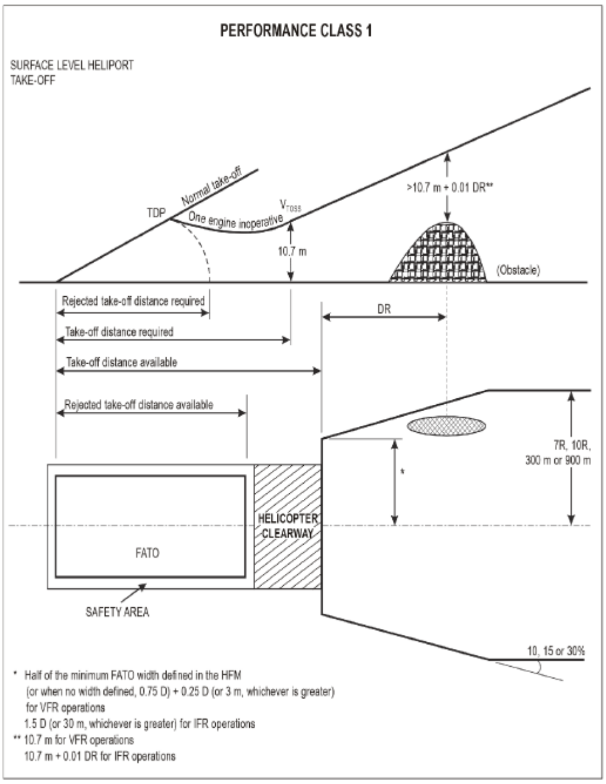

Fig:50- Performance Class I

Operations in performance Class 2 is defined as Operations with performance such that, in the event of critical engine failure, performance is available to enable the helicopter to safely continue the flight to an appropriate landing area, except when the failure occurs early during the take-off manoeuvre or late in the landing manoeuvre, in which cases a forced landing may be required.

Further the helicopters operating in performance Classes 1 and 2 are required to be certified in Category A.

Category A, with respect to helicopters means a multi-engine helicopter designed with specified engine and system isolation features, and capable of operations using take-off and landing data scheduled under a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight or safe rejected take-off.

As per CAR Section 4, Series B, Part III the dimension and slopes for FATO are as below.

Table 4-1. Dimensions and slopes of obstacle limitation surfaces for all visual FATOs

SURFACE and DIMENSIONS	*SLOPE DESIGN CATEGORIES*		
	A	B	C
APPROACH and TAKE-OFF CLIMB SURFACE:			
Length of inner edge	Width of safety area	Width of safety area	Width of safety area
Location of inner edge	Safety area boundary (Clearway boundary if provided)	Safety area boundary	Safety area boundary
Divergence: (1st and 2nd section)			
Day use only	10%	10%	10%
Night use	15%	15%	15%
First Section:			
Length	3 386 m	245 m	1 220 m
Slope	4.5% (1:22.2)	8% (1:12.5)	12.5% (1:8)
Outer Width	(b)	N/A	(b)
Second Section:			
Length	N/A	830 m	N/A
Slope	N/A	16% (1:6.25)	N/A
Outer Width	N/A	(b)	N/A
Total Length from inner edge (a)	3 386 m	1 075 m	1 220 m
Transitional Surface: (FATOs with a PinS approach procedure with a VSS)			
Slope	50% (1:2)	50% (1:2)	50% (1:2)
Height	45 m	45 m	45 m

Fig:51 – Dimension and Slope for FATO

It can be seen that a maximum slope of 4.5 degree is required for operations in Category A. The category A take-off procedure as per the S-76C flight manual features variable critical decision point and take-off safety speed so as to permit trading of payload against available field length in such a manner that category A One Engine Inoperative(OEI) climb performance minima can be maintained over a wide range of environmental conditions.

The maximum AUW permitted for flight at Mean Sea Level 2000 feet and at Temperature of 40 degrees is calculated to be 10400 Lbs. The required rejected take-off distance, for the maximum permissible take-off weight permitted at Critical Decision Point (CDP) of 45Kts comes out to be 1250 feet approx. as per the performance data available in the flight manual. This rejected take-off distance was not available at the temporary landing grounds.

1.18.3 Engine and Drive system Operating Limits

ENGINE OR DRIVE SYSTEM OPERATING LIMITS

THIS TABLE IS A SUMMARY OF LIMITATIONS OBSERVE THE FIRST LIMIT ENCOUNTERED FOR ANY GIVEN OPERATING CONDITIONS

OPERATING CONDITION	TIME	TRANSMISSION TORQUE LIMIT (%)	ENGINE TORQUE LIMIT (%)	T5°C	%N1	%N2
TAKEOFF	5 MIN	**100**	104	930	**100.0**	(1)
Deleted						
MAXIMUM CONTINUOUS (5)	--	**100**	104	893	97.8	(1)
30 SEC SINGLE ENG	30 SEC	136	**135**	996	**103.9**	(1)
2 MIN SINGLE ENG	2 MIN	136	**127**	944	**100.5**	(1)
MAXIMUM CONTINUOUS SINGLE ENG	--	128	**115** (3)	926	**99.4**	(1)
TRANSIENT SINGLE ENG	5 SEC	150 (9)	--	--		--
TRANSIENT	20 SEC	--	160	--	100.5	109/115 (4)
TRANSIENT	10 SEC	115 (8)	--	--	--	--
STARTING	10 SEC	--	--	840 (6)	--	--

NOTES:

(1) 108.5% N2 - maximum.
(2) Deleted.
(3) The DECU will limit single engine torque to 110% at 106 - 108% N2 varying linearly to 115% torque at 100% Nr.
(4) 109% N2 transient maximum, power on. 115% N2 transient maximum, power off.
(5) See paragraph titled Engine Ratings and Recommended Usage in Part 2, Section 1.
(6) Time between 750 and 840°C is limited to 10 seconds. When T5 reaches 840°C. the start will automatically be aborted.
(7) Shaded box with bold number denotes a DECU controlled limiter value.
(8) Dual engine transient limit 230% total torque.
(9) Typically associated with abnormal Nr droop at DECU controlled OEI limit.

Fig:52 – Arriel 2S2 Engine or Drive System Operating Limits

1.18.4 Blowaway Logic

In the Arriel 2S2 engines, Blowaway is an escape logic associated with dual engine limiting that removes the take-off power limiter in certain cases to provide for extraordinary and unforeseen circumstances where increased power beyond the take-off power limit is required for continued safe operation. Extraordinary turbulence encountered in the final moments of a landing approach to an oil platform or pilot mis-judgment of closure rate upon landing to a confined area can serve as operational examples where increased power beyond the limit could be an important contribution.

The blowaway logic can be latched in either of two ways: a slow to moderate rotor decay rate to 100% Nr or an excessive decay rate of 5% per-second or greater occurring at 104% Nr or less. In both cases rotor droop is occurring because more power is being commanded than the engines can deliver at the take off power rating, but in the latter one, the logic is applied sooner to counter the faster rate, presumably related to a more urgent situation. Blowaway is reset over a ten second interval that is initiated when Nr is restored and exceeds 106%. When the logic is tripped, the dual engine take off limit is replaced by the 2-Minute single engine N1 limit or 115% torque whichever occurs first or in combination.

Although normally both engines will blowaway, one engine may trip in some cases at the 100% Nr point if the droop rate is slow and enough power is realized from it to arrest droop and increase the rotor speed before the other engine trips. Other than in the colder ambients where 115% torque can be achieved at low N1 values, blowaway may be expected to result in 2-Minute N1 usage, and therefore, time added to the cumulative 2-Minute counters.

1.19 Useful or effective investigation techniques: NIL

2. ANALYSIS

2.1 Serviceability of the aircraft.

Sikorsky S 76C++ helicopter VT-CMM S/N 760815 has been manufactured in the year 2011 and was registered with DGCA under category A and was issued Certificate of Registration No. 4277 on 26.12.2011.

This helicopter had logged 1265:10 Hrs as on 25th May 2017.The helicopter and its Engine were being maintained under continuous maintenance as per maintenance program consisting of calendar period based maintenance and Flying Hours / Cycles based maintenance as per maintenance program approved by DGCA.

Accordingly the last major inspection viz 03 yearly inspection was carried out at 1204:20 A/F Hrs. on 12.04.2017. Subsequently all lower inspections, after last flight inspection and pre-flight checks were carried out as and when due before the accident. The last inspection carried out on helicopter was 300Hrs/06 month's inspection on 22.04.2017. Prior to the accident flight there was no defect under MEL or pending for maintenance.

The helicopter was last weighed on 11.11.2016 at Juhu, Mumbai and the weight schedule was recomputed on 11.11.2016 and duly approved by O/o DDG (WR), DGCA. There has not been any major modification affecting weight & balance since last weighing hence next weighing was due on 11.11.2021. Prior to the accident flight the all up weight of the helicopter considering the MSL and the prevailing temperature conditions was above the permissible limits.

All the concerned Airworthiness Directive, Service Bulletins, DGCA Mandatory Modification on this helicopter and its engine have been complied with as & when due.

The helicopter Engines had logged with 1265:10 Engine Hrs prior to the accident flight. The last major inspection (600 hrs Inspection on engines) was carried out on 09.02.2017 at 1165:00 Engine Hours. The Last inspection 30 Hrs. on Engine carried out on 22/05/2017 at 1261:35 Engine Hours.

The Engine Power Check records for the previous 5 months of operation were analysed and are shown in graphic format below.

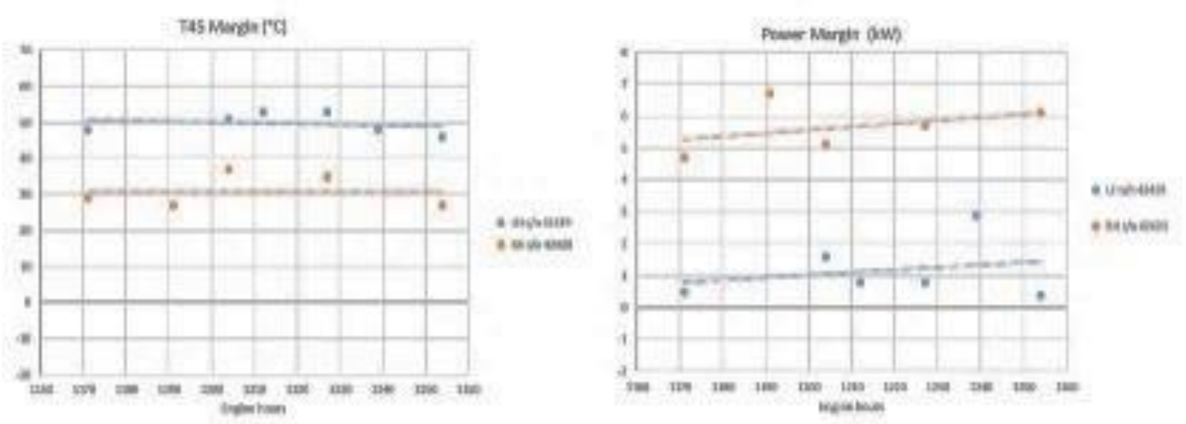

Fig:53 – Engine Power margin trend

One graph shows the T45 margin (shown in °C) and the other one shows the Power margin (shown in kW). Over the period, the trend for the T45 is observed to be stable and the trend for the Power margin is seen rising slightly. Both margins remain positive over the period.

The last Engine Power Check was performed 11 hours before the accident flight. Positive EPC margins indicate that, if needed, both engines were capable to deliver the power required at the 30sec OEI(one engine in-operative) ratings.

From the above it is inferred that serviceability of the helicopter was not the factor to the accident, however, loading of helicopter in excess of permissible weight and incorrect computing the AUW while preparing the load and trim sheet for the flight are a factor to the accident.

2.2 Weather:

Since the operation was from the temporary landing ground, meteorological facilities were not available. Flags were installed to provide wind direction to pilots. The nearest airport where the meteorological facility is available is at Latur which was 40 NM from Nilanga. The temperature at the time of accident was around 40° C which corroborates with the DFDR readout.

As per the media recordings available visibility was above 05 km, with variable winds in the northerly directions. From the above it is inferred that the weather is not a factor to the accident.

2.3 Designated Temporary Landing Area:

The helicopter operated from a temporary landing ground at Nilanga prepared by the district authorities at a school ground. The helipad was prepared in an open ground measuring 118.6 M X 110 M where, an area measuring 75 M X 75M was barricaded for the helipad. The elevation of the helipad is approximately 2000 feet and the geographical co-ordinates are 18º07'34"N and 76º44'57"E. The temporary landing ground was a congested hostile area. The requirements for Touchdown and Lift-off Area (TLOF), Final Approach and Take-off area(FATO) and Safety Area as per CARs was available at temporary landing ground prepared at Nilanga. However the adequate length of take-off climb surface of 8% slope was not available as the landing ground was congested hostile area.

The temporary landing ground and the area within the barricaded was not adequately sprinkled with water considering the high temperatures at the time of hover and lift off. It was evident from the media video coverage that, as the helicopter hover out of ground effect to proceed for take-off, it got engulfed in dust which reduced visibility of the PIC.

The PIC had earlier operated flight from the same landing area in December 2016, and the temperatures were much lower and could manage the take-off with low power requirements.

From the above it can be inferred that the landing area was not suitable to carry out safe operations in Category A as well as Category B due to inadequate take-off climb slope caused by close proximity of obstructions around the temporary landing ground and is a contributory factor to the accident.

2.4 Handling of the Helicopter:

The category A take-off procedure as per the S-76C flight manual features variable critical decision point and take-off safety speed so as to permit trading of payload against available field length in such a manner that category A One Engine Inoperative(OEI) climb performance minima can be maintained over a wide range of environmental conditions. Higher AUW corresponds to a higher CDP and Higher CDP equates to a higher required field length.

The max permissible CDP of 45Kts allows maximum AUW for 11400 Lbs at 2000 feet AMSL and temperature of 40 degrees.

The rejected take-off distance required for maximum permissible AUW 11400Lbs is calculated to be 1275 feet approximately. This rejected take-off distance too was not available at the temporary landing ground. It is therefore evident that the helicopter was not capable of operating in performance class 1 or category A take-off from the temporary landing ground in this case with the AUW 11183Lbs in prevailing weather conditions.

Since sufficient reject take-off distance was not available for category A operations, pilots could have either used backup take-off, so as to be able to land within the available reject take-off distance or attain V_{toss} before clearing the obstacles, however, the PIC chose to hover high to proceed for take-off in prevailing conditions to clear obstacles with no reserve power.

The average torque requirement to hover in OGE configuration with AUW 11183 Lbs is 94.5% as per Airplane Flight Manual (AFM). As the helicopter gained height, the torque kept increasing. The torque limits was reached and even after application of maximum collective, rotor RPM decayed and torque reached 115%. As a result the helicopter started sinking. Thereafter the pilot retracted the landing gear to clear the obstructions, but the rotor RPM decayed further and the helicopter belly came in contact with the high tension cable and snapped it. Thereafter the main rotor blades hit the trees and the roof of the parked truck and crash landed on the ground.

From the above it is inferred that the pilot handling of the control is a factor to the accident, primarily due the following reasons.

1. AUW calculation done by the crew for the prevailing temperature and altitude was lower as compared to the actual all up weight of the helicopter at the time of take-off.
2. The pilot attempting to achieve the OGE climb performance was not in commensuration with the actual AUW of the helicopter.
3. The pilot attempting wrong technique to cross the obstruction.

2.5 CVDFDR Analysis

As per the analysis of CVR and DFDR it is found that PIC had decided to turn left after lift-off and initiate take-off. As, the helicopter lifted off into a 05 feet hover there was left pedal turn of 130 degrees. While the helicopter was in the ground effect, the main rotor speed was regulated at 107 % by the engines.PIC had asked co-pilot to call if the Nr goes below 102%. Approximately 13 seconds after lift-off, the crew attempted to climb applying collective pitch and some aft cyclic and reached a maximum radio height of 39 feet approximately.

As the helicopter gained some height Co-pilot cautioned the PIC of transmission wires and lamp post in front as well as dropping Nr. The main rotor RPM as well as the free turbine speed (N2) kept falling as the helicopter came out of ground effect. With the application of collective, the torque values started rising sharply, reaching 115%, however the rotor RPM kept dropping for next 15 seconds and helicopter began to descent. As the helicopter descended, PIC asks the Co-pilot to retract landing gear. This caused helicopter to rise a few feet momentarily before hitting the transmission line and again drop down. At approximately 43 seconds after weight off wheels, the helicopter experienced anomalous parameters consistent with ground impact.

After the collision with the ground, both engines went into over speed. There was sudden decrease in torque when the main rotor blades broke. Engine #1 was stopped by the ECU (Engine Control Unit) through the over speed protection function. In absence of recording of Engine # 1 N2 in DFDR, this was confirmed during wreckage examination. Subsequently, over speed protection function was deactivated on engine #2 as per design and Engine #2 N2 reached 145% causing the blades to shed.

From the above it is inferred that, the engines parameters variations were consistent with the helicopter taking-off out of the limits of the engine performance. During the take-off phase, the analysis of the engines parameters didn't show any discrepancy of the propulsion system. No warning linked to the engines operation was triggered.

2.6 Circumstances leading to accident:

Maharashtra Government's Sikorsky S76C++ Helicopter, VT-CMM was detailed for a flight with Hon'able Chief Minister on board for 24th & 25th May 2017.

As per the scheduled programme the Hon'able Chief Minister was to be picked up from Nilinga landing ground at around 0600 UTC.

Category A take-off procedure was not possible from temporary landing ground due non availability of required reject take-off distance.

Computed actual AUW of helicopter was 11183 Lbs against the max permissible AUW of 11400 Lbs for a CDP of 45Kts to allow maximum possible Reject take-off distance for Category A take-off.

PIC chose to hover out of ground effect and move forward in prevailing conditions to clear obstacles with no reserve power. The average torque requirement to hover in OGE configuration with AUW 11183 Lbs is 94.5% as per AFM. As the helicopter gained height, the torque kept increasing. The torque limits was reached and even after application of maximum collective, rotor RPM decayed and torque reached 115%. As a result the helicopter started sinking. Thereafter the pilot retracted the landing gear, to clear the obstructions rotor RPM further decayed and the helicopter belly came in contact with the high tension cable and snapped it. Thereafter the helicopter yawed to the right and the main rotor blades hit the trees and the roof of the parked truck and crash landed on the ground.

Both the crew switched off engines by operating the fuel shut off levers, pulling T handles and switching off the helicopter battery. The crew thereafter evacuated the helicopter and also assisted the passengers in evacuation. There was no fire due timely switching off of the engine.

3. CONCLUSIONS

3.1 Findings:

3.1.1 Helicopter had a valid Certificate of Airworthiness and was certified and maintained in accordance with the approved maintenance schedule**.**

3.1.2 Both the pilots were qualified and appropriately licensed to operate the flight.

3.1.3 Helicopter was certified in Category A as per the Certificate of Registration issued by DGCA.

3.1.4 The temporary landing ground was a congested hostile area requiring operations in performance Class 1 as per the DGCA CARs.

3.1.5 The temporary landing area did not have adequate Approach and Take-off climb surface in an inclined plane sloping upwards (8%) from the end of the safety area, as it had obstacles in a close proximity of the FATO.

3.1.6 The crew did not prepare the load and trim sheet using the actual weights of passenger and luggage. The calculated AUW weight for flight was 10891 Lbs as per the load and trim sheet.

3.1.7 The committee had also computed the AUW of the helicopter considering the weight of unaccounted cargo which was 160 Lbs and assumed luggage weight for 04 passengers and two crew members. The computed AUW of the helicopter was approximately 11183 Lbs

3.1.8 The reject take-of distance required for Category A take-off under prevailing conditions with max permissible all up weight was 1275 feet. This distance was not available at the temporary landing ground.

3.1.9 The PIC in view of the obstructions decided to hover out of ground effect and move forward to clear the obstructions prior to initiate take-off.

3.1.10 The Co-Pilot cautioned the PIC of dropping Nr as well as transmission lines and lamp post in the flight path during hover taxi.

3.1.11 The PIC had no reserve power while hovering OGE, to initiate take-off. The crew action of increasing collective to move the helicopter forward, reduced the rotor RPM and the helicopter started sinking.

3.1.12 The engines parameters variations observed from the DFDR readout were consistent with the helicopter take-off out of the limits of the engine performance.

3.1.13 The PIC realising that they may not clear the obstacles, retracted the landing gear and pitched up, which further aggravated the situation and the helicopter hit the high tension cables.

3.1.14 Thereafter the helicopter yawed severed to the right and crash landed.

3.1.15 All the occupants escaped safely and there was no injury to any of the occupant of the helicopter.

3.1.16 There was no fire.

3.2 Probable cause of the Incident:

The committee is of the opinion that accident occurred as the PIC attempted take-off at an AUW higher than the permissible limit for the prevailing conditions at the time of take-off.

The PIC using wrong technique for departure from congested hostile area is a contributory factor.

The PIC attempting to move forward in OGE configuration while using the max available power to clear the obstruction, could not sustain height due drop in Nr is contributory factor to the accident.

4. Recommendations:

4.1. DGCA to ensure that all helicopter operators use actual weight of the passengers and cargo, prevailing temperatures and elevation of the place while computing of load factor for helicopter.

4.2 Operations Manual of all helicopter operator to be revised in conformance of recommendation no 4.1.

4.3 DGCA to ensure that regulatory requirements are strictly followed by all State Govt/operators/agencies while selecting a temporary landing ground for helicopter operations.

A X Joseph
Chairman, Committee of Inquiry

Jasbir Singh Larhga
Member, Committee of Inquiry

Capt Irshad Ahmed
Member, Committee of Inquiry

Place : Delhi
Date : 05.09.2018