FINAL INVESTIGATION REPORT OF SERIOUS INCIDENT TO M/S AIR INDIA A321 AIRCRAFT VT-PPD ON 15.02.2015 AT MUMBAI.

(A X Joseph)
Deputy Director-AAIB
Chairman Committee of Inquiry

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Member Committee of Inquiry

Foreword

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts and laboratory examination of various components. The investigation has been carried out in accordance with Annex 13 to the convention on International Civil Aviation and under the Rule 11 of Aircraft (Investigation of Accidents and Incidents), Rules 2012 of India. The investigation is conducted not to apportion blame or to assess individual or collective responsibility. The sole objective is to draw lessons from this incident which may help to prevent such future accidents or incidents.

INDEX

FINAL INVESTIGATION REPORT ON SERIOUS INCIDENT TO AIR INDIA, AIRBUS A321 AIRCRAFT VT-PPD AT MUMBAI ON 15/02/2015

1.	Aircraft Type	: Airbus A321-211
	Nationality	: Indian
	Registration	: VT - PPD
2.	Owner	: Bayern Aircraft Ltd., Cayman Islands.
3.	Operator	: Air India Ltd., India
4.	Pilot – in –Command	: ATPL holder
	Extent of injuries	: Nil
5.	First Officer	: CPL Holder
	Extent of injuries	: Nil
6.	Place of Incident	: Runway 27, Mumbai Airport (Bombay)
7.	Date & Time of Incident	: 15th Feb 2015 & 09:10 UTC
8.	Last point of Departure	: Mangalore
9.	Point of intended landing	: Mumbai
10.	Latitude/Longitude	: 190530N / 0725158E
11.	Type of operation	: Schedule Operation
12.	Crew on Board	: 07
	Extent of injuries	: Nil
13.	Passengers on Board	: 180
	Extent of injuries	: Nil
14.	Phase of operation	: Landing
15.	Type of Occurrence	: Tail Strike

(ALL TIMINGS IN THE REPORT ARE IN UTC)

SUMMARY

On 15/02/2015, Air India Ltd., Airbus A321 aircraft registration VT-PPD was scheduled to operate sectors Delhi-Mumbai-Mangalore-Mumbai. Both the operating crew were duly qualified on type A321 aircraft to operate the flight.

The first two sector Delhi-Mumbai and Mumbai-Mangalore the Pilot in Command (PIC) performed the duties of the pilot flying (PF) and First Officer performed the duties of pilot monitoring (PM). The first two sectors terminated uneventfully. For the third sector Mangalore-Mumbai (flight AI-680) the PIC allowed the First Officer to perform the duties of the Pilot flying and the PIC was performing the duties of pilot monitoring. There were 187 persons on board the aircraft including 07 crew members.

The Air India aircraft operating flight AI-680 was cleared by ATC for ILS approach runway 27 at Mumbai airport. The weather at the time of landing was haze with visibility 4000 metres. The aircraft bounced during landing and subsequently made a hard landing during the second touchdown. Thereafter the aircraft settled down on the runway and taxied back to the bay. During post flight walk around inspection, the crew observed that the aft fuselage was damaged and the aircraft had suffered a tail strike during landing. There were no fire and no injury to any of the occupants on board the aircraft.

The incident was reported by Air India to DGCA and AAIB. Subsequently AAIB ordered an Inquiry under Aircraft (Investigation of Accidents and Incidents), Rules 2012 to investigate into the cause of the serious incident vide Ministry of Civil Aviation Order No AV.15018/151/2015-DG dated May 2015.

The Sole objective of this investigation is not to blame or apportion liability on anyone and it is for prevention of recurrence.

1. FACTUAL INFORMATION:

1.1 History of the flight:

On 15/02/2015, Air India Ltd., Airbus A321 aircraft registration VT-PPD was scheduled to operate flight sectors Delhi-Mumbai-Mangalore-Mumbai. The flight was under the command of PIC holding current Air Transport Pilot License (ATPL) along with First officer holding current Commercial Pilot License (CPL) respectively. Both the operating crew were duly qualified on type A321 aircraft to operate the flight.

The first two sector Delhi-Mumbai and Mumbai-Mangalore the PIC performed the duties of the pilot flying and First Officer performed the duties of pilot monitoring. For the third sector Mangalore-Mumbai (flight AI-680) the PIC allowed the First Officer to perform the duties of the Pilot flying as he was cleared by the company to carry out supervised take off and landings. For this sector the PIC was performing the duties of pilot monitoring. There were 187 persons including 07 crew members on board the aircraft.

The first two sectors (Delhi-Mumbai-Mangalore) terminated uneventful. The take off and the enroute flight from Mangalore to Mumbai was also uneventful. During in bound Mumbai the crew took briefing from ATS Mumbai Control for ILS approach of runway 27. Weather reported was headwind 08 to 10 Knots with visibility of 4000 meters. The weather prior to landing at Mumbai was haze and there was no significant weather change.

At 09:06 UTC, approach control Mumbai handed over the aircraft to the tower control. The aircraft was fully configured for landing flight at 1000 Ft with autopilot engaged. At 09:08 UTC the Mumbai ATS tower cleared VT-PPD for landing on runway 27. At 600 Ft AGL, the First Officer disconnected the autopilot and took over the controls manually.

At 40 Ft approximately, the PIC advised the First Officer to reduce the rate of descend and flare following which the crew received synthetic aural alert `RETARD'. As per the statement of PIC, the First Officer moved the thrust levers CLIMB to IDLE detent prior to flare. As per the statement of the first officer he observed that the aircraft was not responding after the flare out he immediately increased the pitch to reduce the rate of descent. However the aircraft touched down on the main landing gears and got airborne again.

During the bounce the PIC took over the controls from first officer and brought the thrust levers CLIMB to IDLE detent. As per the statement of the PIC he observed that the aircraft was sinking faster to the ground and he immediately applied full positive pitch simultaneously, however the aircraft made a hard landing on the runway. Both the crew stated that the directional control of the aircraft was maintained and subsequently taxied the aircraft to the bay. During taxing, the PIC apologised to the passengers for the hard landing. The crew did not inform the ATC about the event. After parking in the bay, the crew performed the post flight walk around inspection and observed that the aircraft aft fuselage section had severe damage marks. There was no fire.

PIC was cleared to give assisted take off & landing and the First Officer was cleared to take assisted take off & landing by Air India.

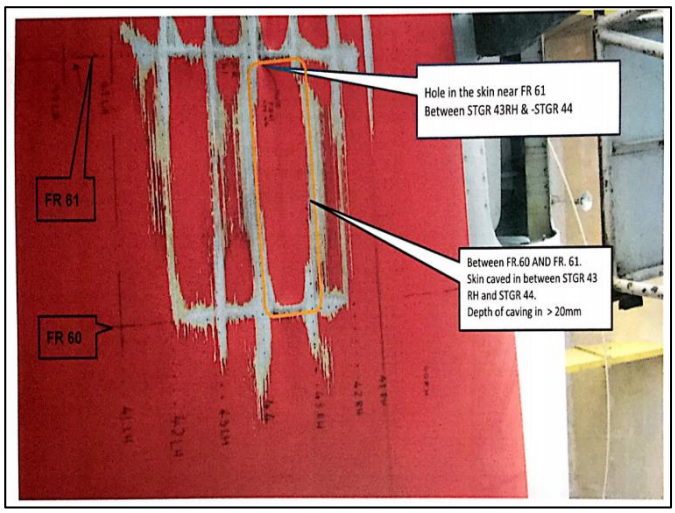
1.2 Injuries to persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	Nil	Nil	Nil
SERIOUS	Nil	Nil	Nil
MINOR/ None	02+05	180	Nil

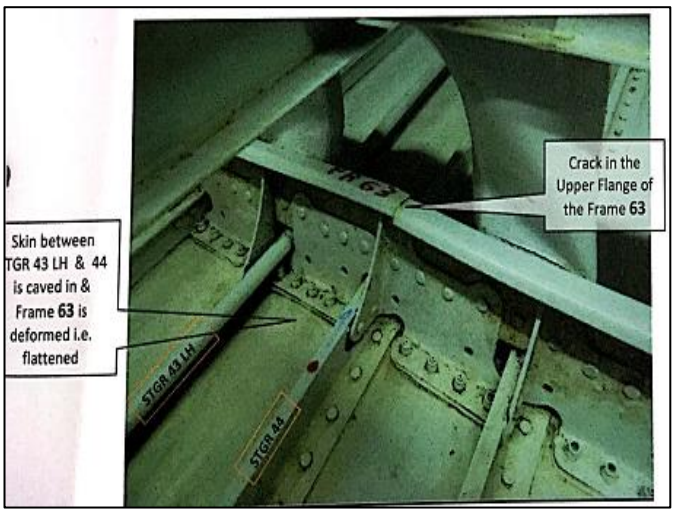
1.3 Damage to Aircraft

The damage on the aircraft was limited to the AFT belly of the aircraft. Following damages were recorded during post flight inspection.

1. AFT fuselage Station no. 17 and Station no. 18 suffered damage of skin and internal structure due to tail strike and contact with the runway.
2. Airframe Frame no. 59 to Frame 68 suffered damage.
3. Frame No. 61 deformed and flattened at bottom.
4. Frame No. 62 heavily distorted and cracked.



Aft Belly damaged during tail strike



Aft frame No.63 cracked due tail strike

5. Crack was observed on the upper flange of frame 63.
6. Both the main landing gear shock absorbers, sliding tubes, wheels and tyres exceeded the design load limits.
7. Through and through hole was observed between the stringer no 43RH and 44RH.
8. Cargo Door support beam was damaged.

1.4 Other damage: NIL

1.5 Personnel information

1.5.1 Pilot – in – Command

AGE	:	41 years
License	:	ATPL Holder
Category	:	Aeroplane, Multi engine, land
Endorsements as PIC	:	C152A/C172/PA 34- 200/ Boeing 737-200/ Airbus 320 family.
Date of Med. Exam.	:	16/10/2014
Med. Exam valid upto	:	15/04/2015
FRTO License	:	Valid
Total flying experience	:	8000 hours approximately
Experience on type	:	6000 hours approximately
Experience as PIC on type	:	3000 hours approximately

Total flying experience during last 365 days	:	574 hours
Total flying experience during last 180 days	:	374 hours
Total flying experience during last 90 days	:	180 hours
Total flying experience during last 30 days	:	64 hours
Total flying experience during last 07 Days	:	11 hours
Total flying experience during last 24 Hours	:	05 hours

1.5.2 Co-Pilot

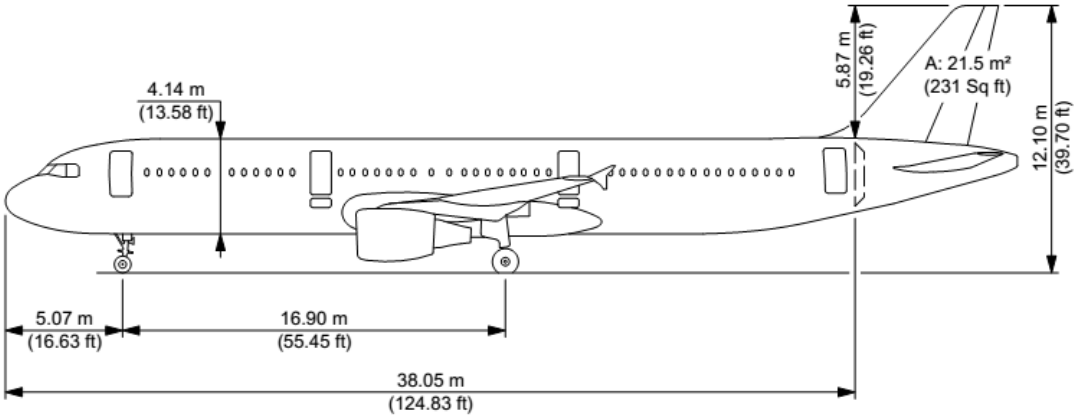
AGE	:	40 years
License	:	CPL Holder
Category	:	Aeroplane, Single engine and Multi engine
Endorsements as PIC	:	Cessna-152 and PA-34
Endorsement as F/O	:	Airbus A320 family.
Date of Med. Exam	:	08th January 2015
Med. Exam valid upto	:	07th July 2015
FRTO License	:	Valid till 27/04/2018
Total flying experience	:	2500 hours
Experience on type	:	1800 hours approximately
Experience as PIC on type	:	Nil

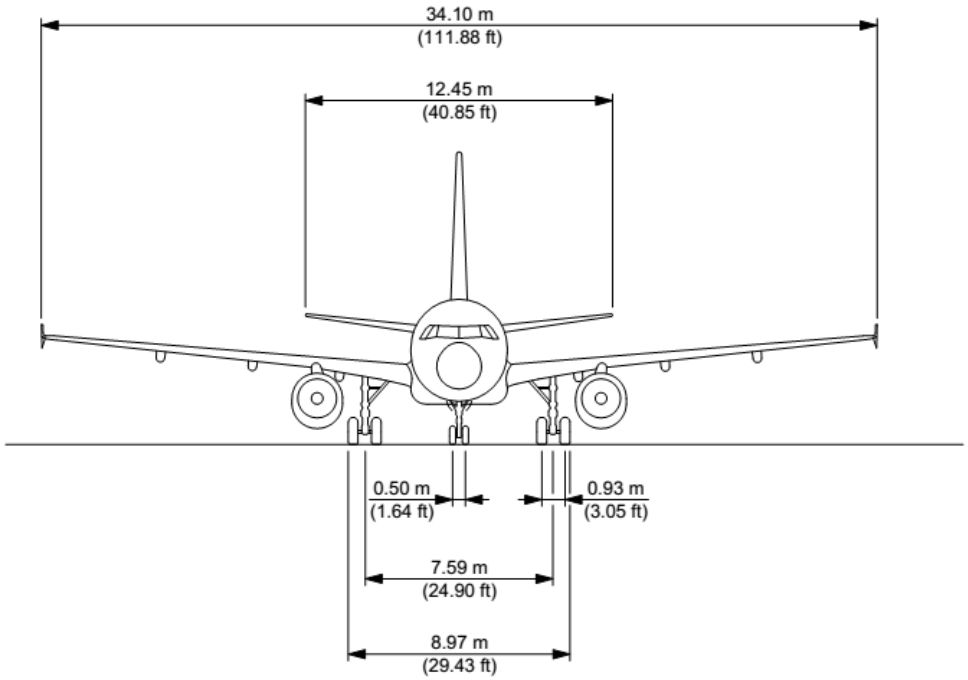
Total flying experience during last 365 days	:	625 hours
Total flying experience during last 180 days	:	310 hours
Total flying experience during last 90 days	:	175 hours
Total flying experience during last 30 days	:	60 hours
Total flying experience during last 07 Days	:	14 hours
Total flying experience during last 24 Hours	:	05 hours

Both the operating crew were not involved in any serious incident/ accident in the past. The licences of both the cockpit crew and all the training were current and valid. The commander was cleared to give assisted take-off & landing and the first officer was cleared to take assisted take-off & landing by the company. Both the crew had adequate rest prior to roster for the incident flight.

1.6 Aircraft Information

The A321-211 is a subsonic, medium-range, civil transport aircraft. The aircraft has two high bypass turbofan engines manufactured by CF56-5B engines. The aircraft is designed for operation with two pilots and was 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 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 12.10 meters. The distance between main wheel centre is 7.59 meters.

The distance between engines is 11.50 meters and Engine Ground Clearance is 0.56 meters.

Each CFM56-5B engines have thrust rating of 32000lb and manufactured by SNECMA France. The principal modules of the engine are fan and booster, high pressure compressor, combustor chamber, high pressure turbine, low pressure turbine and accessory drive gearbox. The description of each engine module is as follows:

A. **Fan/Booster Rotor:** The fan rotor consists of one full diameter booster for the secondary flow single stage fan and a smaller 4 Stage booster for the core engine flow. The fan and the booster are mounted on a common internal concentric shaft driven by the fan pressure turbine. Two bearings support the fan assembly in the frame.
B. **HP Compressor Rotor:** The compressor is a nine stage axial flow assembly.
C. **High Pressure Turbine**: The High Pressure Turbine (HPT) is an air cooled single stage high energy turbine.
D. **Low Pressure Turbine:** The Low Pressure Turbine (LPT) consists of 4 and half stages of blades and vanes. The first stage nozzle vane is cooled and provides cooling air for the high pressure and low pressure turbine discs.

At the time of incident, the #1 PORT engine Serial Number 697290 had done Time since New (TSN) 16779.40 HRS and Cycles since New (CSN) 10287 CYC and #2 STBD engine Serial Number 697815 had done Time since New (TSN) 19349.43 HRS and Cycles since New (CSN) 10836 CYC.

1.6.1 Fuselage: The fuselage is a semi-monocoque structure. Light alloy circular frames and longitudinal stringers support and the primary fuselage skin. There are no longitudinal stringers in the nose assembly. The fuselage is made of different assemblies which are put together to make the complete fuselage shell. The assemblies are nose forward fuselage, forward fuselage, center fuselage, rear fuselage and cone/rear fuselage.

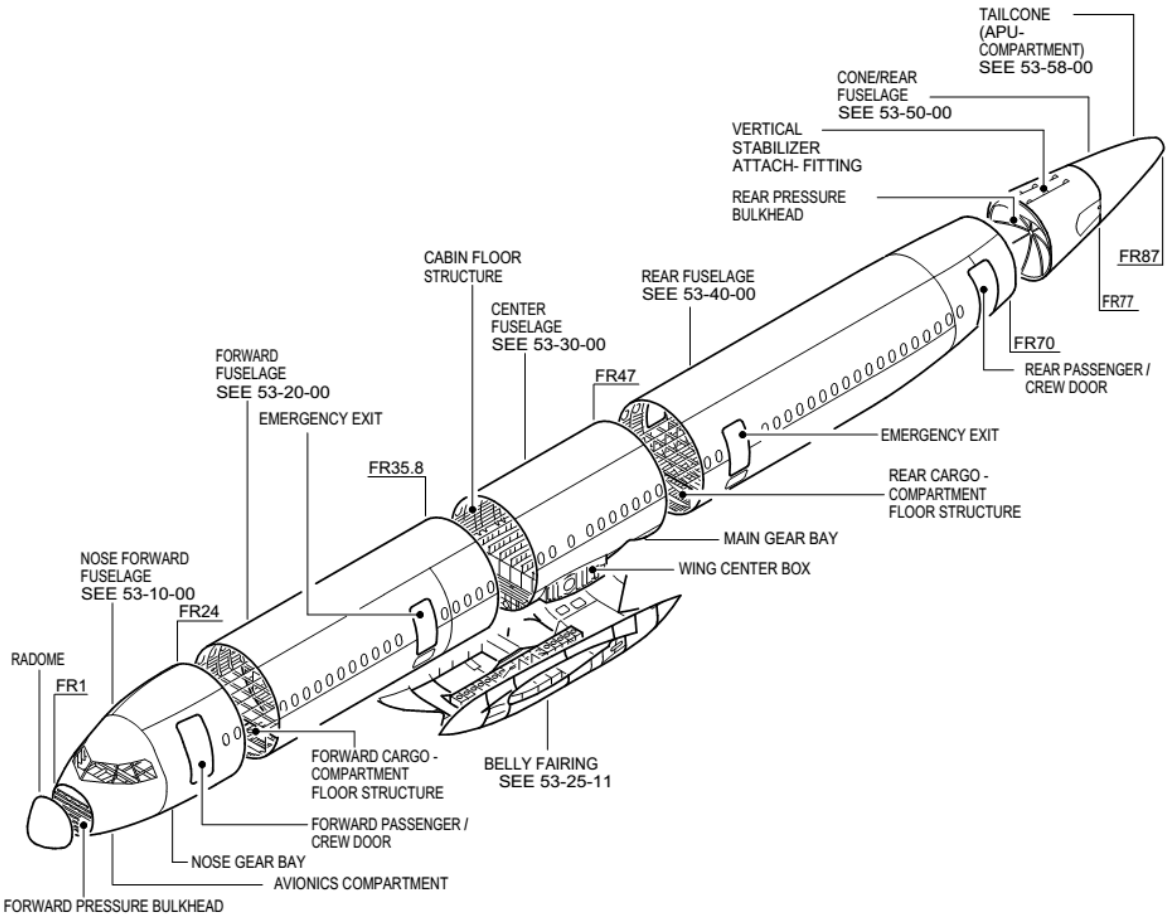


Figure Shows Fuselage sections

Frames 24, 35, 47 and 70 make the joints for the assemblies. Pressure bulkheads are installed at FR1 and FR70. The pressure bulkheads and the fuselage skin make the basic pressurized zone. The cockpit, cabin, avionics compartment and the FWD and AFT cargo-compartments are included in the pressurized zone.

The structure is made of frames, stringers and skin panels. They are riveted together to make the fuselage shell. Crossbeams make the shell stronger in the forward and aft fuselage. Support struts are attached to each end of the crossbeams. Longerons and seat tracks that are attached to the crossbeams make the cabin floor structure. The belly fairing primary structure is installed on the exterior of the lower fuselage between FR31/35 and FR48/FR53. It is an extension to the lower fuselage and contains the air-conditioning and hydraulic services equipment.

The cabin floor structure divides the fuselage into two areas, the upper fuselage and the lower fuselage. The upper fuselage includes the cockpit and the cabin. The lower fuselage includes the avionics compartments, nose & main gear bays and the FWD & AFT cargo-compartments. Crossbeams and support struts support the cabin floor structure at STGR23. The floor panels are made of a honeycomb core which is bonded between Glass- fiber Reinforced Plastic (GFRP) sheets. The radome, wing centre box, nose and main gear bays, belly fairing and cone/rear fuselage are not in the pressurized zone. Skin stiffeners make the fuselage skin stronger. They are riveted to the skin in areas of high stress (dooropenings, emergency exits, cabin windows, etc.). The cabin windows are installed between STGR 14 and STGR 18.

Airbus A321 aircraft VT-PPD (MSN 3212) was manufactured in the August 2007. The aircraft is registered under the ownership of M/s Bayern Aircraft Ltd., Cayman Islands. The Certificate of registration No. 3560/2 under category 'A' was issued on 20/08/2007. On the day of incident, the aircraft VT-PPD had logged 24119:44 airframe hours and 13276 landing.

The aircraft was issued Certificate of Airworthiness Number 2969 under NORMAL category, sub-division PASSENGER / MAIL / GOODS by DGCA and valid till 31/07/2017. The aircraft Aero mobile License No. A-014/003-RLO (NR) and was valid on the day of incident. The aircraft was operated under Scheduled Operator's Permit No. S-09 and valid till 30/06/2018. Prior to flight the Aircraft was holding a valid Certificate of Flight Release.

The aircraft was last weighed on 27/06/2012 at Mumbai and the weight schedule prepared and duly approved by the office of Deputy Director General, DGCA, Mumbai. As per the approved weight schedule the Empty weight of the aircraft is 47500 Kgs. Maximum Usable fuel Quantity is 18605.00 Kgs. Maximum payload with fuel and oil tanks full is 20603 Kgs. Empty weight CG is 22.70 meters aft of datum. As there has not been any major modification affecting weight & balance since last weighing, hence the next weighing is due on 26/06/2017. Prior

to the incident flight the weight and balance of the aircraft was well within the operating limits.

The aircraft and Engines 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 O/o Deputy Director General, DGCA, Mumbai. The last major inspection (1A check) was carried out at 23897.28 A/F Hrs and 13138 Landings on 24.01.2015 at Mumbai. Subsequently, all lower inspections (Preflight checks, Layover Checks, Weekly Checks) were carried out as and when due before the incident.

All the concerned Airworthiness Directive, mandatory Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine has been complied with as and when due.

All Transit Inspections were carried out as per approved Transit Inspection schedules. All the higher inspection schedules include checks 1 inspection were carried out as per the manufacturer's guidelines as specified in Maintenance Program and are approved by the Continuing Airworthiness Manager (Post Holder for Continuing Airworthiness).The last fuel microbiological test was done on 29/11/2014 at Mumbai by Air India Ltd. and the colony count was within acceptable limits.

The defect record of the aircraft were scrutinised for a period of one month from the date of occurrence of the serious incident and no defect was pending on the aircraft prior to the incident flight. .

1.7 Meteorological information

At the time of landing, 0910 hrs UTC, the following weather was reported by MET department.

Wind	:	09 Knots at 270°
Visibility	:	4000 m
Weather	:	Haze
Clouds	:	No Significant Clouds
Temperature	:	30^0 C
Dew Point	:	18^0 C
QNH	:	1011 hPa
Trend	:	No significant Weather Change

1.8 Aids to navigation

At Mumbai Chhatrapati Shivaji International Airport two bidirectional runway are available. The orientation of which is 09/27 and 14/32. Except for runway 32, DME and ILS approach is available for all the other three. PAPI is available for both sides of all the runways. The A320 family of aircraft is fitted with all modern navigational equipment including the DME and ILS systems.

1.9 Communications

There was always two way communication between the ATC and the aircraft.

1.10 Aerodrome information

ChhatrapatiShivaji International Airport, Mumbai

ICAO Code: VABB

Co-ordinates

ARP : 190530N, 0725158E
Elevation : 37 FT / 33.0°C

Runway Orientation and Dimension

Orientation- 09/27 Dimension- 3190 x 46 meters

Orientation- 14/32 Dimension- 2871 x 45 meters

R/W & Taxi Tracks Markings Standard as per Annex- 14.

All the runway has PAPI approach lighting system.

RWY.	HIALS (APCH LGT)	THR LGT	PAPI	Rwy Centre Line LGT	HIRL (RWY edge LGT)
09/27	CAT-I	Yes	Yes (3 degrees)	Yes	Yes

Met Services

MET services are available at the airport. TAF, Trend Forecast and Briefing is available.

Navigation and Landing Aids

PAPI, DVOR, DME and ILS systems are available.

ATS Communication Facilities

MUMBAI Approach : 119.30/ 127.90 MHZ

MUMBAI ATIS : 126.40 MHZ

MUMBAI Tower : 118.10 MHZ

MUMBAI Ground : 121.90 MHZ

Figure: Chhatrapati Shivaji International Airport, Mumbai

1.11 Flight Recorders: Aircraft VT-PPD was installed with a Solid State Digital Cockpit voice Recorder (SSCVR) and Solid State Digital Flight Data Recorder (SSDFDR).

Cockpit voice Recorder (SSCVR):

Make : L3 communication and recording duration of last two hours of flight.

Serial No: 000337251

Part No : 2100-1020-02

The SSCVR was downloaded and following was revealed during the readout.

The last sector Mangalore-Mumbai was flown by the First officer as PF and the PIC was handling the duties of PM. The enroute flight was uneventful. The aircraft was configured for approach and landing on runway 27. All checklist procedures by the cockpit crew were standard. However as per the company procedure, there was no briefing by the commander to the first officer for executing the supervised landing under him.

At time 09:08:46 tower cleared AI-680 to land on runway 27 with Winds 270/09 Knots and the same was acknowledge by the crew of the aircraft. The landing was continued by the FO and the PIC advised FO to reduce the rate of descent.The sound of autopilot disconnect and prior to touchdown the auto callouts "retard retard " is recorded on the CVR. The aircraft landed and bounced. The commander called out and took over the controls from FO. The FO also called out your controls. Thereafter a loud structural sound is recorded on the CVR. After landing during taxing the aircraft to bay the commander made an announcement on the Passenger address system apologize for the hard landing.

Flight Data Recorder (SSDFDR):

Make L3 communication

Serial No: 000542463
Part No : 2100-4043-02

The SSDFDR data was downloaded and was further spitted into different phases of flight and then reviewed.

Final Approach:

The auto pilot was disengagement at 540ft Radio Altitude (RA) at (GMT 09:09:07) up to flare initiation at 50ft RA:

- **On the longitudinal axis**:
  - Pitch angle varies between +1.4° and +3.9° (nose up).
  - CAS varies between 142kt (=VLS+3kt) and 148kt (=VLS+9kt).
  - Rate of descent varies between 540ft/min and 830ft/min.
  - Aircraft is on the glide slope.

- **On the lateral axis**:
  - Roll angle varies between -4.9° (left wing down) and +2.5° (right wing down).
  - Aircraft is on the localizer.

The flight crew disengaged both APs at 540ft RA, then final approach was manually handled from the right side with the A/THR still engaged and active in "SPEED" mode with both thrust levers on the "MAX CLIMB" detent.Speed target was managed.

FLARE PHASE

Flare initiation is at 50ft RA (GMT 09:09:51) and touchdown is at (GMT 09:09:55):

- On the longitudinal axis:
  - Flare is initiated with a smooth and progressive nose up input applied up to full Sidestick deflection:
    - ✓ Elevators deflect from 0° to -12.9° (upward)
    - ✓ Pitch angle gradually increases from +1.8° to +5.6°
  - Vertical load factor increases from +0.95g to +1.14g
  - Rate of descent decreases from 780ft/min to 640ft/min
  - Thrust levers remain on the "MAX CLIMB" detent until touchdown
  - CAS decreases from 146kt (=VLS+7kt) to 144kt (=VLS+5kt)
- On the lateral axis:
  - Sidestick inputs vary between -2.9° (rightward) and +5.9° (leftward)
  - Drift angle increases from -0.1° to -1.6° (aircraft nose toward the right of the track)
  - Aircraft is on the localizer

TOUCHDOWN

At GMT 09:09:55: First touchdown

- The aircraft touches down a first time with:
  - +5.6° of pitch angle.
  - -8.5ft/s (±2ft/s) of recalculated aircraft vertical speed.
  - +1.66g of vertical load factor (Vertical accleration)
  - CAS 144kt.
  - Both thrust levers on MAX CLIMB detent.
- Ground spoilers 1 & 2 partially extend.

First high bounce between GMT 09:09:55 and GMT 09:10:00:

Three seconds after the first bounce, at GMT 09:09:58, sidestick inputs are recorded on the left side without activation of the takeover priority pushbutton. From this time, the aircraft is handled from the left side.

- Vertical load factor decreases to +0.53g.
- Radio altimeter increases to +8ft.
- Main landing gears are recorded uncompressed during approximately (~) 4s.
- Nose up input from the right side is maintained around -4.5° during ~3s and released, then a nose down input is applied from the left side to +7.1° of sidestick deflection, and followed by a strong full back stick input just before second touchdown.
- Pitch angle increases and remains at +7.0° during ~3s then decreases to +5.6° then rapidly increases to +8.1°.
- Thrust levers progressively retarded to the "IDLE" detent, leading to A/THR disengagement and full extension of all the ground spoilers.
- Roll angle reaches +3.2° (right wing down) then decreases.
- Leftward sidestick deflection is applied to +5.8°.

Second bounce and tail strike at GMT 09:10:00:

- The aircraft touches down a second time with:
  - +8.1° of pitch angle.
  - +3.47g of vertical load factor.
  - CAS 136kt.
- Thrust levers are set to the "MAX REV" detent.
- Ground spoilers are fully extended.
- The PFR records the "DRAINMAST HEATER AFT" message at GMT 09:10.

DECELERATION

From GMT 09:10:00:

- A strong nose down input is applied and maintained up to full sidestick deflection.
- Pitch angle rapidly decreased toward 0°.

- Nose landing gear is recorded compressed ~2s after second touchdown.
- Full leftward sidestick input is applied and maintained.
- Manual braking is applied leading to autobrake disengagement.
- The aircraft decelerates uneventfully.

1.12 Wreckage and Impact Information

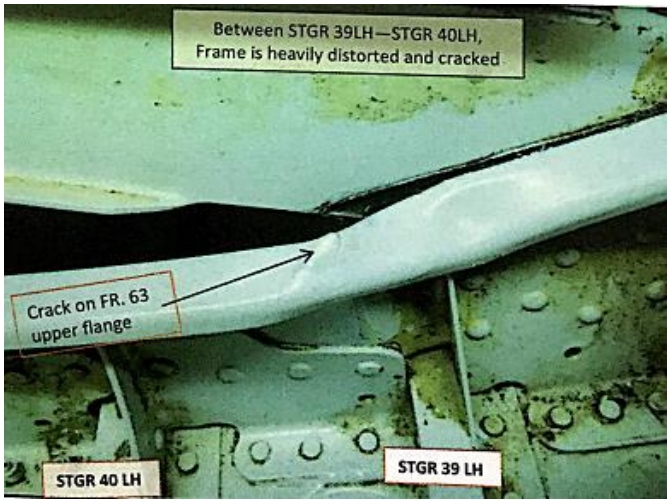
Aircraft touched down on main landing gear with pitch attitude +5.6^{o}and vertical load factor of +1.66g and bounced. At the point of touchdown the CAS was 144 kts with thrust levers as on MAX CLIMB detent and ground spoilers 1 &2 partially deployed.

The strong full back stick input applied just before the second touchdown rapidly increased the pitch angle and significantly reduced the tail strike margin while the aircraft was touching down.

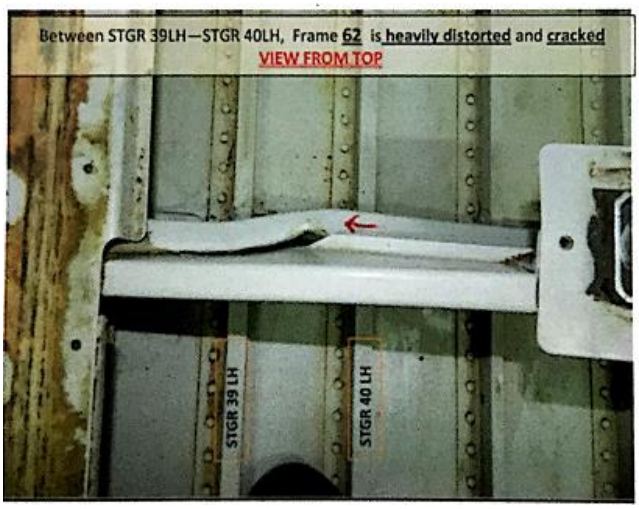
Belly scrape marks on the runway

Damaged aircraft belly

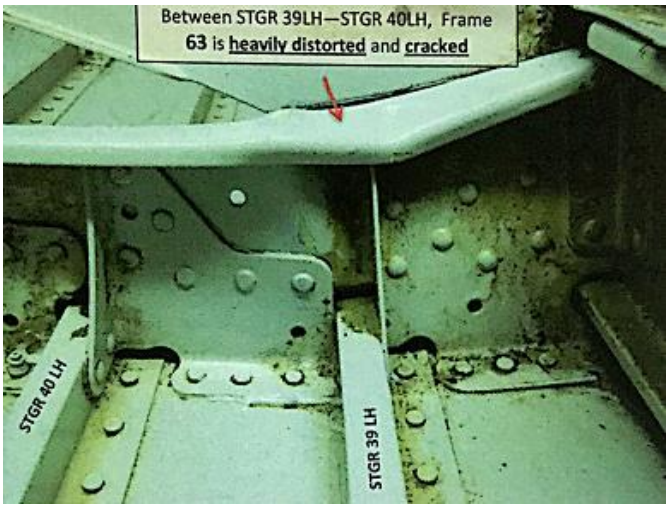
During the bounce, the thrust levers were retarded to the "IDLE" detent which enabled the full extension of all the ground spoilers connected to SEC 123. The nose down input applied by the first officer and thereafter full back stick input applied by the PIC caused the second severe hard landing with vertical acceleration of 3.47 g. During the impact the aircraft suffered following internal damages.



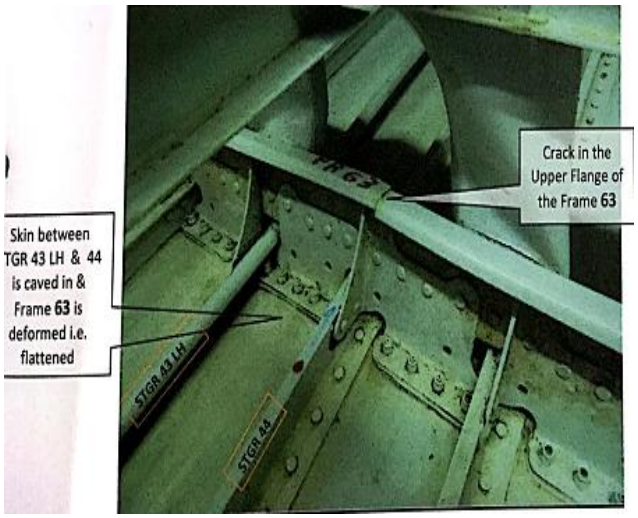
Crack on the Frame 63 rear upper flange



Frame 62 heavily distorted



Frame 63 heavily distorted and cracked



Skin between stringer 43 &44 badly deformed.

1.13 Medical and pathological Information

Both the cockpit crew and all the cabin crew had undergone pre-flight medical check prior to the flight at Delhi and the same was found to be negative.

1.14 Fire

There was no fire.

1.15 Survival aspects

The incident was survivable.

1.16 Tests and research : Nil

1.17 Organizational and management information:

Air India Ltd., is a scheduled airline with an Airbus fleet of 71 aircrafts and 41 aircrafts of Boeing fleet operating flights on domestic and international sectors. The Airlines Head Quarter is located at New Delhi. The Air operator permit of the Airlines is valid till 30/06/2018. The Company is headed by Chairman & Managing Director assisted by a team of professional of 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.

M/s Air India has a full established Operations training facility for the pilots. The training facility for the Airbus pilots is set up at Hyderabad and for the Boeing pilots it is in Mumbai. Both the training facilities are headed by the Executive Director Training who reports to Chairman directly. The Engineering training facility is established at Delhi and Mumbai.

1.18 Additional information

1.18.1 Auto Thrust System: The A/THR computer (within the FG) interfaces directly with the engine computer, referred to as the FADEC. The A/THR sends to the FADEC the thrust targets that are needed to:

• Obtain and maintain a target speed, when in SPEED mode

• Obtain a specific thrust setting (e.g. CLB, IDLE), when in THRUST mode.

INTERFACE

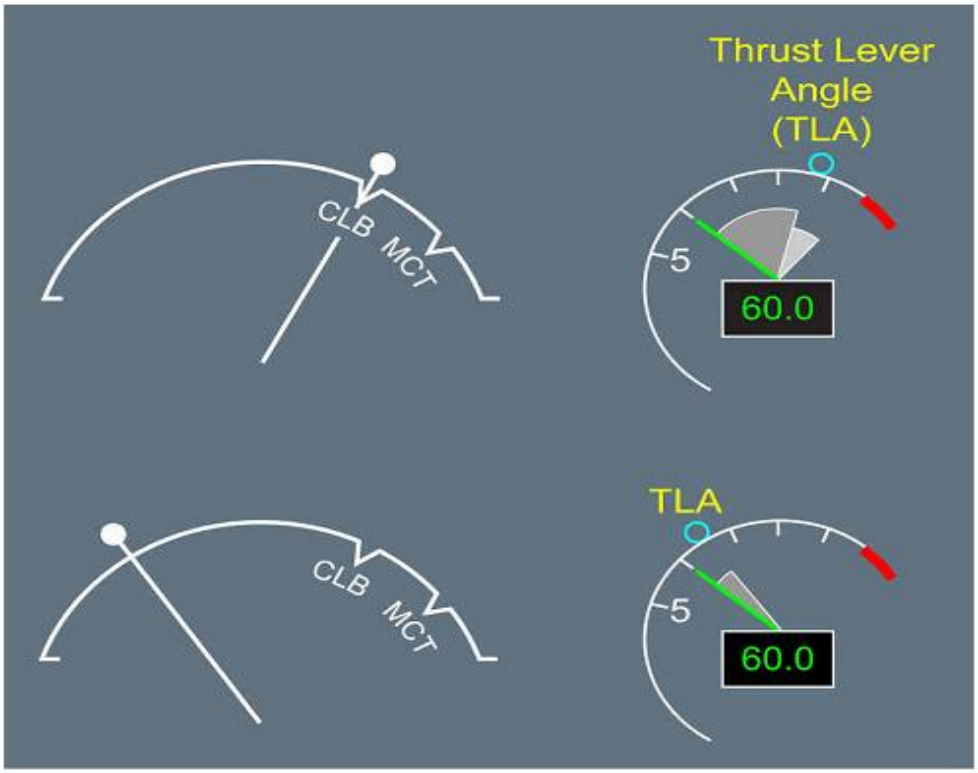
When the A/THR is active, the thrust lever position determines the maximum thrust that the A/THR can command in SPEED or THRUST mode. Therefore, with A/THR active, thrust levers act as a thrust limiter or a thrust-rating panel. The A/THR computer does not drive back the thrust levers. The PF sets them to a specific detent on the thrust lever range. The A/THR system provides clues that indicate the energy of the aircraft:

• Speed, acceleration, or deceleration, obtained by the speed trend vector

• N1, and N1 command on the N1 gauge.

All these clues are in the flight crew's direct line of vision.

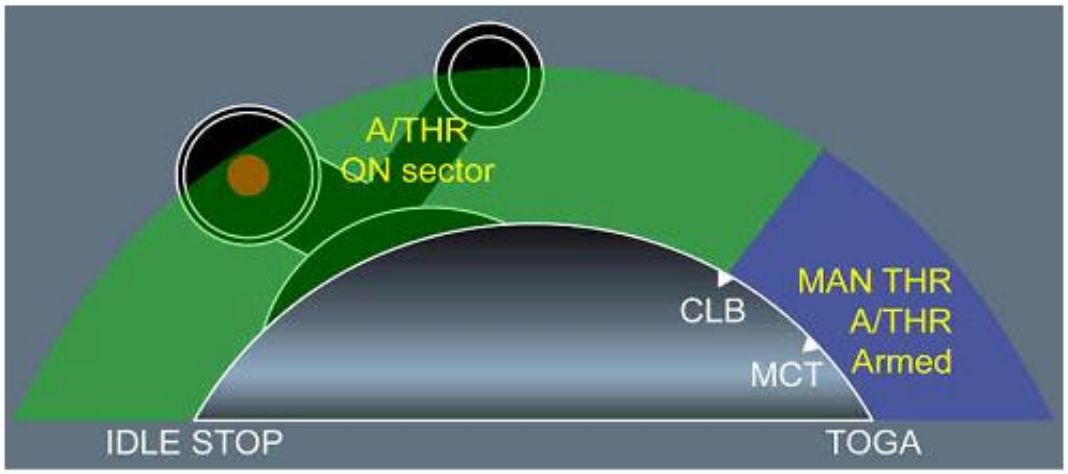
In other words, the Thrust Lever Angle (TLA) should not be used to monitor correct A/THR operation. Neither should the thrust lever position of a conventional auto throttle, be considered a clue because, in many hazardous situations, the thrust lever position can be misleading (e.g. engine failure, thrust lever jammed).

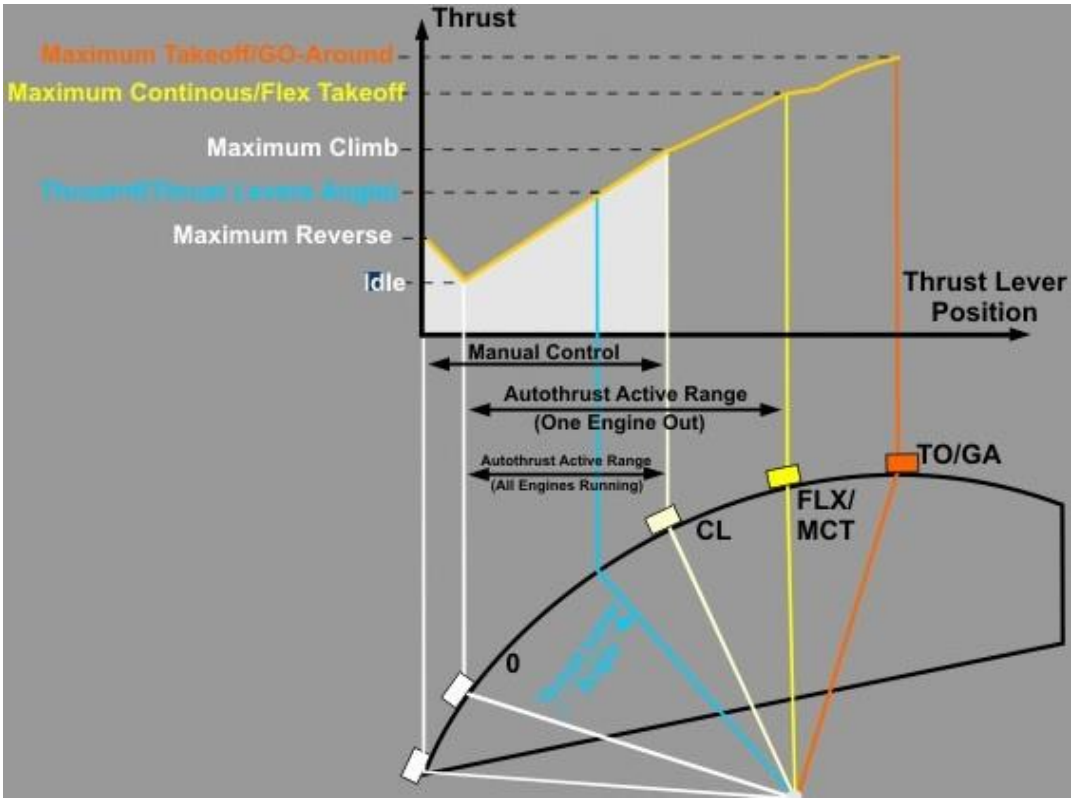


NORMAL OPERATIONS

The A/THR can only be active, when the thrust levers are between IDLE and the CLB detent. When the thrust levers are beyond the CLB detent, thrust is controlled manually to the thrust lever Angle, and the A/THR is armed (A/THR appears in blue on the FMA). This means that the A/THR is ready to be re-activated, when the flight crew sets the thrust levers back to the CLB detent (or below).

A/THR Operating Sectors _ All Engines Operating





AT TAKEOFF

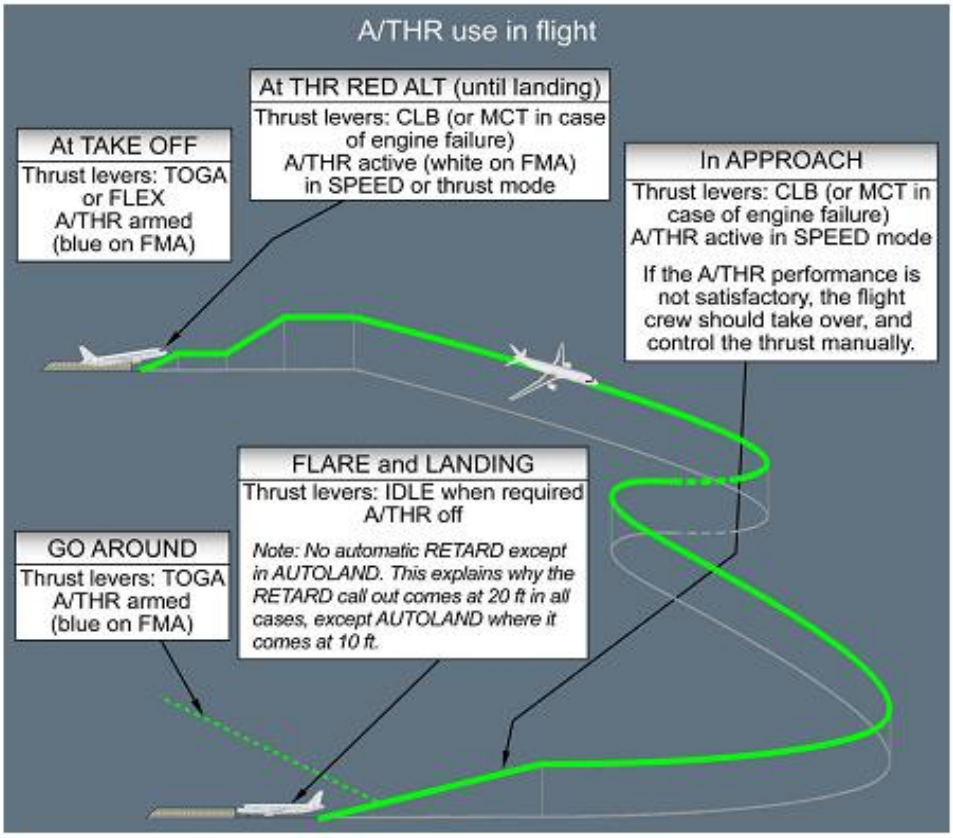
The thrust levers are set either full forward to TOGA, or to the FLX detent. Thrust is manually controlled to the TLA, and A/THR is armed. The FMA indicates this in blue.

AFTER TAKEOFF

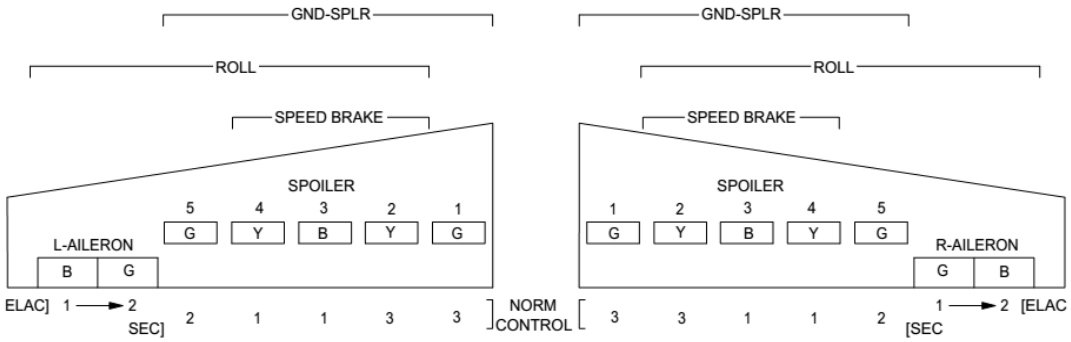
When the aircraft reaches THR RED ALT, the flight crew sets the thrust levers back to the CLB detent. This activates A/THR. MAX CLB will, therefore, be the maximum normal thrust setting that will be commanded by the A/THR in CLB, CRZ, DES, or APPR, as required.

THRUST LEVERS SET TO IDLE

If thrust levers are set to IDLE, A/THR is set to off. This technique is usually used in descent, when the A/THR is in THR IDLE, or at landing. During flare, with the A/THR active, the thrust levers are set to the CLB detent. Then, when thrust reduction is required for landing, the thrust levers should be moved rapidly and set to the IDLE stop. This will retard thrust, and set A/THR to off. As a reminder, the "RETARD" aural alert will sound. In flare, this aural alert will occur at 20 ft, except in the case of autoland, where it occurs at 10 ft. It should be noted that, when the thrust levers are set back to IDLE and A/THR set to off: During GO-Around the A/THR can be reactivated by pressing the pushbutton on the FCU, and returning the thrust levers to the applicable detent.



1.18.2 Spoiler Elevator Control (SEC):



Spoiler Assembly on A-320aircraft

On Airbus A 320 family of aircrafts, the spoiler are controlled by three spoiler and elevator computer (SEC). Prior to the incident, the aircraft VT-PPD was equipped with the following SEC:

Position 1- SEC 112(old version) controlling ground spoilers 3 & 4

Position 2- SEC 112(old version) controlling ground spoilers 5

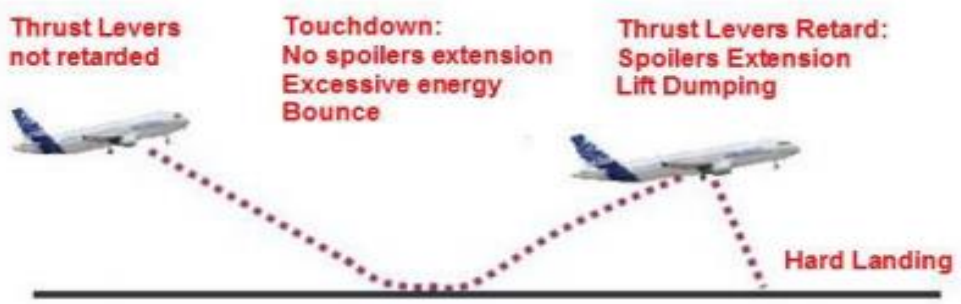
Position 3- SEC 123 (modified version) controlling ground spoilers 1 & 2

Ground spoilers 3, 4 & 5 was controlled by SEC 112 or Older Version in position 1 & 2 and was not modified and does not contain the PLD function. Ground spoiler 1 & 2 was controlled by SEC in position 3 which was of modified version and contained PLD function.

In the following condition when ground spoilers are armed, during touchdown and both thrust levers not at the IDLE position. In this condition, the spoilers 3, 4 & 5 will not extend at touchdown. However, ground spoilers 1 & 2 will extend partially.

As the aircraft was fitted with two different SEC standards (SEC 112 in positions 1 & 2 and SEC 123 in position 3), the ground spoiler extension was controlled with two different extension logics, depending on the SEC controlling each spoiler. As the energy of the first landing associated with the nose up order maintained at touchdown and the inhibition of the full ground spoiler extension caused a high bounce. The partial extension of the ground spoilers 1 & 2 at touchdown did not sufficiently decrease the lift to reduce the severity on the first

bounce. The aircraft touched down on both main landing gears (VRTG = +1.66g) with both thrust levers on the MAX CLIMB detent.



Aircraft fitted with older version SEC112 without Phase Lift Dump function

During the first bounce, the thrust levers were retarded to the "IDLE" detent which enabled the full extension of all the ground spoilers. The nose down input applied during the bounce and thereafter a strong full back stick input applied just before the second touchdown rapidly increased the pitch angle and significantly reduced the tail strike margin reduced the lift and caused the second severe hard landing.

The aircraft VT-PPD was fitted with two different sets of SEC. The Ground spoilers 1 & 2 were controlled by SEC 123 in position 3 which was the modified component and the SEC 123 contained the feature of Phased Lift Dumping (PLD) function. This function enables the ground spoilers to extend with a partial deflection (10°) in order to reduce the severity of a probable bounce at landing in case of an inappropriate thrust lever handling during the flare.

Aircraft fitted with modified version of SEC123 with Phase Lift Dump function

The partial extension conditions are the following:

1) Ground spoilers armed,
2) Both main landing gears on ground and both thrust levers at or below the "MAX CLIMB" position.

As soon as all the previous conditions were fulfilled, the PLD function activated and therefore the ground spoilers 1 & 2 partially extended at touchdown.

1.18.3 Landing Techniques as per FCTM :

As per the Flight Crew Training Manual (FCTM) NO-170 LANDING / BOUNCING AT TOUCHDOWN extract, in case of high bounce, the flight crew must maintain the pitch attitude and initiate a go-around. If the pitch attitude is maintained, in case of bounce, the second touchdown would be soft enough to prevent damage to the aircraft.

Tail Strike Avoidance:

In case of bouncing at touch down, the pilot may be tempted to increase the pitch attitude to ensure a smooth second touchdown. If the bounce results from a firm touch down, associated with high pitch rate, it is important to control the pitch so that it does not further increase beyond the critical angle.

1.18.4 Service Bulletin

The Airbus had issued a SB A320-27-1230 Rev.1 in October 2013 wherein, in the frame of the Sharklet Project, a new Spoiler and Elevator Computer (SEC) software was developed. This modification consists in updating the SEC software by installing the new SEC 123.

After the Service Bulletin was issued it was discussed in the Air India Modification Committee and it was agreed upon that the modification will be carried out in phase wise plan on the M/s Air India aircraft as this was not a mandatory modification.

For A319/A320/A321 aircraft equipped with or without sharklet this new SEC standard will also include these improvements:

Enhancements from SEC 120 to SEC 123:

- Tuning of the refresh monitoring processing of all the SEC digital inputs processing at least 2 labels on the bus, in order to improve the robustness.
- Addition of one COM/MON consolidation as regards the choice of the spoiler order.
- Deletion of A320 original LAF.

Enhancements from SEC 119 to SEC 120:

- Ground spoiler additional logic: authorize ground spoiler deflection with retard
- Partially achieved with one trust lever at climb detent or below and the other one on
- Reverse position when ground condition is confirmed (based on shock absorber and
- Radio altimeter on wheel speed tachometers).
- Adding new conditions in the logic authorizing the Phased Lift Dumping (PLD)
- Function in order to favour its activation.
- Speed brake lever deflection arms as well the ground spoilers.
- Adding new reverse deployment logic based on wheel speed information to be more robust to the radio altimeter misbehaviours.
- On A320 under ultimate emergency electrical configuration, with only blue hydraulic pressure available, availability on the right and left blue spoilers number 3, managed by dedicated Pin Programming.

Old part number is interchangeable and mixable with new part number on A318/A319/A320/A321 without sharklet fitted if modification No. 160500J3283 for A318/A319/A320 or modification No. 160023J3448 for A321 are not embodied on aircraft.

On VT-PPD this modification was carried out only partially and was fitted with two different sets of SEC. The Ground spoilers 1 & 2 were controlled by SEC 123 in position 3 which was the modified component and the SEC 123 contained the feature of Phased Lift Dumping (PLD) function. Ground spoilers 3, 4 & 5 was controlled by SEC 112 in position 1 & 2 which were of older version and was not modified for PLD function.

1.19 Useful or effective investigation techniques: NIL

2. ANALYSIS

2.1 Serviceability of the aircraft

Airbus A321 aircraft VT-PPD (MSN 3212) was manufactured in the august 2007. On the day of incident, the aircraft VT-PPD had logged 24119:44 airframe hours and 13276 landings. Aircraft was holding a valid Certificate of Airworthiness and flight release prior to flight. The Air Operator permit is valid till 31/07/2017.

The aircraft and Engines 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 O/o Deputy Director General, DGCA, Mumbai. The last major inspection (1A check) was carried out at 23897.28 A/F Hrs and 13138 Landings on 24.01.2015 at Mumbai. Subsequently, all lower inspections (Pre-flight checks, Layover Checks, Weekly Checks) were carried out as and when due before the incident.

All the concerned Airworthiness Directive, mandatory Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine has been complied with as on date of event.The defect record of the aircraft were scrutinised for a period of one month prior to the date of occurrence of the serious incident and no defect was found pending on the aircraft.Prior to the incident flight the weight and balance of the aircraft was well within the operating limits.

The Airbus had issued a SB in October 2013 wherein a new Spoiler and Elevator Computer (SEC) software was developed. This modification consists in updating the SEC software by installing the new SEC 123. Enhancements from SEC 120 (old) to SEC 123 for A319/A320/A321 aircraft which had an additional logic for ground spoiler which authorize ground spoiler deflection with retard partially achieved with one thrust lever at climb detent or below and the other one on reverse position when ground condition is confirmed based on shock absorber and radio altimeter on wheel speed tachometers. Also adding new conditions in the logic authorizing the Phased Lift Dumping (PLD) function in order to favour its activation. This service Bulletin was discussed in M/s Air India Modification committee and the committee was in agreement to carry out this modification. Since old Part number was interchangeable and mixable with new modified part number decision was taken to carry out in a phase wise plan. Though the committee had taken decision in December 2013 to carry out the modification it was not complete on the aircraft VT-PPD on the day of incident.

From the above it is inferred that the serviceability of the aircraft is not a factor to the incident, however if the SEC modification was carried out on the aircraft VT-PPD in totality it would have certainly reduced the impact of hard landing and consequently the damages would have been less.

2.2 Weather:

At the time of landing, the weather was haze with a visibility of 4000 meter in a 09 Knots wind condition at a temperature of 30^0 C and with no significant weather change. Weather is not a contributory factor to the incident.

2.3 Analysis of Digital Flight data recorder:

DFDR analysis revealed that aircraft was fully configured at 1350 ft RA for landing. Auto thrust (A/THR) was engaged and active in "SPEED" mode and both the thrust levers remain on the "MAX CLIMB" detent until touchdown.

The rate of descent increased from 670 ft/min to 780ft/min just before the flare initiation.The flare was initiated at 50 ft RA. The aircraft touched down with both thrust levers on the "MAX CLIMB" detent.

Since the thrust levers were not retarded to the "IDLE" detent prior to first touchdown, the A/THR remained engaged and consequently increased the thrust in order to maintain the speed target. As the touchdown speed was high the aircraft bounced during landing. After the first bounce the commander took over the controls and the thrust levers progressively retarded from "CLIMB" to the "IDLE" detent, leading to Auto Thrust disengagement.

The aircraft VT-PPD was fitted with two different sets of SEC. The Ground spoilers 1 & 2 were controlled by SEC 123 in position 3 which was the modified component and the SEC 123 contained the feature of Phased Lift Dumping (PLD) function. This function enables the ground spoilers to extend with a partial deflection (10°) in order to reduce the severity of a probable bounce at landing in case of an inappropriate thrust lever handling during the flare.

The partial extension conditions are the following:
1) Ground spoilers armed,
2) Both main landing gears on ground and both thrust levers at or below the "MAX CLIMB" position.

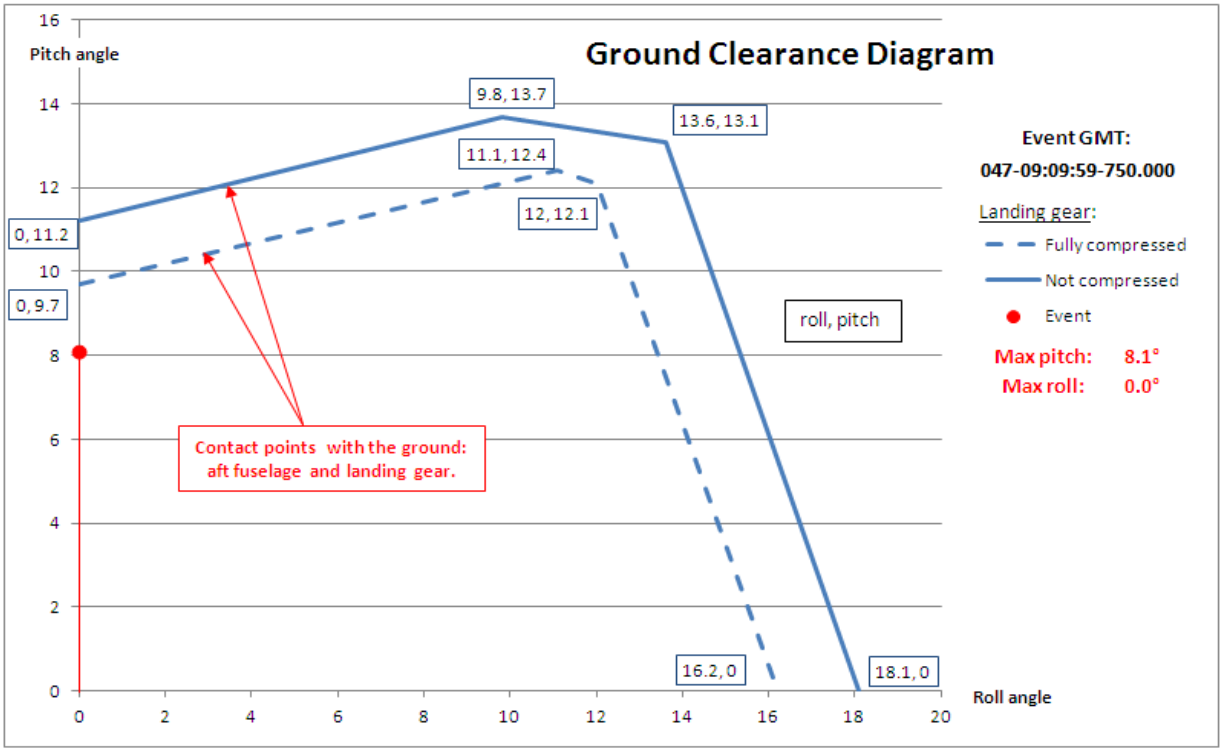
As soon as all the previous conditions were fulfilled, the PLD function activated and therefore the ground spoilers 1 & 2 partially extended at touchdown.

Ground spoilers 3, 4 & 5 was controlled by SEC 112: The SEC 112 was older than the SEC 123 and was not modified and does not contain the PLD function. Therefore, the conditions for the ground spoilers to fully extend are the following: ground spoilers armed, both main landing gears on ground and both thrust levers at the IDLE position. If all the above conditions are not fulfilled, the spoilers 3, 4 & 5 will not extend at touchdown.

As the aircraft was fitted with two different SEC standards (SEC 112 in positions 1 & 2 and SEC 123 in position 3), the ground spoiler extension was controlled with two different extension logics, depending on the SEC controlling each spoiler. As the energy of the first landing associated with the nose up order

maintained at touchdown and the inhibition of the full ground spoiler extension caused a high bounce. The partial extension of the ground spoilers 1 & 2 at touchdown did not sufficiently decrease the lift to reduce the severity on the first bounce.The aircraft touched down on both main landing gears (VRTG = +1.66g) with both thrust levers on the MAX CLIMB detent.

During the bounce, the thrust levers were retarded from "CLIMB" to "IDLE" detent which enabled the full extension of all the ground spoilers. The nose down input applied during the bounce and thereafter a strong full back stick input applied just before the second touchdown rapidly increased the pitch angle and significantly reduced the tail strike margin while the aircraft was coming down.



In accordance with the following ground clearance diagram, with the main landing gears fully compressed, the aft fuselage enters in contact with the ground when the pitch angle exceeds +8.1° associated with the full ground spoiler extension significantly reduced the lift and caused the second severe hard landing.

The maximum pitch angle recorded by the DFDR at touchdown (+8.1°) is smaller than the pitch limit indicated by the ground clearance diagram (+9.7°) this probably taking into consideration the resolution of the recorded parameters, the aircraft fuselage flexibility and the aircraft dynamic at touchdown. However, the "DRAINMAST HEATER AFT" message recorded by the PFR at GMT 09:10, the damage report and the damages recorded on the aft belly further to the event enable to confirm that a tail strike occurred at that time.

2.4 Handling of the controls by the crew

On 15/02/2015, Air India Ltd., Airbus A321 aircraft was scheduled to operate sectors Delhi-Mumbai-Mangalore-Mumbai. For the first two sector Delhi-Mumbai and Mumbai-Mangalore the Captain performed the duties of the pilot flying and First Officer performed the duties of pilot monitoring. For the third sector Mangalore-Mumbai the Captain permitted the First Officer to perform the duties of the Pilot flying as both the crew were cleared for assisted take off and landing by the company. For this sector the Captain was performing the duties of pilot monitoring. The first two sectors were uneventful.The enroute flight from Mangalore to Mumbai was also uneventful. The weather prior to landing at Mumbai was haze and there was no significant weather change. The landing weight on lower ECAM was 74.6 tonnes which was within the maximum landing weight of 75.5 tonnes. The crew received briefing from ATS Mumbai Control for the ILS approach for runway 27. At 09:06 hrs, approach control handed over the aircraft to the tower control. The aircraft was fully configured for landing at 1000 Ft with autopilot engaged. At 09:08 hrs the Mumbai ATS tower cleared VT-PPD for landing on runway 27. At 600 Ft AGL, the First Officer disconnected the autopilot and took over the controls manually. At 40 Ft approximately, the Captain advised the First Officer to reduce the rate of descend and flare. Immediately then the crew received synthetic aural alert `RETARD'. The Captain had stated that during flare the First Officer had moved the thrust levers to IDLE from CLIMB detent. However the DFDR readout revealed that the thrust levers were never moved to idle by the first officer also the auto thrust was active at the time of landing.

Since both thrust levers remained on MAX CLIMB detent and were not retarded to the "IDLE" detent prior to touchdown, the auto thrust remained engaged and consequently increased the thrust in order to maintain the set speed target. This coupled with high rate of descent caused the aircraft to bounce during landing. During the bounce the First Officer observed that the aircraft was not responding, he increased the pitch to reduce the rate of descent. Simultaneously the commander took over the controls and the thrust levers were retarded to the "IDLE" detent, leading to A/THR disengagement.This enabled the extension of all the ground spoilers with the modified SEC. The nose down input applied during the bounce and thereafter a strong full back stick input applied just before the second touchdown by the commander rapidly increased the pitch angle and associated with the ground spoiler extension significantly reduced the lift and the tail strike margin while the aircraft was coming down and caused the second severe hard landing significantly.

From the above it is inferred that the commander did not effectively monitor the first officer while executing the landing as the power levers remained on MAX Climb detent and were never retarded to IDLE during flare. Also the commander did not follow the recommended procedures of FCTM after the bounce landing and instead gave a strong 'noseup' input which further reduced the lift and the 'tail strike' margin and eventually resulted into a tail strike.

2.5 Circumstances leading to the Incident

The sector Mangalore-Mumbai was flown by first officer as PF and the PIC was performing the duties of PM. The enroute flight was uneventful. The aircraft was cleared by ATC Mumbai for ILS approach runway 27. The aircraft was fully configured for landing at 1000 Ft with autopilot engaged. At 600 Ft AGL, the First Officer disconnected the autopilot and took over the controls manually during short finals the Captain advised the First Officer to reduce the rate of descend and flare. During flare the first officer did not retard the thrust levers from MAX CLIMB detent to IDLE, due which the auto thrust remained engaged and consequently increased

the thrust in order to maintain the set speed target. This coupled with high rate of descent caused the aircraft to bounce during landing. During bounce the commander took over the controls and retarded the thrust levers to "IDLE" detent.This action disengaged the A/THR and enabled the extension of all the ground spoilers with the modified SEC. The PIC then gave a full back stick input which rapidly increased the pitch angle and associated with the ground spoiler extension significantly reduced the lift resulting into a severe hard landing.

3. CONCLUSIONS

3.1 Findings

a) The Certificate of Airworthiness and the Certificate of Registration of the aircraft was valid on the date of incident.
b) The certificate of flight release was valid on the day of incident.
c) Both the pilots were appropriately qualified to operate the flight.
d) All the concerned Airworthiness Directive, DGCA Mandatory Modifications on aircraft and its engine were found complied with.
e) The Airbus had issued a Service Bulletins in October 2013 wherein, a new Spoiler and Elevator Computer (SEC) software was developed. This modification consists in updating the SEC software by installing the new SEC 123. Air India Modification Committee was agreed upon that the modification will be carried out in phase wise plan as the modification was not mandatory and the old part number was interchangeable and mixable with new part number without sharklet.
f) At the time of serious incident, the modification as per the Service Bulletins was partially completed.
g) Prior to the incident flight the same crew had operated a flight Delhi-Mumbai-Mangalore and there was no snag reported on the aircraft.
h) For the sector Mangalore-Mumbai (flight AI-680) the Captain allowed the First Officer to perform the duties of the Pilot flying and the Captain was performing the duties of pilot monitoring.

i) ATC Mumbai cleared VT-PPD for ILS approach on Rwy 27.

j) Both the crew followed Standard Operating Procedure (SOP) while approach and landing at Mumbai.

k) The auto pilot was disconnected at MDA by First officer and thereafter aircraft was flown manually.

l) At 40 Ft approximately, the Captain advised the First Officer to reduce the rate of descend and flare following which the crew received synthetic aural alert `RETARD'.

m) The first officer landed the aircraft with throttle levers at Max CLIMB due which the Auto thrust was active.

n) As the Auto thrust was active during landing, the rate of descent was high and the aircraft bounced during landing.

o) After bounce the First Officer increased the pitch to reduce the rate of descent.

p) During the bounce the Captain took over the controls from first officer and brought the thrust levers to IDLE from CLIMB detent. This disconnected the auto thrust.

q) With Auto thrust disengaged, it enabled the extension of all the ground spoilers with the modified SEC. With a strong full back stick input applied just before the second touchdown by the commander rapidly increased the pitch angle and associated with the ground spoiler extension significantly reduced the lift and caused the second severe hard landing.

r) The aircraft vacated the active runway via taxiway 'N8' and taxied the route L1, L to the stand number A7.

s) During post flight walk around inspection the crew observed that the aircraft undercarriage had severe damages on the aft fuselage section.

t) The weather reported at the time of landing was visibility 4000m, wind 09 Knots at 270 degrees and temperature 30^0 C. There was no significant weather change at the time of landing and is not a contributory factor to the incident.

u) There was no injury to any of the occupants on board the aircraft.

3.2 Probable cause of the Serious Incident:

The crew did not initiate the proper corrective actions after first bounced landing which subsequently resulted into tail strike.

The PIC not briefing the First officer prior to landing and not monitoring the First Officer on controls during flare and touchdown was the contributory factor to the incident.

2 SAFETY RECOMMENDATIONS:

1. Tail strike prevention, Supervised take off & landing training should be part of the flight crew recurrent training program of Air India.

Capt. Nitin Anand
Operations Member
Commander A320 Family Aircraft

31/5/16
A X Joseph
Deputy Director AAIB
Investigator In-Charge VT-PPD

Date: 31.05.2016
Place: New Delhi