AIRCRAFT ACCIDENT INVESTIGATION BUREAU

MINISTRY OF CIVIL AVIATION

GOVERNMENT OF INDIA

FINAL INVESTIGATION REPORT ON ACCIDENT TO M/s AIR INDIA EXPRESS B737-800 AIRCRAFT VT-AYD AT TIRUCHIRAPPALLI (TRICHY) ON 11 / 10 / 2018

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 shall be the prevention of accidents and incidents and not 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 interpretation.

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GLOSSARY

AAIB	Aircraft Accident Investigation Bureau, India
ACARS	Aircraft Communication Addressing and Reporting System
AI MUM HF	Air India Operations HF
AME	Aircraft Maintenance Engineer
AMSL	Above Mean Sea Level
AOCC	Airline Operations Control Centre
APP	Approach
ARC	Airworthiness Review Certificate
ATC	Air Traffic Control
ATPL	Airline Transport Pilot License
AUW	All Up Weight
CAM	Cockpit Area Mike
C of A	Certificate of Airworthiness
CAR	Civil Aviation Requirements
CCIC	Cabin Crew In Charge
CFIT	Controlled Flight Into Terrain
CISF	Central Industrial Security Force
CPL	Commercial Pilot License
CTC	Continuous
CVR	Cockpit Voice Recorder
DFDR	Digital Flight data Recorder
DGCA	Directorate General of Civil Aviation
DME	Distance Measuring Equipment
DVOR	Doppler Very High Frequency Omni Range
ETA	Estimated Time of Arrival
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FIR	Flight Information Region
FO	First Officer
FOD	Foreign Object Debris
FL	Flight Level
FRTOL	Flight Radio Telephone Operators License
GP	Glide path
HIRL	High Intensity Runway Lights
hrs	Hours
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IOCC	Integrated Operations Control Centre
ILS	Instrument Landing System
LLZ	Localizer

LT	Local Time
MEL	Minimum Equipment List
MLG	Main Landing Gear
MUM RAD	Mumbai Radar HF
MUM CTRL	Mumbai Control VHF
MUS CTRL	Muscat Control VHF
NDB	Non-Directional Beacon
NOTAM	Notice To Airmen
NM	Nautical Miles
NNC	Non-Normal Checklist.
OBBI	Bahrain International Airport
OEM	Original Equipment Manufacturer
OMDB	Dubai International Airport
OMSJ	Sharjah International Airport
OKBK	Kuwait International Airport
PA	Passenger Address
PAPI	Precision Approach Path Indicator
PDR	Pilot Defect Report
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
QRH	Quick Reference Handbook
RA	Radio Altitude
RDH	Reference Datum Height
RESA	Runway End Safety Area
RTOW	Regulatory Take Off Weight
SB	Service Bulletin
SCC	Senior Cabin Crew
SOP	Standard Operating Procedures
Str. No.	Structure Number
UTC	Coordinated Universal Time
VAPO	Pune International Airport
VFR	Visual Flight Rules
VIAR	Amritsar International Airport
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range
VOCL	Calicut International Airport
VOML	Mangalore International Airport
VOTR	Tiruchirappalli (Trichy) International Airport
THR	Threshold
T/o	Take off
TWY	Taxiway
UTC	Coordinated Universal Time

FINAL INVESTIGATION REPORT ON ACCIDENT TO M/s AIR INDIA EXPRESS LTD.
BOEING B 737-800 AIRCRAFT VT-AYD AT TIRUCHIRAPPALLI (TRICHY) AIRPORT ON 11-10-2018

1.	Aircraft	Type	Boeing 737-800
		Nationality	Indian
		Registration	VT-AYD
2.	Owner		M/s Kai Ting Aircraft LLC, Delaware
3.	Operator		M/s Air India Express Ltd., Mumbai
4.	Pilot – in –Command		ATPL Holder
	Extent of injuries		NIL
5.	Co-Pilot		CPL Holder
	Extent of injuries		NIL
6.	Date & Time of Accident		11-10-2018; 1949 UTC (12-10-2018; 01:19 IST)
7.	Place of Accident		Tiruchirappalli (Trichy) Airport, India
8.	Last point of Departure		Tiruchirappalli (Trichy) Airport, India
9.	Intended landing place		Dubai, UAE
10.	No. of Persons on board		130 Passengers + 06 (02+04) Crew
	Extent of injuries		NIL
11.	Type of Operation		Scheduled Passenger Flight
12.	Phase of Operation		Take off
13.	Type of Accident		Aircraft Hit Boundary wall of airport, Controlled Flight into Terrain (CFIT)
14.	Co-ordinates of Accident Site		Lat 10° 45′ 55.21″ N, Long 78° 42′ 18.51″ E AMSL 260 feet

(ALL TIMINGS IN THE REPORT ARE IN UTC UNLESS OTHERWISE SPECIFIED)

SYNOPSIS

M/s Air India Express, Boeing 737-800 aircraft VT-AYD while operating flight IX 611 Trichy-Dubai was involved in an accident during take-off from Trichy Airport on 11.10.2018 at 1949 UTC.

There were 130 passengers and 06 Crew Members (02 Cockpit Crew & 04 Cabin Crew) onboard the aircraft. The aircraft was under the command of PIC having valid ATPL and Co-Pilot having valid CPL. There was no injury reported to the crew as well as passengers.

The previous sector operated by the crew was Dubai- Trichy, wherein aircraft took off from Dubai at 1447 UTC and landed Trichy at 1832 UTC. The Dubai- Trichy flight was uneventful.

During take-off from runway 27, the aircraft consumed the full length of the runway and continued rolling past the paved surface while initiating take off rotation.

During the take-off roll at 1949 UTC, the PIC seat recline mechanism failed causing the seat back to recline at a speed of 117 knots. The PIC was unsettled and handed over the controls to Co-pilot. The throttle levers and control column moved back inadvertently as the seat reclined. The PIC subsequently adjusted his seat and took back control from the co-pilot and the take off was continued. Neither crew member noticed the reduction of thrust.

Take off rotation was initiated with limited runway remaining and higher than normal control column force resulting in a higher pitch rate causing a tail strike on the soft ground (in RESA). The aircraft then continued to hit 5 units of the localizer antenna and the boundary wall of the airport. The thrust levers were advanced just as the aircraft contacted the boundary wall (25 sec after initial reduction)

The aircraft's main landing gear along with the bottom of the fuselage impacted the localizer antenna and the upper part of the perimeter wall of the airport.

ATC Trichy observed on NAV aids status indicator that ILS localizer indication turned red. The CNS was immediately informed to check the status of localizer and report. Meanwhile, the CISF control room intimated tower duty officer that CISF staff posted near ILS localizer antenna observed that the ILS Localizer antenna and a portion of perimeter wall is damaged as a result of the IX 611 departure. ATC Trichy informed the crew about the CISF staff observation. The crew reported all operations normal and continued the flight toward the destination. Subsequently, ATC Trichy passed the information and confirmed to crew "*While you take off you hit the Localizer and Boundary Wall and Localizer Antenna broken*". Crew reply was "Ok *sir copied thank you"*.

The crew carried out confidence checks in the climb phase by checking their engine instruments, systems indications and recycled the landing gear. All verification checks were observed to be satisfactory by the crew and the crew continued the flight as planned.

While the aircraft was over the Arabian Sea, Air India IOCC contacted the aircraft through ACARS to check whether the flight was progressing normally and if all systems were normal. Once the aircraft was in Muscat Flight Information Region (FIR), Air India IOCC (ACARS), ATC Mumbai (HF) and Muscat ATC Control conveyed to crew that their company requires them to divert to Mumbai.

The crew assessed the fuel requirements and once cleared for a direct routing the crew diverted the flight to Mumbai and landed at 0008 UTC (0538 IST) on 12-10-2018 i.e. 4:19 hrs of flight time after departure from Trichy.

The occurrence was classified as Accident by AAIB as per the Aircraft (Investigation of Accidents and Incidents) Rules, 2017. Director General, AAIB vide its order No. 11011/05/2018-AAIB dated 14th October 2018 appointed an investigation team to inquire into the circumstances of this accident. Mr. Amit Gupta, Director, AED, DGCA was appointed as Investigator- In- Charge and Mr. Dinesh Kumar, Air Safety Officer, AAIB along with Capt. Gaurav Pathak, Jet Airways as Investigator.

The probable cause of the accident is "Delayed take-off due to reduction of take-off thrust N1 from 98 % to 77 % before reaching V1, inability of both the crew members to monitor the thrust parameters and to take timely corrective action. This resulted in tail strike and subsequent hitting of the localizer Antenna and boundary wall of the airport.

Contributory factors:-

- PIC seatback recliner mechanism failure during takeoff roll.
- Breakdown of Crew coordination during switching between PF, PM and back.
- Loss of situational awareness.

1. FACTUAL INFORMATION

1.1 HISTORY OF FLIGHT

On 11.10.2018, Boeing 737-800 aircraft was involved in an accident while operating a scheduled flight from Trichy to Dubai. The flight was under the command of an ATPL holder pilot (Pilot Flying) with a CPL holder pilot as Co-Pilot (Pilot Monitoring). There were 130 passengers and 06 crew on board the aircraft.

Previous Sector:

During the previous sector, both PIC and Co-Pilot operated the flight IX612 sector Dubai Trichy on 11.10.2018. Both pilots reported at Dubai airport at 1725 (LT DXB) and subsequently, underwent pre-flight medical examination at around 1730 (LT DXB).

After clearance from Dubai ATC, aircraft took off at 1447 UTC. The flight from Dubai to Trichy was uneventful and no abnormality or snag was reported/observed by the crew. Aircraft landed at Trichy airport at 1832 UTC. Arrival AME who was rostered on duty, received the aircraft at 1837 UTC in Bay 06. Crew reported aircraft normal. However, during walk around inspection, AME observed that # 2 main wheel assembly was worn out beyond the limits with multiple patches. As per Transit Check, Routine cockpit and cabin checks were carried out. PDR was reviewed and found “Nil Sector Snag”. Main wheel #2 was changed and refuelling was carried out. After pre-departure checks, aircraft was declared serviceable and handed over to PIC. Crew accepted the aircraft at 1925 UTC.

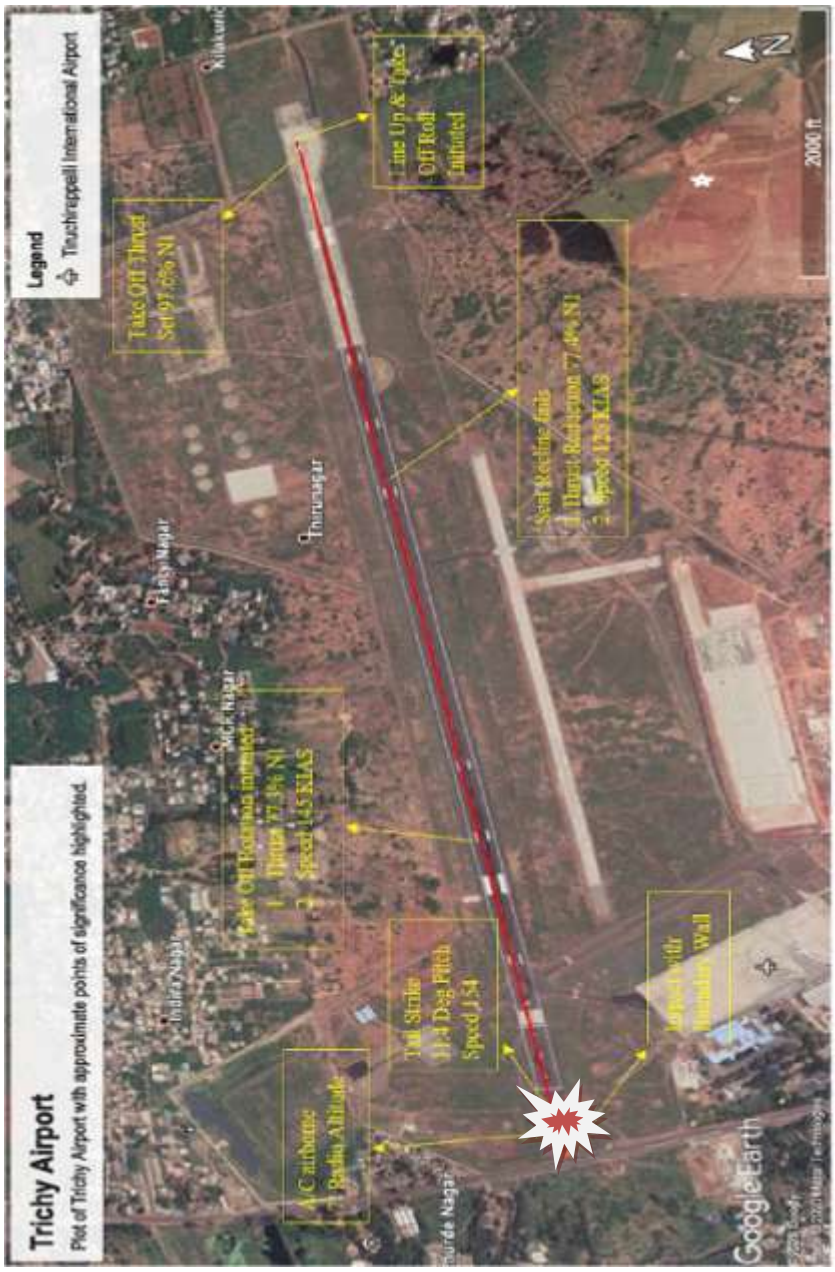
Accident Sector:

As per the statement of PIC, performance was checked for both runways. PIC gave preference to runway 27 as the intercept radial is closer to runway 27 and winds were favourable. The Take Off performance was calculated for the correct aircraft weight, using Flap 5 and the stabiliser trim of 6° pilot units. The Take-off speeds calculated for the above Aircraft configuration and the existing weather conditions using the RTOW charts issued were V1- 143 Kts, VR- 144 Kts & V2- 151 Kts.

The aircraft back tracked and lined up on runway centreline at the beginning of runway 27. All checklists including the Before Take-off checklist were completed prior to commencement of Take-off. Thrust levers were advanced and TOGA was pressed when engine N1 reached 40 %. The PIC called for setting take-off thrust. Co-Pilot checked and verified that the take-off thrust was set and called out T/o thrust set, which was acknowledged by the PIC. When the aircraft speed reached ‘80 knots’, Co-Pilot gave out the call and the PIC cross checked it on his PFD.

PIC stated that during high-speed segment of take-off roll, at around 110-115 knots (as per DFDR it was 117 Knots), his seat recliner collapsed and he lost his balance. Both his hands were

displaced from the control column as well as thrust levers. The DFDR records thrust reduction from 98% to 77%. The PIC immediately handed over the controls to Co-Pilot by calling out loud 'Your Controls' and as per him it took approx. 5 seconds to regain the correct seating position by adjusting collapsed seat recliner. After PIC recovered from the disbalanced position, he looked outside and realised that they are left with last 2000 feet of runway and aircraft still had not attained V1 speed of 143 Kts. The PIC took over the controls while the speed was close to V1 and aircraft was at 1000 feet to go marker, PIC pulled the control column aft to commence the rotation. Crew felt that aircraft rotation was slower and the force required on the control column was higher than normally required. In addition, they also experienced minor vibration during lift off which was described similar to wake turbulence. Once the aircraft was airborne, Co-Pilot called 'positive rate' and landing gear up command was executed. Figure 1 explains the sequence of events during take off phase.



Events during Take Off (Figure 1)

Both cabin crew, stationed at L2 and R2 (rear stations), observed that aircraft acceleration had reduced while it was on take-off roll on the runway and the aircraft took off at a comparatively low height. Further, a thud sound which they perceive was due to baggage shifting in the aft cargo hold, was heard by both cabin crews. They communicated the same to Senior Cabin Crew (L1) after the seat belt sign went off in the cabin.

The duty officer ATC , Trichy observed on NAV aids status indicator that ILS localizer indication has turned red. The CNS was immediately informed to check the status of localizer and report.

CISF security guard stationed near crash gate (P6) heard a sound at around 1950 UTC. Immediately, he passed the message to their control room that it appears that M/s Air India Express aircraft, during take-off, might have touched the boundary wall or fence and some smoke was also observed in the nearby area. Subsequently, the CISF control room intimated ATC, Trichy.

Once the aircraft got airborne and attained 400 feet height, PIC gave call out 'HDG SEL' and same was executed by Co-Pilot, the flaps were retracted, autopilot was engaged and aircraft followed the departure clearance and continued to the climb on track to destination.

At 1954 UTC, Trichy ATC informed crew that "*while departure aircraft crossed at the end of Runway at very low altitude*". ATC asked the crew to confirm all ops normal. Subsequently, crew reported all operations normal.

At 1956 UTC, ATC Trichy passed the additional information to crew that "*Fire Station reported that at the end of Runway 27 compound wall is broken*". Crew transmitted "*OPS NORMAL AXB611*".

NOTAM No. A 2266/18 was issued at 1959 UTC regarding unavailability of localizer facility at Trichy airport.

At 2001 UTC, crew requested ATC Trichy "can you come up with what happened". Crew were apprised that "*while you take off, you hit the localizer and boundary wall and localizer antenna broken*". Thereafter, crew replied that "*ok sir copied thank you*".

The crew requested HAL ATC to level out at FL 210 so that aircraft speed could be reduced up to landing gear operational speed limit and landing gears could be checked for extension & retraction operation. During landing gear operational check, no abnormality was found. The crew also checked the other aircraft systems including pressurisation system, hydraulic system and engine parameters. It was observed that all the systems are normal and engine parameters were within the limits. Crew informed ATC about normal operations and continued their climb.

Once the aircraft reached its cruise flight level of FL360, the crew once again checked the hydraulic system pressure and quantity, Engine parameters and cabin pressurisation. At FL360, crew observed that pressurisation system of the aircraft was able to maintain differential pressure of 7.9 and cabin altitude of around 7000ft, which was normal as per FCOM. Hydraulic pressure and fluid

quantity for both system A and B were checked. Pressure displayed in the cockpit was 3000psi, which was normal. As per the crew, engine parameters were completely normal.

As per the statement of Senior Cabin Crew (SCC), after the seat belt signs were off, cockpit crew called her inside the cockpit to confirm whether they felt any vibration or abnormal noise during take-off phase. The SCC informed the crew that during take-off roll, cabin crew stationed at L2 and R2, heard a thud sound which they perceive as some cargo having shifted as the aircraft pitched up. In addition to this, SCC also passed the information that aircraft speed got reduced once at the time of take-off roll. However, no other abnormality was observed in the Passenger Cabin.

Crew after taking into consideration that no abnormality was observed in any of the aircraft system or parameters and cross verification with SCC on the cabin status, decided to continue the flight to the destination.

At about 2024 UTC, Operator's AME was called on site for inspection. He identified and confirmed that the broken VHF antenna and honeycomb structure debris present near the localizer antenna belongs to their aircraft. Thereafter, AME informed IOCC and briefed that there might be a possibility of severe damage to the aircraft based on his observation of the accident site.

While the aircraft was close to Muscat FIR point -TOTOX, crew were contacted by Mumbai ATC on HF communication and information was passed that M/s Air India Express wants the aircraft to be diverted to Mumbai. Crew checked the fuel and found that fuel available on board for landing was close to diversion fuel to Pune. Crew informed Mumbai Area that they would be able to land at Mumbai only if direct BBB route will be assigned to them. Crew were instructed to standby. Crew continued the flight to Dubai perceiving that if there would be any delay in response from Mumbai Area, in that situation they could have insufficient fuel for diversion.

While the aircraft was near waypoint TOTOX, Muscat ATC established VHF contact with the crew. Muscat ATC informed the crew that their company wants them to divert to Mumbai. The crew assessed the fuel requirements and checked with Mumbai Area for direct routing to BBB. Muscat ATC confirmed that requested route was assigned and aircraft was directed to descend to FL350 and turn for a direct routing to BBB (Mumbai). Figure 2 indicates progress of flight after take off.

Progression of flight after take off (Figure 2)

Communication with the crew after take off (Figure 3)

Crew requested Mumbai ATC for a straight in ILS runway 09 approach with full runway 09 and positioning of firefighting equipment as a precautionary measure on arrival. During approach to Mumbai, landing gears and flaps were extended early to check for normal operations and were found to operate normally.

The aircraft landed on runway 09 at Mumbai airport at 0008 UTC on 12/10/2018, exited via N5 and taxied into bay K6L. Normal deplaning of passengers was carried out and no injury was reported.

1.2 INJURIES TO PERSONS

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	Nil	Nil	Nil
SERIOUS	Nil	Nil	Nil
MINOR	Nil	Nil	Nil
NONE	06	130	Nil

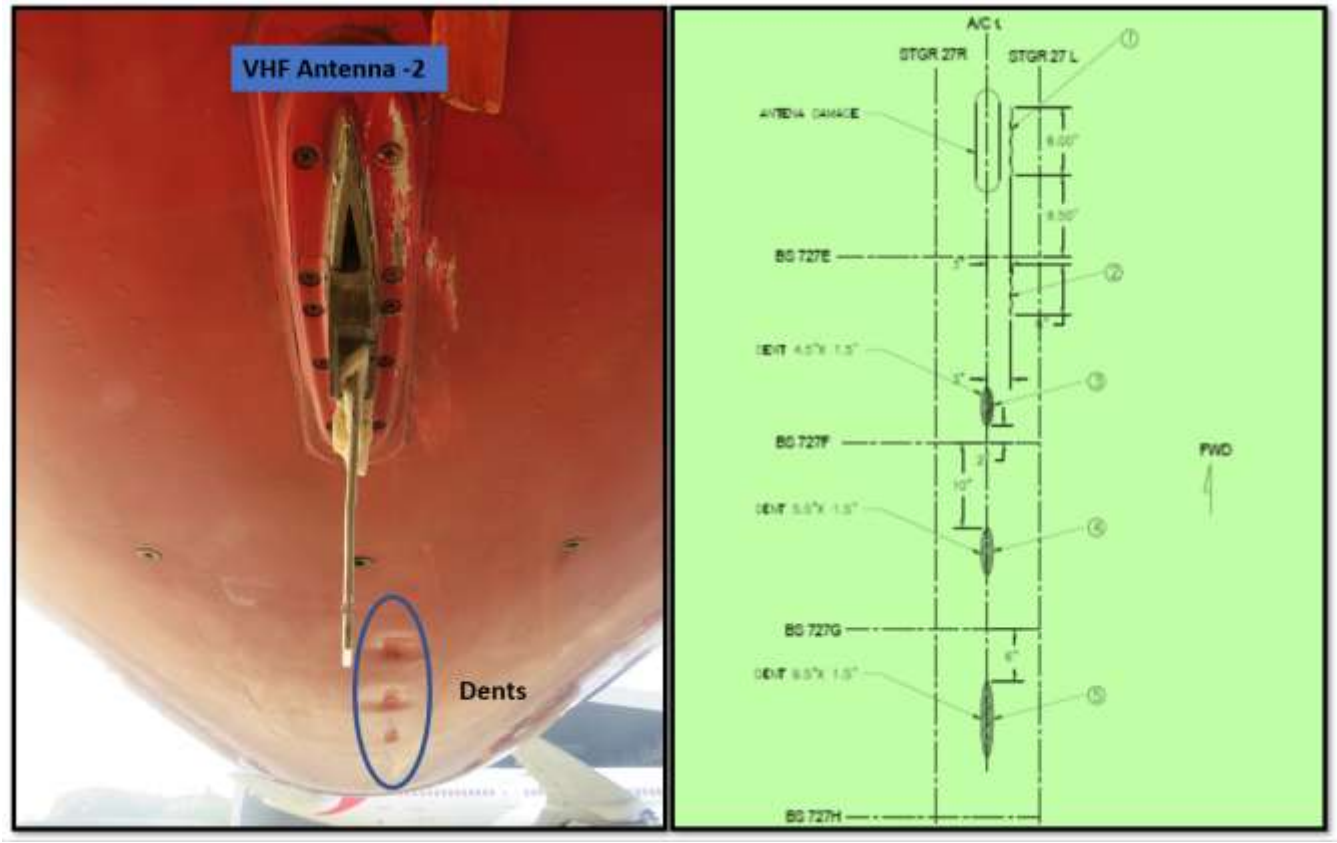
1.3 DAMAGE TO AIRCRAFT

The aircraft received substantial damage due to impact with the Localizer Antenna unit, metal rods holding the Green Plastic Mesh over the Airport Boundary wall and boundary wall of the Trichy airport. After landing at Mumbai, Green Plastic Mesh was found entangled on both Main Landing Gears. Following main damage were found: -

1. Aircraft Lower Beacon was found damaged.
2. VHF – 2 (lower) Antenna found broken at root end.
3. Multiple damages on LH & RH side panels behind aft bulk head of the wheel well noticed.
4. Lower Beacon to VHF lower # 2 Antenna panel was found damaged.
5. At 6 o'clock position on fuselage, dents and scratch marks observed on aft cargo skin.
6. Forward of the aft- cargo around 4 o'clock scratches & dents noticed.
7. LH horizontal stabilizer inboard Leading edge found damaged.
8. Tail skid green & red paint band not visible and scratch marks were present.
9. RH Engine received damages at 6 o'clock at Nose cowl & fan cowl.
10. Aircraft belly was severely damaged (skin ripped off)

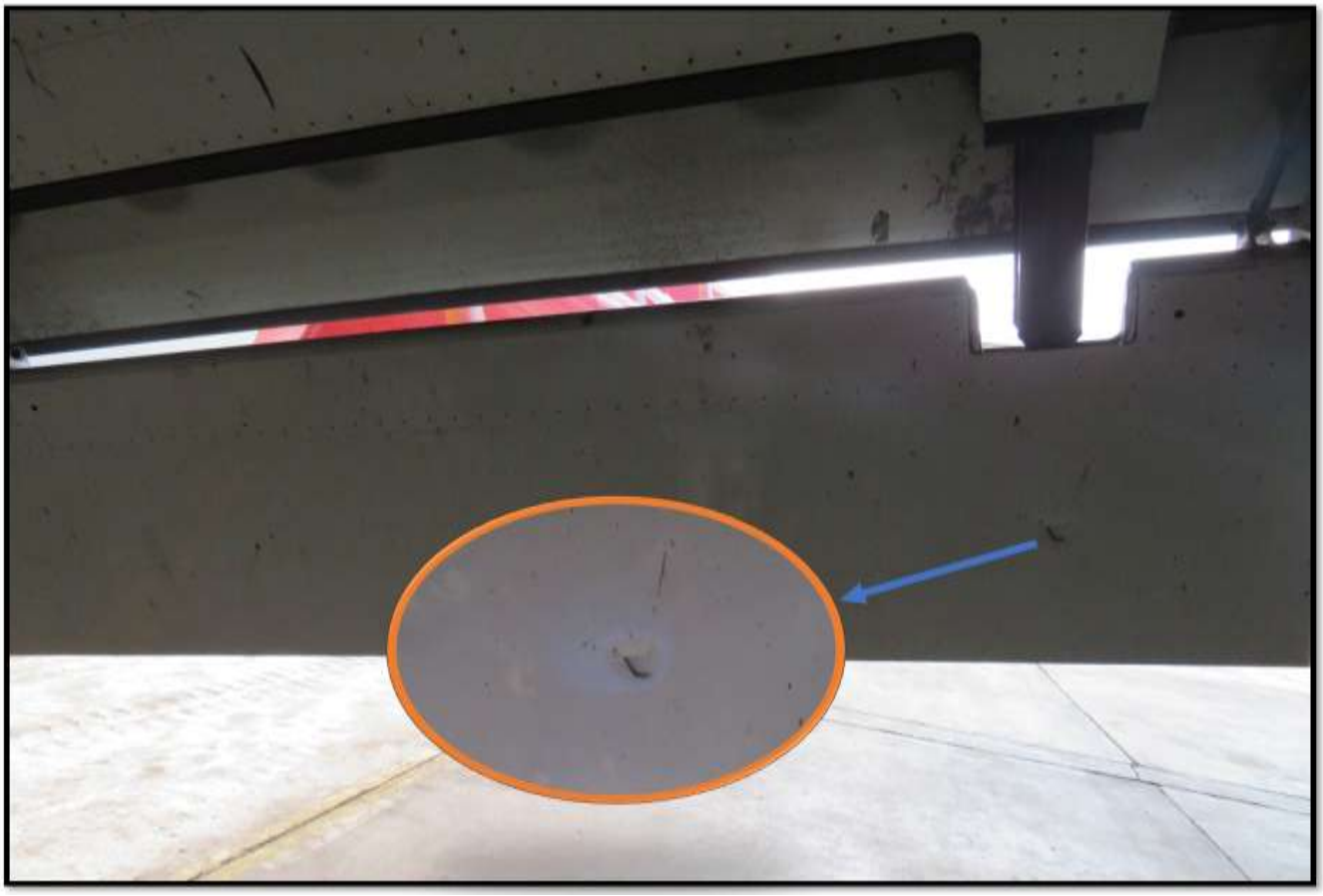
Damage on Lower Beacon & LH MLG Tyre

Damage on aircraft belly

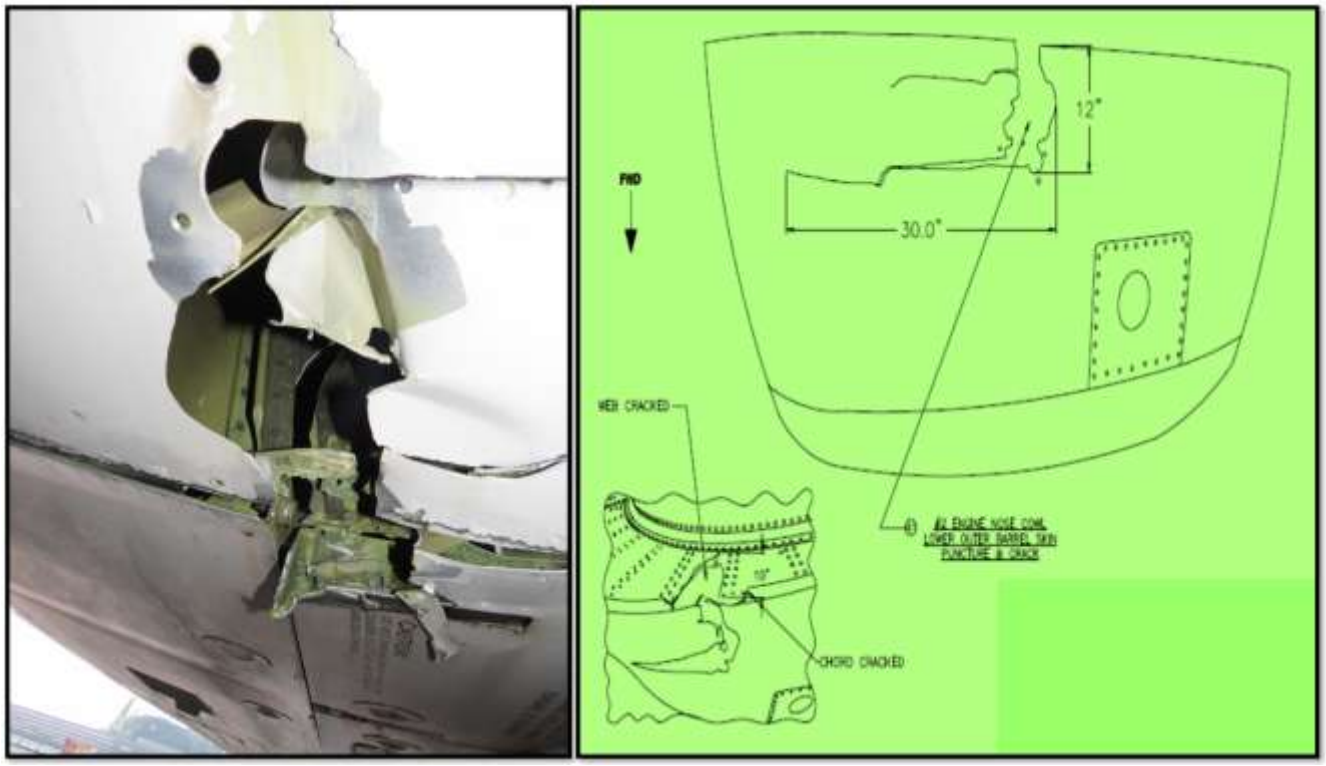


Dents observed on lower aft section of Fuselage

Damage on LH Horizontal Stabilizer



Damage on LH Wing Flap



Damages on # 2 Engine

Detailed view of damages observed on Lower Fuselage Section (aircraft Belly)

A detailed damage assessment on aircraft structure was carried out and following damages were observed on the different sections/stations of the aircraft.

I. **<u>Damages/ Defects on Aircraft Fuselage Skin</u>**

Defect No.	*Name of Defective part*	*Description of Defect*	*Size of Defect*	*Location of Damage*		
				B.S.	*Str. No.*	*Geometric Location*
1	Bottom Fuselage Skin	Dent & Scratch	Length:3.7'' Width:2'' Max.Depth:0.040''	727D-727E	27L-27R	---------
2	Bottom Fuselage Skin	Dent & Scratch	Length:5.57'' Width:2'' Max.Depth:0.040''	727E	27L-27R	0.600'' Aft of BS 727E
3	Bottom Fuselage Skin	Dent & Scratch	Length:6.47'' Width:2.15'' Max.Depth:0.040''	727F	27L-27R	2'' FWD of BS 727F
4	Bottom Fuselage Skin	Dent & Scratch	Length:5.7'' Width:1.45'' Max.Depth:0.230''	727F	27L-27R	9.5'' Aft of BS 727F
5	Bottom Fuselage Skin	Dent	Length:9.0'' Width:2.2'' Max.Depth:0.190''	727G-727H	27L-27R	4'' Aft of BS 727G

6	Bottom Fuselage Skin	Deep Scratch	Length:5'' Max.Depth:0.025''	727J	27R-26R	1.5'' Aft of BS 727J
7	Bottom Fuselage Skin	Dent & Deep Scratch	Length:10'' Width:3.5'' Max.Depth:0.085''	747	27R-26R	6'' Aft of BS 747
7A	Shear Tie	Damaged	---	747	23R-24R	---
7B	Stringer U Clip	Damage	---	747	23R	---
7C	Stringer U Clip	Damage	---	747	24R	---
7D	Shear Tie	Crack	---	747	19R-20R	---
7E	Stringer U Clip	Damage	---	767	23R	---
8	Bottom Fuselage Skin	Dent & Deep Scratch	Length:11.5'' Width:5.5'' Max.Depth:0.070''	747 - 767	27R-27L	7'' Aft of BS 747
9	Bottom Fuselage Skin	Multiple Scratch	Length:4'' Width:3''	787	27L	7.5'' AFT of BS 787
10	Bottom Fuselage Skin	Multiple Scratch	Length:4.25'' Width:2.5''	807	27L	5.5'' Aft of BS 807
11	Bottom Fuselage Skin	Deep Dent	Length:9.74'' Width:1.39'' Max.Depth:0.340''	847-867	27L-26L	5'' Aft of BS 847
11A	Frame Shear Tie	---	---	867	27L-26L	---
12	Bottom Fuselage Skin	Deep Dent	Length:10.5'' Width:3.5'' Max.Depth:0.150''	887	26L-27L	1.5'' Fwd of BS 887(Butt Joint)
13	LH Fuselage Skin	Multiple Scratch	Length:6.3'' Width:1.11'' Max.Depth:0.060''	727H	20L-21L	4.2'' Aft of BS 727H
14	LH Fuselage Skin	Scratch	Length:3.25'' Width:0.56'' Max.Depth:0.065''	772 to 777	21L-22L	5.4'' Aft of BS 767 4.5'' above str.22 L
15	RH Fuselage Skin	Multiple Scratch	Length:21'' Width:6'' Max.Depth:0.045''	727G to 727H	21R-22R	---
16	RH Fuselage Skin	Scratch + Dent	Length:1.5'' Width:4'' Max.Depth:0.060''	727H-727I	20R-21R	7.5'' Aft of BS 727H
17	RH Fuselage Skin	Dent	Length:18'' Width:4.5'' Max.Depth:0.145''	727H-727I	19R-20R	---
18	RH Fuselage Skin	Dent	Length:31'' Width:8'' Max.Depth:0.150''	727J-767	20R-21R	---
19	RH Fuselage Skin	Scratch	Length:18'' Width:3.25'' Max.Depth:0.030''	727J-747	20R-21R	---

20	RH Fuselage Skin	Crease	Length:8'' Width:11''(Circumferential) Max Depth-0.030''	747	22R-24R	---------
21	RH Fuselage Skin	Multiple Scratch	Length:7'' Width:12.5''	767	22R-24R	---------
33	Centre F/L Skin	Deep Scratch+ Dent	Length:20'' Width:6'' Depth:0.190''	727A-727B	27R-27L	---------
33A	Frame Shear Tie	---------	---------	727B	27R-27L	---------

II. <u>Damages on LH Wing Flap and Landing gear door</u>

Defect No.	Name of Defective part	Description of Defect	Size of Defect	Geometric Location of Damage
34	LH Aft I/B T/E Flap Lower Skin	Puncture	Length:6'' Width:4''	From O/B end 8'' and from T/E end 5''
35	LH Inner L/G Door	FWD L/E Portion Sheared off	---------	---------

III. Damages observed on LH Horizontal Stabilizer

Defect No.	Name of Defective part	Description of Defect	Size of Defect	Geometric Location of Damage
36	LH Hor. Stab. Removable LE Panel Bottom Skin (IB Most)	Puncture + Dent	Length:14'' Width:12''	From I/B end 8'' and Starting from Lower Edge of Panel
37	LH Hor. Stab. Front Spar Web	Puncture	3''x3''	4.5'' From Top End of Web. 3.5''O/B from Rib No.2
38	LH Hor. Stab. Removable LE Panel Skin (# 2 From Inboard)	Dent & Loose Rivet	Length:3'' Width:1.5'' Max.Depth:0.050''	From I/B end of Panel and 11''From Lower Edge of Panel
39	LH Hor. Stab. Bottom Skin	Dent	Length:18'' Width:11'' Max.Depth:0.160''	66''From I/B end and 25''From Aft Edge.
40	LH Hor. Stab. Bottom Skin	Dent	Length:4'' Width:3'' Max.Depth:0.115''	22''From O/B end and Starting From T/E Edge

IV. Damages on #2 Engine

Defect No.	Name of Defective part	Description of Defect	Size of Defect	Geometric Location of Damage
41	# 2 Engine Nose Cowl – Lower Outer Barrel Skin	Puncture & Crack	Length:30'' Width:12''	Between 4 O'Çlock to 6 O' Clock (Fwd Looking Aft).
42	LH Fan Cowl	Fwd Lwr Corner Skin Crack	Length:10'' Width:6''	Bottom FWD Side
42-A	LH Fan Cowl-Access Door	Distorted	---------	Bottom Side
42-B	LH Fan Cowl-FWD Latch	Damaged	---------	Bottom Side
43	RH Fan Cowl Skin (FWD)	Bend	Length:13'' Width:3''	Lower FWD Corner

V. Damages on Fairing Support Structure

Defect No.	Name of Defective part	Description of Defect	Size of Defect	Location of Damage		
				B.S.	Str. No.	Location
44	Fairing Support Structure for Fairing193D, Below Keel Beam	Damaged/ Broken	Lateral Length:18''	682	---------	---------
45	Fairing Support Structure for Fairing 193D, Below Keel Beam	Damaged/ Broken	Lateral Length:18''	707	---------	---------

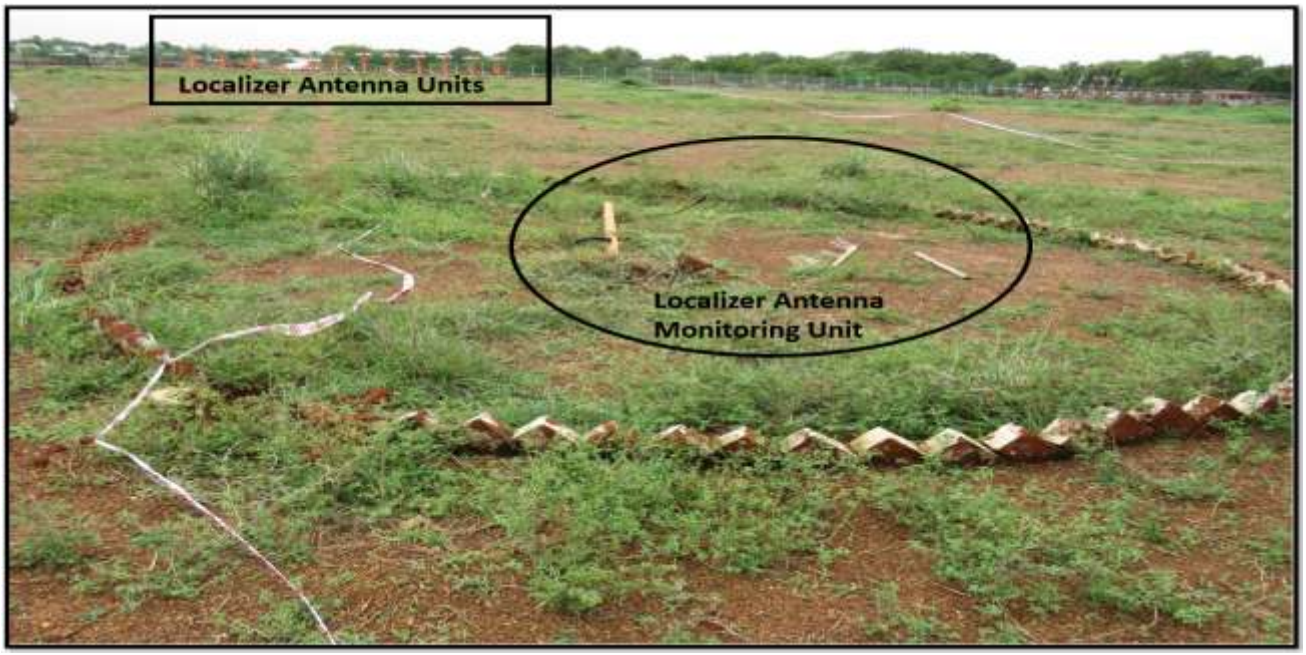
46	Fairing Support Structure	Damaged/ Broken	Lateral Length:30''	727	27L-27R	BL 00
47	Fairing Support Structure	Broken	Lateral Length:24''	727C	27L-27R	---------
48	Fairing Support Structure Chord	Broken	Lateral Length:24''	727B	---------	---------

1.4 OTHER DAMAGES

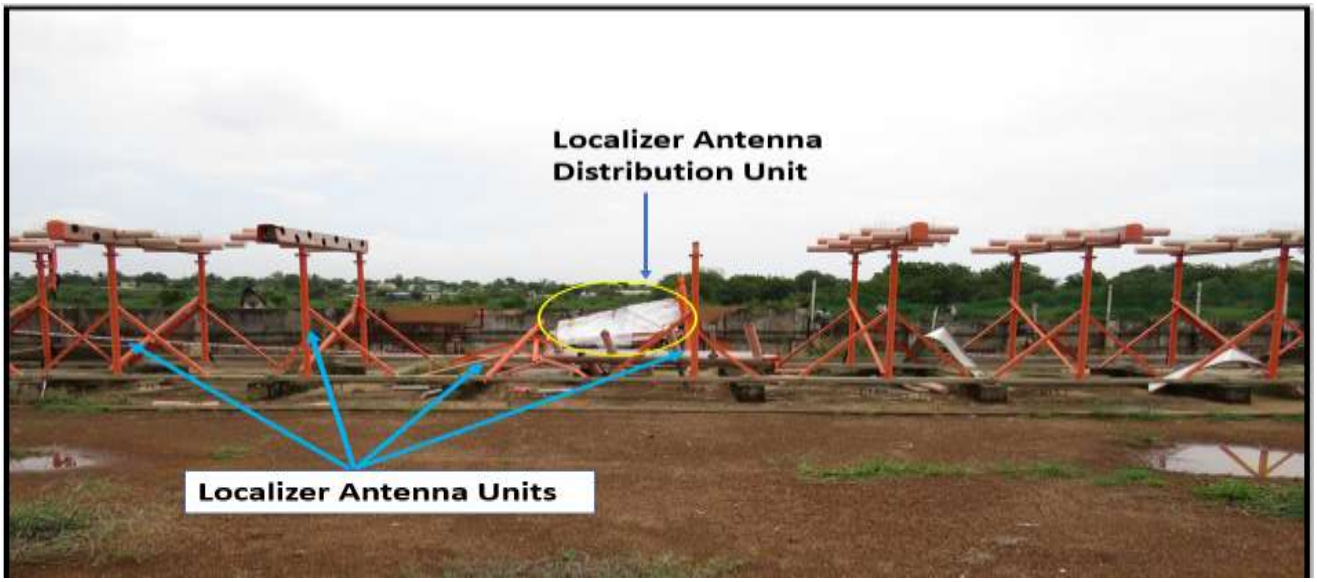
During onsite investigation, following other damages were observed at Trichy airport: -

1. One Runway end light of runway 27 was found damaged.
2. Localizer antenna monitoring unit installed beyond runway 27 on RESA was found damaged.
3. Five (05) units of Localizer antenna installed near the boundary wall of the airport were found damaged.
4. Localizer antenna distribution unit & monitor control unit were found damaged.
5. Airport boundary wall along with the plastic PVC mesh wire which was erected on the airport boundary wall, were found broken at two places.

Broken Runway End Light



Damaged Localizer Monitoring Antenna



Damaged LLZ unit & Distribution unit

Broken Boundary Wall Portion after impact

1.5 PERSONNEL INFORMATION

1.5.1 Pilot – In – Command

Age	32 years
Licence	ATPL Holder
Date of Issue	06.04.2017
Valid up to	05.04.2022
Date of Joining Company	04.10.2010
Category	Airplane
Class	Multi Engine
Endorsement as PIC	Cessna 152 A, Piper Seneca PA -34, B-737-800
Date of Med. Exam	03.05.2018
Med. Exam valid upto	06.05.2019
Issue Date of FRTO Licence	26.08.2008
Valid up to	25.08.2023
Date of Endorsement as PIC on B 737 Type	09.02.2018
Total flying experience	4295:16 hrs
Experience on B 737 Type	4045:16 hrs
Experience as PIC on B 737 Type	542:46 hrs

Flying Experience (in Hrs)

Total flying experience during last 180 days	424:08
Total flying experience during last 90 days	183:04
Total flying experience during last 30 days	70:15
Total flying experience during last 07 Days	15:32
Total flying experience during last 24 Hours	9:25

1.5.2 Co-Pilot

Age	51 years
Licence	CPL Holder
Date of Issue	18.10.1990
Valid up to	27.09.2021
Category	Airplane
Class	Multi Engine
Endorsement as PIC	Pushpak, Cessna 152 A, PA-34
Endorsement as Co-Pilot	B-737-200, B-737-800
Date of Joining Company	Nov 2011
Date of Med. Exam.	04.05.2018
Med. Exam valid upto	05.11.2018
Issue Date of FRTO Licence	18.05.1990
Valid up to	11.07.2021
Date of Endorsement as Co-Pilot on B-737-800 type	21.01.2013
Total flying experience	4204:20 hrs
Experience on type	3884:15 hrs

Flying Experience (in Hrs)

Total flying experience during last 180 days	335:18
Total flying experience during last 90 days	120:39
Total flying experience during last 30 days	33:06
Total flying experience during last 07 Days	17:27
Total flying experience during last 24 Hours	09:25

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

The training records of the PIC were reviewed for the last five years and his performance was rated satisfactory.

Co-pilot training profile was reviewed for the last 05 years.

In the year 2014, it was observed that comments were made regarding inadequate performance in MCP procedures, unreliable air speed, single engine go around and Raw data

flying. The co-pilot was recommended 02 corrective simulator sessions followed by proficiency checks which were carried out satisfactorily.

In 2015, the instructor commented on improvement required for auto flight skills, MCP usage, FMC, understanding of QRH NNC, crew coordination and flying skills. However, the trainer passes the co-pilot in the assessment during IR/ PPC checks. The operations manual part D does not have a process for review in cases where competence issues are raised for a pass assessment. The manual only addresses competency aspects for failure cases.

In subsequent checks upto the date of the accident, there were no adverse comments recorded.

The Co-Pilot had received training for Reject Take Off and Incapacitation of flight crew member in the Simulator.

1.5.3 Crew Combination

PIC and Co-Pilot were based at Mangalore & were operating for the first time together on the Dubai- Trichy- Dubai flight. The first flight Dubai- Trichy IX612 on 11-10-2018 was uneventful. The accident flight Trichy – Dubai Flight No. IX 611 on 11-10-2018 was their 2nd Flight together

The details of Flights Operated by PIC prior to 1 month of accident is as under:

S. No.	Date	From	To	ATD (UTC)	ATA (UTC)
1.	18-09-2018	VOML	OMDB	0304	0712
2.	18-09-2018	OMDB	VOML	0813	1205
3.	22-09-2018	VOML	OMDB	0327	0702
4.	22-09-2018	OMDB	VOML	0809	1157
5.	24-09-2018	VOML	OMDB	1426	1811
6.	24-09-2018	OMDB	VOML	1931	2326
7.	26-09-2018	VOML	OMDB	1423	1829
8.	26-09-2018	OMDB	VOML	1950	2326
9.	28-09-2018	VOML	OBBI	0057	0514
10.	28-09-2018	OBBI	OKBK	0608	0720
11.	30-09-2018	OKBK	VOCL	1106	1609
12.	01-10-2018	VOCL	OKBK	1757	2316
13.	03-10-2018	OKBK	VOML	0800	1243
14.	04-10-2018	VOML	OMDB	1446	1846
15.	04-10-2018	OMDB	VOML	1943	2326
16.	09-10-2018	VOML	OMAA	1535	1927
17.	09-10-2018	OMAA	VOML	2026	0002
18.	11-10-2018	OMDB	VOTR	1425	1837

The details of Flights Operated by Co Pilot prior to 1 month of accident is as under:

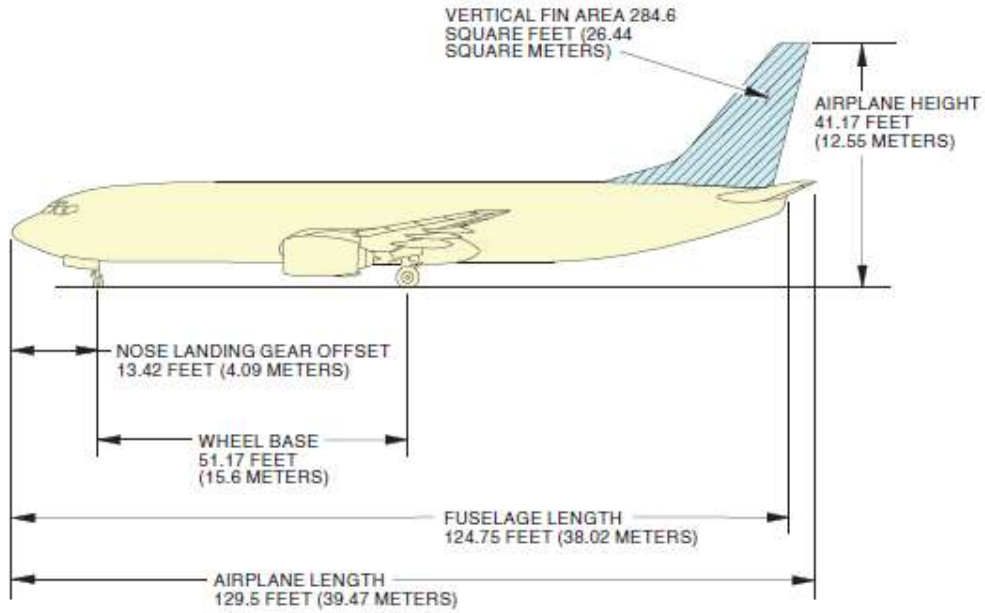
S. No.	Date	From	To	ATD (UTC)	ATA (UTC)
1.	10-09-2018	VOTR	OMDB	1955	2357
2.	12-09-2018	OMDB	VIAR	0518	0847
3.	12-09-2018	VIAR	OMDB	0941	1308
4.	14-09-2018	OMSJ	VOTR	1654	2121
5.	15-09-2018	TRZ	OMSJ	2209	0219
6.	05-10-2018	VOML	OMDB	0334	0719
7.	05-10-2018	OMDB	VOML	0820	1150
8.	07-10-2018	OMDB	VAPO	0603	0904
9.	07-10-2018	VAPO	OMDB	1015	1327
10.	11-10-2018	OMDB	VOTR	1425	1837

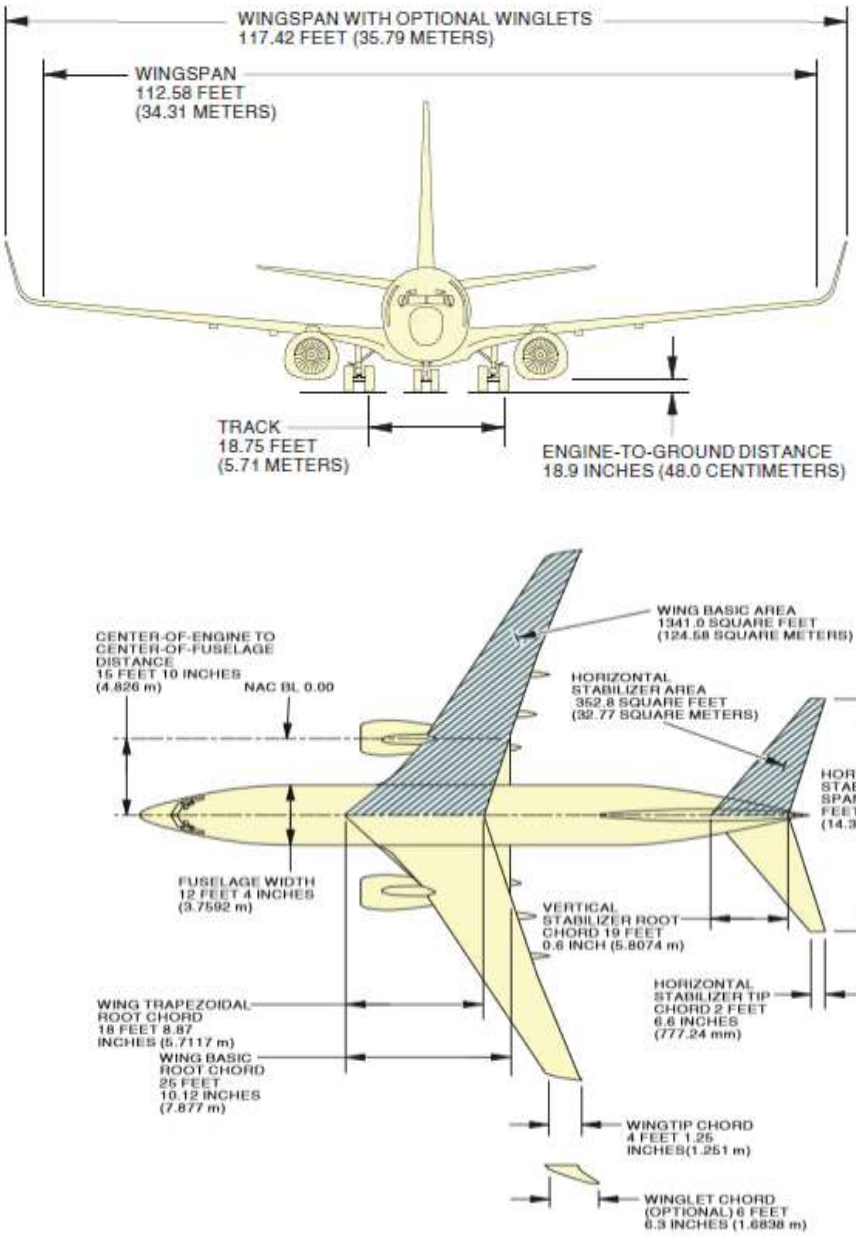
PIC had operated 14 sectors and Co-Pilot operated 12 sectors from Trichy Airport during last 1 year. PIC operated last flight from Trichy on 17-05-2018 and Co-pilot operated last flight from Trichy on 10-09-2018.

1.6 AIRCRAFT INFORMATION

1.6.1 General Description

The airframe structure is fabricated, in general, of high-strength aluminum alloys. Steel, titanium, and other approved materials are also used where required. Aluminum alloy sheet stock are clad for gages less than 0.063 inch thick. The fuselage is a semi-monocoque structure with zee-type frames and skin stiffened with hat-type stiffeners. The fuselage skin panels are made of longitudinal stiffeners mechanically fastened to sheets or plates. Circumferential tear straps and doublers are used where necessary. A nacelle encloses each engine. A strut attached to the wing holds the engine and nacelle.





Aircraft View and Dimensions

Boeing 737-800 is a twin-engine aircraft fitted with CFM 56-7B Engines which are manufactured by CFM. The aircraft is certified in Normal category, for day and night operation under VFR & IFR. The maximum operating altitude is 41000 feet and maximum take-off weight is 79,015 Kgs. The Maximum Landing weight is 66,360 kg. Aircraft length is 129.59 feet (39.50 meters), wingspan is 117.42 feet (35.79 meters) and height of this aircraft is 41.17 feet (12.55 meters). Distance between main wheels is 18.75 feet (5.71 meters), distance between engines is 30 feet 20 inches (9.652 meters) and Engine Ground clearance is 18.9 inches (0.48 meters). This airplane is certificated in the Transport Category, FAR Part 25 and Part 36.

The aircraft was certified for 186 passengers and is configured for 186 all economy-class passengers' seats. At the time of accident, there were 130 passengers on board the aircraft.

1.6.2 Aircraft Technical Information

Name of Owner	M/s Kai Ting Aircraft LLC, USA
Name of Lessor	M/s Munster Aviation Leasing Ltd, Irish
Name of Operator	Air India Express
Lease Valid up to	07.10.2021
Aircraft Type	B737-800 HG
Registration Marking & S. No.	VT-AYD, MSN: 36340
Model	B737-85R
Date of Manufacture	June 2009
Date of Arrival in India	Dec 2009
Certificate of Registration No.	4056/3
Validity of Certificate of Registration	07.10.2021
Certificate of Airworthiness No.	6165
Validity of Certificate of Airworthiness	Unlimited (subject to validity of ARC)
C of A Category	Normal
C of A Sub Division	Passenger/ Mail/Goods
Date of Issue of ARC	15.12.2017
ARC was valid	14.10.2018
Total Flying Hrs / Cycles since manufacture as on 11.10.2018	FH: 29719:26 Hrs FC: 10023 Cycles
The last major check/inspection carried out on the aircraft	Check-66 (33000 FH/ 3960 days/13200 FC) Carried out at 29621:48 Hrs/ 9992 cycles at Mumbai on 04.10.2018
Type of Engine	CFMI CFM56-7B27
Left Engine (#01) serial number and hrs/cycles logged on the day of accident	ESN # 897249 FH: 30797:01 Hrs. FC:10683 cycles
Right engine (#02) serial number and hrs/cycles logged on the day of accident	ESN # 802727 FH: 25909:54 Hrs. FC: 8575 cycles
Aero Mobile license Number	A-016/007/WRLO-10
Last Weighted on with approved weight schedule	11.11.2014
Maximum Take-off weight	79015.00 Kgs
Aircraft Empty Weight	42455.19 Kgs
Maximum Usable fuel Quantity.	20427.35 Kgs.
Maximum payload with fuel tanks full	15110.26 Kgs
Empty weight CG	16.75 meters aft of datum
Datum (from forward of front spar)	540 inches or 13.716 m

The CG at take-off was 19.88 % MAC (Mean Aerodynamic Chord) and Stabilizer trim for take-off was calculated as 6.0° pilot units.

The aircraft and its Engines were maintained as per the maintenance programme consisting of calendar period/ flying Hours or Cycles based maintenance as per maintenance programme approved by Regional Airworthiness office, Kochi.

After the flight IX 612 Dubai- Trichy, the aircraft was parked at Bay 06. No MEL was revoked or invoked at Trichy airport and there was no entry in PDR. During routine inspection by AME, it was noticed that No. #2 Main Wheel was worn beyond limits with multiple patches. Thereafter, the wheel was replaced with a serviceable one and aircraft was released to service.

After the accident, both Engines performance was checked in consultation with CFM and it was established that there was no abnormal performance degradation in any engine.

1.6.2.1 Details of Crew (Pilot & Co-Pilot) Seat

Seat Construction

The crew seat is of advanced ergonomic design which allows the seat to perform efficiently in the aircraft, whilst providing maximum long term comfort and free movement of the occupant. The seat base structure is of light weight construction comprising aluminium alloy machined parts and panels. The assembly comprises two basic structures: the upper structure containing the adjustable thigh supports, adjustable armrests, and controls to adjust back cushion recline and lumbar support; the base structure containing the controls to adjust horizontal and vertical positions. The seat is either left or right hand (Captain or First Officer) dependent upon the positioning of the horizontal control, vertical control, recline control lever, and thigh support control. A headrest is fitted as standard to the seat and is attached to the backboard.

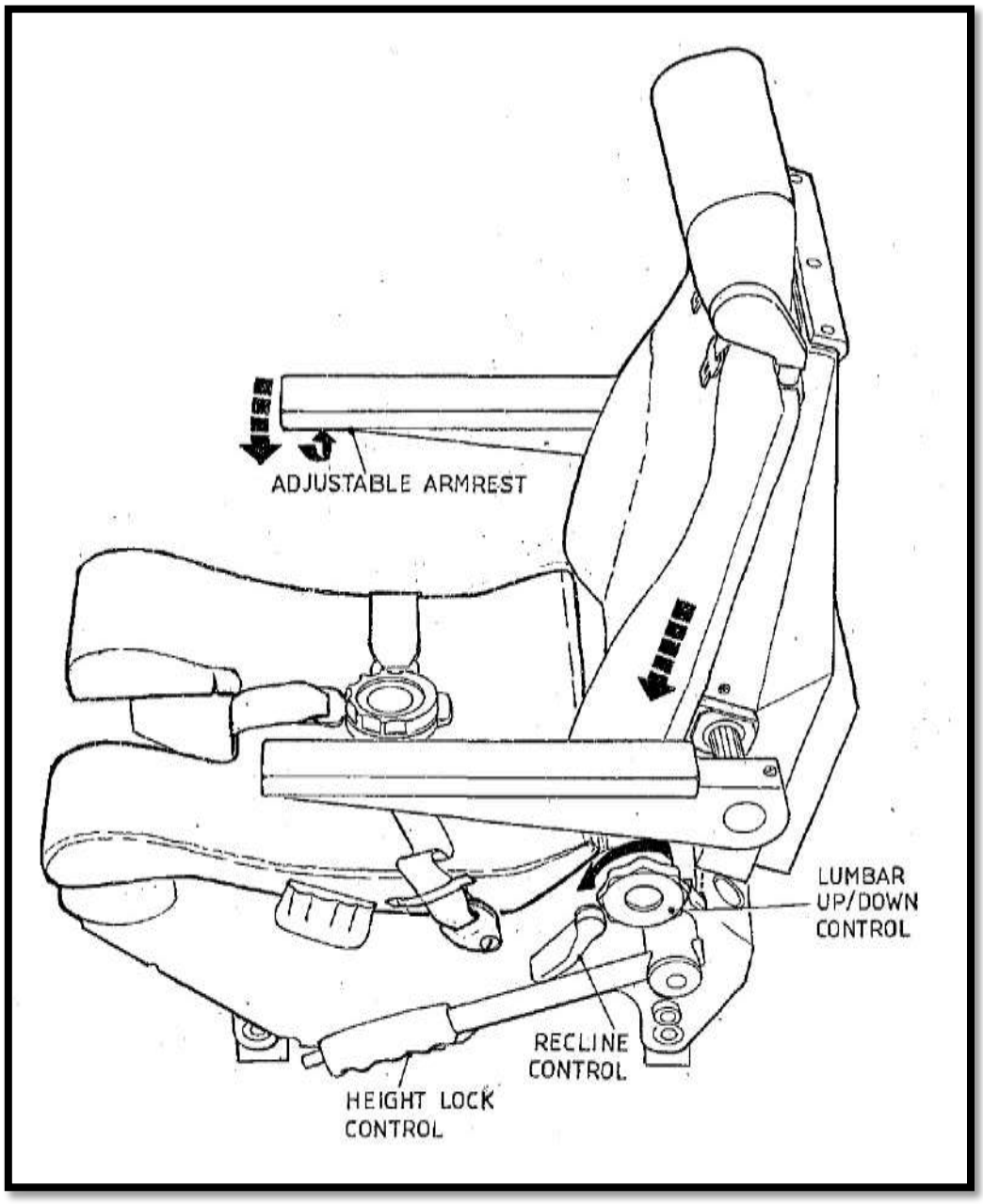
This Structure houses the mechanism for vertical and horizontal adjustment, and the controls for both functions. Four bogie Assemblies retain the base to the aircraft seat tracks and prevent lateral movement. Rollers located within each bogie Assembly assist the freedom of movement when adjusting the fore and aft location. A positive spring-loaded track lock mechanism prevents fore and aft movement on the seat tracks. The structure houses all mechanism and controls for the adjustment of seat recline, thigh pad pressure, back cushion in/out and up/down movement. The armrests are padded and individually adjustable, and may be folded back towards the seat back structure when not required. The restraint system inertia reel is attached to the rear of the seat back structure. The lap straps and crotch strap are mounted on the seat pan. A life jacket stowage is provided at the rear of the back structure.

The details of Involved Pilot Seat is as under

- **Seat part number –** 3A296-0007-01-1
- **Serial number –** 43046
- **Name of manufacturer -** M/s IPECO Holdings Ltd, United Kingdom
- **Date of manufacture –** 17th February 2005

- **Date of installation on aircraft VT-AYD**: 21.04.2018
- **Date of last Weekly Check (75FH / 07Days)**: 09.10.2018 at Mangalore
- **Flight Cycle Time since new**: 36882 FH/13012 FC
- **Time since installation on VT-AYD**: 2267 FH/678 FC
- **Time since last weekly check**: 43 FH/13 FC
- **Any defect reported since installation**: Nil
- **Any Maintenance History with Seat OEM**- Nil

Pilot Seat



The involved P1 seat was earlier installed on the aircraft VT-AXI and was installed on VT-AYD on 21-04-2018 as the existing P1 seat P/No. 3A296-0007-01-1 s/ No. 58788 vertical handle push button was broken.

1.6.2.2 SEAT RECLINE CONTROL

The RECLINE unit is located between the base of the seat back structure and the underside of the seat pan, and is operated by the RECLINE control.

When the RECLINE control is raised, a relay shaft rotates and linkage withdraws a spring loaded latch plate from contact with a coarse threaded nut within the recline unit. The application of pressure on the seat back pushes a threaded strut against a spring and through the threaded nut which turns in response to the threaded strut, the spring is then compressed and the seat reclines.

When the RECLINE control is released, the spring loaded latch plate re-engages the nut and the seat back structure is locked in position. If the RECLINE control is raised again and pressure is released from the seat back, the spring which was compressed re-asserts itself. The action of the spring causes the nut to turn in the opposite direction, the threaded strut pushes on the base of the seat back structure which returns to an upright position. On release of the RECLINE control the seat back is locked in position.

The subject P1 seat assembly of accident aircraft VT-AYD is the original installation and never visited shop and hence no record in the History Card held at Shop Facility.

The recline and vertical mechanism (operation and locking) is part of seat assembly itself, the locking of horizontal movement of the seat is on the seat track which is mounted on the flight deck floor.

There is no maintenance task in the MPD as such to inspect the seat recline and vertical mechanism but the inspection of seat track and locking mechanism for wear, condition and security. The inspection and operation of seat harness, shoulder harness are in the MPD Task no 25-010-01, 25-010-02 with 7500 FH as threshold and interval and 25-020-00 and 25-030-00 with 7000 FH as threshold and interval.

The inspection of Captain's and First Officer's seat operation is listed in Transit Check and Weekly Check Schedule in accordance with AMP Section 7, Paragraph 4, item 4.7.

As per pt. 4.7 of Air India Express Aircraft Maintenance Program Transit/ weekly check schedule (75 Hrs/7 Days) “check condition, security and correct operation of P1 and P2 and observer seats, seat belts and shoulder harness”. As per pt. 4.9 “Clean control cabin floor, control pedestal and areas adjacent to P 1 and P2 seats*”.*

The last Weekly Check (75FH / 07Days) was carried out on 09.10.2018 at Mangalore. After the inspection, the aircraft operated 12 flights totalling 39.30 hours before the accidented flight.

As per Boeing 737-800 Maintenance Planning Document (MPD) following checks were required to be carried out at 7000 Flight Hours (FH). The same was carried out at 25799 FH / 8843 FC on 12-09- 2017.

1) Inspect (detailed) the captain, first officer, first observers, and second observer (if installed) seat harnesses, crotch straps and shoulder belts (as applicable) for wear, condition and security. (25-020-00)

2) Operationally check the captain, first officer, and the first observer seat harness inertia reels.(25-030-00)

Following Checks were carried out 7500 Flight Hours. The same was carried out at 27189 FH / 9266 FC on 31-03-2018.

1) Inspect (detailed) the Captains seat tracks and locking mechanism for wear, condition and security. (25-010-01)

2) Inspect (detailed) the first officers seat tracks and locking mechanism for wear condition and security.(25-010-02)

The inspection and maintenance process is detailed in the Seat Component Maintenance Manual CMM 296 SM654 (25-11-39). As per record submitted by Air India Express, there were no failure of Seat Recliner during year 2016- 2018 (Oct). However, there were 02 incidents of Seat Recliner inoperative of Co- Pilot Seat in 2019 and 01 incident Seat Recliner Inoperative of Co-pilot in 2020. MEL was invoked and the affected seats were replaced.

The Pilot & Co-Pilot Seat Recline mechanism is under MEL Category 'A' .i.e. items in this category shall be repaired within the time interval specified in the remarks column of the MEL. The MEL dispatch procedure requires the seat to be secured in a position acceptable to Crew Member.

1.6.2.3 TESTING & FAULT ISOLATION

The testing & Fault Isolation of Recline Unit is to be carried out as per CMM 25-11-39.

For testing operate the RECLINE control and check the following

i. The seat can be fully reclined and will recover to the upright position, when the pressure is removed from the back cushion.

ii. The recline unit will lock the seat back in any position of its travel, when the RECLINE control is released.

For Fault Isolation of RECLINE, following actions were carried out.

FAULT	POSSIBLE CAUSE	ACTION
SLUGGISH IN OPERATION	STIFF RECLINE UNIT DRIVE NUT	LUBRICATE
LOOSE IN OPERATION	BROKEN RETURN SPRING	REPLACE
LEVER HAS FREE MOVEMENT	CABLE OUT OF ADJUSTMENT	REMOVE PLAY

1.6.2.4 LOCATION OF PRIMARY FLIGHT DISPLAY (PFD) & ENGINE INSTRUMENT DISPLAY

One Primary Flight Display (PFD) is installed in front of each PIC & Co-Pilot for indication of GS Ground Speed, Vref, Vr,V1,Green flap speeds, Magenta selected speeds, ILS / DME read / IDENT, FMA,AP on/off, Magenta selected Altitudes, Altimeter tape, VS indicator, Green mins Baro bar, Current Altimeter setting, LOC & GS scales.

A Primary and Secondary Engine display unit is situated at the middle of the central pedestal which can be viewed by both Pilot & Co-pilot. N1 and EGT are the primary Engine Indications on the upper display Unit & N2, Fuel Flow, Oil Pressure, Oil Temperature, Engine Vibrations and Fuel Quantity are displayed on the lower display unit.

The Pilot Flying (PIC in this case sitting on Left hand side) is required to have one hand on control column and other hand on throttle lever for takeoff before rotation speed. Once the rotation speed is achieved, PIC moves hand from the thrust levers and places both hands on the control column and pull the control column aft for rotation.

Cockpit Layout Boeing 737-800

1.6.3 The B737 Auto Throttle System

The B737 Auto throttle system provides automatic control from the start of Takeoff through landing. The system consists of a separate servo motor on each thrust lever. The thrust levers are moved to set the computed thrust settings except in "THR HLD" (Throttle Hold) and "ARM" modes. For both these modes the Autothrottle servo motors would not move the thrust levers.

Autothrottle System

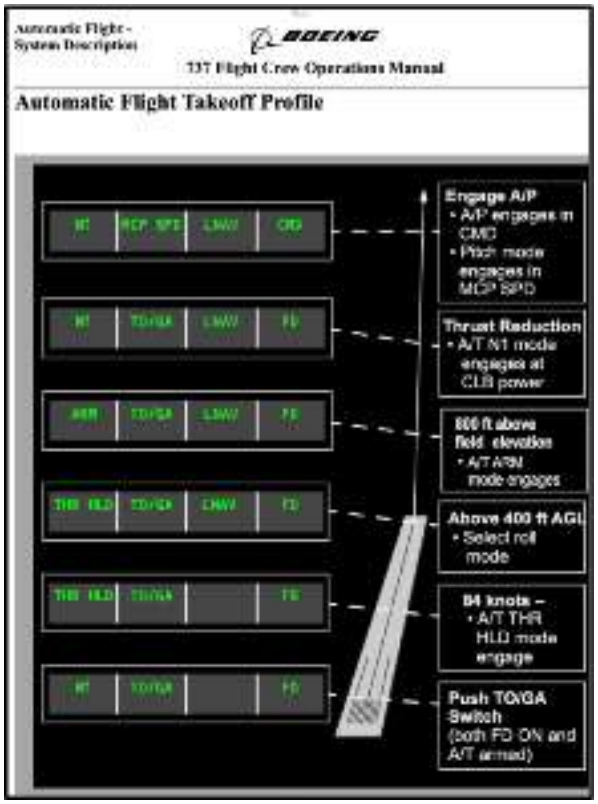
The A/T system provides automatic thrust control from the start of takeoff through climb, cruise, descent, approach and go around or landing. In normal operation, the FMC provides the A/T system with N1 limit values.

The A/T moves the thrust levers with a separate servo motor on each thrust lever. Following manual positioning, the A/T may reposition the thrust levers to comply with computed thrust requirements except while in the THR HLD and ARM modes.

The A/T system operates properly with the EECs ON or in ALTN. In either case, the A/T uses the FMC N1 limits. During A/T operation, it is recommended that both EECs be ON or both be in ALTN, as this produces minimum thrust lever separation.

Take Off segment features for the Auto-throttle

At the beginning of take-off, once the TOGA switches are pressed, the auto throttle would position the thrust levers to the computed take-off thrust entered in the FMC. At 84 Knots on Takeoff the autothrottle will revert to THR HLD function and will not position the thrust levers. (Fig 2) The autothrottle will engage in N1 mode once the aircraft has climbed 800'.



1.6.4 Engine Performance

After reviewing performance parameters for both engines on the aircraft, CFM confirmed that there was no abnormal performance degradation and both engines may be further utilised for flying operations.

1.6.5 Aircraft Weight & Balance

The aircraft was last weighed on 11th Nov 2014 at Trivandrum, India and the weight schedule was prepared and duly approved by the DGCA at Delhi. On the day of accident, Computerized Load & Trim sheet was prepared for the flight. The details of basic weight schedule are as follows:-

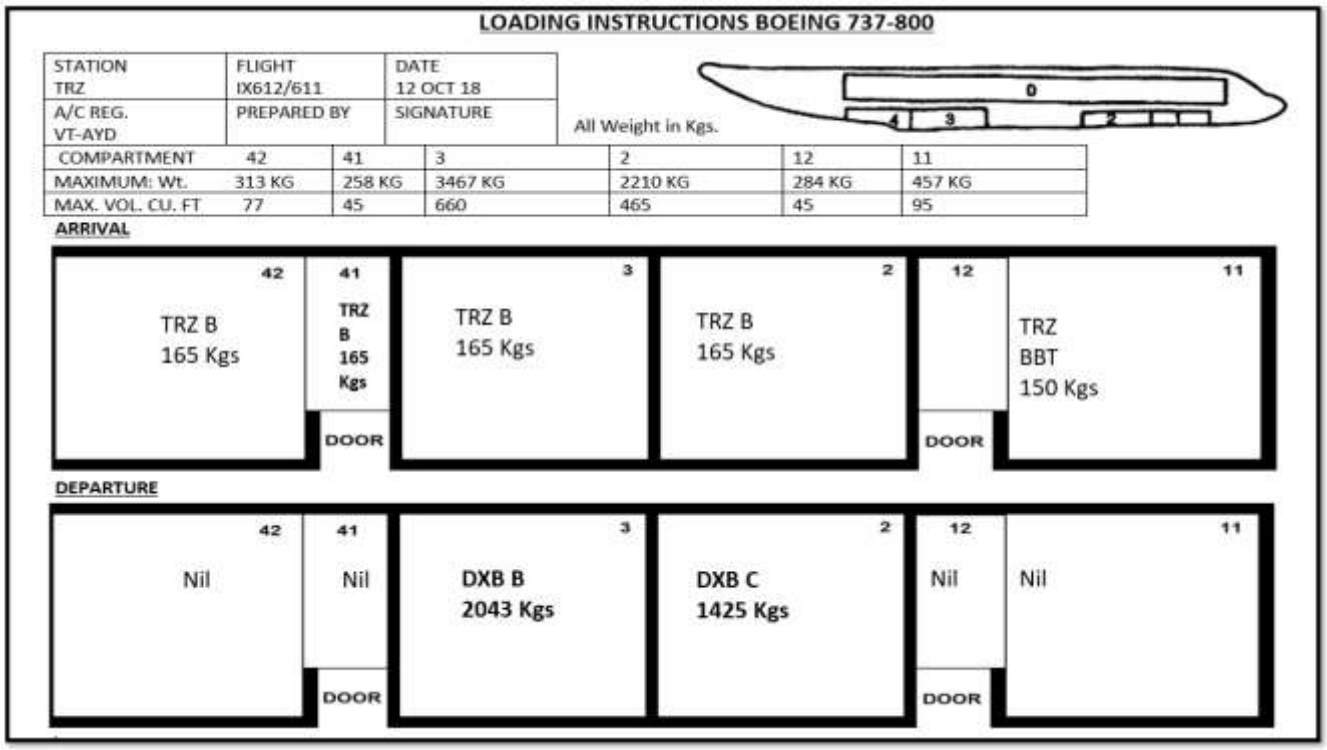
Weight	Actual Weights for Flight on 11-10-2018 in Kgs	Maximum Permissible weight in Kgs
Take-off Weight	71434	79015
Zero fuel Weight	57534	62731
Landing Weight	60734	66360

There were total of 130 Passengers (127 Person + 03 Infants) on board the aircraft. To facilitate the calculation of the centre of gravity (CG) position, the passenger cabin is divided into four zones: 0A, 0B, 0C & 0D. Passenger's actual seating for the Trichy Dubai flight is tabulated below:-

Zone	**Actual Seating**
0A	29
0B	33
0C	33
0D	32

The aircraft has two lower cargo compartments for Baggage & Cargo. A forward cargo compartment, which is divided in hold #1 and hold #2 and an aft cargo compartment consisting of hold #3 and hold #4. The total baggage load for the flight was 3468 Kgs (147 Pcs /1425 Kgs cargo in Hold 2 & 150 Pcs /2043 Kgs in Hold 3) & Passenger load was 9624 Kgs. Total Traffic load calculated was 13092 Kgs.

A total of 2043 Kgs of baggage and 1425 Kgs of cargo was loaded in the middle section 3 and 2 respectively. It has been established that the aircraft was loaded in accordance with the company's laid down procedures for the sector Trichy-Dubai and cargo & baggage weight was particularly concentrated in the middle section. Furthermore, no load was contained in the aft section of the aircraft.



Baggage & Cargo Loading

Dry Operating weight for the flight was 44442 Kgs. Take off fuel was 13900 Kgs, Trip fuel was 10700 Kgs. And the Aircraft was under load (could carry an additional) of 4066 Kgs.

Fuel uplifted at Trichy was 11945 Ltrs (9269 Kg) by HP aviation and total fuel at the time of take-off was 14200 Kgs. The Fuel at the time of Diversion, at 2256 UTC on 11-10-2018, was 5895 Kgs and at the time of landing at Mumbai, at 0008 UTC on 12-10-2018, was 2953 Kgs.

1.7 METEOROLOGICAL INFORMATION

The accident occurred at 1949 UTC and the METAR of 1930 hours UTC (after sunset) was applicable at the time of accident. As per the METARs issued for Trichy, following meteorological conditions existed.

Time in UTC	Wind Direction	Wind Speed (K)	Vis (m)	Clouds	Temp (° C)	Dew Point (° C)	QNH	Weather
1900	Calm	00	5000	FEW018 SCT 100	28	25	1008	NOSIG
1930	Calm	00	5000	FEW018 SCT 100	27	24	1008	NOSIG
2000	Calm	00	5000	FEW018 SCT 100	27	24	1008	NOSIG

1.8 AIDS TO NAVIGATION

Trichy airport is equipped with following Navigational and Landing Aids: -

Type of aid CAT of ILS/MLS (For VOR/ILS/MLS, give VAR)	ID	Frequency	Hours of Operation	Site of transmitting antenna	ELEV of DME transmitting antenna	Remarks
NDB	TR	307.0 kHz	As ATS	104541.0 N 0784306.0 E	….	…..
LLZ 27	ITCY	110.9 MHz	As ATS	104555.2 N 0784217.9 E	….	ILS CAT-1
DME	…..	1102/ 1165 MHz	H24	104544.7 N 0784248.2 E	311 FT	Collocated with VOR
DME (ILS)	ITCY	1070/ 1007 MHz	As ATS	104557 N 0784333 E	371 FT	Collocated with GP27
DVOR	TTR	113.1 MHz	H24	104544.7 N 0784248.2E	…….	……
GP27	….	330.8 MHz	As ATS	104557 N 07843.33 E	113 M AMSL	3°, RDH 50 FT

Navigation and Landing Aids at Mumbai Airport

Mumbai airport is equipped with VOR (frequency 116.60 MHz), DME (frequency 1200/1137 MHz), NDB (frequencies 396 kHz), ASDE (frequency 9375 MHz). PAPI & ILS Cat- II is installed on Runway 27. PAPI &ILS Cat-I is installed at 09 & 14 and SALS is installed at Runway 32.

1.9 COMMUNICATIONS

ATC Trichy

The aircraft was in positive contact with the Trichy ATC on frequency 118.3 MHz. From the tape transcript, it is apparent that there was always two-way communications between the Flight Crew & ATC. Crew maintained positive communication with Trichy ATC.

Following are the salient observations from Trichy Tape transcript:-

Time (UTC)	*FROM /TO*	*Tape Transcript Description*
19:35:21	AXB611/APP	TRICHY AXB611
	APP/AXB611	AXB611 TRICHY
	AXB611/APP	READY TO PUSH AND START
19:35:45	APP/AXB611	ROGER PUSHBACK APPROVED FACING NORTH AFTER COMPLETION OF PUSHBACK STARTUP APPROVED RWY 27
19:47:48	APP/AXB611	AXB611 RWY 27 CLEARED FOR TAKE OFF WIND CALM
19:51:59	APP/AXB611	AXB611 TRICHY AIRBORNE 49 REPORT ESTABLISH R340TTR
19:54:00	APP/AXB611	AXB611 TRICHY WHILE DEPARTURE YOU CROSSED AT THE END OF RWY AT VERY LOW ALTITUDE CISF REPORTED CONFIRM ALL OPS NORMAL
19:55:04	AXB611/APP	FURTHER CLIMB AXB611
	APP/AXB611	AXB611 TRICHY RECLEARED F200
	AXB611/APP	RECLEARED F200 AXB611
19:56:44	APP/AXB611	AXB611 TRICHY
	AXB611/APP	GO AHEAD AXB611
	APP/AXB611	FIRE STATION REPORTED THAT AT THE END OF RWY 27 COMPOUND WALL IS BROKEN
19:57:00	AXB611/APP	COPIED AXB611
	AXB611/APP	OPS NORMAL AXB611
	APP/AXB611	ROGER REPORT IN CONTACT WITH HAL 127.7
	AXB611/APP	CALL YOU IN CONTACT WITH HAL AXB611
19:58:31	AXB611/APP	TRICHY AXB611 IN CONTACT WITH HAL
	APP/AXB611	AXB611 TRICHY ROGER FREQUENCY CHANGE APPROVED GOOD DAY
	AXB611/APP	THANK YOU SIR
20:01:36	AXB611/APP	TRICHY AXB611
	APP/AXB611	AXB611 TRICHY
	AXB611/APP	CAN YOU COME UP WITH WHAT HAPPENED
	APP/AXB611	WHILE YOU TAKE OFF YOU HIT THE LOCALIZER AND BOUNDARY WALL AND LOCALIZER ANTENNA BROKEN
	AXB611/APP	OK SIR COPIED THANK YOU

ATC Bangalore

After leaving Trichy Control Area, aircraft came in contact with ATC Bangalore on frequency 125.95 MHz. It was evident from the tape transcript that the aircraft maintained positive communication with ATC Bangalore.

ATC Mumbai

ATC Mumbai tried to establish contact with the aircraft on company HF frequency. Aircraft was in positive contact with the Mumbai ATC on frequency 133.3 MHz, Radar 133.85 MHz, Approach 127.9 MHz, Arrival 119.3 MHz and Tower 118.1 MHz till it landed safely at Mumbai Airport.

Communication held with ATC Mumbai was captured in CVR. Relevant communication is incorporated in Flight Recorder Section of this report.

ACARS Messages

Aircraft Communications Addressing and Reporting System (ACARS) is a digital data link system for transmission of short messages between aircraft and ground stations via air band radio or satellite.

After presuming the damage on the aircraft which was based on the information available to M/s Air India Express, it was decided to call back the aircraft to its Mumbai base as the aircraft was in the area of Mumbai AOCC. The aircraft was contacted by Flight Dispatch Air India Express, Mumbai through ACARS.

Following messages were sent through ACARS System:

Time (UTC)	*From*	*Messages*
2134	IOCC	Dear Capt. Please confirm all ops normal. All equipment serviceable.
2136	Aircraft	Ops normal. All equipment serviceable.
2146	Aircraft	All Ops normal. ETA Dubai 0000.No joy on company HF.
2217	IOCC	Dear Capt. Under instruction from Chief of Operations, please divert to VABB (BOM). Please acknowledge and confirm.

At 2234 UTC, crew decided to divert the aircraft to Mumbai.

1.10 AERODROME INFORMATION

Trichy International Airport Limited is an international airport located in Trichy, Tamil Nadu. The IATA location Identifier code is TRZ and ICAO location Indicator code is VOTR. The

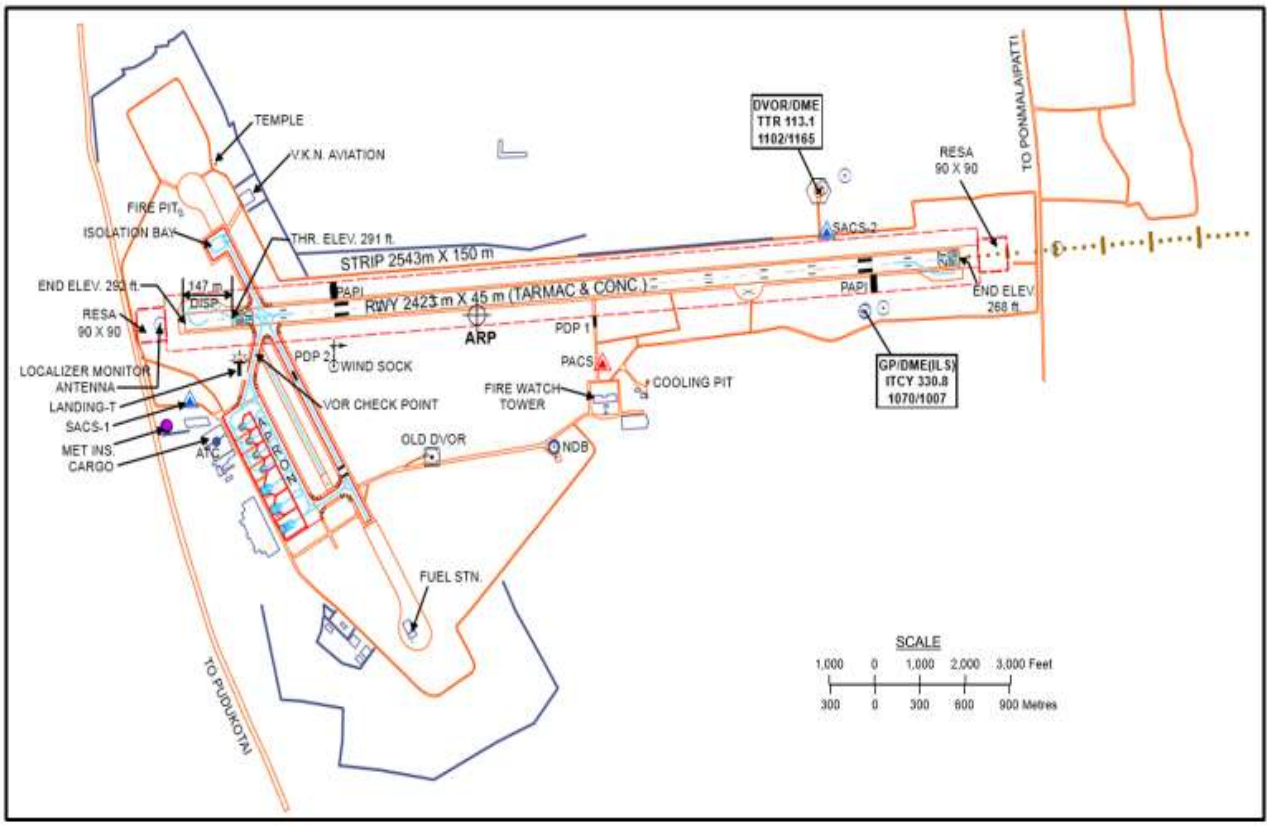
airport is operated by Airports Authority of India (AAI). The elevation AMSL of airport is 85 m (279 ft). The airport reference code is 4C.

The Airport Reference point is 10°45'56.113" N and 78°42'54.159" E. Runway has marking for Designation, THR, TDZ, Centreline, Rwy Edge and is lighted for THR, Edge, End, TDZ, and Centreline. R/W & Taxi Tracks markings are standard as per Annex- 14 Rescue & Fire Fighting Services of Category VII (7).

As per the Trichy Airport manual, Para 3.2 (l) it is clearly mentioned that top elevation of significant obstacles in approach and take-off areas are cleared to 2% from each runway strip end.

AERODROME DIMENSIONS AND RELATED INFORMATION

Rwy No.	Elevation (Ft)	TORA (M)	TODA (M)	ASDA (M)	LDA (M)	RESA (M)	THR Co-ordinates	Slope %
09	291	2423	2423	2423	2276	90 X 90	10°45'55.64" N 78°42'28.97" E	-0.21
27	268	2423	2423	2423	2423	90 X 90	10°46'01.51" N 78°43'43.65" E	+0.21



Trichy Airport Map with all the installations

The length of Runway was 2423 Meters (7949 feet), height of Localizer Antenna was 7.97 feet and height of boundary wall was 07 feet with 04 feet of fence. The Localizer antenna was situated at 449.50 feet from runway end & Boundary wall was situated at 475.70 feet from runway 27 end. The localizer monitoring antenna height of 5 feet was situated at 77.80 m from localizer.

VISUAL AIDS installed at Trichy Airport:

RUNWAY	09	PAPI, Displaced Threshold Lights, HIRL, End Lights
	27	PAPI, Threshold Lights, HIRL, End Lights, CAT I Approach lights
Taxiway		Edge Blue Lights
Apron		Edge blue lights, Flood Lights
Runway Markings		Runway Designator, Threshold, Aiming point, Centre line, Touch down Zone, Runway edge, Displaced Threshold marking , Runway End
Taxiway Markings		Taxiway edge, Centre line, Holding Positions at all TWY/RWY Intersections
Other Visual Markings		Signage – both mandatory and information signs are provided
Apron Markings		Aircraft Stand marking,
RWY Lights		THR, Edge, End
TWY Lights		Edge
Remarks		PAPI Glide angle for Runway 09/27 is 3º

1.11 FLIGHT RECORDERS

The aircraft was fitted with Solid State CVR & DFDR as per the specification given below. Both recorder units showed no signs of damage. Data from both CVR & DFDR were downloaded and analysed after the accident.

No.	Unit	Manufacturer	Part Number	Serial Number	Total Duration of available Recording
1	CVR	Honeywell	980-6022-001	08155	02 Hrs 05 min 19 sec
2	DFDR		980-4700-042	13759	30 Hrs17mins 43 sec

1.11.1 CVR

The CVR was downloaded with the help of RPGSE unit and decompressed into 05 Audio channels found in CVR. The channels are

- 1 P Channel recordings of last duration 30:21 minutes
- 2 P Channel recordings of last duration 30:21 minutes
- 3 P Channel recordings of last duration 30:21 minutes

- 4 P Channel recordings containing Cockpit Area microphone (CAM) of last duration 02:00:59 minutes
- MP Channel recordings containing the audio information from all the individual crew positions (HOT) Microphone of last duration 02:05:09 minutes.

The Take-off and climb segment were not covered in the CVR due to the flight duration exceeding the recording capability of the CVR.

Following are the salient observations from CVR:

GMT	***From***	***Contents***
22:12:14	---	Recording Starts
22:18:05	HF Radio	SELCAL Chime
CTC	PIC	Call him Up, Call him
CTC	FO	Mumbai Radio Mumbai Radio XI-611 answering SELCAL. Go head
CTC	MUM RAD	Message for you message for you, a piece of antenna of the aircraft suspected to be fallen near localizer end. Also portion of the wall behind localizer is broken. Advise your intention.
22:19:06	FO	Continuing to…… destination XI-611.
22:19:35	MUM RAD	Stand by, we…… your advice you. Confirm you have copied the message. A piece of antenna of the aircraft suspected to be fallen near localizer end. Also portion of the wall behind the localizer is broken.
22:19:48	PIC	Copied XI-611, we are all operations normal and parameters are within the limits. We are continuing to the destination.
22:19:57	MUM RAD	Roger, all operations normal, all operations normal and continuing to the destination, Mumbai
22:20:04	PIC	Thank You
	Inter cockpit	Wall is broken, no, wall is broken That is the antenna, that hit the wall.... And, everything is ok, pressurization ..... I hope it doesn't become a news I hope it doesn't become a news Now what to do? We are coming close to the destination, what we can do?
22:23:15	MUM RAD	XI-611, Mumbai. As per Air India Operation, as per Air India operation XI-611 has to return to Mumbai
22:25:24	MUM RAD	Confirm you have copied the message… which I have sent.
22:25:30	FO	Stand by, checking the fuel Standing by standing by stand by sir, we are checking the fuel.
22:25:36	MUM RAD	The message is a piece of antenna of the aircraft suspected to be fallen near the localizer end and also outer portion of the wall, wall behind the localizer is broken.

22:25:42	FO	Copied sir, copied and stand by. We are checking for fuel to return to Mumbai.
22:26:33	Inter Cockpit	Can't , unable , unable , we can't go to Mumbai. Unable Captain we don't have fuel for Bombay. Continue to destination naa
22:27:02	FO	Sir we are unable to proceed to Mumbai, proceeding direct to destination due fuel sir.
22:27:10	MUM RAD	Confirm unable to proceed to Mumbai and proceeding directly to destination due fuel.
22:27:52	PIC	We will proceed BRAVO BRAVO BRAVO direct if required XI-611
22:28:03	MUM RAD	Confirm you can proceed direct to BRAVO BRAVO BRAVO
22:28:05	PIC	Affirm
22:28:30	MUM RAD	Stand by sir, we will call you
22:29:29	MUS CTRL	Muscat Control. Good morning XI-611 level 360
22:30:09	FO	Sir we are approaching position TOTOX, now we are contact with Muscat.
22:30:15	MUM RAD	Confirm approaching TOTOX and contact with Muscat.
22:30:18	FO	Affirm Sir, XI-611
22:30:40	MUM RAD	Confirm you have decided to proceed to Dubai
22:30:45	FO	If you can give us direct now, we can proceed Sir, otherwise we have not sufficient fuel
22:30:56	MUS CTRL	we have message from operations saying that you have to go back to Mumbai
22:31:06	PIC	Copied Sir, working on Fuel sir
22:31:36	Inter Cockpit	Muscat *keh raha hai*, you have to go back. What did Muscat say We are a message for you, you have to go back to Mumbai All operations are normal now they want to go
22:31:55	PIC	Muscat XI-611, Now we can proceed direct BRAVO BRAVO BRAVO we have the fuel only for direct BRAVO BRAVO BRAVO and now we are position TOTOX.
22:32:08	MUS CTRL	OK Standby, and just to confirm if you go direct to BRAVO BRAVO BRAVO and what will be your, what turn will you take and what heading you'll be flying?
22:32:22	PIC	It will be on a heading of One-Zero-Five, XI 611
	Inter Cockpit	We are so close to destination. They don't want any incident know, That's why After TOTOX what is the headwind?
22:34:14	MUS CTRL	Ok what heading now would you take to track to BRAVO BRAVO BRAVO
22:34:20	PIC	We will take a heading of 105 if required XI-611
22:34:24	MUS CTRL	XI-611, descent now to flight level 350 and heading 105 is approved to the right
22:34:35	PIC	Level 350, XI-611 and heading 105 is approved, XI-611
22:35:48	Inter	Change the destination -- Ya, it must have been a news. Altitude

	Cockpit	Acquired
22:36:52	PIC	We have been cleared by Muscat on a heading of 105 to BRAVO BRAVO BRAVO
22:37:00	MUM RAD	Confirm XI-611 on a heading 105 to proceed to Mumbai
22:37:04	PIC	Affirm XI-611
22:37:06	MUM RAD	And confirm Muscat has cleared
22:37:08	PIC	Yes sir, they have given us, you can take a heading of 105 and maintaining flight level 350 now
22:37:17	MUM RAD	Roger maintaining level 350, heading 105 to BRAVO BRAVO BRAVO, Roger Muscat has cleared you. standing by for estimate BRAVO BRAVO BRAVO
22:38:10	MUM RAD	XI-611 Mumbai report operations normal, report. every half an hour
22:38:10	PIC	We are operations normal, XI-611
22:39:09	Inter Cockpit to Cabin Crew	We are proceeding to Bombay now, I think there is some antenna has fallen from the aircraft, so they wanted to come back to Bombay, from Bombay there might be an aircraft change and a crew changed.
22:41:15	MCT CTRL	Break-Break XI- 611 you can contact now Bombay on HF 8-8-7-9, 6-6-6-1. Radar service terminated, AI already advised you time at BRAVO BRAVO BRAVO, Bombay time, Thank you
22:41:29	PIC	Thank you sir, over the Bombay XI-611
22:42:42	AI MUM HF	Air India Mumbai, XI-611 on 8930, Air India Mumbai XI-611 on 10072
22:43:06	FO	We have been informed by Mumbai HF …… to come back to Mumbai, We are proceeding direct BRAVO BRAVO BRAVO, now estimating Mumbai at time 0005, XI - 611
22:43:24	AI MUM HF	Estimating 0005 time
22:43:30	FO	That's affirmative, 0-0-0-5 and all operations are normal, XI 611, we have checked, uh, both the hydraulics, of course there is no loss in quantity. On airborne we have checked the operations of the Landing gear, it was normal, everything is under normal ma'am.
	AI MUM HF	Personally, we have informed DGCA and Flight Despatch, all operations are normal and uh, confirm you are diverting to Mumbai and .....Mumbai.
22:43:57	FO	Yah, we are coming back Mumbai as informed by Mumbai HF and Muscat, they informed that company wanted us back to Mumbai
22:44:15	AI MUM HF	(Understand) All aircraft operations are normal. We'll inform Flight Dispatch & IOCC
22:51:19	PIC	Check the diversion for Ahmedabad, Ahmedabad diversion fuel. We have two point five, keep it at two point nine, ok? Just crosscheck once Pune is closer, no? Just check alternate destination file, no? Just check it
22:58: 30	PIC	We have fuel for both
23:35:14	MUM CTRL	Confirm, Require any inspection of Undercarriage?

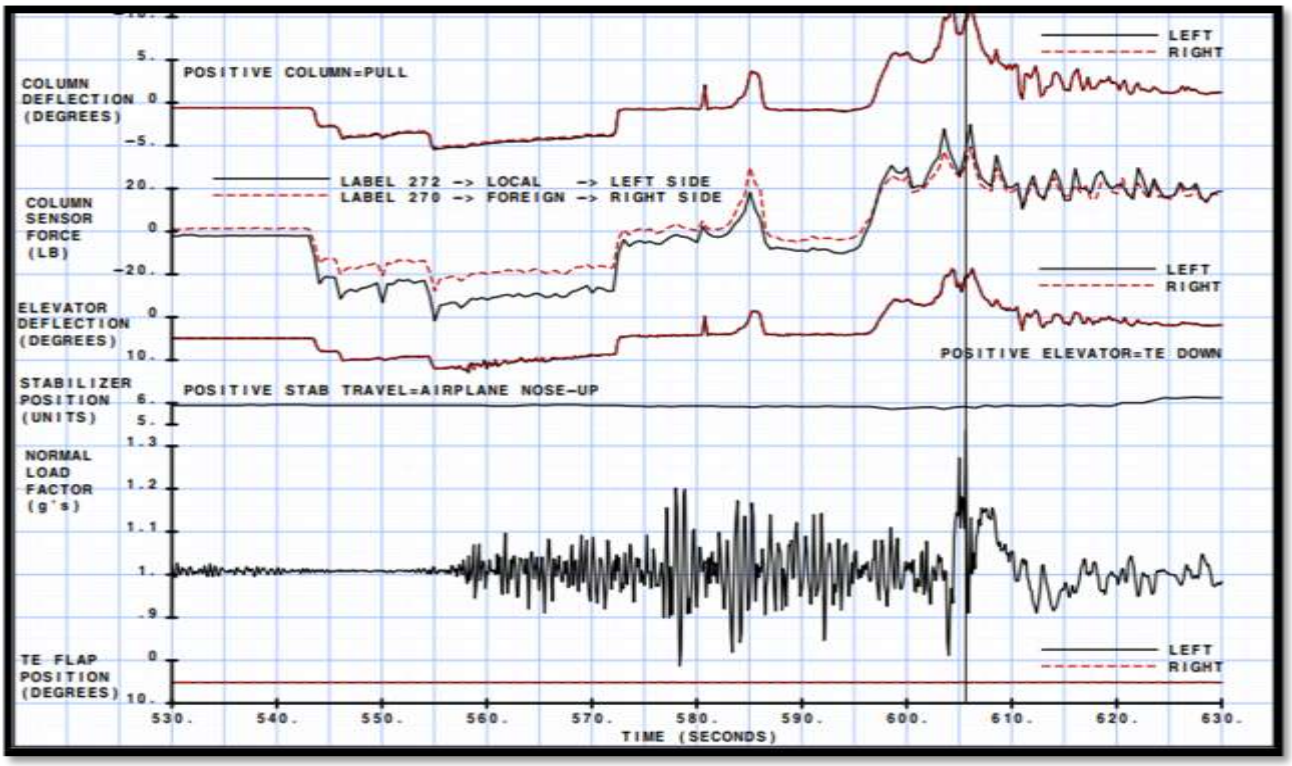
23:35:20	PIC	Negative Sir, All operations are normal. As a precautionary measure request the full length of the runway and any firefighting services to be available, if required. As of now all operations are all normal.
23:48:16	FO	Mumbai, Express India 6-1-1, Persons on Board is (1-3-7) and the endurance approximately one hour.
00:05:39	MUM CTRL	XI-611, runway 09 clear to land wind 070 degree 04 knots
00:08:32	CAM	Sound of Landing / Touchdown
00:14:52	PIC	Seat is not locking in properly yaar-APU on Busses
00:17:23		Recording ends

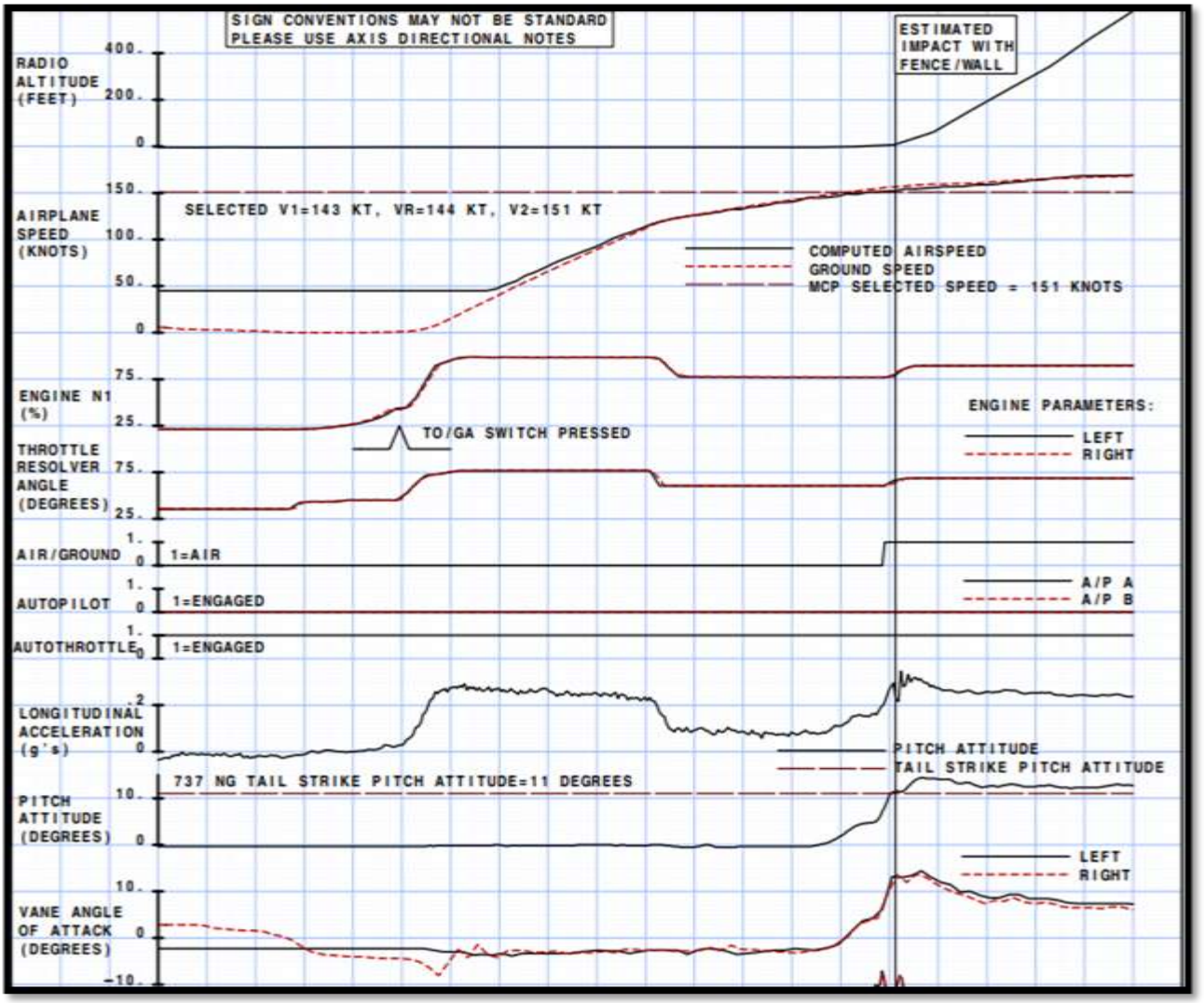
1.11.2 DFDR

The Flap was set 5 for take off and the speeds were calculated as V1 143 kts, VR 144 kts and V2 was 151 kts. The DFDR readout of the involved aircraft was analysed and following are the salient observations.

Comment by Occurrence (Events)	UTC	Eng. (1) N1%	Eng. (2) N1%	Left Thrust Resolver Angle	Right Thrust Resolver Angle	Ground Speed (knots)	Capt control column	CC-1 force LBS	Pitch Attitude	Pitch Rate	Long Acceleration	Vert Acceleration
Flap 5 Selected	19:40:31	21.4	21.3	35.5	36.0	0	0.12	-1.3	-0.5	0.00	-0.004	1.01
Start of Taxi	19:41:54	***32.8***	***32.6***	42.5	42.4	1	-0.6	-1.5	-0.5	0.00	0.010	1.01
Start of Take off	19:48:20	***43.8***	***42.1***	***45.0***	***45.9***	1	-3.4	-14.1	-0.4	0.00	0.028	1.02
Takeoff thrust set	19:48:26	***97.6***	***97.4***	***76.3***	***76.6***	19	-0.8	-19.6	-0.2	0.00	***0.283***	1.03
Thrust reduced	19:48:47	****77.3***	****77.4***	***60.5***	***60.6***	120	-0.8	-0.6	0.0	0.00	***0.197***	1.05
Takeoff rotation initiated	19:49:03	77.0	77.3	60.5	60.6	147	***3***	***7.8***	0.0	0.35	0.083	1.08
Pitch Attitude increases	19:49:05	77.1	77.1	60.5	60.6	150	-0.8	17.0	***1.6***	***1.05***	0.112	1.08
Additional pull back force resulting in high pitch rate	19:49:09	77.0	77.1	60.6	60.6	155	5.7	***21.4***	***5.3***	***4.04***	0.177	1.05
Tail-strike	19:49:11	77.0	77.1	66.1	66.1	157	7.9	15.9	***10.7***	2.29	0.295	***1.34***

Comment by Occurrence (Events)	UTC	Eng. (1) N1%	Eng. (2) N1%	Left Thrust Resolver Angle	Right Thrust Resolver Angle	Ground Speed	Capt control column	CC-1 force LBS	Pitch Attitude	Pitch Rate	Long Acceleration	Vert Acceleration
Thrust levers advanced to below takeoff setting	19:49:12	***89.5***	***88.8***	***68.2***	***68.6***	158	10.857	***30.6***	12.1	0.53	0.346	1.13
Aircraft Hit the wall	19:49:13	***89.5***	***89.4***	***68.7***	***68.6***	158.5	6.9	**---**	12.7	---	0.299	1.114


COLUMN DEFLECTION (DEGREES)
POSITIVE COLUMN=PULL
LEFT
RIGHT
COLUMN SENSOR FORCE (LB)
LABEL 272 -> LOCAL -> LEFT SIDE
LABEL 270 -> FOREIGN -> RIGHT SIDE
ELEVATOR DEFLECTION (DEGREES)
POSITIVE ELEVATOR=TE DOWN
STABILIZER POSITION (UNITS)
POSITIVE STAB TRAVEL=AIRPLANE NOSE-UP
NORMAL LOAD FACTOR (g's)
TE FLAP POSITION (DEGREES)
530. 540. 550. 560. 570. 580. 590. 600. 610. 620. 630.
TIME (SECONDS)

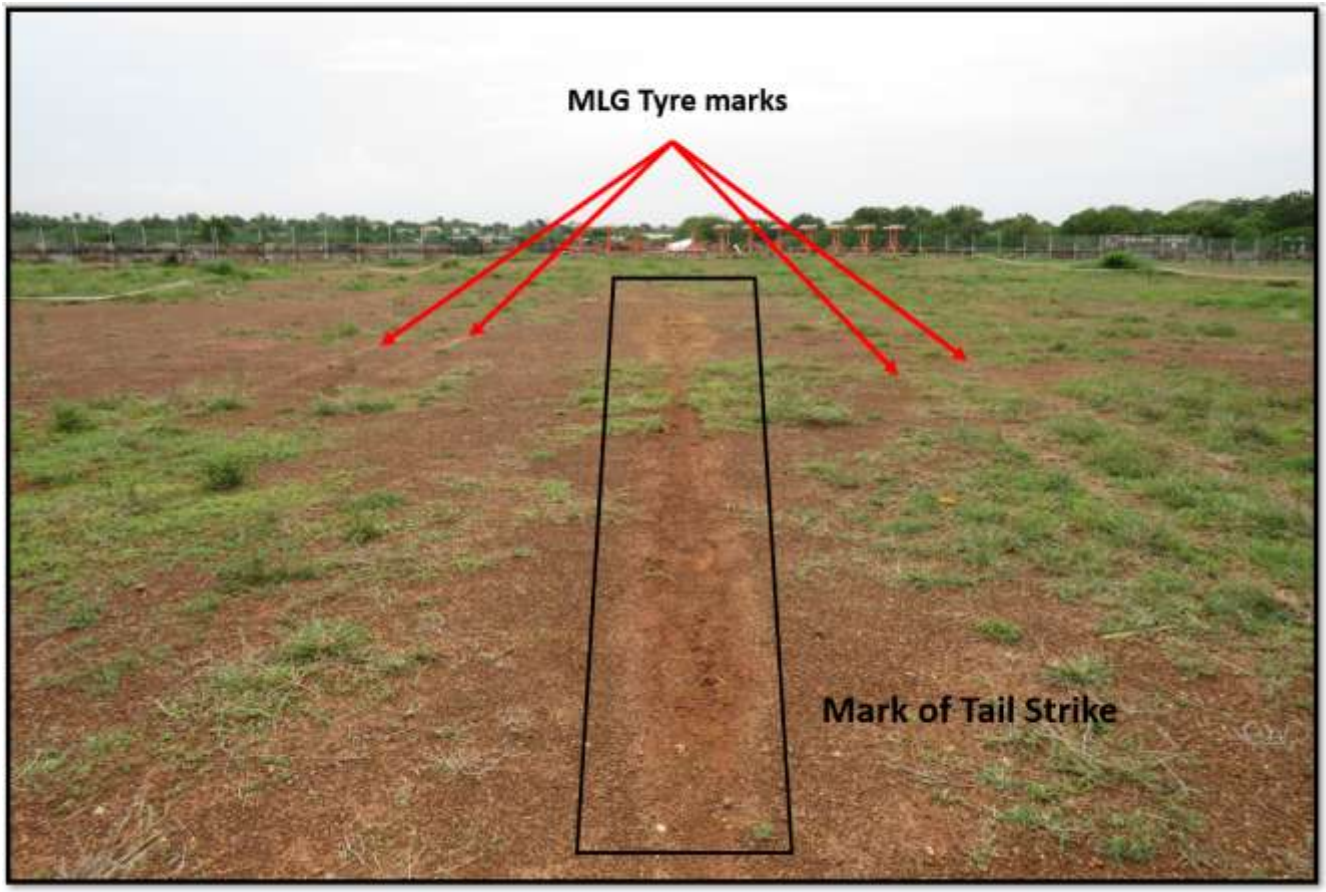

SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ESTIMATED IMPACT WITH FENCE/WALL
RADIO ALTITUDE (FEET)
AIRPLANE SPEED (KNOTS)
SELECTED V1=143 KT, VR=144 KT, V2=151 KT
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED = 151 KNOTS
ENGINE N1 (%)
ENGINE PARAMETERS:
LEFT
RIGHT
TO/GA SWITCH PRESSED
THROTTLE RESOLVER ANGLE (DEGREES)
AIR/GROUND
1=AIR
AUTOPILOT
A/P A
A/P B
1=ENGAGED
AUTOTHROTTLE
1=ENGAGED
LONGITUDINAL ACCELERATION (g's)
PITCH ATTITUDE
TAIL STRIKE PITCH ATTITUDE
737 NG TAIL STRIKE PITCH ATTITUDE=11 DEGREES
PITCH ATTITUDE (DEGREES)
VANE ANGLE OF ATTACK (DEGREES)

DFDR Plots

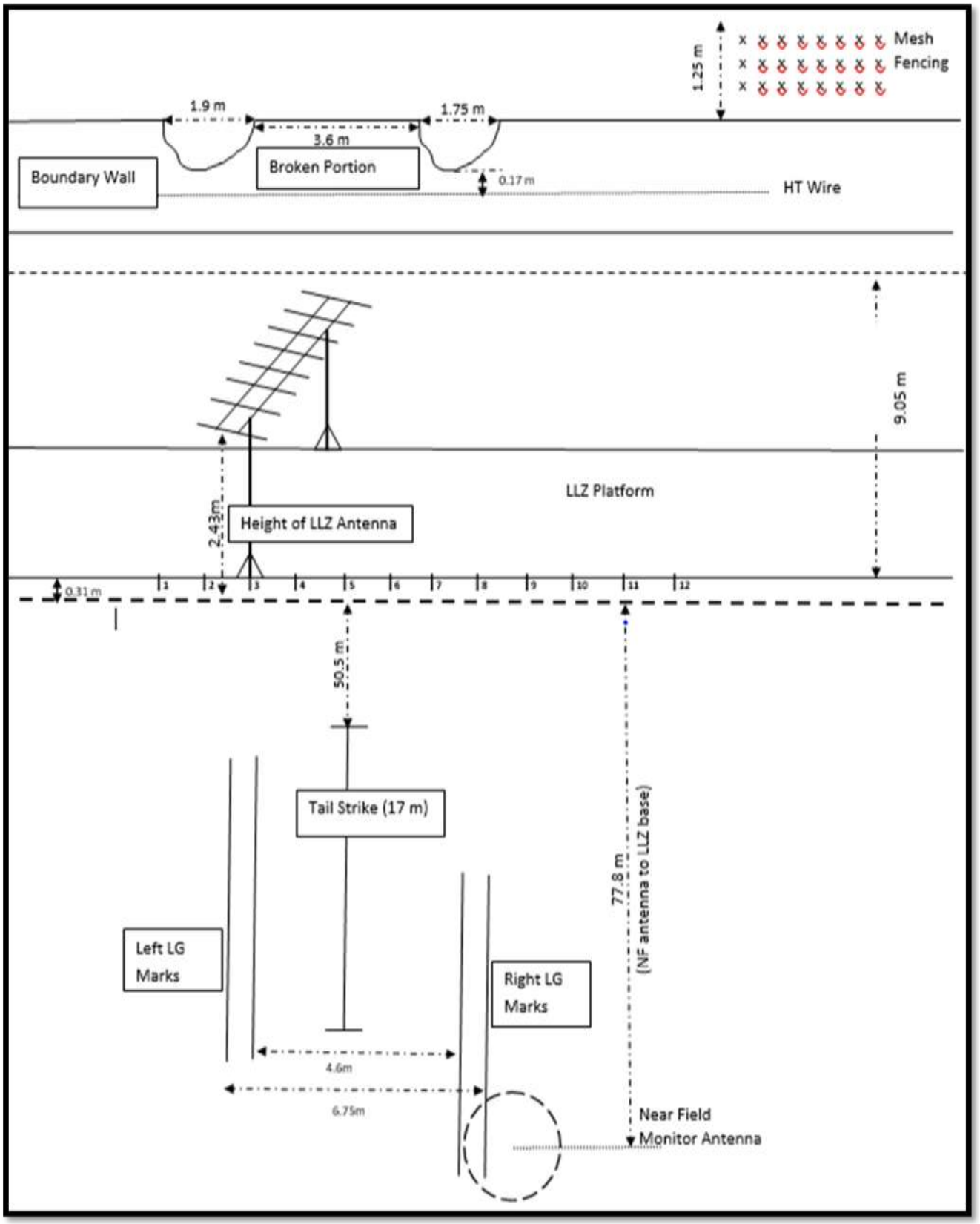
1.12 WRECKAGE AND IMPACT INFORMATION

The aircraft continued its take off roll past the end of runway 27 and rolled onto the RESA area prior to getting airborne from soft ground. In doing so, there was considerable damage to the aircraft and surface equipment / facilities.

Initially, the left tyre of MLG passed over a runway end light which was found broken. Thereafter, aircraft started rolling on soft ground and hit a localizer monitoring antenna which was installed at a distance of 255.2 feet (77.8 metres) from localizer . Aircraft accelerated further and suffered a tail strike. Tail strike marks 55.77 feet (17 metres) in length was clearly visible on the soft ground. In addition to this, both MLG tyre marks were also visible. The distance measured between both tyres marks was 15 feet (4.6 metres). The left MLG tyre mark was imprinted for a slightly longer distance than the right MLG. Before the aircraft lift-off, the belly of the fuselage and left engine lower cowl had impacted with the array of localizer antenna units which were installed at distance of 449.50 feet (137 meters) from the end of runway 27. During onsite investigation, five (05) localizer antenna units were found damaged. The height of each antenna unit was 7.97 feet (2.43 metres) from the ground. However, both MLG were able to pass through the gap present between two antenna units, which was 6.69 feet (2.04 metres). While passing between antenna unit 2 and 3, the tyres of left MLG hit the supporting structures of antenna unit 3, which were clearly visible on antenna supporting structures.



Tail Strike Marks and MLG Marks on Soft Ground



Distances measured after the first Impact

MLG Tyre marks o Antenna

Broken Boundary Wall Portion after impact

Both MLG of the aircraft impacted the boundary wall and PVC mesh wire erected on the boundary wall. The mesh entangled in landing gear before they got retracted. Due to the impact of the landing gear, the boundary wall was found broken at two locations. The left broken portion was measured 1.9 metres and right side was 1.75 meters. The distance between two broken portions was measured 3.63 meters. The direction of damage pattern to the Perimeter wall and Localizer antenna was in the flight direction indicating that it was hit by the moving aircraft and not from the jet blast of the engine.

Mesh wire found entangled after landing at Mumbai

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Cockpit crew as well as cabin crew underwent pre-flight medical examination at Dubai and after diversion and safe landing at Mumbai. The cabin crew and flight crew underwent post flight medical examination at Mumbai airport. All the crew were found negative for alcohol consumption.

1.14 FIRE

There was no pre or post impact fire.

1.15 SURVIVAL ASPECTS

The accident was survivable. However, an assessment made during the course of this investigation highlights that any further deterioration in the takeoff performance would have led to a catastrophic outcome.

1.16 TESTS AND RESEARCH

1.16.1 Functional / operational checks on PIC seat

The involved seat of the PIC was sent to the OEM to carry out operational checks and to examine the seat functionality. The seat was examined in the presence of IIC, NTSB representative, Accredited representative nominated by NTSB, two FAA members, two members from Boeing and a team of five representing the OEM of the seat from 10th June to 11th June, 2019 at OEM facility in UK. During strip examination following checks were performed: -

OEM Technician sat on the seat, leaned against the seat back which immediately reclined without operation of the control lever – recline. During the movement a clicking noise was audible. Upon leaning forward, the seat back returned to its upright position.

The below checks were then performed with the following evaluation in accordance with CMM and following are the observations: -

I. Forward / Aft movement – Result was unsatisfactory
II. Vertical adjustment – Heavy to operate and clicking noise when moving
III. Comfort checks
   a. Headrest check was found satisfactory
   b. Lumbar operation check was found satisfactory
   c. Armrests check was found satisfactory
   d. Thigh pads check was found satisfactory
IV. Restraint – minor fray on shoulder strap webbing but locking was satisfactory
V. Recline – seat back was not locked in position and could be moved with minimal force.

Measurement of Force required on Seat Recliner and Control Lever and Measurement of Force

Recline measurements - baseline

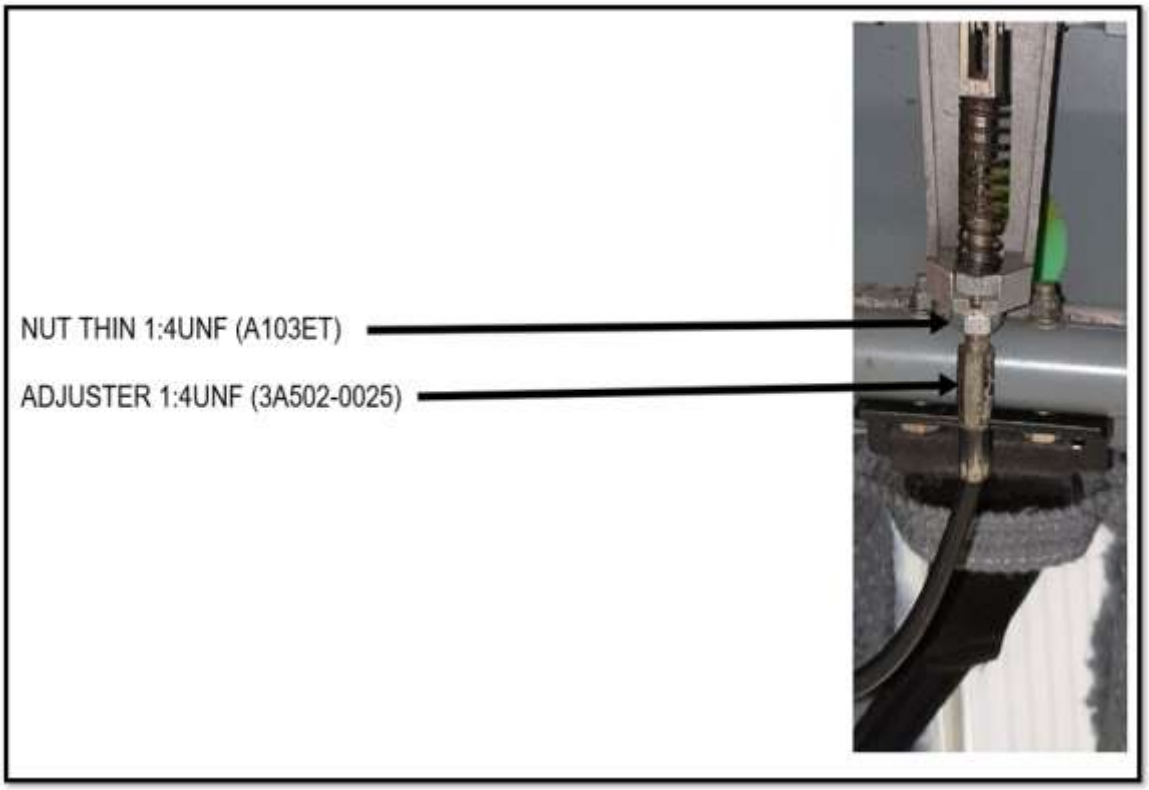
The force required to recline the seat without operation of the control lever – recline was recorded using the measuring equipment shown in above photograph.

i. Force required to recline the seat from the fully upright position was measured ranging from 13 to 24 lbs.
ii. Force required to recline the seat from a semi-reclined position was measured between 20 and 26 lbs.
iii. The force required to operate the control lever – recline was recorded and the force required was measured at 9.4 to 11.1 lbs.

Recline adjustment

Before the seat was dismantled, the cable assembly – recline was adjusted for correct operation, as that would indicate if cable adjustment was the likely cause of the uncommanded movement. The below process was carried out in accordance with standard maintenance practices:-

1. A spanner was used to loosen the nut thin 1:4UNF signifying that the cable assembly – recline could not have come out of adjustment on its own and that the nut thin 1:4UNF was secured to more than a finger tight amount of force.
2. The adjuster 1:4UNF was then rotated anti-clockwise to extend the length of the cable to allow the latch plate – recline unit to lock fully into position.
3. The amount of movement in the control lever – recline was then checked and the adjuster 1:4UNF adjusted slightly until the control lever – recline had a small amount of movement.
4. The nut thin 1:4UNF was then tightened to secure the recline adjustment.



Seat Nut and Adjuster position

The functional check on recline was then repeated. The seat back moved fully and freely between stops and when the control lever – recline was released, seat locked in position. Thereafter, functional check was repeated several times.

After adjustment Recline was measured

After adjustment, the seat recline performed as specified in Operation 2.D of Component Maintenance Manual (CMM).

A force was applied to the seat back to attempt to recline without operation of the control lever – recline. This was not possible, however, the force applied was measured using the measuring equipment as listed below: -

i. Force required to recline the seat from the fully upright position was unsuccessful as the seat did not recline. The maximum force that Compliance Manager could pull measured at 62 lbs.
ii. Force required to recline the seat from a semi-recline position was unsuccessful as the seat did not recline. The maximum force that Compliance Manager could pull measured at 80 lbs.
iii. The force required to operate the control lever – recline was recorded and the force required was measured between 9 and 10.5 lbs.

Recline assembly investigation

Recline unit assembly of the involved seat was removed to inspect for other faults that may have contributed to the reported failure.

One broken spring

During inspection, it was found that recline unit assembly has one broken spring extension, however, this did not restrict the return of the locking element.

The use of two spring extensions in this position is a built in redundancy feature and in case, if one spring extension fails, the force applied by single spring compression is sufficient to return the locking element latch plate – recline unit. The cable assembly – recline was observed, minor damage to the outer conduit cover and a bend positioned between the recline bracket and the cable clamp attachment point was found.

The recline unit assembly was dismantled to identify any further damaged parts within the recline unit assembly using CMM 25-11-39 Disassembly 8. Recline Unit.

Seat Locking Nut & Spring

While carrying out disassembly on Seat locking Mechanism, OEM observed the nut - recline unit displayed minor burrs on one of the slots. The burr was positioned on the same side of the slot in all positions indicating that it had been caused by movement in one direction only.

This was identified as minor damage that would not be expected to affect the operation of the recline unit assembly.

As per OEM, the damage/wear of this type is not unusual for a seat that has seen significant service and concluded that it would not require the nut - recline unit to be replaced if the recline unit assembly was being serviced.

OEM Final Observations

1) Indications from the investigation into the seat and the reported occurrence of uncommanded seat back movement showed that incorrect adjustment (too tight) of the cable assembly – recline allowed the seat back to move without operation of the control lever – recline.
2) On adjustment of the cable assembly – recline, it was not possible to repeat the movement of the seat back without operating the control lever – recline.

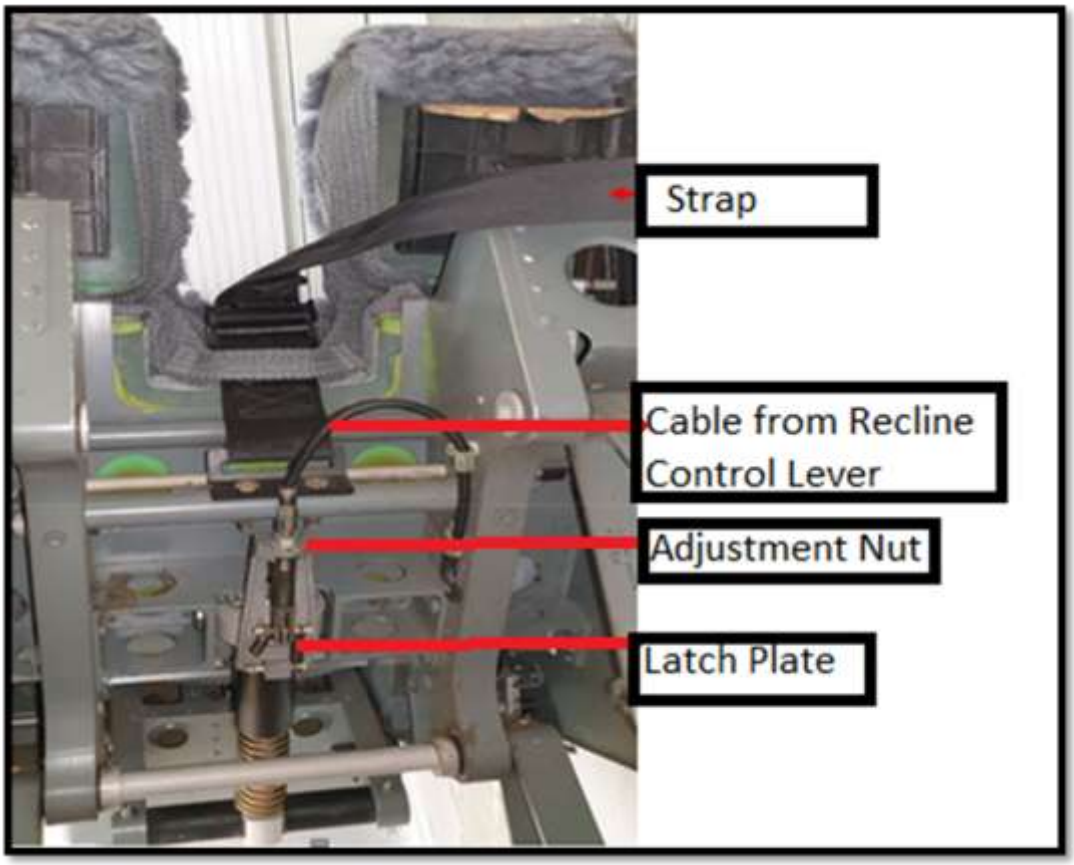
3) Inspection of the seat showed that the nut thin 1:4UNF were fully tightened, further inspection of recline unit assembly and its component parts did not show any damage that would affect the operation of the unit and as such the recline system.
4) To verify the above, OEM replicated the incorrect adjustment of the cable assembly – recline on an OEM training seat. The seat back on the training seat moved under low force and the noise associated with the Air India Express seat was repeated.
5) The general condition of the seat was considered poor and operation of the vertical control indicated that adjustment was required to the operating cable.

Additional information in respect of seat

The below information is provided as additional information with regards to the seat, its operations and its associated technical documents:

Seat recline

- The routing of the cable assembly – recline is secured out of the way of any potential pulling when reaching for the crotch strap as shown in below Fig. An attempt was made to operate recline by pulling on the cable assembly – recline whilst sitting in the seat, this was unsuccessful.
- This spring extension is used in several positions not solely associated with this recline unit assembly, OEM have used in excess of 69,000 spring extension since 2009.
- The nut thin 1:4UNF that holds the adjustment of the recline in position is a standard nut.



Recliner Assembly

On 12th October 2018, PIC seat of the subject aircraft was inspected in-situ by B1 Engineer in presence of Line In-charge of M/s Air India Engineering Department and officers from western regional office of DGCA for Seat Recliner operation and found that after seat was locked and it did not recline even after a full force was exerted by the AME.

On 14th Oct 2018, PIC was called in the cockpit and operation of the involved seat was examined in the presence of member Investigator. PIC sat on the left seat and operated his seat back with the help of control lever. And it was noticed that the PIC seat back moved aft as pressure was applied on it without operating the seat recline control lever.

1.16. 2 Simulator Assessment

A simulator assessment of the accidented flight was carried out on B 737-800 Simulator at Air India, Mumbai by AAIB team to validate the event and to perceive the pilot's perspective during the take off phase.

The following points were established :-

1. When the seat back is reclined the crew member on seat would have brought back the thrust levers to a similar extent.
2. The takeoff rotation at the same speed but reduced thrust takes longer to get airborne and the aircraft nose seems heavier during rotation.
3. A reject Takeoff manoeuvre with 2000' of runway remaining resulted in an overrun.

The restrictions of a training device as compared to actual aircraft operations was duly factored in the assessment.

1.16.3 Anthropometric Study

A Human factors analysis carried out by Boeing replicating the seat failure scenario using Anthropometric data concluded that there is relationship between seat back recline and hand grip position such that when the flight deck seat back is reclined to the mechanical limit, 3 degree aft column, command is possible using the assumption of the test criteria. The report also mentions that the analysis would vary outside of the test criteria used and are therefore not applicable to the broader population. This aft column deflection is corroborated with DFDR data.

1.17 ORGANISATION AND MANAGEMENT INFORMATION

Air India Express Limited (AIXL) operates a low cost airline under brand name 'Air India Express'. The DGCA had issued the Air Transport Operating Permit (AOP) No S-14, in Passenger/Cargo Category, on 22nd April 2005. The permit was re-validated up to 21.4.2023. The airline commenced its operations on 29th April 2005 with 26 flights per week. The airline operates with a fleet of 25 Boeing 737-800 aircraft.

The Air India Express connect Indian cities directly to destinations in the Gulf, South and South East (SE) Asia. Air India Express Headquarters is at Cochin International Airport, Cochin and operation bases are located in Kozhikode, Chennai, Thiruvananthapuram, Mumbai, Delhi, Mangalore and Dubai. Maintenance bases are situated in Mumbai and Trivandrum. Crew training facility is setup in Mumbai.

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.

1.18 ADDITIONAL INFORMATION

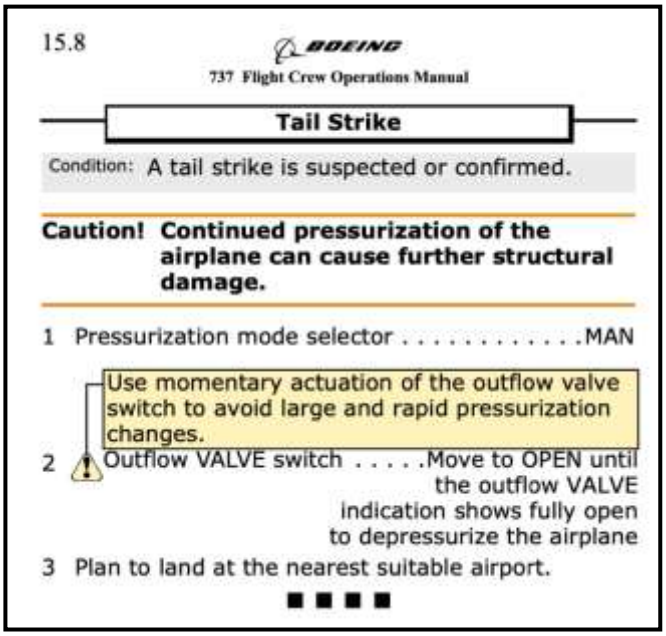
1.18.1 Tail Strike

Tail strike is defined as when the lower aft fuselage or tail skid (as installed) contacts the runway during take-off or landing. A significant factor that appears to be common is the lack of flight crew experience in the model being flown. *A tail strike can be identified by the flight crew or cabin crew.*

Any one of the following conditions can be an indication of a tail strike during rotation or flare:

- a noticeable bump or jolt
- a scraping noise from the tail of the airplane
- pitch rate stopping momentarily

As per Boeing 737 QRH NNC, when there is suspected Tail Strike, the aircraft shall not be pressurised to prevent any further structural damage & land at the nearest suitable airport.



15.8

BOEING

737 Flight Crew Operations Manual

Tail Strike

Condition: A tail strike is suspected or confirmed.

Caution! Continued pressurization of the airplane can cause further structural damage.

1 Pressurization mode selector . . . . . .MAN

Use momentary actuation of the outflow valve switch to avoid large and rapid pressurization changes.

2 Outflow VALVE switch . . . . .Move to OPEN until the outflow VALVE indication shows fully open to depressurize the airplane

3 Plan to land at the nearest suitable airport.

■ ■ ■ ■

A. Tail Skid Assembly

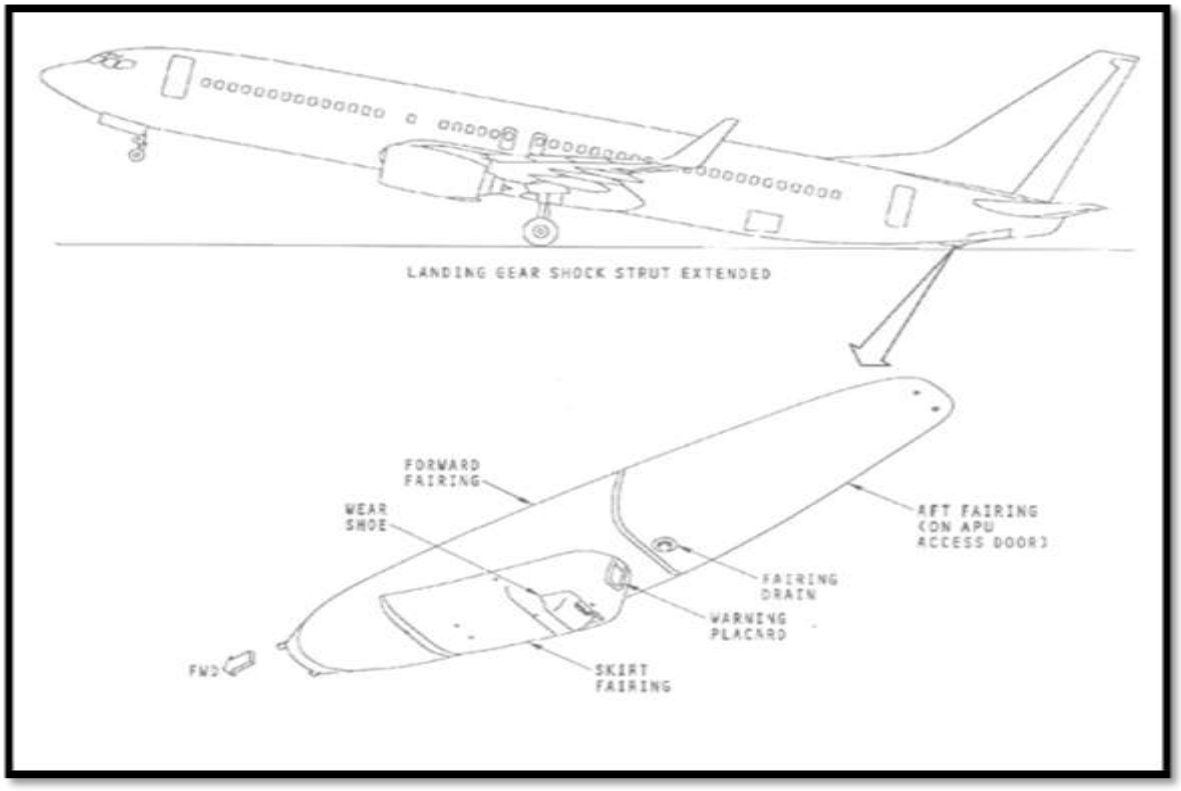
To protect the aft lower fuselage from over rotation damage, the Boeing 737-800/900 is equipped with tail skid. It consists of a sort-of-shock absorber cartridge, a skid fairing and a skid "shoe," where the last two parts are outside the fuselage.

The involved aircraft has a single position tail skid. It is used to protect the Fuselage during a tail strike on rotation and during landing.

The cartridge assembly consists of a crushable honeycomb material. When the tail skid strikes the runway the skid moves upward and the honeycomb material crushes. The tail skid is serviceable when the cartridge warning decal shows both green and red. The green disappears gradually as the cartridge is crushed. When the warning decal is all red, the cartridge must be replaced. The shoe is what contacts the runway in the event of an over rotation. The shoe surface displays "wear dimples" which serve as a reference for shoe replacement. Cartridge assembly warning placard must be checked as soon as possible after the tail strike. The tail skid skirt fairing may re-extend due to gravity as time passes resulting in a reading error on the warning placard decal.

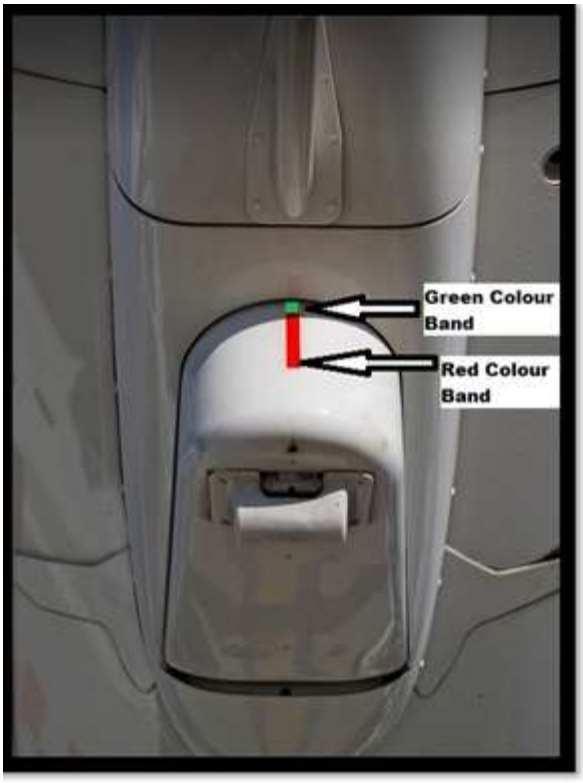
A light touch of aircraft tail to runway causes the shoe to wear off, indicating the amount of wear and is an indication when the shoe needs to be replaced.

When the touch is more than firm, the skid disappears and totally get inside fuselage and a safety pin (fuse pin) allows the cartridge to pivot inside (other than crushing) there by protecting the aircraft structure against massive loads.



Tail Skid position on the aircraft

The red & green indicator is required to be checked during every walk around to ensure an inadvertent tail strike did not occurred on the previous take-off or landing. Due to longer fuselage length B-737-400/800/900 series are prone to tail strike.



Normal Tail Skid without Damage

Damaged Tail Skid of the aircraft

Difference between serviceable and damaged Tail Skid

The aircraft VT-AYD suffered tail strike on the soft ground (RESA) while take off in soft ground. During post flight inspection at Mumbai, both red and green bands were not visible which indicated a firm tail strike.

B. Factors for Tail Strike

Understanding the factors that contribute to a tail strike can reduce the possibility of a tail strike occurrence.

Any one of the following take-off risk factors may precede a tail strike:

i. Mis trimmed Stabilizer

This usually results from using erroneous take-off data, e.g., the wrong weights, or an incorrect centre of gravity (CG). In addition, sometimes information is entered incorrectly either in the flight management system (FMS) or set incorrectly on the stabilizer. The flight crew can prevent this type of error and correct the condition by challenging the reasonableness of the load sheet

numbers. Comparing the load sheet numbers against past experience in the airplane can assist in approximating numbers that are reasonable.

ii. Rotation at Improper Speed

This situation can result in a tail strike and is usually caused by early rotation due to some unusual situation, or rotation at too low an airspeed for the weight and/or flap setting.

iii. Trimming during Rotation

Trimming the stabilizer during rotation may contribute to a tail strike. The pilot flying may easily lose the feel of the elevator while the trim is running which may result in an excessive rotation rate.

iv. Excessive average or instantaneous pitch rate near liftoff

v. Rotating during an airspeed stagnation

vi. Excessive control wheel input

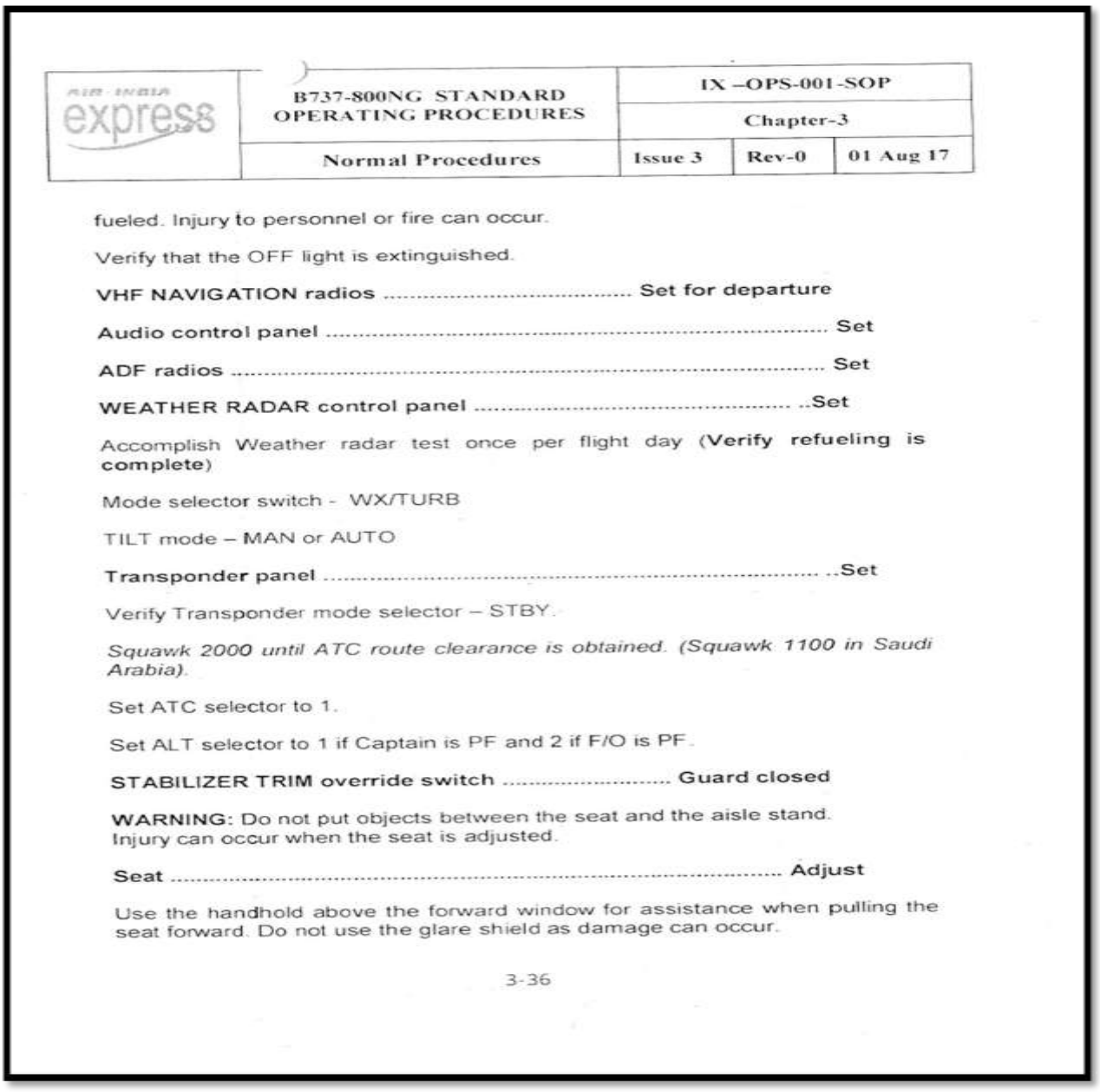
1.18. 2 Flight Deck Perspective

As per Boeing FCTM and FCOM, the pilot's seat should be adjusted for optimum eye position. The flight crew must adjust their seating position before the aircraft moves, typically before the pushback or engine start.

General adjustment procedures provided in FCTM & FCOM are:

1. Use the handhold above the forward window for assistance when pulling the seat forward. Do not use the glareshield as damage can occur.
2. Whenever the seat is adjusted, verify a positive horizontal (fore and aft) seat lock by pushing against the seat.
3. Rudder pedals should be adjusted so that it is possible to apply maximum braking with full rudder deflection.
4. Towards the end of a flight, especially for long sectors, the pilot's position may change due to muscle fatigue often causing them to adopt a position that is lower than at the beginning of the flight. Therefore, it is recommended to re-adjust the seating position before commencing the approach.
5. During the cruise flight phase where the pilots' eye level alignment is not as critical, pilots may adjust their seat to be out of the eye reference point position for increased comfort. To be able to face any unexpected situation, pilots should still ensure that they can reach all of the flight controls and their view of the control panels is not impaired.

In addition to this, M/s Air India Express has clearly laid down in their SOP published in Chapter 3 of B737-800 NG Standard Operating Procedure that crew should adjust the seat for optimum eye reference.



fueled. Injury to personnel or fire can occur.

Verify that the OFF light is extinguished.

VHF NAVIGATION radios ..... **Set for departure**

Audio control panel ..... **Set**

ADF radios ..... **Set**

WEATHER RADAR control panel ..... **..Set**

Accomplish Weather radar test once per flight day (**Verify refueling is complete**)

Mode selector switch - WX/TURB

TILT mode – MAN or AUTO

Transponder panel ..... **..Set**

Verify Transponder mode selector – STBY.

Squawk 2000 until ATC route clearance is obtained. (Squawk 1100 in Saudi Arabia).

Set ATC selector to 1.

Set ALT selector to 1 if Captain is PF and 2 if F/O is PF.

STABILIZER TRIM override switch ..... **Guard closed**

WARNING: Do not put objects between the seat and the aisle stand. Injury can occur when the seat is adjusted.

Seat ..... **Adjust**

Use the handhold above the forward window for assistance when pulling the seat forward. Do not use the glare shield as damage can occur.

3-36

Adjust the seat for optimum eye reference.

Whenever the seat is adjusted, verify a positive horizontal (fore and aft) seat lock by pushing against the seat.

Rudder pedals ..... **Adjust**

Adjust the rudder pedals to allow full rudder pedal and brake pedal movement.

Seat belt..... **Adjust**

Do the PREFLIGHT checklist on the captain's command.

1.18.3 Pre-departure briefing & FCOM inputs on Crew Coordination during Take-off

As per Boeing 737 FCOM, both crew should follow the checklist in co-ordination with each other and proper call outs shall be given in case the pilot monitoring (PM) finds any abnormal indication or parameter during take-off. Procedure to be followed during take-off is appended below.

Takeoff Procedure

YL461 - YL478

Pilot Flying	Pilot Monitoring
Before entering the departure runway, verify that the runway and runway entry point are correct.	
	When entering the departure runway, set the STROBE light switch to ON. Use other lights as needed. Set the transponder mode selector to TA/RA.
Verify that the brakes are released. Align the airplane with the runway.	
Verify that the airplane heading agrees with the assigned runway heading.	
	When cleared for takeoff, set the FIXED LANDING light switches to ON.
Advance the thrust levers to approximately 40% N1. Allow the engines to stabilize.	
Push the TO/GA switch.	
Verify that the correct takeoff thrust is set.	
	Monitor the engine instruments during the takeoff. Call out any abnormal indications. Adjust takeoff thrust before 60 knots as needed. During strong headwinds, if the thrust levers do not advance to the planned takeoff thrust, manually advance the thrust levers before 60 knots. Call "THRUST SET".
After takeoff thrust is set, the captain's hand must be on the thrust levers until V1.	

Pilot Flying	Pilot Monitoring
Monitor airspeed. Maintain light forward pressure on the control column.	Monitor airspeed and call out any abnormal indications.
Verify 80 knots and call “CHECK.”	Call “80 KNOTS.”
Verify V1 speed.	Verify the automatic V1 callout or call “V1.”
At VR, rotate toward 15° pitch attitude. After liftoff, follow F/D commands.	At VR, call “ROTATE.” Monitor airspeed and vertical speed.
Establish a positive rate of climb.	
	Verify a positive rate of climb on the altimeter and call “POSITIVE RATE.”
Verify a positive rate of climb on the altimeter and call “GEAR UP.”	
	Set the landing gear lever to UP.
Above 400 feet radio altitude, call for a roll mode as needed.	Select or verify the roll mode.
At thrust reduction height, verify that climb thrust is set.	
At acceleration height, call for flaps up maneuvering speed.	
	Set the flaps up maneuvering speed.
Verify acceleration. Call “FLAPS ___” according to the flap retraction schedule.	
	Set the FLAP lever as directed. Monitor flaps and slats retraction.
After flaps and slats retraction is complete, call “VNAV.”	
	Push the VNAV switch.
Engage the autopilot when above the minimum altitude for autopilot engagement.	

1.18.4 Pilot Incapacitation

As per Boeing 737 FCTM, Pilot incapacitation occurs frequently compared to other routinely trained non-normal conditions. It has occurred in all age groups and all phases of flight. Incapacitation occurs in many forms ranging from sudden death to subtle, partial loss of mental or physical performance. Subtle incapacitations are the most dangerous and they occure the most frequently. Incapacitation effects can range from loss of function to unconciousness or death.

The key to early recognitions of pilot incapacitation, is the regular use of crew resource management concepts during flight deck operation. Proper crew coordination involves checks and cross checks using verbal communications. Routine adherance to standard operating procedures and standard profiles can aid in detecting a problem.

If a pilot is confirmed to be incapacitated , the other pilot should take over the controls and check the position of essential controls and switches.

1.18.5 Reject Take-off (RTO)

As per Boeing 737 FCTM, the RTO manoeuvre is initiated during the takeoff roll to expeditiously stop the airplane on the runway. The PM should closely monitor essential instruments during the takeoff roll and immediately announce abnormalities, such as “ENGINE FIRE”, “ENGINE FAILURE”, or any adverse condition significantly affecting safety of flight. The decision to reject the takeoff is the responsibility of the captain, and must be made before V1 speed. If the captain is the PM, he should initiate the RTO and announce the abnormality simultaneously.

1.18.6 Performance Analysis

Boeing carried out performance analysis for this accident flight and assuming that engine N1 was constant at 98 % throughout the take off roll with following data.

Flap	05
Weight (lb)	158,120
Temp (C)	28
Runway Length (feet)	7949 ft
Unfactored all Engine Operative *	6556 ft
Factored all Engine Operative *	7539 ft
One Engine Inoperative *	7490 ft
Accelerate Stop Distance *	7490 ft
Winds	Calm
Runway Altitude (feet)	266
V1/Vr/V2 Speed (knots)	143/144/151
Engine model	CFM-56-7B27
Runway Slope (%)	0.30

(*) Computed using AFM DPI

The result shows that if engine N1 had been maintained at 98% throughout the take off roll, the distance required for the airplane to take off would have been less than the distance available.

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

Nil.

2. ANALYSIS

2.1 SERVICEABILITY OF THE AIRCRAFT

The aircraft had a valid Certificate of Airworthiness and a Valid Certificate of Registration at the time of accident. All scheduled Inspections were carried out as and when due before the accident. There was no MEL action pending on the aircraft.

Both engines performance parameters were checked after the accident and performance of both engines were found satisfactory.

There was no evidence of aircraft structure or engines having any serviceability issue prior to departure.

2.2 SERVICEABILITY OF PIC SEAT

During the course of investigation, PIC seat was examined to establish whether the PIC seat collapse contributed to the accident.

To establish the serviceability of PIC Seat, inspections and test were done at the OEM facility. After carrying out functional/ operational check on the seat, it was established that recline system of the seat was not locking in position and could be moved with minimal force due to incorrect adjustment of the cable assembly recline. However, after the adjustment of cable assembly-recline, the seat back moved fully & freely between stops and while the control lever recline was released, seat was locking in position. Furthermore, this functional check was repeated several times and results were found satisfactory.

During the inspection done on 12th October and 14th October 2018 at Mumbai, the force required to operate the Recline & Recline control lever was not recorded following procedures as laid down by the OEM. Therefore, the outcome of inspection at OEM facility is considered for this investigation report.

Last 75 Flight Hours/ 15 days Check was carried out on 9th Oct 2018 at Mangalore base and the operation was found satisfactory. In addition, before departure from Dubai & Trichy, the seat was operated by the crew and no discrepancy was recorded. However, these checks only cover the

functional elements. The integrity checks of the mechanism is not covered in any of the maintenance schedules prescribed by the manufacturers. Whenever such a defect is recorded, either the provision of MEL are invoked or the seat is replaced with a serviceable one.

Thus, it is clear that recline mechanism failed during take off roll without any prior defect.

Considering the critical nature of seat recliner failure in the present accident , OEM may study the worldwide defect data and consider issuing suitable preventive maintenance guidance.

2.3 OPERATORS TRAINING PROCESS

The Co –pilot assessment check carried on 31-05-2015 was graded as Pass with adverse remarks in the comments section. The operations manual part D does not have a process for review in cases where competence issues are raised for a pass assessment. The manual only addresses competency aspects for failure cases.

2.4 OPERATIONAL ASPECT (by flight phase)

2.4.1 Take off

The PIC was PF from the start of take off roll as established by PIC statement and the left side column force signal, which registered a larger magnitude relative to the right side's signal in the DFDR. In accordance with the take off procedure, the PIC as PF would have his left hand on the control column and his right hand on the thrust lever. At 117 knots the PIC seat reclined causing the PIC to fall back and become unsettled. Review of PIC statement, DFDR data, Simulator Assessment & Boeing Anthropometric study establishes that a momentarily aft control column pressure was applied and both thrust levers retarded from take off thrust of 98% to 77 % due to PIC hand grip position. The PIC announced your controls and handed over the aircraft to the co-pilot who now becomes PF. Since the Auto Throttle is in Throttle Hold mode above 84 Kts, the Auto Throttle is no longer commanding thrust requirements. The servos are disconnected and the thrust levers remain in their new position. The FMA displays THR HLD after 84 Kts till N1 is engaged after take off. As a result the airplane's acceleration is reduced due to the thrust decrease, which can be observed in the speed and longitudinal acceleration parameters which is observed in the DFDR and remained till the aircraft was airborne.

The Co- Pilot while assuming the PF duties did not factor the PIC being momentarily incapacitated due to inability to perform function. As per Boeing FCTM, in the event of Incapacitation the pilot assuming the control must ensure all control levers and switches are in the correct position. In doing so, the co-pilot would be expected to detect the reduction of thrust, announce the abnormality and adjust the thrust levers back to take off thrust.

The co –pilot's inability to restore the thrust may stem from the fact that the combination of events experienced were unanticipated. The Co-pilot carried out the PF duties by maintaining directional control and exerted positive pressure on control column as seen from DFDR.

The PIC adjusted his seating position and assumed controls by announcing "my controls". Subsequent to this the PIC assumed the PF duties and the co-pilot reverts to PM duties. At this

moment neither crew member has observed the reduction in thrust for takeoff as the focus is now on the end of runway approaching and the rotation speed not having been achieved. At this stage, a rejected take off was no longer an option. With approximately 2000 feet runway remaining, the PIC exerts aft control column pressure to initiate the take off rotation. The PIC observed the rate of rotation & control forces were higher than normal and the same was corroborated with DFDR data. Computed airspeed at the initial rotation was 145 knots, consistent with the computed rotation speed (VR) of 144 knots.

During the simulator assessment replicating the incident flight, scenarios for recovery were assessed. The results are as below:

1. The Co-pilot rejects Take off 5 seconds after 117 Kts: the reject manoeuvre was possible with adequate margin. This was also established based on the Boeing performance analysis without the 5 second delay.
2. PIC Rejects Take Off after resuming PF Duties: The Reject manoeuvre resulted in an overrun.
3. PIC advances thrust to Max rated with 2000' of runway remaining (B737 QRH windshear manoeuvre): Take off with adequate margin was possible. There was no tail strike or excursion from the paved surface.

From the above it is concluded that:

- Had the PIC announced "Reject" after announcing "your controls", as he was unsettled, a reject take off manoeuvre could have been carried out safely by the Co-pilot.
- Had the PIC advanced the thrust to maximum rated (forward stop) on assuming controls, the aircraft would have got airborne safely. (since no derate take off thrust was used)
- Had the PIC rejected take off assuming controls, the aircraft would have overrun.

2.4.2. Airborne phase

The reduction in longitudinal acceleration caused by the thrust reduction led to the liftoff point being later than what is expected for the normal take off performance for given conditions. The PIC experienced slower rotation rate and higher control column force required than normal. The same is corroborated by the DFDR data and subsequent inputs from Cabin Crew. The PIC increased the control column force aft in order to get airborne. This caused a higher rotation rate, a pitch angle of 10.7 degrees leading to tail strike on the undulated soft surface for 17 meters followed by aft fuselage contacting the localizer antenna and boundary wall as the aircraft pitch was 11.4 degrees. This is corroborated by increase in vertical acceleration from the DFDR.

2.4.3 Initial Climb

Based on the above information, the crew were aware that their take off initiation was later than normal. The crew also felt light turbulence as they got Airborne. This perception of turbulence was due to the aircraft contacting the localizer Antenna and the boundary wall and would have lasted for few seconds as stated by the crew and corroborated by the DFDR.

Shortly after the aircraft was airborne, ATC Trichy advised the crew that the:

- take off was low as observed from CISF watch post located near the boundary wall.
- compound wall was broken as advised by Fire Station
- aircraft hit the localizer and Boundary wall and localizer antenna broken. (This was in response of crew query as to what had happened)

The crew decided to carryout system confidence check by levelling at FL 210. This included Hydraulic, Landing Gear, Pressurisation and Engine Parameters. At the time of this check all parameters were found to be normal as per the crew statements and corroborated with the DFDR.

Given the information available to the crew based on their observations and subsequent ATC communication, the probability of structural damage should have been ascertained. Had the crew recognized the possibility of structural damage from the information available to them, it is likely that they would consider not pressurizing the aircraft and accessing a suitable airport for landing. The B737 QRH for tail strike also requires the crew to not to pressurize the aircraft and land at nearest suitable airport.

A Comprehensive decision making Model should have been used to effectively address the threat and error management. The crew's decision to continue to destination was based on confidence checks alone.

3. CONCLUSION

3.1 FINDINGS

1) Aircraft had a valid "Certificate of Airworthiness" and was certified and maintained in accordance with the approved maintenance schedule. The aircraft and engines were airworthy prior to take off and did not contribute toward the accident.
2) Both the crew were current and qualified on type to operate the flight. PIC and Co-Pilot were based at Mangalore & were operating first time together for Dubai- Trichy- Dubai Sector. The accident flight Trichy – Dubai Flight was their second flight.
3) As per the MET report the weather at the time of accident at Trichy airport was visibility 5000 meters and winds calm.
4) PIC seat reclined mechanism failed during take off roll at 117 knots. As PIC was unsettled, he handed over the controls to Co-pilot for 05 seconds. The throttle levers and control column were moved back inadvertently. PIC adjusted his seat and took control from the co-pilot and take off was continued.
5) Both the crew member failed to capture drop in Engine Thrust during the critical phase of operation and therefore no timely corrective action was initiated by either of the crew member to increase the thrust for continuation of the flight.
6) PM & PF role reversal occurred twice during takeoff roll affecting the decision making.
    - Had the PIC announced the "Reject" after announcing "your controls", as he was unsettled, a rejected take off manoeuvre could have been carried out safely.
    - Had the PIC advanced the thrust to maximum rated on assuming controls, the aircraft likely would have been airborne safely.
    - Had the PIC rejected take off assuming controls, the aircraft would have overrun.

7) The PIC was the Pilot Flying (PF) at the time of take off rotation initiation.
The crew decision making process undermined relevant information that was observed by the crew and subsequently conveyed by ATC regarding late lift off and ground facilities damage. The crew based their decision solely on confidence checks of the aircraft systems and undermined the possibility of structural damage and possibility of subsequent structural failure.

8) The company AME confirmed that the VHF antenna recovered from debris present near the localizer antenna belonged to M/s Air India Express aircraft.

9) When the aircraft was approaching Muscat FIR, Mumbai ATC contacted the crew on HF communication advising them about the accident and asked about their intention. At his point the Crew reported all operations normal and continuing to destination. 17 minutes prior to diversion an ACARS message was sent to the crew requesting them to divert the flight and land at Mumbai as per company instructions. Muscat ATC also passed the information that they have message from operations saying that you have to go back to Mumbai.

10) After assessment of fuel and requesting a direct route provided by Muscat Control, crew commenced diversion to Mumbai. PIC requested ATC Mumbai for full length of runway and firefighting services as a precautionary measure. Firefighting services and other emergency services were activated at Mumbai airport.

11) The crew did not declare an emergency. The PIC configured the aircraft early to ensure the Flaps and Landing Gear operate normally. The Aircraft landed on runway 09 at Mumbai airport at 0008 UTC on 12/10/2018. The total flight time was 04:21 hrs. The fuel available after landing at Mumbai was 2953 Kgs which was adequate for a diversion to Pune. Normal deplaning of passengers was carried out and no injury was reported.

12) The aircraft sustained extensive damage on the lower fuselage and engine cowling as it contacted the Localizer antenna and rods holding the Green Mesh over the Airport Boundary wall. No FOD was observed in the engine core area.

13) The cockpit conversation at the time of take-off from Trichy was not available as the CVR installed is capable of continuous recording of last 2 hours of data only.

14) During functional check at OEM facility, uncommanded seat back movement showed that incorrect adjustment (too- tight) of the cable assembly – recline allowed the seat back to move without operation of the control lever – recline.

15) The operations manual part D does not have a process for review in cases where competence issues are raised for a pass assessment.

3.2 PROBABLE CAUSE OF THE ACCIDENT

The probable cause of the accident is “Delayed take-off due to reduction of take-off thrust N1 from 98 % to 77 % before reaching V1, inability of both the crew members to monitor the thrust parameters and to take timely corrective action. This resulted in tail strike and subsequent hitting of the localizer Antenna and boundary wall of the airport.

Contributory factors:-

- PIC seatback recliner mechanism failure during take-off roll.
- Breakdown of Crew coordination during switching between PF, PM and back.
- Loss of situational awareness

4. SAFETY RECOMMENDATIONS

4.1 DGCA may issue advisory to all airlines to incorporate general safety instructions for the guidance of crew in handling situations which are not covered in the manufacturer documents as seen in the present accident based on analysis of their safety data.

4.2 Considering the critical nature of failure, the crew seat manufacturer may study the worldwide defect data and consider issuing suitable preventive maintenance guidance.

4.3 Air India Express pilot training processes must continuously evaluate proficiency of crew by review of training forms during endorsement & recurrent training.

4.4 Air India Express pilot training to reassess their decision making skills training for pilots in similar situations while addressing the deficiencies observed in this report.

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