

**AIRCRAFT ACCIDENT INVESTIGATION BUREAU  
MINISTRY OF CIVIL AVIATION  
GOVERNMENT OF INDIA**

## **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 2017, the sole objective of the investigation of an accident/serious incident shall be the prevention of accidents and incidents and not to apportion blame or liability. The investigation conducted in accordance with provisions of the above said rules shall be separate from any judicial or administrative proceedings to 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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## **GLOSSARY**

<b>AAIB</b>	:	Aircraft Accident Investigation Bureau, India
<b>AMSL</b>	:	Above Mean Sea Level
<b>ARC</b>	:	Airworthiness Review Certificate
<b>ASR</b>	:	Airport Surveillance Radar
<b>ATPL</b>	:	Air Transport Pilot Licence
<b>ATC</b>	:	Air Traffic Control
<b>AUW</b>	:	All Up Weight
<b>C of A</b>	:	Certificate of Airworthiness
<b>C of R</b>	:	Certificate of Registration
<b>CAR</b>	:	Civil Aviation Requirements
<b>CPL</b>	:	Commercial Pilot License
<b>CVR</b>	:	Cockpit Voice Recorder
<b>DFDR</b>	:	Digital Flight data Recorder
<b>DGCA</b>	:	Directorate General of Civil Aviation
<b>ECS</b>	:	Environmental Control System
<b>ECAM</b>	:	Electronic Centralised Aircraft Monitor
<b>EGT</b>	:	Exhaust Gas Temperature
<b>EMCD</b>	:	Electronic Magnetic Chip Detector
<b>FO</b>	:	First Officer
<b>FCOM</b>	:	Flight Crew Operating Manual
<b>FCTM</b>	:	Flight Crew Training Manual
<b>FRTOL</b>	:	Flight Radio Telephone Operators License
<b>FL</b>	:	Flight Level
<b>IATA</b>	:	International Air Transport Association
<b>ICAO</b>	:	International Civil Aviation Organization
<b>IFR</b>	:	Instrument Flight Rules
<b>IGB</b>	:	Inlet Gear Box
<b>ILS</b>	:	Instrument Landing System
<b>MEL</b>	:	Minimum Equipment List
<b>MLG</b>	:	Main Landing Gear
<b>MCT</b>	:	Max Continuous Thrust
<b>NM</b>	:	Nautical Miles
<b>PA</b>	:	Passenger Address
<b>PF</b>	:	Pilot Flying
<b>PIC</b>	:	Pilot in Command
<b>PM</b>	:	Pilot Monitoring
<b>QRH</b>	:	Quick Reference Handbook
<b>RA</b>	:	Radio Altitude
<b>RESA</b>	:	Runway End Safety Area
<b>SB</b>	:	Service Bulletin
<b>SEP</b>	:	Safety and Emergency Procedures Manual
<b>VFR</b>	:	Visual Flight Rules
<b>VMC</b>	:	Visual Meteorological Conditions
<b>VOR</b>	:	VHF Omnidirectional Range
<b>UTC</b>	:	Coordinated Universal Time

**FINAL INVESTIGATION REPORT ON SERIOUS INCIDENT INVOLVING**  
**M/S AIR INDIA AIRBUS A321 AIRCRAFT VT-PPT**  
**AT RAIPUR ON 08.11.2019**

1.	<b>Aircraft Type</b>	:	Airbus A321-211
2.	<b>Nationality</b>	:	Indian
3.	<b>Registration</b>	:	VT -PPT
4.	<b>Owner</b>	:	Air India Limited.
5.	<b>Operator</b>	:	Air India Limited.
6.	<b>Pilot –in–Command</b>	:	ATPL holder on type
	<b>Extent of injuries</b>	:	Nil
7.	<b>First Officer</b>	:	CPL Holder qualified on type
	<b>Extent of injuries</b>	:	Nil
8.	<b>Place of Incident</b>	:	Raipur (VERP)
9..	<b>Date &amp; Time of Incident</b>	:	08 <sup>th</sup> November 2019 & 1157 UTC
10.	<b>Last point of Departure</b>	:	Bhubaneswar (VEBS)
11.	<b>Point of intended landing</b>	:	Mumbai (VABB)
12.	<b>Type of operation</b>	:	Scheduled
13.	<b>Crew on Board</b>	:	02 Pilot, 05 Cabin Crew
	<b>Extent of injuries</b>	:	Nil
14.	<b>Passengers on Board</b>	:	182
	<b>Extent of injuries</b>	:	Nil
15.	<b>Phase of operation</b>	:	Cruise

(All the timings in this report are in UTC unless otherwise specified)

## **1. FACTUAL INFORMATION**

### **1.1 History of the Flight**

On 08.11.2019, M/s Air India A-321 aircraft VT-PPT was scheduled to operate Flight AI-670 from Bhubaneswar to Mumbai. There were 182 passengers on board and the flight was being operated by 02 cockpit crew and 05 cabin crew.

Flight took off at 1136 UTC from Bhubaneswar Runway 32 and was cleared for climb to FL300. The aircraft later came in contact with Kolkata Radar and was cleared for FL340. While passing FL260, a loud bang was heard by the crew from LH Engine and the aircraft yawed to the left. "ENG1 REV UNLOCK" warning was observed by the crew in the cockpit at 1157 UTC. LH Engine was observed to have spooled down and vibration was observed to have reached 9.9. Significant Airframe vibration was also felt but no buffeting was felt.

Crew observed other parameters to be normal and brought the LH engine thrust Lever to Idle. RH Engine thrust lever was moved to MCT and ECAM actions for "ENG1 REV UNLOCK" warning was initiated. No Fire warning was observed in the Cockpit. However, a passenger noticed LH engine on fire and informed the Cabin Crew. Cabin Crew tried calling the Pilots on intercom but did not get any response as the crew was busy in cockpit procedures and ECAM actions.

Crew decided to divert and gave a "Mayday" call to Kolkata Radar. The aircraft descended to FL220. Since maximum recommended cruise altitude for "ENG OUT" was FL198, crew later descended to FL180. Kolkata control asked the Pilot if they want to return to Bhubaneswar. Crew accepted but later realized that Raipur was closer and hence decided to divert to Raipur.

After carrying out the ECAM Actions, LH Engine was shut as EGT was increasing continuously. The Cabin Crew again contacted the Pilots on intercom to report sighting LH Engine fire by a passenger. After confirmation of actual fire on LH engine by the Cabin Crew, one Fire Agent was discharged. Sometime later, PIC again asked the Cabin Crew to check the LH Engine for fire. Cabin Crew again confirmed presence of fire; hence, second Fire bottle was also discharged.

During the Approach to Raipur, ATC was asked to visually observe fire on left engine and the same was confirmed by the ATC. The aircraft safely landed at Raipur Runway at 1226 UTC without any need for an overweight landing. After landing, the aircraft was parked on the runway and ATC was again asked if the fire was visible before initiating evacuation to

which the ATC replied that light was being seen. Since there was no positive confirmation of fire being extinguished, evacuation was initiated as per procedure.

While evacuating, the able-bodied passengers assisted the crew in the evacuation, and all passengers were evacuated in 50 seconds by using 70 percent of the exits. Subsequently, after ensuring that all passengers have evacuated, the Crew also evacuated the aircraft.

## 1.2 Injuries to Persons

<b>INJURIES</b>	<b>Crew</b>	<b>Passengers</b>	<b>Others</b>
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/ None	02+05	182	Nil

## 1.3 Damage to Aircraft

The aircraft had not suffered any damage apart from the damage to its LH Engine. During the post Flight inspection, no damage was observed on the inlet area. Thrust Reverser lower LH Side was found displaced.



**Fig-1: Aft mount and Centerbody of Engine**

Heavy metal particles were found in the exhaust area with various turbine blades damaged and missing. Metal particles were also found on the EMCD. Only 3.6 quarts of Engine oil was found in the Engine Oil Tank.



**Fig-2: Damaged Centerbody - Close View (viewed from rear)**

Subsequently, the engine was replaced with a serviceable unit and aircraft was released for service. The damages to the Engine observed during post flight inspection are shown in the figure 1 and 2.

#### **1.4 Other Damage**

Nil



## **1.5 Personnel Information**

### **1.5.1 Pilot - In – Command (PIC)**

AGE	:	<b>37 Yrs</b>
License	:	<b>ATPL</b>
Date of Issue of License	:	<b>24.05.2010</b>
Validity of License	:	<b>23.05.2021</b>
Endorsements as PIC	:	<b>Cessna 152 A, P-68C,A319, A320, A321</b>
Date of Medical	:	<b>12.09.2019</b>
Validity Of Medical		<b>11.09.2020</b>
Date of issue of FRTOL	:	<b>02.12..2015</b>
Date of validity of FRTOL		<b>01.12.2020</b>
Total flying experience	:	<b>9215Hrs</b>
Total Experience as PIC on type	:	<b>4300Hrs</b>
Last flown on type	:	<b>07.11.2019</b>
Total flying experience during last 01 Year	:	<b>775 Hrs</b>
Total flying experience during last 06 Months	:	<b>418Hrs</b>
Total flying experience during last 01 Month	:	<b>78Hrs</b>
Total flying experience during last 07 Days	:	<b>18Hrs</b>
Total flying experience during last 24 Hours	:	<b>04Hrs</b>

### **1.5.2 Co-Pilot**

AGE	:	<b>60 Yrs</b>
License	:	<b>CPL</b>
Date of Issue of License	:	<b>10.03.2010</b>
Validity of License	:	<b>09.03.2025</b>

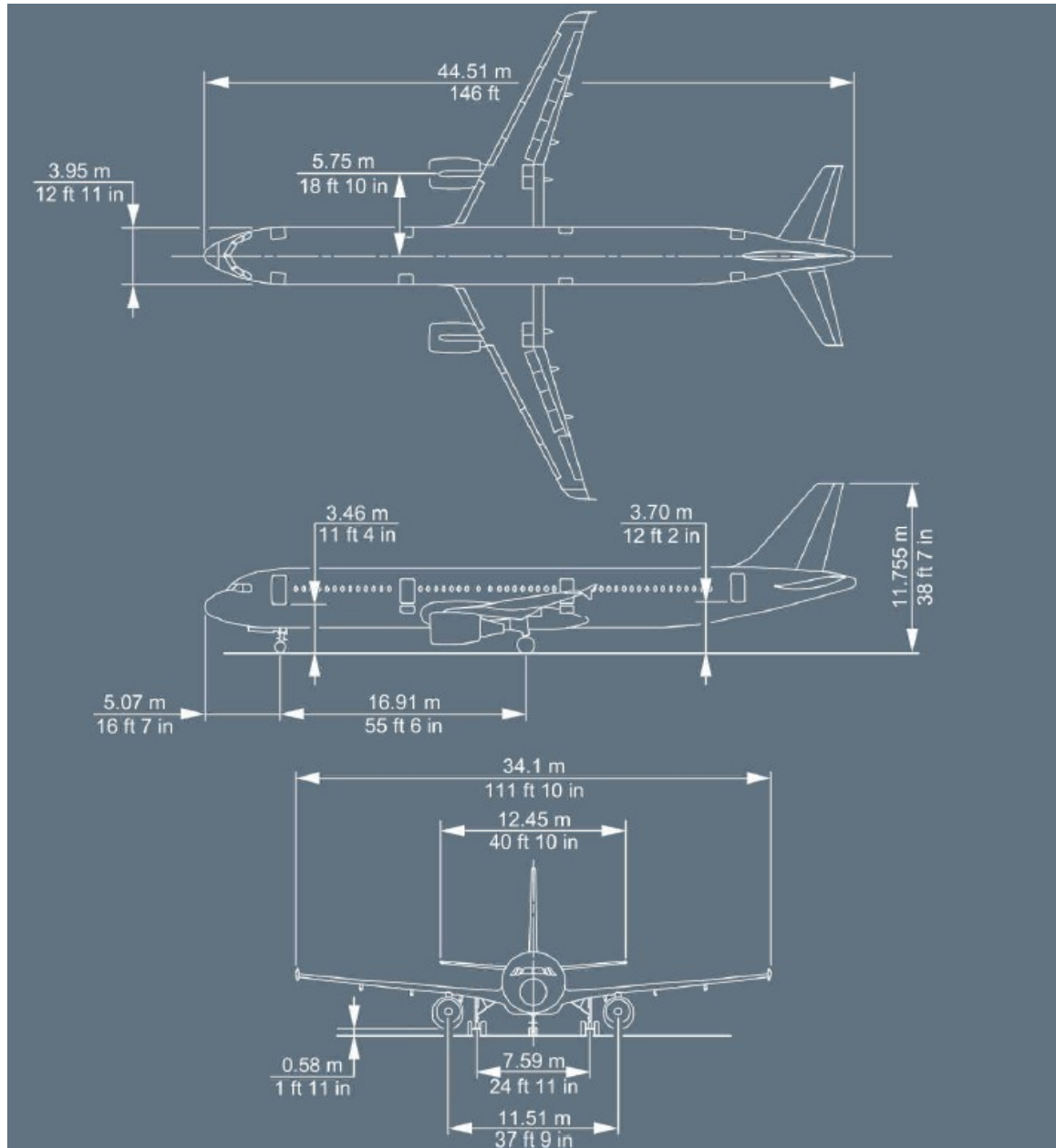
Category	:	<b>Aeroplane</b>
Date of Medical	:	<b>18.10.2019</b>
Validity Of Medical	:	<b>17.04.2020</b>
Date of issue of FRTOL	:	<b>17.12.2018</b>
Date of validity of FRTOL	:	<b>16.12.2023</b>
Total flying experience	:	<b>6850 Hrs</b>
Total flying experience during last 01 Year	:	<b>755 Hrs</b>
Total flying experience during last 06 Months	:	<b>437 Hrs</b>
Total flying experience during last 01 Month	:	<b>90 Hrs</b>
Total flying experience during last 07 Days	:	<b>26 Hrs</b>
Total flying experience during last 24 Hours	:	<b>05:23 Hrs</b>

The crew was current on their trainings. They had adequate rest before the incident flight and were not involved in any accident/incident in the past.

## **1.6 Aircraft Information**

The A321-211 is a subsonic, medium-range, civil transport aircraft. The aircraft has two high bypass turbofan CF56-5B engines. The aircraft is designed for operation with two pilots and has been configured by M/s Air India for passenger seating capacity of 182.

The aircraft is certified in Normal (Passenger) category, for day and night operation under VFR & IFR. The maximum operating altitude of the aircraft is 39,100 feet and maximum takeoff weight is 89000 Kgs. The Maximum Landing weight is 75500 kg. The Aircraft length is 44.507 meters, wingspan is 34.1 meters and height of this aircraft is 11.755 meters. The distance between main wheel centre is 7.59 meters. The distance between engines is 11.51 meters and Engine Ground Clearance is 0.58 meters.

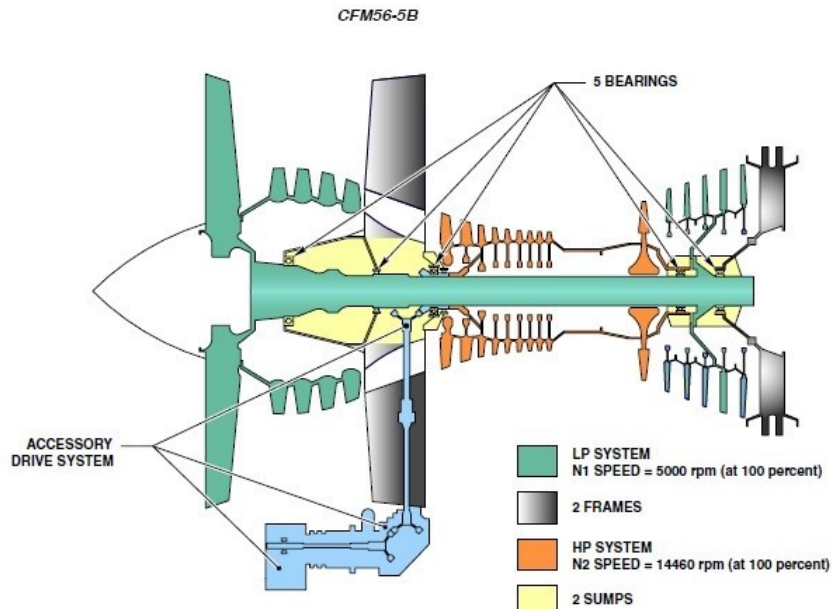


**Fig-3: Three-Dimensional View Principal Dimensions of Airbus 321-211(VT-PPT)**  
**(Reference: DSC-20-20 P6/14 Of FCOM Dt 14 Jan19)**

The aircraft was equipped with CFM56-5B Engine. The CFM56-5B engine is a high bypass, dual rotor, axial flow, advanced technology turbofan. It is supported by the wing pylon and streamlined by cowlings. The description of the Engine and its various modules relevant to the investigation are given below.

The CFM56-5B engine consists of two independent rotating systems:

- The low pressure system rotational speed is designated N1.
- The high pressure system rotational speed is designated N2.



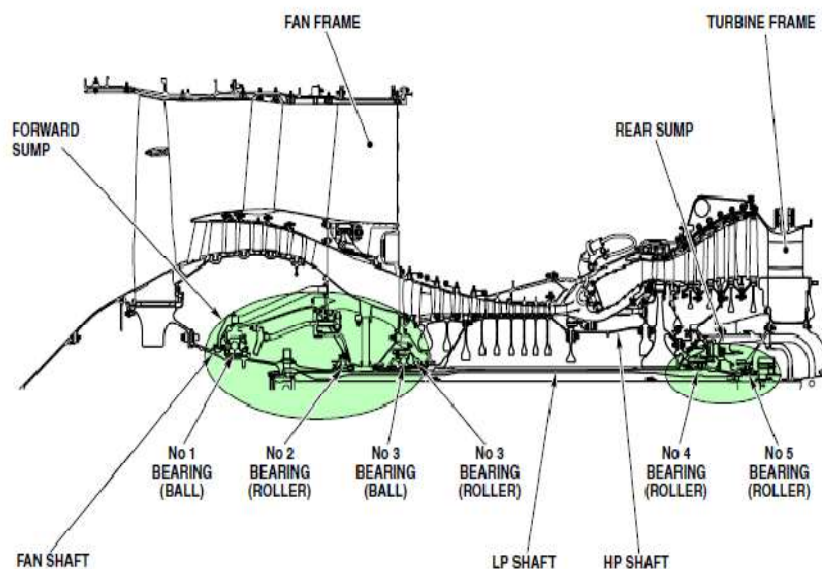
**Fig-4: Engine Rotating System**

The engine rotors are supported by 5 bearings, identified as numbers 1 thru 5, where No 1 is the most forward and No 5 the most aft. These bearings are housed in 2 dry sump cavities provided by the fan and turbine frames. The **forward sump cavity** houses No 1, No 2 and No 3 bearings:

- No 1 and No 2 bearings hold the fan shaft.
- No 3 bearing holds the front of the HP shaft.

The **rear sump cavity** houses No 4 and No 5 bearings:

- No 4 bearing holds the rear of the HP shaft.
- No 5 bearing holds the rear of the LPT shaft.



**Fig-5: Location of Bearings and Sump**

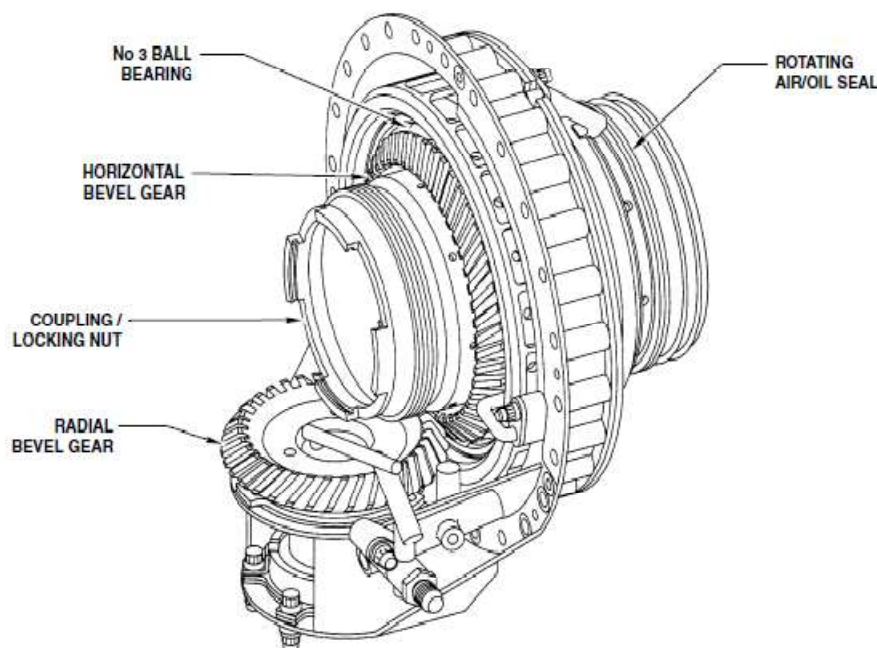
Engine structural rigidity is obtained with short lengths between two main structures (frames). The accessory drive system uses energy from the high pressure compressor rotor to drive the engine and aircraft accessories. It also plays a major role in starting.

### ***The Inlet Gearbox (IGB)***

The IGB transfers torque between the HPC front shaft and the accessories. It also supports the front end of the core engine. It is located in the **fan frame sump** and is bolted to the **forward side of the fan frame aft flange**. It is only accessible after different engine module removals.

The IGB contains the following parts:

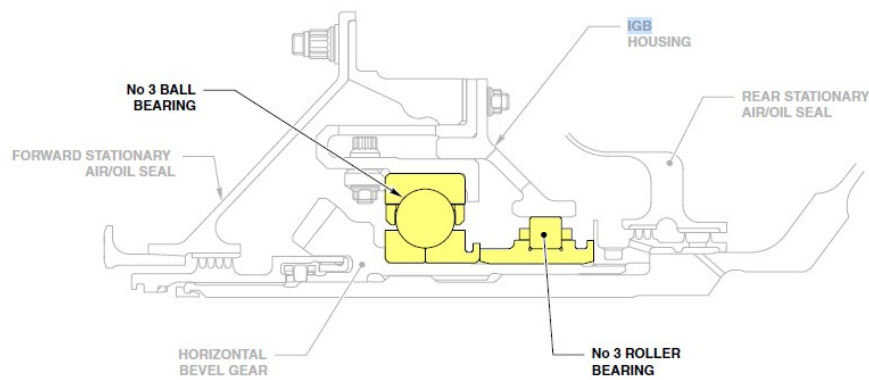
- Horizontal bevel gear (with coupling/locking nut).
- Radial bevel gear.
- No 3 bearing (ball and roller).
- Rotating air/oil seal.



***Fig-6: The Inlet Gear Box***

### ***The No. 3 Bearing***

The No. 3 bearing assembly consists of a ball bearing (No.3B) and a roller bearing (No.3R). The assembly is installed between the IGB housing and horizontal bevel gear. The No. 3 bearing acts as a core engine thrust bearing and provided axial positioning of the forward end of the HPC rotor. The roller bearing is located directly after the ball bearing and radially positions the core engine rotor. The bearing and gear are lubricated and cooled by oil, supplied through the forward sump oil manifold assembly.

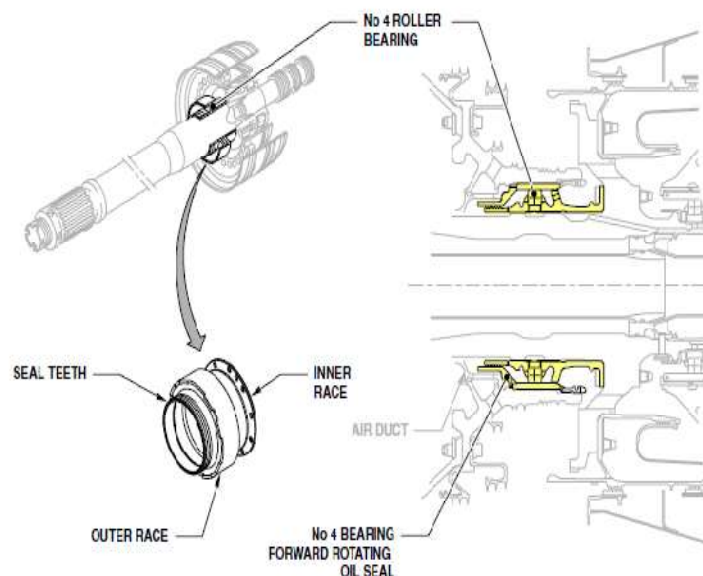


***Fig-7: The No. 3 Bearing***

### **The No. 4 Bearing**

The No 4 bearing takes up the radial loads generated by the High Pressure Turbine rotor. It is a roller bearing, installed between the HPT rear shaft and the LPT shaft, at the front of the LPT shaft hub. The bearing outer race is housed in the HPT rear shaft bore. Its inner race is bolted to the front face of the LPT shaft integral hub.

The No 4 bearing inner race has a shoulder, which acts as an emergency bearing in case of roller failure. The forward end of the inner race has seal teeth that rub against an abradable coating located on the No 4 bearing forward rotating oil seal, thus acting as one of the sump air/oil seals.



***Fig -8: No. 4 Bearing***

Aircraft VT-PPT (MSN 04078) had been manufactured in year 2009. The aircraft was registered with DGCA under the ownership of M/s Air India Limited. The aircraft was issued Certificate of Registration No. 4036/4 on 05.08.2014.

The Certificate of Airworthiness Number 6145 under "Normal category" subdivision "Passenger / Mail / Goods" was issued by DGCA on 30.10.2009. The validity of the CoA is subject to the validity of Annual Review Certificate and the same was issued on 07.03.2019 and was valid till 06.03.2020. The specified minimum operating crew is two and the maximum all up weight is 79,015 Kgs.

The Aircraft was holding a valid Aero Mobile License at the time of incident which was valid till 31.12.2022. As on date of incident, the aircraft had logged 32150:03 Airframe Hours and 18610 cycles.

The aircraft and its Engines are being maintained as per the maintenance program consisting of calendar period/ flying Hours or Cycles based maintenance as per maintenance program approved by Regional Airworthiness Office, Mumbai.

Accordingly, the last major inspection was carried out at 31792 Hrs and 18416 cycles on 09.10.2019. Subsequently, all lower inspections (Pre-flight checks, Service Checks, Weekly Checks) were carried out as and when due before the incident.

The aircraft was last weighed on 19.01.2015 at Mumbai and the weight schedule was prepared and duly approved by DGCA. As per the approved weight schedule the Empty weight of the aircraft is 43014 Kg Maximum Usable Fuel Quantity is 18605 Kg. Maximum payload with fuel tanks full is 20642 Kg. Empty weight CG is 15.28% of MAC. As there has not been any major modification affecting weight & balance since last weighing, hence the next weighing is due on 19.01.2020. The weight and balance of the aircraft was well within the operating limits.

The aircraft was equipped with CFM56-5B3 engines. The details of the Engines are given below:-

<b><u>Details</u></b>	<b><u>RH Engine</u></b>	<b><u>LH Engine</u></b>
Serial Number	: 569979	: 699526
Date of Manufacture	: 29.07.2015	: 06.08.2009
Last Major Inspection	: 09.10.2019	: 09.10.2019
Total Engine Hours/Cycles	: 15231:11 / 8668	: 33099:26 / 19796

The LH Engine had completed 17768 Hrs /10067 Cycles since the last shop visit. All concerned Airworthiness Directives, mandatory Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine has been complied with as on date of event.

### 1.7 Meteorological Information

The weather reported at Raipur at 1200 UTC was as follows:-

#### **Raipur MET report : 1200 UTC**

**Wind** : 360°/03 Kts  
**Visibility** : 3000 m  
**Clouds** : FEW 2000 Feet : SCT 10000 Feet  
**Temperature** : 25°  
**Dew pt** : 17°  
**QNH** : 1011  
**Trend** : No Sig

### 1.8 Aids to Navigation

Navigation Aids available at Raipur Airport are as per the table below: -

Type of Aids	Identification	Frequency / Channels	Geographical Coordinates of the position of the transmitting antenna
DVOR	RRP	116.100	211051.330 N 0814438.083 E
DME	RRP	CH108X	211051.839 N 0814437.968 E
LOC 24	IRAI	110.300	211028.175 N 0814341.556 E
GP 24	IRAI	335.000	211103.000 N 0814451.7 E
DME ILS 24	IRAI	CH 40X	211103.000 N 0814451.7 E

### 1.9 Communications

Aircraft maintained a positive contact with the ATC during the flight. The crew declared "MAYDAY" to ATC Kolkata at approximately 11:58:32 UTC. Later after deciding to divert to Raipur, Crew contacted ATC Raipur at 12:08:44 UTC. The following is the relevant transcript/observation from ATC recordings.



Time (UTC)	Communication
12:08:44	Crew contacts ATC Raipur on 124.75 Mhz.
12:14:01	<b>AIC 670:</b> SIR WE ARE RELEASED BY KOLKATA AIR INDIA SIX SEVEN ZERO <b>TOWER:</b> AIR INDIA SIX SEVEN ZERO TOWER ROGER SIR REPORT DISTANCE ROMEO ROMEO PAPA LEVEL DESCENDING TO <b>AIC 670:</b> THREE SEVEN ZERO WE ARE NOW TRACKING TO ROMEO ROMEO PAPA AND WE ARE MAINTAINING LEVEL ONE HUNDRED
12:16:50	<b>AIC 670:</b> ...THE FIRE IS STILL NOT EXTINGUISHED PLEASE INFORM ALL CONCERNED FOR ALL THE ASSISTANCE REQUIRED ON ARRIVAL. WE MIGHT HAVE TO EVACUATE ON RUNWAY IF THE FIRE IS STILL ON AND IT IS THE PORT ENGINE SIR. <b>TOWER:</b> ROGER SIR COPIED ALL...
12:24:19	<b>AIC 670:</b> RAIPUR AIR INDIA SIX SEVEN ZERO IS ON THE ILS RUNWAY TWO FOUR
12:27:30	<b>TOWER:</b> AND WE CAN SEE...FROM HERE ON LEFT...LEFT ENGINE WE CAN SEE SOME FIRE
12:30:08	<b>AIC 670:</b> ADVISE IF YOU CAN ABLE TO TAXI <b>TOWER:</b> SIR WE HAVE PUT THE ENGINES OFF NOW WE HAVE ALREADY INITIATED EVACUATION
12:30:25	<b>AIC 670:</b> AFTER WE LANDED YOU SAW FIRE SIR CONFIRM <b>TOWER:</b> IT WAS KIND OF LIGHT SINCE IT IS ON THE OTHER SIDE FROM THE TOWER WE ASSUMED IT IS FIRE BUT AS PER THE CFT REPORT NOW THEY SAY THERE IS NO FIRE

### 1.10 Aerodrome Information

Raipur Airport is known as Swami Vivekananda Airport and is operated by M/s Airport Authority of India. ATS services are also provided by the M/s Airport Authority of India Ltd. ICAO nomenclature for the airport is VERP and IATA code is RPR. The geographical co-ordinates of the airport are 21°10.52' N / 81°44.19' E.

The elevation of the airport is 1041 feet (AMSL). The runway is 2286 m in length and 45 m in breadth. The orientation of the runway is 06/24.

R/W & Taxi Tracks markings are standard as per Annex- 14. Rescue and Fire Fighting Services of category 6 are available during the watch hours.

## 1.11 Flight Recorders

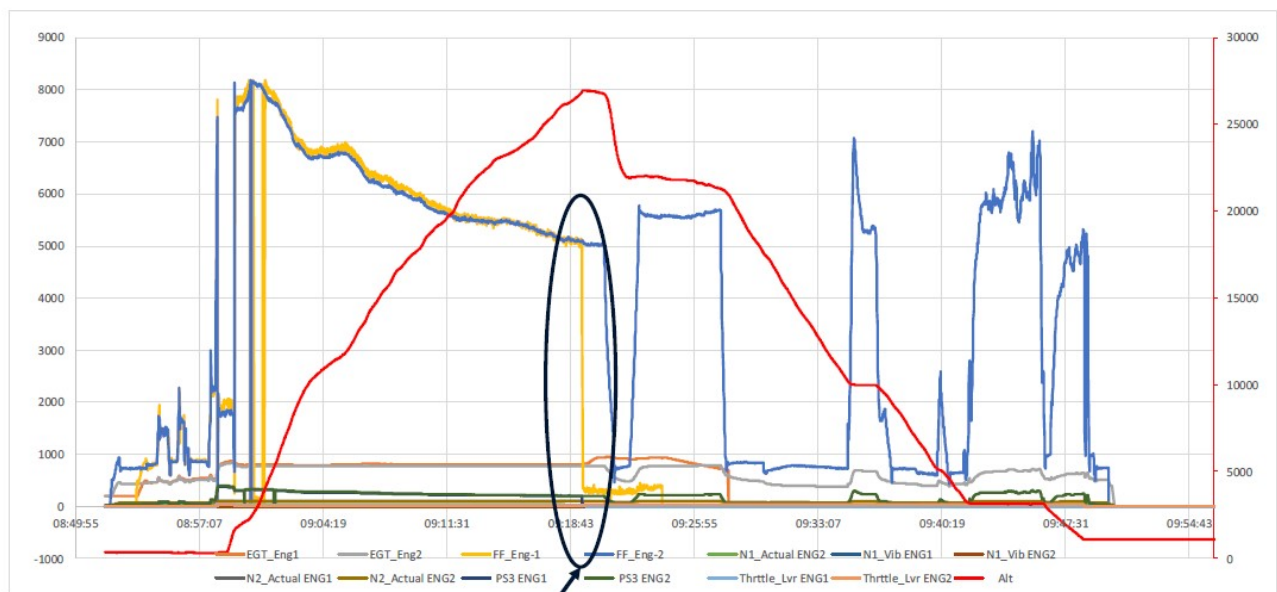
Aircraft was equipped with a CVR and DFDR. The details of the Flight Recorders are as below.

CVR	L3 Technologies	DFDR	L3 Technologies
Part No.	2100-1020-00	Part no.	2100-4043-02
Sr. No.	000193482	Sr. No.	000511450

The download of CVR and DFDR was carried out at DGCA Lab on 22.11.2019. Total 02:04:04 Hrs of recording was available in the CVR. The CVR was analysed and following are the salient observations from the CVR.

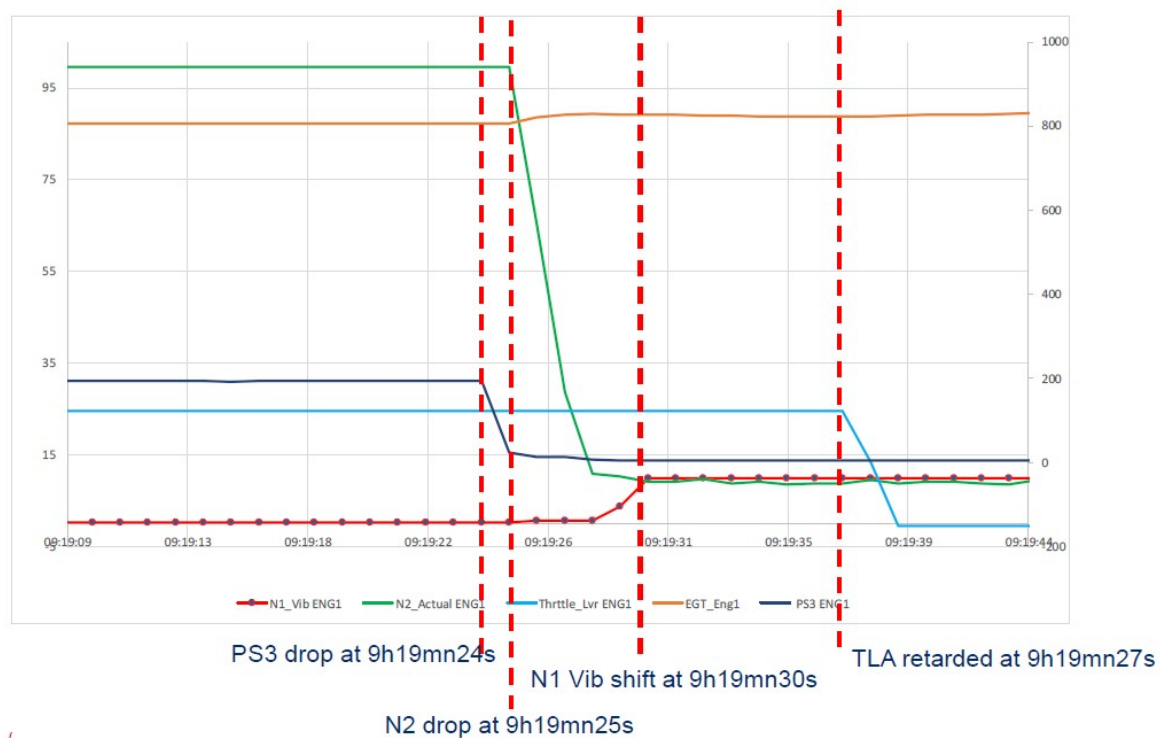
- At 01:27:59 CVR elapsed time, a sudden change in Engine Noise is observed and is followed by the ECAM warnings.
- At 01:28:57 Hrs CVR elapsed time, Crew declared "Mayday" to ATC Kolkata.
- At 01:32:00 CVR Elapsed time Cabin Crew informs Pilots about Fire observed on the LH Engine.
- At 01:39:09 CVR elapsed time the crew came in contact with Raipur ATC. This time corresponds to 12:08:44 UTC.

The DFDR data for the last 10 hours of flight was downloaded. At elapsed time 09:19 Hrs, the LH Engine parameters showed some disturbances. The graphs created using DFDR data with assistance of Technical Adviser appointed by NTSB are shown in Fig-9 and 10: -



Event at +/- 9h19

**Fig-9: DFDR Plot**



**Fig-10: DFDR Plot**

### 1.12 Wreckage and Impact Information

The damages were confined to core LH engine only.

### 1.13 Medical and Pathological Information

Pre and post flight BA test were carried out and all crew were tested negative.

### 1.14 Fire

No Fire warning was observed in the cockpit by the Crew. However, a few passengers noticed flames from the LH Engine and alerted the cabin crew. After, the Cabin Crew confirmed presence of Fire on LH Engine, one fire-bottle was discharged by the pilot.

Later after some time, Pilot again asked cabin crew to conform if the fire has subsided. The cabin crew was able to notice fire and hence 2<sup>nd</sup> bottle was also discharged. While on approach Pilot requested ATC to visually observe any signs of fire on the LH Engine and the ATC confirmed presence of fire.

After landing, Pilots initiated evacuation and again enquired from ATC if any fire was visible. ATC informed them that only some light was visible and not actual fire. The CFT arrived after the aircraft landed and halted on the runway, but CFT personnel also did not report any fire.

### **1.15 Survival Aspects**

The incident was survivable.

### **1.16 Tests and Research**

The damaged engine was stripped at a DGCA approved maintenance facility. LPT Module, Core Module and Fan Major Module were disassembled for Investigation. The observations during the disassembly are as follows:-

#### **Observations during LPT Module Disassembly are as follows: -**

- (a) LPT Module as per ESM usual procedures could not be removed as LPT Shaft was not rotating. LPT Module was removed successfully using the alternate procedure recommended by the OEM.
- (b) LPT Module exhibited heavy damage in form of missing blades and NGVs across stages. Heavy damage to Honeycomb of "No.4 Bearing" air/oil seals was observed. LPT shaft had rubbing grooves at multiple locations.
- (c) All HPT blades were liberated from the root. Air/ oil seals on HPT rear shaft showed damage/ rubbing marks.
- (d) VBV position sensor found dangling with feedback rod, two mounting flanges observed fractured and one bolt from third mounting location observed missing.
- (e) VBV doors at location 7, 8, 9 & 10 observed closed, and rest VBV actuators observed open. VBV flex shafts at few locations observed out of drive port of actuators, few flex shafts show missing springs.
- (f) Excessive play was observed in RHS VSV crank assembly.
- (g) Forward stationary seal pieces were visible post LPT shaft removal.
- (h) Heavy rub marks observed on #4 bearing inner race, stationary oil seal and rotor air duct.
- (j) One fuel supply line to fuel nozzle no.11 found fractured.

#### **Observations during removal of CORE Module are as follows: -**

- (a) All HPC stage one blade exhibited heavy rubbing marks at the tip.
- (b) Heavy damage to forward and rear stationary seal was observed.

- (c) Horizontal bevel gear of IGB along with ruptured No. 3 bearing housing found separated from IG but engaged with HPC front shaft.
- (d) Heavy damage to vertical IGB bevel gear and internal parts of IGB was visible.

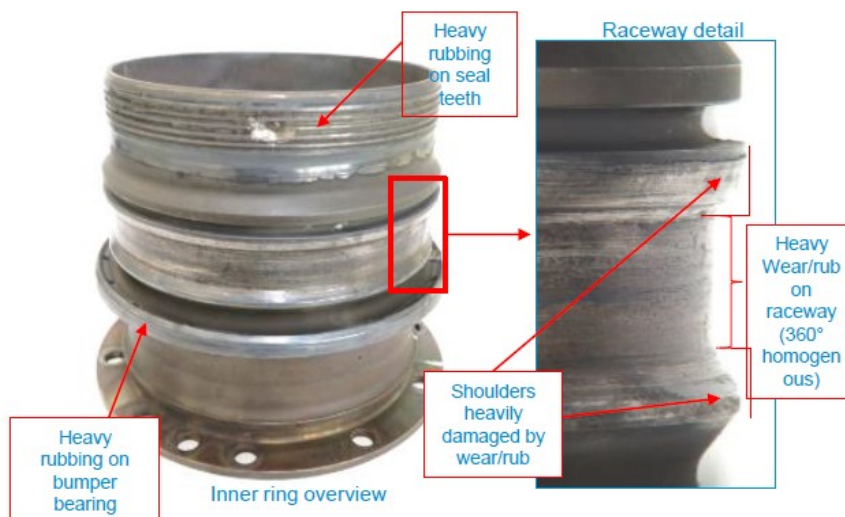
**Observations during modular disassembly of fan major module are as follows: -**

- (a) Rear face No.1 and No.2 bearing support assembly had metal chips and metallic debris.
- (b) Forward stationary seal observed broken into multiple pieces.
- (c) Heavy damage observed on IGB.
- (d) RDS housing outer and inner removed as single unit has metal debris on outer surface. However no apparent damage observed to fan and booster module, TGB and AGB module.

Further to disassembly carried out at DGCA approved facility, detailed examination of **"No. 4 Bearing"**, **"HPT Module"** and **"Inlet Gear Box and No. 3 Bearing Module"** was carried out at Lab facility of OEM, with assistance from the Technical Adviser appointed by the NTSB, USA. The findings of Lab Examinations are elaborated below.

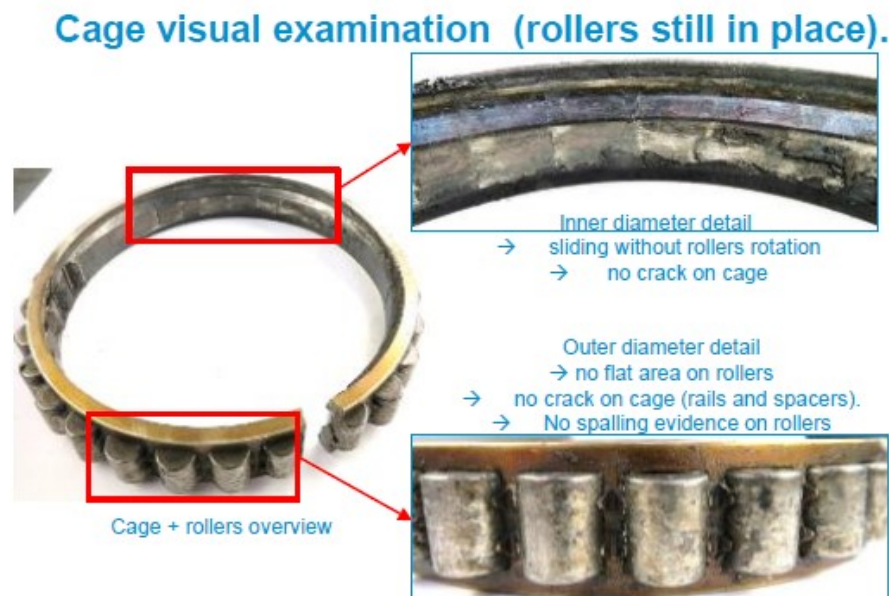
**The findings of Lab Examination of No.4 Bearing are as below: -**

- (a) Sectorial wear (160°) of the outer ring raceway machined-grooved by rollers rubbing. No spalling evidence detected on this race.
- (b) Inner ring raceway and shoulder wear due to rubbing.



**Fig-11: Disassembly – Bearing no. 4**

- (c) Cage with no crack. All rollers still in place on pockets.
- (d) No spalling evidence on rollers.
- (e) Sectorial rubbing of the cage driving diameter and presence of a flat area on the rollers associated on this area.

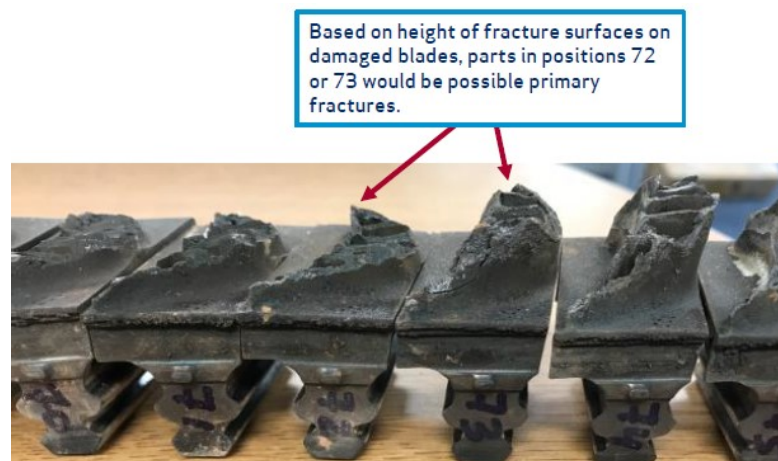


**Fig-12: Disassembly – Bearing no. 4**

Owing to the above observations, the No. 4 bearing condition could be attributed to a sudden radial overload (probably brutal HPT unbalance) and was not established as the root cause of the engine event.

**The findings of Lab Examination of HPT Blades Lab are as below: -**

Based on height of fracture surfaces on damaged blades, parts in positions 72 or 73 would be primary fractures. However, these blades show purely tensile fracture features, alongside indications of elevated temperature exposure, and therefore appear to be secondary mechanisms.



**Fig-13: HPT Blades position 72 and 73**



The HPT blade events generally do not cause IGB failure, but it is other way that leads to rotor shift and hence HPT blade failure could be ruled out as cause of failure of the engine.

**The findings of Lab Examination of Inlet Gear Box and No.3 Bearing are as below: -**

(a) All IGB studs were found broken, majority of the stud fracture surface morphology consistent with tensile overload –based on comparative analysis to historical cases.



***Fig-14: IGB Broken Studs***

(b) Liberated remnants of IGB studs and nuts showed IGB nuts still in place, but at different height and loose.



***Fig-15: Damaged IGB studs***

- (c) Wear and secondary impact marks observed on #3R Bearing Outer Ring and Rollers but no spalling.



***Fig-16: Damaged Bearings***

- (d) No. 3B Bearing showed evidence of secondary damage.
- (e) No. 3B Spring finger Housing beams were broken.



***Fig-17: Damaged No 3B Bearing Finger Housing***

- (f) Non-uniform contact pattern on the Teeth of Horizontal bevel gear.



As per the report received from the Technical Adviser appointed by NTSB, based on Visual Inspection and Lab Examinations, IGB and No. 3 Bearings Module failure could be established as the most probable cause of Engine Failure.

### **1.17 Organisational and Management Information**

M/s Air India is a scheduled airline which operates Airbus and Boeing fleet on domestic and international sectors. The Airlines Head Quarter is located at New Delhi. The Company is headed by a Chairman & Managing Director who is assisted by a team of professionals from various departments. The Flight Safety Department is headed by Chief of Flight Safety approved by DGCA. The Chief of Safety is an Executive Director who reports directly to the Chairman.

### **1.18 Additional Information**

Nil

### **1.19 Useful or Effective Investigation Techniques**

Nil

## **2. ANALYSIS**

### **2.1 Serviceability of the Aircraft**

The aircraft had a valid Certificate of Airworthiness on the date of incident. The last major inspection on the aircraft was carried out in Oct 2019. Aircraft did not have any pending snag and was neither operating under any MEL.

The aircraft had clocked 32150:03 Hrs on the day of occurrence. Aircraft was maintained as per the approved program and was airworthy on the date of occurrence. The LH engine had clocked 33099:26 Hrs and the RH Engine had clocked 15231:11 Hrs on the day of incident. Both engines were serviceable and did not have any pending snags.

From the above, ***it is inferred that the serviceability of the aircraft is not a contributory factor to the incident.***

## **2.2 Operations – Pilot Factor**

The flight was operated by Crew having valid Licenses and Qualifications to operate the flight. After observing Engine Failure warning in the cockpit at 1157 UTC, the crew declared "Mayday" to Kolkata ATC, with whom the crew was in contact at the time of occurrence.

After evaluating the distance from Bhubaneswar and Raipur, crew decided to divert to Raipur. All necessary checklists were carried out by the crew and aircraft safely landed at Raipur at 1226 UTC.

The crew had carried out two Squib discharge but it could not be confirmed if the fire had been extinguished. Even after discharge of second Squib, the cabin crew observed fire on the engine. The ATCO who was requested by the pilot to observe for fire also confirmed presence of Light. Hence, crew decided for evacuation after bringing the aircraft to halt. However, it was informed later by CFT crew that there was no fire after the aircraft had halted.

From the above, ***it is inferred that the Crew handling of the aircraft is not a contributory factor to the incident.***

## **3. CONCLUSION**

### **3.1 Findings**

- (a) The Certificate of Airworthiness, Certificate of Registration and Certificate of Flight Release of the Aircraft was valid on the day of Incident.
- (b) All concerned airworthiness directives, mandatory service bulletins, mandatory modifications on the aircraft and its engines on date of incident had been complied with. There was no pending snag reported prior to the incidented flight.
- (c) Both operating crew were duly qualified on type A321 aircraft to operate the flight and had adequate rest prior to undertaking the flight on 08 Nov 2019 as per Flight Duty Time Limitations (FDTL).
- (d) On the day of incident, LH Engine had completed 19796 CSN against life limitation of 20000 CSN (LH Engine had completed 98.98% of life limitation as per manufacturer).
- (e) As per DFDR downloads, LH Engine misbehaved abruptly in the air at 1157 UTC.
- (f) No fire warning or indication in the cockpit was recorded by cockpit crew. However, Fire was observed on LH Engine by passengers and cabin crew.

- (g) Crew declared MAYDAY and an emergency landing was executed at Raipur with only RH Engine operative.
- (h) Safe emergency evacuation of all onboard was carried out as per SOP.
- (i) The aircraft landed safely at Raipur and no injury to personnel or property was reported.
- (j) During post landing inspection of LH Engine, heavy metal particles were found in exhaust area and turbine blades were found heavily damaged and missing.

### **3.2 Probable Cause of the Incident**

The probable cause of incident was due to failure of IGB and No. 3 bearing module of LH Engine thereby causing multiple secondary failures / damages to engine which led to "in-flight engine shutdown".

## **4. SAFETY RECOMMENDATIONS**

The extent of Engine internal Damages and distress level of hardware, made it difficult to narrow down to primary cause of failure. As per OEM of CFM56 Engines, these types of failure in the CFM56 fleet are very rare and failure rate is almost negligible based on per billion of flying hours. Hence, **NIL** recommendation is made.



(Jasbir Singh Larhga)  
Deputy Director, AAIB  
Investigator



(Anil Tewari)  
Director, AAIB  
Investigator – In - Charge

Date: 07 Aug 2020  
Place: New Delhi