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FINAL INVESTIGATION REPORT

ACCIDENT INVOLVING
M/S AIR INDIA EXPRESS LIMITED
B737-800 AIRCRAFT VT-AXH
ON 07 AUGUST 2020 AT KOZHIKODE

AIRCRAFT ACCIDENT INVESTIGATION BUREAU
MINISTRY OF CIVIL AVIATION
GOVERNMENT OF INDIA

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ACKNOWLEDGEMENT

I am truly honoured to have been given the opportunity to head the Investigation into the Accident at Kozhikode on 07 August 2020 involving B737-800 aircraft VT-AXH operated by M/s Air India Express Limited.

My team and I have worked sincerely and painstakingly to write this report without any bias or influence affecting our judgement. This has been a long and painstaking effort to bring out the truth about the crash of AXB 1344. I hope this report will contribute to highlight all the factors that led to the crash so that mitigating measures may be taken to prevent or at the least minimize such occurrences in the future

I would like to place on record my deep appreciation for my team Mr Ved Prakash, Gp Capt (Dr) Y S Dahiya, Mr Mukul Bhardwaj, Mr Jasbir Singh Larhga and Capt G S Sumra for working tirelessly even during the worst of Covid-19 pandemic. It would not have been possible to carry the investigation to its logical conclusion without their varied expertise and crucial inputs.

I would like to make a special mention of the hard work, commitment and support extended by Mukul Bharadwaj who was always willing to go the extra mile to help in this exercise.

I am grateful to Mr Daniel R Bower, Accredited Representative, NTSB, USA and his entire team for all the assistance and expert opinion provided by them to the Investigation Team.

I am thankful to AAIB, India for all the administrative support provided to us.

Place: New Delhi

Date: 17th August 2021

Capt. Surender Singh Chahar
Former Designated Examiner Boeing 737
Investigator-in-Charge

SYNOPSIS

This report contains the details of the investigation carried out by the Team constituted according to the Order (INV/11011/6/2020-AAIB) of 13 August 2020 by the Director General AAIB, Ministry of Civil Aviation, Government of India. The Investigating Team was asked to determine the probable cause(s) and contributory factor(s) leading to the accident of Air India Express Boeing 737-800 aircraft, registration VT-AXH, on 07 August 2020 at 14:11 UTC (19:41 IST) at Kozhikode airfield. The investigation was carried out in accordance with Annexure 13 to the Chicago Convention of International Civil Aviation Organisation. The period of this investigation was amidst the peak of Covid-19 pandemic worldwide, which influenced the timelines for almost every activity of the team which included travel, availability of witnesses, and finalisation of test reports.

The purpose of this aircraft accident investigation is not to apportion blame or liability. The sole objective of this investigation is the prevention of such accidents or incidents in future. The use of this report for any other purpose other than the one specified would be inappropriate.

The draft report was shared with the Accredited Representative appointed by the National Transport Safety Board of the United States of America. Relevant comments from them have been incorporated in the report.

Timings are expressed in UTC. In order to give better perspective local timing in IST (UTC +5:30) is also mentioned for the important events.

Air-India Express Limited B737-800 aircraft VT-AXH was operating a quick return flight on sector Kozhikode-Dubai-Kozhikode under 'Vande Bharat Mission' to repatriate passengers who were stranded overseas due to closure of airspace and flight operations owing to the Covid-19 pandemic. The aircraft departed from Kozhikode for Dubai at 10:19 IST (04:49 UTC) on 07 August 2020 and landed at Dubai at 08:11 UTC. The flight was uneventful. There was no change of crew and no defect was reported on the first sector. The aircraft departed from Dubai for Kozhikode at 10:00 UTC as flight AXB 1344 carrying 184 passengers and six crew members.

AXB 1344 made two approaches for landing at Kozhikode. The aircraft carried out a missed approach on the first attempt while coming into land on runway 28. The second approach was on runway 10 and the aircraft landed at 14:10:25 UTC. The aircraft touched down approximately at 4,438 ft on 8,858 ft long runway, in light rain with tailwind component of 15 knots and a ground speed of 165 knots. The aircraft could not be stopped on the runway and this ended in runway overrun. The aircraft exited the runway 10 end at a ground speed of 84 knots and then overshot the RESA, breaking the ILS antennae and a fence before plummeting down the tabletop runway. The aircraft fell to a depth of approximately 110 ft below the runway elevation and impacted the perimeter road that runs just below the tabletop runway, at a ground speed of 41 knots and then came to an abrupt halt on the airport perimeter road just short of the perimeter wall.

There was fuel leak from both the wing tanks; however, there was no post-crash fire. The aircraft was destroyed and its fuselage broke into three sections. Both engines were completely separated from the wings.

The rescue operations were carried out by the ARFF crew on duty with help of Central Industrial Security Force (CISF) personnel stationed at the airport and several civilians who rushed to the crash site when the accident occurred. Upon receipt of the information about the aircraft crash the district administration immediately despatched fire tenders and ambulances to the crash site. Nineteen passengers were fatally injured and Seventy Five passengers suffered serious injuries in the accident while Ninety passengers suffered minor or no injuries. Both Pilots suffered fatal injuries while one cabin crew was seriously injured and three cabin crew received minor injuries. The rescue operation was completed at 16:45 UTC (22:15 IST).

TABLE OF CONTENTS		
PARA	**CONTENT**	**PAGE NO.**

LIST OF FIGURES

ABBREVIATIONS

AACU	Antiskid Autobrake Control Unit
AAI	Airports Authority Of India
AAIB	Aircraft Accident Investigation Bureau.
ACARS	Aircraft Communication Addressing and Reporting System
ADIRU	Air Data Inertial Reference Unit
ADSB	Automatic Dependent Surveillance Broadcast
AEP	Airport Emergency Plan
AFE	Airfield Elevation
AGL	Above Ground Level
AICL	Air India Charters Limited
AIESL	Air India Engineering Services Ltd
AIP	Aeronautical Information Publication.
AIXL	Air India Express Ltd
ALAR	Approach & Landing Accident Reduction
ALD	Actual Landing Distance
AME	Aircraft Maintenance Engineer
AMM	Aircraft Maintenance Manual
AMO	Aircraft Maintenance Organisation
AMS	Aviation Meteorological Services
ANS	Air Navigation Services
AOC	Air Operator Certificate
AOP	Air Operator Permit
AP	Auto Pilot
APD	Airport Director.
APHO	Airport Health Officer
ARFFS	Airport Rescue and Fire Fighting Services.
ARMS	Aviation Risk Management Solutions
ARP	Aerodrome Reference Point
ASC	Air Safety Circular
ASDA	Accelerated Stop Distance Available.
ASP	Annual Surveillance Plan
AT (A/T)	Auto-Throttle
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATO	Approved Training Organization
ATPL	Airline Transport Pilot License
ATR	Action Taken Report
ATS	Air Traffic Services
AVSEC	Aviation Security
AWO	All Weather Operation
BCAS	Bureau Of Civil Aviation Security
BDDS	Bomb Detection And Disposal Squad
BDDS	Bomb Detection And Disposal Squad
BITE	Built-In-Test Equipment

CAME	Continued Airworthiness Management Exposition
CAMO	Continued Airworthiness Management Organization
CAR	Civil Aviation Requirements
CAS	Computed Air Speed
CAT	Category
CB	Cumulonimbus Cloud
CBR	California Bearing Ratio
CBT	Competency Based Training
CCIC	Cabin Crew In-Charge
CCJ	IATA Three Letter Code for Calicut Airport
CCTV	Close Circuit TV
CDFA	Continuous Descent Final Approach
CDL	Configuration Deviation List
CDS	Common Display System
CDU	Control Display Unit
CFP	Computerised Flight Plan
CFT	Crash Fire Tender
CG	Center Of Gravity
CISF	Central Industrial Security Force.
CL	Clearance
CLC	Calicut
CMM	Component Maintenance Manual
CNS	Communication and Navigation Services.
COI	Court of Inquiry
COSPAS	Space System For Research Of Distressed Vessels
CPL	Commercial Pilot License
CRM	Crew Resource Management
CRS	Child Restraint Systems
CTE	Central Training Establishment
CVR	Cockpit Voice Recorder
DA	Decision Altitude
DAS	Directorate Of Air Safety
DATCO	Duty Air Traffic Control Officer
DFDAU	Digital Flight Data Acquisition Unit
DFDR	Digital Flight Data Recorder
DG	Director General
DGCA	Directorate General of Civil Aviation
DGR	Dangerous Goods.
DIWE	Distant Indicating Wind Equipment
DME	Distance Measuring Equipment
DMS	Directorate of Medical Services, DGCA
eAIP	E-Aeronautical Information Publication
EAU	Engine Accessory Unit
EDTO	Extended Diversion Time Operation.
EEC	Electronic Engine Control

EFB	Electronic Flight Bag
EGPWS	Enhanced Ground Proximity Warning System
ELT	Emergency Locator Transmitter
EMAS	Engineered Material Arresting System
FAA	Federal Aviation Administration
FBL	Feeble Rain
FCOM	Flight Crew Operation Manual
FCTM	Flight Crew Training Manual
FDAU	Flight Data Acquisition Unit
FDM	Flight Data Monitoring
FDTL	Flight Duty Time Limitation
FFRC	Friends And Family Reception Centre
FIM	Flight Information Management
FL	Flight Level
FMC	Flight Management Computer
FO	First Officer
FOD	Foreign Object Damage
FOQA	Flight Operations Quality Assurance
FPM	Feet Per Minute
FPS	Flight Progress Strip
FRTOL	Flight Radio Telephony Operator License
FSB	Flight Safety Bulletin
FSD	Flight Standards Directorate
FSM	Flight Safety Manual
ft	Feet
FWD	Forward
G	Gravity (Si Unit)
GNSS	Global Navigation Satellite System
GOI	Government Of India
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GS	Glide-Slope
HFACS	Human Factors Analysis And Classification System
HQ	Head Quarters
IAF	Indian Air Force
IAM	Institute Of Aerospace Medicine
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Condition
IMD	Indian Meteorological Department
INMCC	Indian Mission Control Center
INSAT-3D	Satellite
IOD	Instrumental Overhaul Division
IOS	Instructor Operating Station

IST	Indian Standard Time
KG	Kilogram
KINCON	Kinematic Consistency
kt	Knots
L1	Forward Entry Door
L2	Aft Entry Door
lb	Pound
LDA	Landing Distance Available
LDR	Landing Distance Required
LHS	Left Hand Side
LOC	Localizer
LOFT	Line Oriented Flying Training
LOPA	Layout Of Passenger Arrangement
LVDT	Linear Variable Differential Transformer
LVTO	Low Visibility Takeoff
MATS	Reduced Vertical Separation Minima
MCP	Mode Control Panel
MEHT	Minimum Eye Height over Threshold
MEL/CDL	Minimum Equipment List/Configuration Deviation List
MET	Meteorology
METAR	Meteorology Aerodrome Reports
MHZ	Megahertz
MLG	Main Landing Gear
MMI	Missing, Malfunctioning, or Inoperative Component Reporting
MOCA	Ministry of Civil Aviation
MOU	Memorandum of Understanding
MRO	Maintenance and Repair Organization
NASP	National Aviation Safety Plan
NAV	Navigation
NM	Nautical Miles
NOSIG	No Significant Change
NOTAM	Notification to Airmen
NTSB	National Transport Safety Board, USA
OEM	Original Equipment Manufacturer
OM	Operations Manual
OPS	Operations
OPT	On-Board Performance Tool
P.S.I	Pound Per Square Inch
P1	Captain
P2	First Officer
PA	Pressure Altitude
PAPI	Precision Approach Path Indicator
PBN	Performance Based Navigation
PCMCIA	Personal Computer Memory Card International Association
PCN	Pavement Classification Number
PDP	Pre determined point

PDR	Pilot Defect Report
PF	Pilot Flying
PIC	Pilot In Command
PI-QRH	Performance In-Flight Quick Reference Hand Book
PM	Pilot Monitoring
PMR	Pilot Medical Report
PPC	Pilot Proficiency Check
PSU	Passenger Service Units
QAR	Quick Access Recorder
QNH	Barometric Pressure at Sea Level (Q code)
QRH	Quick Reference Handbook
R1	Forward Right Service Door
R2	Aft Right Service Door
RA	Radio Altitude
RCC	Rescue Coordination Centre
RDR	Rubber Deposit Removal
RESA	Runway End Safety Area
RH	Right Hand
RIV	Rapid Intervention Vehicle
RLD	Required Landing Distance
ROD	Rate of Descent
RPM	Revolution Per Minute
RST	Runway Safety Team
RTO	Rejected Takeoff
RTOW	Runway Take Off Weight
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minima
SALS	Simple Approach Lighting System
SARPS	Standards And Recommended Practices
SARSAT	Search And Rescue Satellite Aided Tracking System
SBA	Speed Brake Armed
SBDNA	Speed Brake Do Not Arm
SCN	Show Cause Notice
SCT	Scattered
SEP	Safety and Emergency Procedures
SFP	Short Field Performance
SGA	Soft Ground Arresting
SIC	Safety Investigation Coordinator
SLF	Supervised Line Flying
SMS	Safety Management System
SOCC	Security Operations Control Centre
SOP	Standard Operating Procedure
SPECI	Special Meteorological Report
SPI	Safety Performance Indicators
STA	Station
T/D	Touch Down

TDZ	Touch Down Zone
THR	Threshold
TMO	Tower Meteorological Officer
TOD	Top of Descent
TODA	Take Off distance Available
TORA	Take Off Run Available
TR	Thrust Reverser
TRA	Throttle Resolver Angle
TRE/TRI	Type Rated Examiner / Type Rated Instructor
TRTO	Type Rated Training Organisation
TS	Thunderstorm
TSN	Time Since New
TSRA	Thunder Storm And Rain
TWR	Tower
UTC	Coordinated Universal Time
V_{APP}	Approach Speed
V_{REF}	Reference Landing Approach Speed, All Engines Operating
VMC	Visual Meteorological Conditions
VOCB	Coimbatore
VOCI	Cochin
VOCL	Kozhikode (Calicut)
VOKN	Kannur
VOLMET	Metrological Broadcast
VOR	Very High Frequency Omni Range
VOTR	Tiruchirappalli
WDI	Wind Direction Indicator
WDM	Wring Diagram Manual

FINAL INVESTIGATION REPORT ON ACCIDENT INVOLVING M/S AIR INDIA EXPRESS LIMITED B737-800 AIRCRAFT VT-AXH ON 07 AUGUST 2020 AT KOZHIKODE

1.	Aircraft	Type	BOEING 737-800
		Nationality	INDIAN
		Registration	VT-AXH
2.	Owner & Operator		AIR INDIA EXPRESS LIMITED
3.	Pilot		ATPL HOLDER
	Extent of Injuries		FATAL
4.	Co- Pilot		CPL HOLDER
	Extent of Injuries		FATAL
5.	No. of Persons on board		184 PASSENGERS 06 CREW
6.	Date & Time of Accident		07 AUGUST 2020, 1411 UTC
7.	Place of Accident		KOZHIKODE AIRPORT
8.	Co-ordinates of Accident Site		LATTITUDE : 11° 07' 59.7" N LONGITUDE : 75° 58' 13.5" E
9.	Last point of Departure		DUBAI
10.	Intended landing place		KOZHIKODE
11.	Type of Operation		REPATRIATION FLIGHT UNDER VANDE BHARAT MISSION
12.	Phase of operation		LANDING
13.	Type of Accident		ABNORMAL RUNWAY CONTACT RUNWAY EXCURSION

1 FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

Air India Express operations were curtailed during 2020 due to closure of airspace and other restrictions in place due to Covid-19 pandemic outbreak. The restricted passenger flight operations had resumed on 07 May, 2020 after a gap of nearly two months. The Operations department of Air India Express Limited planned an IFR flight for sector Kozhikode-Dubai-Kozhikode on 07 August, 2020 with radio telephony call sign AXB 1343/1344. The flight was operated using a Boeing 737-800 type of aircraft with registration VT-AXH. The flight was operated under 'Vande Bharat Mission' to repatriate passengers from Dubai who were stranded due to the closure of airspace and international flight operations.

The flight was operated by an ATPL holder PIC and a CPL holder Co-Pilot and assisted in the cabin by 04 cabin crew. The same crew operated both legs of the quick return flight. Flight AXB 1343 departed for the first leg (Kozhikode-Dubai) at 04:49 UTC after a delay of 14 minutes from the scheduled departure time. The Kozhikode-Dubai sector was uneventful and the flight landed safely at Dubai at 08:11 UTC.

The return flight from Dubai to Kozhikode with call sign AXB 1344 was scheduled to depart at 09:30 UTC. As per the statement of Cabin Crew, PIC showed urgency for departure and was trying to expedite the same. However, the flight got delayed and departed at 10:00 UTC. PIC was concerned about the undue delay and was anxious for an on-time arrival at Kozhikode.

There were 184 passengers on board, including 10 infants. The return sector was uneventful until the commencement of the first approach for landing into Kozhikode. PIC was the Pilot Flying (PF) and Co-Pilot was the Pilot Monitoring (PM) during this phase of the flight.

1.1.1 DESCENT INTO KOZHIKODE

The PM obtained destination and alternate airfields weather through ACARS. As per Airline monsoon circular, CFP departure fuel from Dubai was uplifted catering for Tiruchirappalli (VOTR), which was the farthest alternate airfield. However, latest weather update showed that even the closer airfields to Kozhikode i.e. Cochin and Coimbatore had suitable weather. Cochin airfield had a visibility of 2500 m in rain, hence Cochin was designated as diversion alternate in the approach briefing by the PF, for which they had 30 minutes of holding fuel overhead the destination. At 13:19 UTC Chennai Upper Area Control transmitted Kozhikode airfield weather details to AXB 1344 as runway in use 28, visibility of 1500 m in moderate thunderstorm and rain with surface winds of 270/14 kt. Visibility minima required for ILS approach for both runways (10/28) at Kozhikode was 1300 m. PF approach briefing before top of descent covered ILS approach details for runway 28, wherein no contingency for change of runway in use was briefed. Configuration of landing flaps and auto brake setting were decided by the crew without discussing and verifying the mandatory Landing Distance Required (LDR) calculations. As per the CVR transcript, the PF did not carry out the arrival briefing for the CCIC.

AXB 1344 requested descent at 13:25:21 UTC. The aircraft was cleared for descend to FL260 by Chennai Upper Area Control and subsequently handed over to Cochin Lower Area Control. The aircraft was later cleared for descend to FL120 by the Cochin Lower Area Control and came in contact with Kozhikode ATC at 13:33 UTC, while descending through FL170 for FL120 (12000 ft) at a distance of 52NM from Kozhikode. The Air Traffic Controller on duty further cleared the aircraft to 7000 ft after checking the radial and distance from Kozhikode VOR. At 13:34 UTC, the aircraft requested for visibility and winds prevailing at Kozhikode airfield. The DATCO reported visibility 1500 m in feeble rain and thunderstorm.

Kozhikode airfield was under two concurrent 'Aerodrome Warnings' at the time when the aircraft came in for landing. The first warning was for TSRA and the second warning was for wind speed exceeding 17 kt. Due to these two warnings a 'Weather Standby' was declared by DATCO and the Crash Fire Tenders (CFTs) were especially positioned at 'Pre-Determined Points' (PDPs) along the runway.

1.1.2 FIRST APPROACH

The aircraft was cleared for descend to 3600 ft at 13:41 UTC. Prevailing weather at Kozhikode was 2000 m visibility in light rain. The aircraft was cleared for ILS approach runway 28 from overhead CLC VOR at 13:44 UTC. Prior to the approach for runway 28, the flight crew did not make the mandatory announcement for the cabin crew to be seated.

After following the published procedure, AXB 1344 established on the localiser for runway 28. ATC cleared the aircraft to land with a reported visibility of 2000m and a trend decreasing to 1500m, winds 280/05 kt in light rain and runway surface wet. As per CVR recording, at 13:48:24 UTC PF is heard saying *"You just see that it works....remember put it to high...high speed"* referring to the wiper. Approximately two minutes later PF called *"Isko ON kar dete hain (let us put it ON)"* and the PM selected the wipers for landing at time 13:50:41 UTC while at 2258 ft on approach. At 13:51:05 UTC visual contact with the lead-in lights was confirmed by both the pilots. Thereafter, the wiper on the Captain side stopped working after operating for approximately 27 seconds while at approximately 1881 ft and CVR recorded PF saying *"Wiper is gone...what a day for the wiper to go".*

The aircraft continued on ILS approach for runway 28 to the prescribed Decision Altitude and then at 13:52:39 UTC carried out a missed approach as per company SOP on not being able to sight the runway at minimums. Upon being asked the reason for missed approach by DATCO, the PM asked the PF the reason to be given for the missed approach before transmitting the same to the ATC as "*Due weather and heavy rain*". Prior to commencing the ILS approach, AXB 1344 had taken clearance from ATC for a non standard missed approach *for a possible contingency* due to CBs all around. The aircraft therefore did not follow the prescribed missed approach procedure and was cleared to climb to 10,000 ft on an approximate runway heading in co-ordination with ATC.

1.1.3 MISSED APPROACH

The aircraft was cleaned up (undercarriage and flaps retracted) during the missed approach from runway 28 and the PM completed After Take-off Checklist at 13:55:46.3 while climbing through 3800 ft. Thereafter he sought clearance from PF to again set up the FMC for ILS approach runway 28. PF concurred after slight hesitation. Immediately around the same time a departing aircraft of Air India, call sign AIC 425 (Kozhikode-Delhi) at time 13:55:52 UTC requested ATC for permission to depart from Runway 10 although the runway in use was runway 28 owing to the prevailing winds at that time. ATC accepted the request of AIC 425 and immediately changed the runway from runway 28 to runway 10. The DATCO then enquired from AXB 1344 whether they too would like to use runway 10 for arrival and reported current surface winds as 270°/08 kt.

Despite unserviceable wiper on the Captain side, AXB 1344 did not consider diversion to alternate airfield and responded to DATCO's call by enquiring about the visibility and winds for Runway 10. DATCO confirmed visibility 2000 m and winds 260/05 kt. AXB 1344 which was climbing to 10,000 ft stopped climb and levelled out at 7000 ft after seeking permission from ATC. Later, DATCO once again confirmed from AXB 1344 if they would like to make an approach for runway 10. AXB 1344 again requested for winds and visibility with position of CBs. ATC transmitted the weather as 'visibility 2000 m, winds 260°/05 kt and CBs all around the airfield at 2500 ft'. Thereafter, AXB 1344 accepted runway 10 for landing.

1.1.4 FINAL APPROACH, LANDING AND LANDING ROLL

At 13:59:42 UTC, AXB 1344 requested descent clearance from 7000 ft. The aircraft was given descent clearance to 3600 ft and was cleared for ILS-Z approach for runway 10 via 284 radial 15 DME fix as published. No mandatory calculation of LDR was carried out by the crew during approach briefing for runway 10. In the mean time, Flight AIC 425 obtained take-off clearance and departed at 14:01 UTC from runway 10. During the takeoff clearance for AIC 425, ATC reported surface winds as 270°/10 Kt.

At 14:01:32 UTC, AXB 1344 was cautioned by DATCO for crossing beyond 25NM from the VOR and not turning inbound to intercept radial 284 CLC as instructed. Thereafter, the aircraft commenced the inbound turn, reaching a maximum distance of 27.5NM during the turn. At 14:06 UTC aircraft reported established on localiser runway 10 and was cleared to descend to 2200 ft as per procedure. At 14:07:03 UTC, PF was heard instructing the PM in context of windshield wiper *"you put it on properly in there… I will tell you when to put it on. I hope it works"*. Few seconds later, at 14:07:42 UTC, PF asks PM *"Isko Karen (shall we do it)"* and PM states *"Thodi der mein karte hain (let's do it little later)"*. At probably 14:07:47 UTC, the windshield wiper was switched on. This was immediately followed by the remarks of PF, *"What is this?"* After around four seconds, the PF confirms *"speed toh itni he rahegi (the speed is going to be this much only?)"*. This indicates that the windshield wiper on the PF side worked but at a speed lower than the selected speed.

At 14:07:59 UTC, aircraft captured the glideslope. At 14:08 UTC, ATC cleared AXB 1344 to land on runway 10 reporting latest weather update as visibility of 2000 m in light rain, runway surface wet and winds 250°/08 Kt. At 14:08:29 UTC the crew discussed Landing Flap selections and decided to go for Flap 30 selection instead of the initially discussed Flap 40 due to expected turbulence. Thereafter flap 30 was selected and Landing Checklist was completed at PA 1667 ft.

At 14:09:41 UTC, the aircraft was established on ILS with autopilot and auto throttle engaged at a PA of 633 ft with a CAS of 150 kt, the ground speed was approximately 175 kt with a calculated descent rate of 750 fpm. .

At 500 ft AGL the autopilot was disengaged while the autothrottle remained engaged, the pitch attitude was reduced and the descent rate began to increase, momentarily reaching 1500 fpm. The PM cautioned PF twice for high ROD, which was acknowledged by the PF for 'correction'. The approach soon became unstabilized, wherein the ROD and glideslope deviation increased beyond the stabilized approach criteria. The aircraft deviated 1.7 dots below the glideslope. This was followed by two EGPWS alerts (caution) for glideslope *'glideslope... glideslope'*. The PF increased the pitch attitude and the descent rate began to decrease, reaching 300 fpm before increasing again to 1000 fpm.

The aircraft crossed the runway threshold at RA of 92 ft and was moving left of centre line with an actual tail wind component of slightly more than 14 Kt and a cross wind component of 6 knots. At this point speed began to gradually increase towards 160 kt CAS and sink rate was gradually arrested as additional thrust was being manually added despite autothrottle command to reduce thrust. The engine power was continuously increased and reached 83% N1. This happened when the aircraft had already gone past the runway threshold by approximately 1363 ft and was at a height of 20 ft RA. The aircraft continued to float above the runway and moved towards the centreline as its lateral deviation was corrected. The engine thrust was reduced and at 3000 ft beyond the threshold, CAS began to decrease towards the approach speed at approximately 15 ft RA. During this time, 07 seconds before touchdown, while the aircraft was at 16 ft RA, the PM tried to catch the attention of the PF by giving a non standard call "*Just check it*". At this point, the aircraft was at 2500 ft beyond threshold, 500 ft short of end of touchdown zone. At Kozhikode, end of touchdown zone is marked at a distance of 3000 ft from the threshold by the simple touchdown zone lights on either side of the centre line.

05 seconds before touchdown, the sink rate began to increase gradually towards 12 fps (720 fpm) as the nose was lowered and thrust was reduced. 03 seconds before touchdown, PM again tried to catch the attention of the PF by giving a feeble, uncomfortable call "*...Captain*" when the aircraft had crossed the end of

touchdown zone (3600 ft beyond the threshold). During this time the engine thrust levers reached idle power setting.

Approximately 1 second before touchdown, while the aircraft was crossing 10 ft RA, at 4200 ft beyond the threshold the PM gave a call of "*Go around*". There was no response from PF to the "Go-Around" call and he continued with landing. During the flare, the aircraft floated, which resulted in a long landing along with an extended flare of 16 seconds. The aircraft touched down at 4438 ft on the 8858 ft long runway with a CAS of approximately 150 kt and a GS of 165 kt. It was raining at the time of touchdown and the runway condition reported by DATCO was wet.

PF immediately resorted to max manual braking overriding the auto brake selection, auto speed brakes were fully deployed 1.2 seconds after touchdown extending the spoilers. PM gave the standard calls for "SPEED BRAKE UP" and "AUTOBRAKE DISARM" there was no response from the PF to the standard calls given by the PM as per SOP. Autothrottle disengaged automatically 03 seconds after touchdown. The thrust reversers were commanded to deploy 03 seconds after touchdown. They were deployed within 02 seconds after initiating the command and remained in that state for a brief period of approximately 02 seconds with both engines power increasing to 59%N1. There was no call from PM of "REVERSERS NORMAL" as per SOP. None of the standard calls given by PM were acknowledged by the PF.

Before the thrust reversers could take any effect, they were stowed back. While the reversers were being stowed, the aircraft brake pressure was momentarily reduced, decreasing the longitudinal deceleration. This action by the PF coincides with a call by him of "*shit*".

Thrust reversers were deployed for the second time 15 seconds after touchdown, when the aircraft was at 8200 ft beyond the threshold, max reverse thrust was commanded and the engine began to spool up. Thrust reversers remained deployed for a period of approximately 07 seconds and by 9100 ft beyond the threshold (paved portion of RESA) as the CAS approached 60 kt, they were stowed back with the engine fan speed (N1) still high.

Two distinct calls from the PF and PM of *"shit"* were recorded within a gap of one second on the CVR, when the thrust reversers were stowed again and the aircraft was about to leave the runway surface (paved portion of RESA) and enter soft ground.

Speed brakes were stowed back shortly after 'SPEED BRAKE DO NOT ARM' light came on. At this time, aircraft had travelled 105 ft in to RESA (soft ground). However, the commanded brake pressure was recorded on the DFDR till the recording stopped. At no stage, after touchdown, were the thrust levers moved forward at any time on the landing roll.

The aircraft did not stop on the runway and this resulted in runway overrun. The aircraft exited the designated end of runway 10 (8858 ft) at a ground speed of 84.5 Kt and then overshot the RESA, broke the ILS antennae and a fence before plummeting down the tabletop runway. The aircraft fell to a depth of approximately 110 ft below the runway elevation and impacted the perimeter road that runs just below the tabletop runway, at a ground speed of 42 Kt. Aircraft came to an abrupt halt on the airport perimeter road, close to the perimeter wall. There was no post accident fire. The impact caused the aircraft to separate into three sections and resulted in 21 fatalities including both pilots.

Figure 1: One of the first images of accident site before commencement of ARFFS Operations.

1.2 INJURIES TO PERSONS ON BOARD

Injuries	Crew	Passengers	Total
Fatal	2	19	21
Serious	1	75	76
Minor	1	33	34
None	2	57	59

A total of 184 passengers and 06 crew members were on board flight AXB 1344. The mortal remains of 16 deceased passengers and 02 crew members were sent to Government Medical College and Hospital, Kozhikode for post-mortem examination. Later, three more passengers succumbed due to complications of polytrauma at different hospitals during the course of their treatment. The 169 survivors on-board were examined and treated at different hospitals in and around Kozhikode.

1.3 AIRCRAFT DAMAGE

Aircraft was completely destroyed in the accident and the fuselage split into three sections. Detailed information is given in 1.12 – Wreckage and Impact information.

Figure 2: Aircraft broken into three sections.

1.4 OTHER DAMAGES

Damage to airport property included some of the runway approach lights, a localizer antenna array, runway area perimeter fence, perimeter road lamp post and the airport perimeter road. The detail of the damaged fixtures is given below:

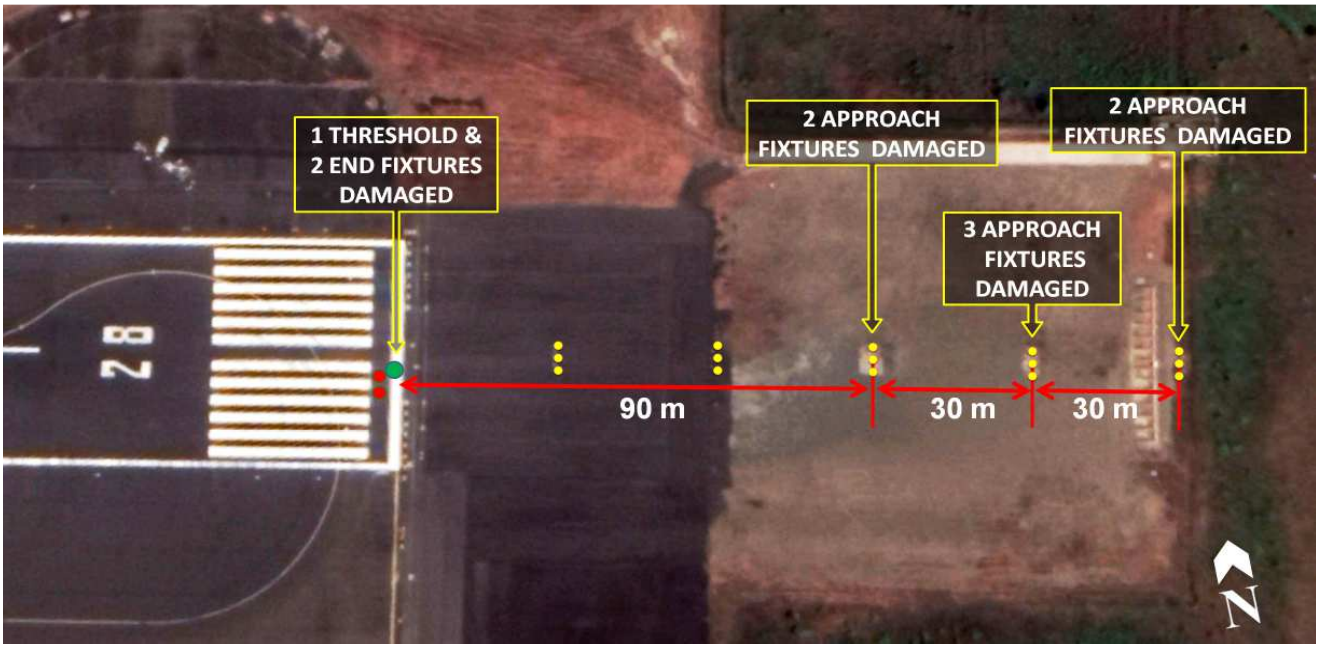


Figure 3: The location of the damaged lights in RESA.

(a) 02 Runway End Lights and 01 Threshold Light was damaged by the aircraft wheels.

(b) 03 units of SALS were partially damaged by the aircraft wheels.

Figure 4: Damage to ILS Localiser Antenna

Figure 5: Damage to fence at end of RESA

(c) Localiser Antenna Array was damaged when the aircraft went through the array.

(d) Runway Area Perimeter Fence was damaged due to impact with aircraft as it slid down the slope after overshooting the runway and RESA.

Figure 6: Lamp post broken by impact with right wing

(e) A lamp post on the perimeter road was also broken due to impact with the right wing of the aircraft.

1.5 PERSONNEL INFORMATION

1.5.1 PILOT IN COMMAND (PIC)

Gender	Male
Age	59 Years 03 Months
License	ATPL
Validity of License	24 January, 2022
Type Endorsements	C152/P68C/B737-800 as PIC HS748/ A310/ B777-200/B777-300 as Co-pilot
Date of Class I Medical Exam	24 July, 2020
Validity of Medical Exam	23 January, 2021
FRTO License Validity	24 January, 2022
Total Flying Experience	10848.50 hrs
Total Flying Experience on Type	4612.59 hrs
Total Flying Experience during last 180 days	100.09 hrs
Total Flying Experience during last 30 days	20.04 hrs
Total Flying Experience during last 07 days	07.38 hrs
Total Flying Experience during last 24 hours	07:38 hrs

Note- the total flying hours include the accident flight.

PIC was an ex-military pilot and had applied for issue of ATPL on 24 August, 1998 while still in active military service with 2504 hrs of flying experience. He was issued ATPL with endorsement on Cessna 152A aircraft and FRTOL on 07 September, 1998 after clearing DGCA exams and undergoing medical assessment as per DGCA standards.

His ATPL was later endorsed with HS-748 type of aircraft on 30 January, 2003 while he was still serving in the military. Later, he joined a non-schedule operator and obtained P-68C multi engine aircraft endorsement on 19 February, 2004. He joined Air India as co-pilot on Airbus A310 fleet on 01 November, 2004. As per DGCA CAR Section 8, series F, Part II, Para 14.3 airlines are required to retain training records for a period of 03 years from the date of training, checking and qualification undertaken by fight crew, old training records from the airlines were not available, however training records since 2009 were available with the airlines and provided to the investigation team.

He underwent Type Training on B737-800 and his application for Type endorsement was submitted to DGCA. He was granted Type endorsement on B737-800 on 19 February, 2010 as Co-pilot. In 2011-12, he underwent Type training on B777-200 and his documents were submitted in DGCA for Type endorsement with Instrument Rating on B777-200 as Co-pilot. The ATPL of PIC was endorsed as Co-Pilot on Boeing 777-200 aircraft with IR on 13 January, 2012. After undergoing the Differential Training for B777-300 aircraft, the ATPL of PIC was also endorsed for the same on 28 February, 2012.

As per the records made available by M/s Air India, the PIC was unable to make the grade as Pilot-in-Command (PIC) on Boeing 777 type of aircraft in the year 2013 in spite of undergoing corrective training. Thereafter, he submitted his application to M/s Air India, requesting a switch over to AIXL as Trainee Captain, which was acceded to and he left Air India and joined AIXL in October 2013.

Accordingly, on 22 January, 2014 AIXL requested DGCA for grant of revival of Type endorsement on B737-800 aircraft after conducting extended refresher course as per CAR Section 8 Series F Part I. DGCA granted the same by renewing the Instrument Rating on Type on 29 January, 2014 as per CAR Section 8 Series F Part I para 3(d) and (e).

During his PIC training on B737 in AIXL, his progress was found unsatisfactory during Route Check # 7 on 01 Nov 2014. However, subsequently he cleared the PIC tests and on 31 December, 2014 AIXL submitted his documents for grant of B737-800 Pilot-In-Command (PIC) endorsement on his ATPL. The documents submitted were examined by DGCA and found to be in order and Type endorsement as PIC on B737-800 aircraft was granted on 02 January, 2015, along with renewal of ATPL and IR. The ATPL was last renewed on 25 January, 2017 and was valid up to 24 January, 2022. The PIC was a Line Training Captain with AIXL as per the approval issued by Chief of Training dated 06 November, 2017. He had been regularly operating from Kozhikode airport and had operated 36 flights in and out of Kozhikode during the last one year prior to the accident. As per information made available by AIXL flight safety there are no Grounding/Violation records against PIC.

As part of his last Annual Ground Refresher, he had undergone CRM, Adverse Weather, PBN, RVSM, EDTO and Monsoon Refresher on 03 July, 2020. He was current on all his trainings and checks. The old training records of the PIC were obtained from Air India and AIXL and were scrutinised. Some of the adverse observations/remarks related to safety concerns made by various examiners/trainers are tabulated below:

Date	**Company**	**Details**	**Remarks** *(as mentioned in records)*
2004-2009	Air India	A310 (P2)	Training Records not available
5 Dec 2009	AI Express	Full Flight Simulator, lesson 8 on B737 (P2 training)	"*He loses his concentration sometimes*"
28 Dec 2009	AI Express	CRM LOFT on B737 (P2 training)	"*When under stress he loses his concentration which leads to mistakes and not planning forward*"
20 Aug 2012	Air India	Counselling for "landing and flare technique" on B777 (P1 upgrade)	

09 Dec 2012	Air India	Command SLF FLT No. 23 on B777	*"Unsatisfactory for:* *1. SOP* *2. Situational awareness* 3. *Speed control"* Recommended for corrective training after which recommence SLF 23.
15 Jan 2013	Air India	• Command SLF FLT No. 26 on B777 • Counselling by Fleet Captain for -Flare and landing -Awareness levels	"*Unsatisfactory*" Two corrective sessions on simulator recommended after which recommence SLF 26.
25 Aug 2014	AI Express	Command SLF – 9 & 10 on B737	"*Tendency to float during landing*"
03 Sep 2014	AI Express	Command SLF – 16 & 17 on B737	"*Needs to be more stable on short finals*"
05 Sep 2014	AI Express	Command SLF – 20 & 21 on B737	"*Prolonged flare – landing beyond touchdown zone*"
01 Nov 2014	AI Express	Route check #7 on B737	"*Not satisfactory"* *"Flare technique (no flare, pilot had to be assisted)"*

On 12 April, 2016 PIC was declared 'Temporary Unfit for flying' for 03 months for Diabetes Mellitus. He was advised to undergo further medical reviews at Boarding Centres only and was subsequently declared fit for flying as 'PIC with Qualified Experienced Pilot', with an advice for monthly Blood Sugar Test and three monthly HbA1C. He was finally declared 'fit as PIC without any limitations' on 10 January, 2017. However, it was recommended that he should undergo all his future renewal medical examinations at Boarding Centres only, each time with fresh opinion of an Endocrinologist. This recommendation continued till the date of accident with an exception during his last medical renewal, wherein, due to the prevailing Covid-19 pandemic, certain exemptions were granted by DGCA and he was permitted to undergo renewal medical examination by any DGCA empanelled Class 1 Examiner.

The home base of PIC, as per information available from AIXL, was Mumbai. As per the scheduling information passed to the PIC on 01 August, 2020, he was informed of the duty roster for the period 05 August, 2020 to 10 August, 2020. He underwent Covid Test on 05 August, 2020 and was positioned at Kozhikode on 06 August, 2020 from Mumbai. He had checked into the hotel at 13:40 UTC (19:10 IST). As per the duty roster, he was to operate Kozhikode-Dubai-Kozhikode Flight AXB1343/44 on 07 August, 2020 followed by Standby duty on 08 August, 2020. He had the mandatory rest as per FDTL requirements before operating the flight.

1.5.2 FIRST OFFICER (CO-PILOT)

Gender	Male
Age	32 Years 03 Months
License	CPL
Validity of License	25 April, 2023
Type Endorsements	DA-40/DA-42 as PIC B737-800 as Co-pilot
Date of Class I Medical Exam	13 January, 2020
Validity of Medical Exam	14 January, 2021
FRTO License Validity	25 April, 2023
Total Flying Experience	1989.17 hrs
Total Flying Experience on Type	1723.49 hrs
Total Flying Experience during last 180 days	154.17 hrs
Total Flying Experience during last 30 days	31.02 hrs
Total Flying Experience during last 07 days	15.11 hrs
Total Flying Experience during last 24 hours	07:38 hrs

Note- the total flying hours include the accident flight.

Upon compliance of all requirements as contained in Section J of Schedule II of the Aircraft Rules 1937, the Co-Pilot was issued CPL with validity from 26 April, 2013 to 25 April, 2018 along with PPL with IR. He was also issued FRTOL with validity from 26 April, 2013 to 25 April, 2018.

The First Officer underwent Type Training on B737-800 aircraft from a DGCA approved training organization in 2017. Co-Pilot endorsement on B737-800 aircraft with Instrument Rating was endorsed on his License on 22 November, 2017 by DGCA. He joined Air India Express on 01 December, 2017

The CPL was renewed by the office of DGCA, Western Region, Mumbai and validity extended from 26 April 2018 to 25 April, 2023. The Instrument Rating was valid up to16 December, 2020. His Medical Assessment was valid up to 14 January, 2021 and was declared 'Fit for Flying with no limitation'.

As part of Annual Ground Refresher, Co-Pilot had undergone CRM, Adverse Weather, PBN, RVSM, EDTO and Monsoon Refresher training on 19 September, 2019. The IR endorsement had lapsed on 16 June, 2020 and PPC had lapsed on 04 June, 2020 along with CAT-II/CAT-IIIA/CAT-IIIB P2 training. However, DGCA had issued extension of trainings up to 30 September, 2020 vide Operations Circular 02 of 2020 in view of the Covid-19 pandemic situation.

The Co-pilot was based in Kozhikode and had operated his previous flight on 01 August, 2020. He underwent Covid Test on 04 August, 2020 and was rostered for Kozhikode-Dubai-Kozhikode Flight AXB1343/44 for 07 August, 2020.

1.5.3 CABIN CREW

The cabin crew requirement on board the aircraft as per Rule 38B of Aircraft Rules, 1937 was 04. Accordingly, a total of 04 cabin crew were detailed for the flight. The qualification and experience of cabin crew manning different stations is shown in the table below:

Training and Validity	**Cabin Crew Station**			
	L1	**R1**	**L2**	**R2**
Annual Recurrent Training	14 May 2021	21 May 2021	13 Jul 2021	21 May 2021
DGR Training	25 Jun 2020*	23 Jul 2021	20 Aug 2021	23 Jul 2021
AVSEC Training	11 Feb 2022	13 May 2021	27 May 2021	15 Apr 2021
Ditching drill	02 Jan 2022	18 Jul 2020*	30 Aug 2020	18 Jul 2020*
Fire drill	02 Jan 2022	17 Jul 2020*	13 Sept 2020	17 Jul 2020*
Emergency Exit Training	02 Jan 2022	16 Jul 2020*	06 Sept 2020	16 Jul 2020*
Escape Slide Drill	02 Jan 2022	16 Jul 2020*	06 Sep 2020	16 Jul 2020*
CRM/ Joint CRM	12 May 2021	21 May 2021	13 Jul 2021	21 May 2021
Medical Check	16 Jul 2021	25 Aug 2021	05 May 2021	29 Aug 2021

All cabin crew members were current on their training and checks except the ones marked with (*). However, in view of Covid-19 pandemic, DGCA Circular dated 19 June, 2020 granted extension of DGR validity up to 30 September, 2020 and Operations Circular 02 of 2020 for extension of validity of various training/checks was applicable for cabin crew as well.

1.5.4 DUTY AIR TRAFFIC CONTROLLER

Age	29 Years 5 Months
Date of Joining ATC	28 June, 2017
Date of Joining Station	02 July,2018
Rating Held	Aerodrome control and Approach control procedural (combined)
Ratings Date	09 August, 2019
Last Proficiency check	28 November, 2019
Last Annual Refresher	24-25 April, 2019
Recency Details	DATCO was current in August 2020 and had performed duty as per details below:- 14 July,2020 (Duty time - 4 hrs 45 min) 17 July ,2020 (Duty time - 4 hrs 35 min) 21 July,2020 (Duty time -6 hrs)

1.6 AIRCRAFT INFORMATION

1.6.1 GENERAL

Aircraft VT-AXH bearing Serial No. 36323 was manufactured by M/s Boeing Company in the year 2006. The variable number was YL461. The aircraft was registered with DGCA under the ownership of M/s Air India Express Limited. It was registered in India with effect from 06 December, 2006 and had a valid Certificate of registration No. 3453/4 dated 14 November, 2018 under Category 'A'.

The Certificate of Airworthiness Number 2862 under 'Normal Category' and subdivision 'Passenger / Mail / Goods' was issued by DGCA on 24 November, 2006. The last Airworthiness Review Certificate was issued on 27 November, 2019 and was valid up to 29 November, 2020. The Aircraft had a valid Aero Mobile License valid up to 23 November, 2023.

VT-AXH was a Short Field Performance Type I aircraft with enhanced short runway takeoff and landing capabilities.

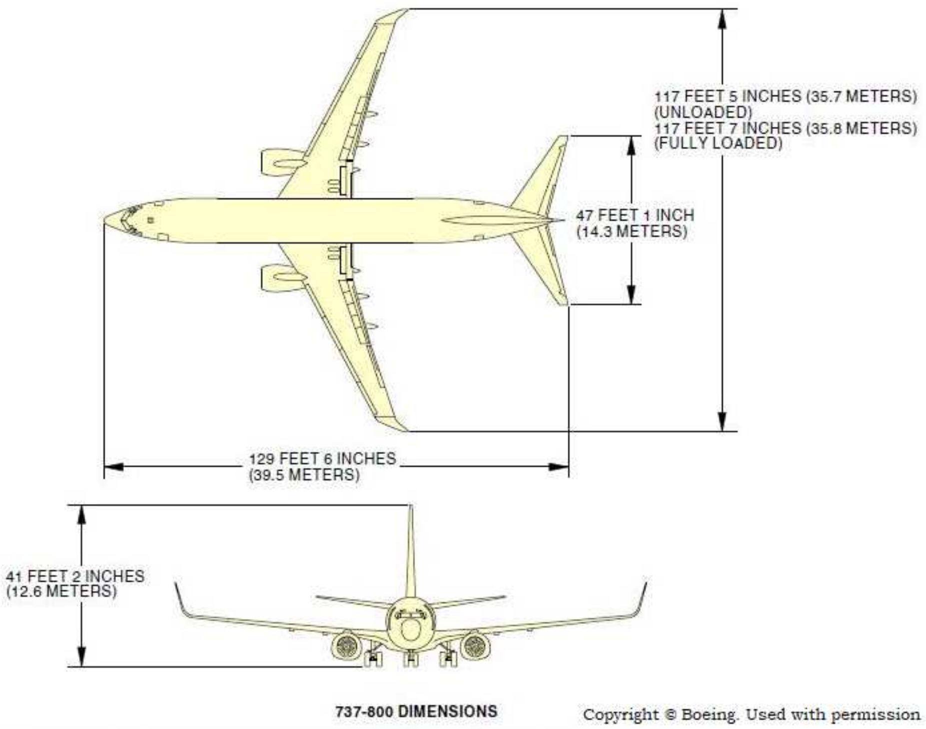


Figure 7 : Aircraft Dimensions

1.6.2 BOEING 737-800 AIRCRAFT SYSTEMS DESCRIPTION

1.6.2.1 SPOILERS

The airplane is equipped with spoilers (speed brakes) which help the airplane to decelerate after landing by disrupting the airflow over the wings, maximizing the airplane weight on its landing gear and increasing the wheel brakes effectiveness. The speed brakes are generally more effective at higher ground speeds.

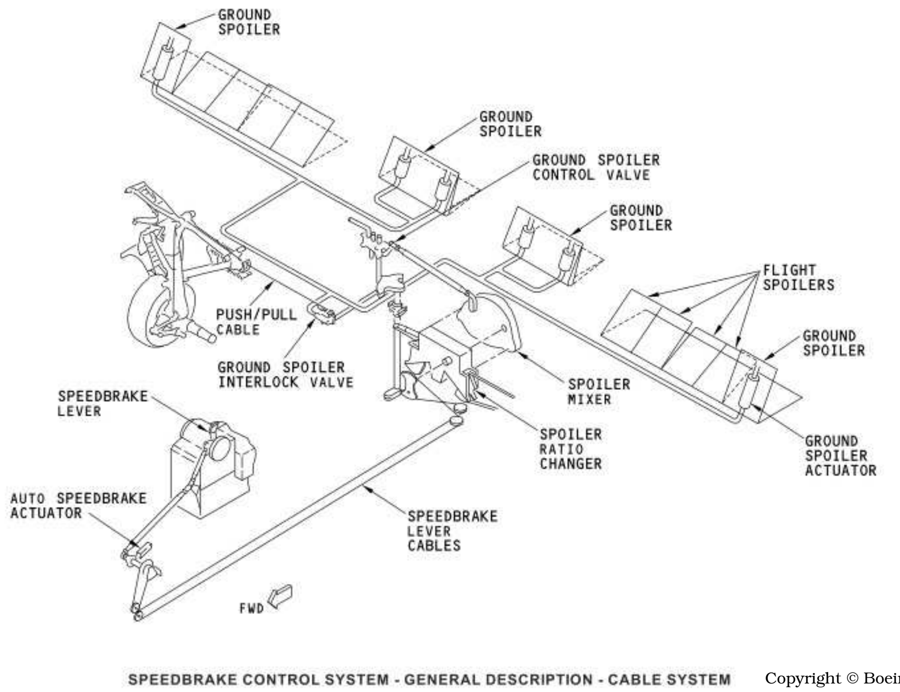


Figure 8 : Speedbrake Control System

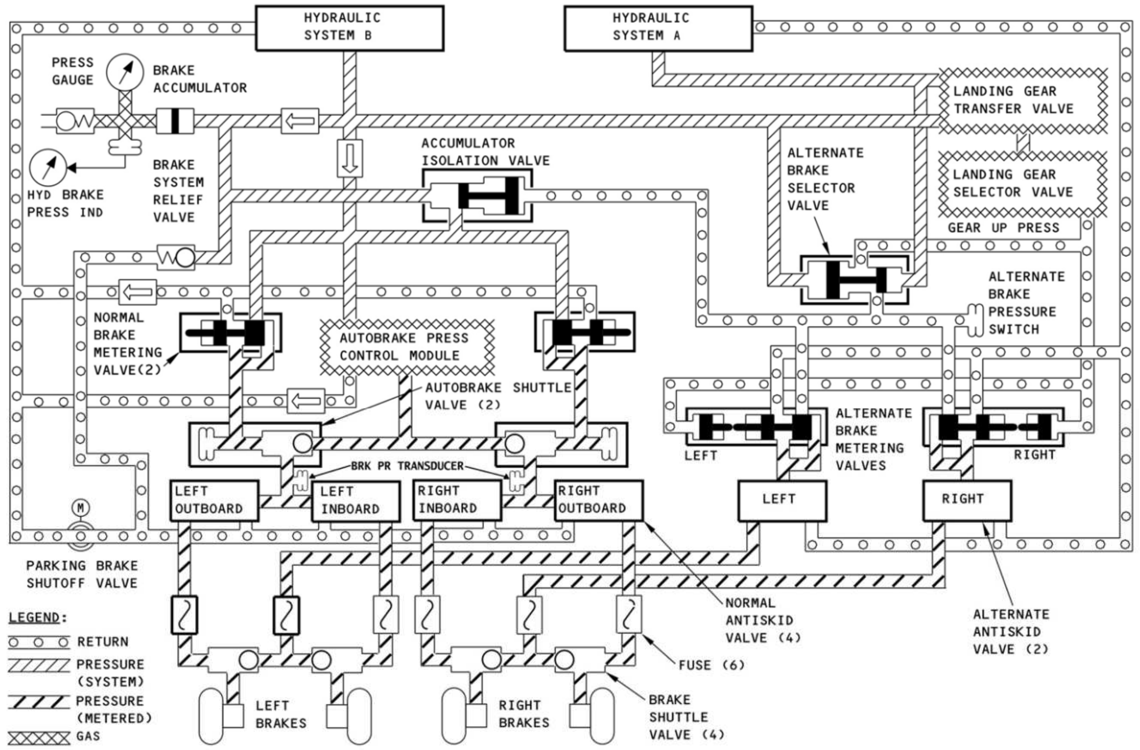
There are six spoilers on each wing. The most outboard and the most inboard spoiler on each wing are ground spoilers, while the rest of the spoilers are flight spoilers. The flight crew uses the speed brakes lever to manually move the spoilers and the auto speed brake computer controls automatic extension of all the spoilers during landing.

If armed correctly, the auto speedbrake operates upon landing. The auto speedbrake actuator moves the speedbrake lever and commands all spoilers to move up. Speed brake handle movement, flight spoiler deflection and ground spoiler interlock valve status are recorded in the DFDR.

1.6.2.2 BRAKE SYSTEM

The airplane wheel brake system is intended to slow and stop the airplane after landing. It consists of brakes installed on each of the main landing gear wheels that are hydraulically actuated manually or automatically, when autobrakes are selected before touchdown. Under normal operations all four brakes use system 'B' hydraulic pressure.

Anti-Skid system prevents individual wheel skidding by limiting the metered pressure applied to the normal brakes. The pilot applies metered pressure through the brake pedals. Four Anti-skid valves, which operate independently of each other, continuously vary metered pressure in accordance with signals received from the Antiskid/Autobrake Control Unit (AACU). The speed of each wheel is compared to detect wheel skids. When a skid is detected a correction signal is sent to the anti-skid valve to reduce brake pressure. During friction limited braking conditions as on a wet runway, the anti-skid system continuously seeks a level of brake application to attain maximum braking efficiency. The anti-skid system also provides locked wheel and hydroplane protection.



HYDRAULIC BRAKE SYSTEM

Figure 9 : Hydraulic Brake System

Locked wheel protection compares wheel speed between a pair of wheels. If the slower wheel speed decreases below a defined limit it releases brake pressure from the slower wheels and prevents the wheel from skidding (locked wheel).

Hydroplane protection compares the wheel speed data with aircraft ground speed, if the wheel speed decreases below a defined limit the brake pressure is released.

A transducer in each main landing gear wheel axle supplies wheel speed data to the AACU, the left and right ADIRUs supply ground speed data. The PSEU supplies air/ground status. AACU uses the wheel speed data for calculation of anti-skid control and also provides this data to other computers. However the wheel speed data is not recorded in the FDAU. When the BITE card in the AACU finds a fault in the system it causes the amber 'ANTI SKID INOP' light to come on.

The auto brake system is controlled by AACU and provides a scheduled rate of deceleration as per the selection. It automatically applies the brakes to stop the airplane after it lands. Manual brake application by the pilot will override and disarm the auto brake system. The auto brake shuttle valve sends auto brake pressure to the normal brake system. It does this when normal metered pressure is less than auto brake pressure. The metered pressure switch on the auto brake shuttle valve sends signals to the antiskid/auto brake control unit when the pressure from the normal brake metering valve increases above the autobrake override threshold. The antiskid/auto brake control unit uses this signal to disarm the operation of the auto brakes and the 'AUTO BRAKE DISARM' amber light comes on.

1.6.2.3 THRUST REVERSER

Each of the airplane engines is equipped with a cascade type thrust reverser (T/R) system which is electrically controlled and hydraulically actuated and is used to slow the airplane after landing. Each T/R has a left and right translating sleeve. Reverse thrust levers are hinged on the throttle levers. When they are raised for deploying, hydraulic actuators move the translating sleeves aft of the cascades. Each drag link permits its blocker door to move into the fan air exhaust flow as the sleeve move aft. The blocker doors and cascade change the direction of the fan air exhaust as it flows out and this causes reverse thrust.

Proximity sensors and LVDTs installed on the T/R supply signals to monitor the state and percentage of travel of the sleeves. These inputs are processed for fault indication, unlocking of interlock solenoids and display of sleeve position data on the CDS (REV message above the engine N1 indication shows amber when one or both sleeves of a T/R are 10% to 90% deployed and changes to green when both sleeves are more than 90% deployed). They are also recorded in the DFDR.

1.6.2.4 ICE AND RAIN

The windshield wiper system removes rain from the forward 1L and 1R flight compartment windows. Two wiper control switches on the P5 forward overhead panel give the flight crew independent control of the wipers. There are two windshield wiper drive assemblies mounted on the windshield sill beam behind the P1 and P2 panels.

The windshield wiper and drive assembly moves the windshield wiper, controls the force applied on the windshield and gives rigging adjustments for wiper sweep. Each windshield wiper drive assembly has a 28V DC motor which operates a rotary to oscillatory reduction gearbox. The output shaft mounted on the gearbox drives the wiper. The wiper arm adjustment nut sets the force that the wiper blade applies on the window.

The wiper switch is a four-position (PARK, INT, LOW, and HIGH) selector. It is a voltage divider and sends different voltage signals to the motor electronic control package to provide intermittent, low, and high speed wiper operation. The PARK position will cause blade to rotate outboard to the lower window edge and stay there. The motor electronic control package controls the motor speed in response to the WIPER switch position signal. A thermal switch in the motor assembly cuts out motor operations if the temperature in the motor exceeds a threshold. The thermal switch resets automatically when the motor cools.

1.6.2.5 DOORS

There is an entry and galley service door in both forward and aft location. They are plug type doors. Torque tube in the door and frame provide structural support to the door and hinges. The hinges support the weight of the door and control the motion (swing and rotation) of the door as it opens. There is a provision for mounting escape slide on the lower area of the door lining.

There are two emergency exit doors above the wings on both sides of the airplane. Each over-wing exit door is hinged at the top and automatically opens outward and upward when released by pulling the handle.

Figure10: Escape Slide

An escape slide is mounted on the inside lower door. If the slide girt bar is in the armed position, as the door is opened, the girt strap will extend and the girt latch assembly will open and let the slide pack fall out of the slide cover. The slide will deploy automatically as the door opens. The girt latch assembly should release with a force of less than 30 lbs.

1.6.2.6 EMERGENCY LIGHTS

The Emergency Lighting System lights up the area inside and outside of the airplane during an emergency. It also shows the exit path. The emergency lights inside the airplane are mounted on the overhead bins, ceiling panels and sidewall panels. They operate when there is a loss of airplane DC power and the P5 forward overhead panel emergency light switch is in the ARMED position. The power packs that supply power to these lights are mounted behind the ceiling panel and the side structure near the floor.

There is another switch on the aft attendant panel to operate the emergency lights. The attendant panel switch will cause the lights to come on even if the P5 switch is OFF.

There are ten emergency lighting power supply units installed at different location on the aircraft, each power supply provides power and control to its series of emergency lights. The emergency lights operate for more than 10 minutes. When the flight deck emergency lighting switch is in the ARM position, emergency lights will illuminate when the associated power supply receives a signal from the aft attendant panel or when its input from 28Volts DC Bus 1 power drops below 12 Volts.

1.6.3 MAINTENANCE

Air India Express Ltd has an MoU with Air India Engineering Services Limited (AIESL) to carry out maintenance of its aircraft as per the maintenance program approved by DGCA which was last revised in November, 2019. On 24 March, 2020 VT-AXH was put under active storage (preservation) at 43511:07 Total Aircraft Hours(TAH) as all flight operations were stopped due to Covid-19 pandemic. Aircraft was depreserved and reinstated into operation on 26 May, 2020.

Details of Aircraft/Engine Hours and major inspections are given in the table below:

Total Aircraft Hours	43691:16 Hours
Total Aircraft Cycles	15309 Cycles
Aircraft last major inspection	Ph-12 on 18 Oct 2019 at 41917:23 Hours / 14740 Cycles
Engine Type / Manufacturer	CFM56-7B / CFM International
L.H Eng Year of Manufacture	2007
LH Engine Sl. No.	894768
Last major inspection (LH Engine)	Ph-12
LH Engine Total Hours/Cycles	38271:09 Hours / 13332 Cycles
RH Eng Year of Manufacture	2008
RH Engine Sl. No.	897487
Last major inspection (RH Engine)	Shop Check
RH Total Engine Hours/Cycles	25764:38 Hours / 8580 Cycles

The last Phase Check (Phase 17) was carried out on 28 July, 2020 at TSN 43653:44/CSN 15296 and last weekly check was carried out on 05 August, 2020 at TSN 43674:18/ CSN 15304. The last transit check was carried out on the day of the accident before departure from Dubai and no defect was reported or observed during this check. All required airworthiness directives, mandatory service bulletins and DGCA mandatory modifications on this aircraft and its engine had been complied with, as on date of the accident. There was no deferred maintenance item. A CDL was being reflected in the Flight Release documents presented to the crew. However, on further investigation it was found that the said CDL was invoked in October 2019 and revoked after rectification in Nov 2019, but the status was not updated by the Maintenance Control Center of AIESL.

On scrutiny of documents it was observed that on occasions, an unsafe practice of not recording defects in the technical log/PDR and communicating the same through verbal reporting was being followed in the company, especially at outstations without giving due consideration to safety or procedure. The scrutiny of technical log and maintenance documents and interaction with AIXL personnel revealed a few instances where it was observed that snags were not recorded but only communicated through verbal briefings. Two of such instances noticed by the Investigation Team are given below:

(a) Cockpit crew on returning from an international station reported a defect in the technical log followed by a statement *"in previous sector same observation"*.

(b) A component was replaced by an engineer during a transit check in spite of fact that no defect was reported by the cockpit crew in the technical log and component was not required to be tested during Transit Check.

1.6.3.1 INSPECTION OF WINDSHIELD WIPERS

Following are a few additional tasks incorporated by Air India Express for their fleet (B-737 800 aircraft) and included in the DGCA approved maintenance program.

(a) Check cockpit windows and windshield wipers for condition

(b) Check the condition of windshield wiper blades for excessive wear or missing material

(c) Wet windshield abundantly with water and check operation of wipers

These tasks were required to be carried out during weekly inspection and Phase 1 inspection which were last done on 28 July, 2020 and 05 August, 2020 respectively. Condition and operation of windshield wipers was found to be satisfactory. Another Captain who had operated VT-AXH just a day prior (06 August, 2020), confirmed that he had operated the windshield wipers while landing into Kozhikode during rain and the windshield wiper operation was satisfactory during that time.

Airline's Preliminary Investigation Board during investigation of an incident in AIXL had recommended carrying out Hydrophobic coating on the entire fleet. As per the recommendation, it was supposed to be carried out annually before every monsoon. However it was not always being carried out before monsoon but was planned round the year. In some instances, it was not even done annually due to shortage of hydrophobic kits.

Hydrophobic coating consists of a transparent film on the outer surface of the left and right forward flight compartment windows that repels water. The coating wears off over time and use and then it no longer repels water droplets as efficiently.

Hydrophobic coating was not part of any scheduled maintenance, it was being carried out round the year at Thiruvananthapuram maintenance facility as and when it was due. The hydrophobic coating was last carried out on VT-AXH on 19 August, 2019 which was late into the monsoon season. The condition of the hydrophobic coating could not be assessed due to damage to the windshield during accident and rescue of cockpit crew.

1.6.3.2 INSPECTION OF FLIGHT RECORDERS

Inspection of Flight Recorder System is required to be carried out once a year as per CAR Section 2, Series I Part V. A flight recorder system shall be considered unserviceable if there is a significant period of poor quality data, unintelligible signals, or if one or more of the mandatory parameters is not recorded correctly. The last annual inspection was carried out by AIXL as per the procedure laid in its CAME on 25 October, 2019, and all the recorded parameters were certified to be active. However, on checking it was found from the DFDR data of AXB 1344 that the value of right brake pressure was completely illogical but had not been detected during the last annual inspection.

DFDR data is required to be analyzed on quarterly basis in accordance with CAR Section 5, Series F, Part II. This was last done during Phase 15 inspection carried out in January, 2020. No observation regarding missing/illogical right Brake Pressure Value was made during the analysis.

Apart from the requirements laid in the above mentioned CAR, the functional check of required parameter (DFDR, DFDAU output, Interfacing Systems) is also required to be carried out in Phase 15 inspection. The same was last carried out on 21 January, 2020. The DFDR data of earlier flights and the one used for annual inspection and certification was sought from the operator and checked by the Investigation Team. It was found that the right Brake Pressure reading had not been recorded correctly on VT-AXH since installation of the right Brake Pressure Transducer in December, 2018.The right brake pressure parameter is provided for data recording purpose only. It does not affect aircraft performance.

1.6.3.3 BRAKE PRESSURE TRANSDUCER

Brake pressure transducer is a sealed assembly with a piston, disc spring, and an electrical sensor. It monitors the metered brake pressure of the brake system and this parameter is recorded in the DFDR. There is one transducer each for the left and the right normal brake system. They monitor the metered brake pressure up stream of the antiskid valves.

During analysis of DFDR data it was observed that right metered brake pressure being recorded was indicating a constant (-)165 psi during all phases of flight. On further analysis of archived DFDR data it was observed that right brake pressure transducer had been recording the same value since installation.

VT-AXH was grounded for base maintenance in Aug 2018. The right normal brake pressure transducer was cannibalised from it to service another aircraft. It was installed back in Dec 2018 again by cannibalising from another aircraft (VT-AXI) which was being grounded for base maintenance. The right normal brake system was fitted with a pressure transducer with following details, Part Number-18-2141-3 & Serial number - 22518.

Investigation Team analyzed the DFDR data of the last flight operated by VT-AXI before the brake pressure transducer was cannibalized. It was observed that the reading for left normal brake pressure for VT-AXI was also not being recorded in the DFDR. On further scrutiny of maintenance records it was confirmed that brake pressure transducer Part Number- 18-2141-3 & Serial number- 22518, which was removed from VT-AXI to service VT-AXH was earlier fitted on the left normal brake system of VT-AXI.

The installation task of brake pressure transducer as per aircraft maintenance manual requires it to be checked for measuring and recording the data. On application of the brakes at different pressure settings the recording of this data in the designated DFDR sub frame is required to be checked using a hand-held multi-purpose interface unit/download unit. This task was certified by an authorized AME, however, the unserviceable condition of right brake pressure transducer was not identified and was overlooked.

1.6.4 LAYOUT OF PASSENGER ARRANGEMENT

The aircraft was equipped with '3163 series' passenger seats from Zodiac Seats France. Copy of Aircraft Layout of Passenger Arrangement for 186 passengers with 29"/30"/38" Zodiac Aerospace Seats attested by DGCA was part of on-board documents and is placed at Appendix 'A'.

1.6.5 LAYOUT OF SAFETY AND EMERGENCY EQUIPMENT

Copy of Safety & Emergency Equipment Layout attested by DGCA on 13.02.2020 retrieved from Aircraft on-board documents is placed at Appendix 'B'.

1.6.6 OPERATIONS SPECIFICATION

This aircraft was operated under Air Operator Certificate no.S-14 which is valid up to 21 April, 2023. Summary of Operations Specifications approved by DGCA is as below:

Specific Approval	Description
Dangerous Goods	Approved
Low Visibility Operations	
Approach & Landing	CAT II; RVR:300m; DH:100 ft CAT IIIA; RVR:175m; DH:50 ft CAT IIIB; RVR:50m; DH: NO DH
Take-off	RVR:125m
RVSM	Approved
EDTO	Threshold Time: 60 Min Max Diversion Time: 120 Min Engine CFM56-7B27
EFB	Portable(iPad)
ADS-B (Out)	Approved

1.6.7 WEIGHT AND BALANCE

Weight and Balance control of aircraft is governed by CAR Section 2, Series X, Part II. Periodic airplane weighing for Air India Express fleet is carried out every five year as per Boeing 737-800 Weight and Balance Manual and requirements laid down by DGCA.The aircraft was last weighed on 15 August, 2016 after seat modification due to installation of Zodiac make seats. The summary of Weight and C.G as per the approved weight schedule is given below:

Summary of Weight and C.G	
Maximum All-up-Weight	79015 Kg
Aircraft Empty Weight	41561.37 Kg
Maximum Usable Fuel Quantity	21340.17 Kg
Maximum Payload with Fuel Tank Full	15091.26 Kg
Maximum Zero Fuel Weight	62731 Kg
Maximum Aircraft Landing Weight	66360 Kg
Empty Weight C.G	660.98 inches from datum
Date of next weighing	15 August, 2021

The aircraft actual take-off weight at the time of departure from Dubai was 74115 kg with a departure fuel of 14600 kg as per the Load and Trim sheet. The mass and centre of gravity were within the prescribed limits.

1.7 METEOROLOGICAL INFORMATION

1.7.1 METARS

As per CAR Section 9, Series M, Part I, Meteorological observations and reports at aerodromes shall be made throughout the 24 hours period each day, unless otherwise agreed between IMD, the appropriate ATS authority, and the operator concerned. Such observations shall be made at intervals of one hour or if so determined by regional air navigation agreement, at intervals of half an hour.

At other aeronautical meteorological stations, such observations shall be made as determined by the IMD taking into account the requirements of air traffic services units and aircraft operations. Reports of routine observations shall be issued as:

(a) Local routine reports, only for dissemination at the aerodrome of origin, (intended for arriving and departing aircraft)

(b) METAR for dissemination beyond the aerodrome of origin (mainly intended for flight planning, VOLMET broadcasts and D-VOLMET

Similarly, reports of special observations as per CAR Section 9, Series M, Part I, shall be issued as:

(a) Local special reports, only for dissemination at the aerodrome of origin, (intended for arriving and departing aircraft)

(b) SPECI for dissemination beyond the aerodrome of origin (mainly intended for flight planning, VOLMET broadcasts and D-VOLMET) unless METAR are issued at half-hourly intervals.

1.7.1.1 DUBAI METAR

Meteorological reports in respect of Dubai International Airport were obtained from their Civil Aviation Authorities. Relevant METAR issued from 0700 UTC to 1030 UTC corresponding to time before and after arrival of aircraft call sign AXB1343 and departure of AXB1344 is given below:

UTC	**0700**	**0730**	**0800**	**0930**	**1000**	**1030**
Wind	220/10 Kt	260/10 Kt	260/09 Kt	290/14 Kt	280/14 Kt	290/13 Kt
Visibility	8 km	8 km	CAVOK	CAVOK	CAVOK	CAVOK
Weather	180V260 NSC	230V290 NSC				260V320
Clouds	-	-	-	-	-	-
Temperature	40	41	41	39	39	39
Dew Pt	26	25	23	28	28	28
QNH	0994	0994	0993	0993	0993	0993
Trend	NOSIG	NOSIG	NOSIG	NOSIG	NOSIG	NOSIG

1.7.1.2 KOZHIKODE METAR

The Aviation Meteorological Information at Kozhikode Airport is provided by Aviation Meteorological Office, Indian Metrological Department, Ministry of Earth Science, Government of India. The meteorological services are available 24 hours and METAR are issued every half-hour. The details of METAR and additional METAR issued from 1330 to 1430 UTC are as follows:

UTC	**1300**	**1330**	**1344**	**1400**	**1430**
Wind	200/06 Kt	270/13 Kt	270/08 Kt	260/12 Kt	270/13 Kt
Visibility (m)	1500	1500	2000	2000	2000
Weather	FBL TSRA	FBL TSRA	FBL TSRA	FBL RA	FBL RA
Clouds	SCT 300ft SCT 1200ft FEW CB 2500 ft OVC 8000 ft	SCT 300ft SCT 1200ft FEW CB 2500 ft (N,NW,W, E, SE) OVC 8000 ft	SCT 300ft SCT 1200ft FEW CB 2500 ft (N,NW,W,E, SE) OVC 8000 ft	SCT 300ft SCT 1200ft FEW CB 2500 ft (N,NW,W,E, SE) OVC 8000 ft	SCT 300ft SCT 1200ft FEW CB 2500 ft (N,NW,W,E, SE) OVC 8000ft
Temperature (°C)	24	24	24	24	24
Dew pt	24	23	23	23	23
QNH	1007	1008	1008	1008	1009
Trend	NOSIG	NOSIG	TEMPO 1500 RA BR	TEMPO 1500 RA BR	TEMPO 1500 RA BR

The METAR of 14:00 UTC indicated the winds as 260/12 Kt. Relative to Runway 10, there was a tailwind component of 11 Kt and a crosswind component of 4 Kt from the right. Moreover, the report indicates 02 km visibility in light rain, temperature 24 degree Celsius and QNH 1008 hpa. Local sunset time was 13:19 UTC (18:49 IST).

1.7.1.3 METAR AT ALTERNATE AERODROMES

Aviation Meteorological Reports for time 13:30 UTC in respect of alternate aerodromes as per the flight plan of AXB 1344 for sector Dubai-Kozhikode was as follows:

	VOCI (Cochin)	**VOCB (Coimbatore)**
Wind	220/10 Kt	200/12 Kt
Visibility	2000 m	6 km
Weather	Rain	Clear
Clouds	SCT 006, SCT 012, OVC 080	SCT 012, SCT 080
Temperature	25°C	25°C
Dew pt	25°C	23°C
QNH	1009	1009
Trend	TEMPO 2000m, Rain	NO SIG

1.7.2 WEATHER FORECAST AT KOZHIKODE

As per the local forecast for Kozhikode Airport for 07 August, 2020 from 06:00 to 14:00 UTC and 100 NM around the airfield issued by Local Aviation Met Office at 05:27 UTC, the weather forecast was rain with moderate turbulence in CB and a visibility of 3000 m with trend reducing to 2000 m in rain. As per Aviation Met Office, Kozhikode Airport, there was continuous rain from 1000 UTC (15:30 IST). The sky was overcast throughout the day. The visibility was 3000 m and improved to 4000 m at 1100 UTC (16:30 IST). Low clouds and CBs were reported in the Met Reports. Moderate rain was observed at 11:32 UTC (17:02 IST) and continued till 12:04 UTC (17:34 IST) and feeble rain thereafter. The visibility deteriorated from 3000 m at 11:32 UTC (17:02 IST) to 1500 m at 11:47 UTC (17:17 IST) and improved to 2000 m at 12:04 UTC (17:34 IST). Scattered low clouds at 300 ft were reported from 11:30 UTC (17:00 IST) and CB from 06:30 UTC (12:00 IST) onwards. At 12:45 UTC (18:15 IST), visibility was reported as 2000 m in feeble TSRA.

On 07 August, 2020, Kozhikode airport was under two concurrent Aerodrome warnings at the time of the crash. Met Office at Kozhikode Airport issued first warning for 'Thunderstorm and Rain', which was valid up to 1645 UTC (22:15 IST). The second warning for wind speed exceeding 17 Kt was issued at 1310 UTC (18:40 IST), valid up to 1710 UTC (22:40 IST). The weather warnings were as given below:

(a) VOCL 071245Z AD WRNG 1 VALID 071245/071645 TSRA OBS AT 1245Z NC

(b) VOCL 071310Z AD WRNG 2 VALID 071310/071710 SFC WSPD 17 KT OR MORE FROM 230 DEG FCST NC

The visibility deteriorated to 1500 m in feeble thunder storm and rain from 1352 UTC (18:22 IST) and persisted till 1344 UTC (19:14 IST). At 1342 UTC (19:12 IST), AXB 1344 asked for the latest visibility. After a short delay the DATCO transmitted the improvement in visibility from 1500 m to 2000 m. Immediately thereafter, at 13:44 UTC (19:14 IST), a fresh METAR was issued, declaring visibility of 2000 m. A Special Met Report (SPECI) was issued by Met Office at Kozhikode Airport at 14:00 UTC (19:30 IST) to notify the cessation of Thunderstorm (TS). However, feeble rain continued. The mean wind of 270/13Kt was reported at 1330 UTC (19:00 IST). At 14:00 UTC (19:30 IST) the mean wind was reported as 260/12 Kt. Prior to the accident, the visibility reported was 2000 m in feeble rain, with scattered low clouds at 300 feet and CB reported in North, Northwest, West, East and Southeast and the sky was overcast.

1.7.2.1 SATELLITE IMAGE

The satellite image shown in figure 11 and 12 was taken by INSAT-3D at 14:00 UTC. The images indicate the strongest convection and the heavy rain south of Kozhikode owing to active monsoon conditions in the Indian peninsula.

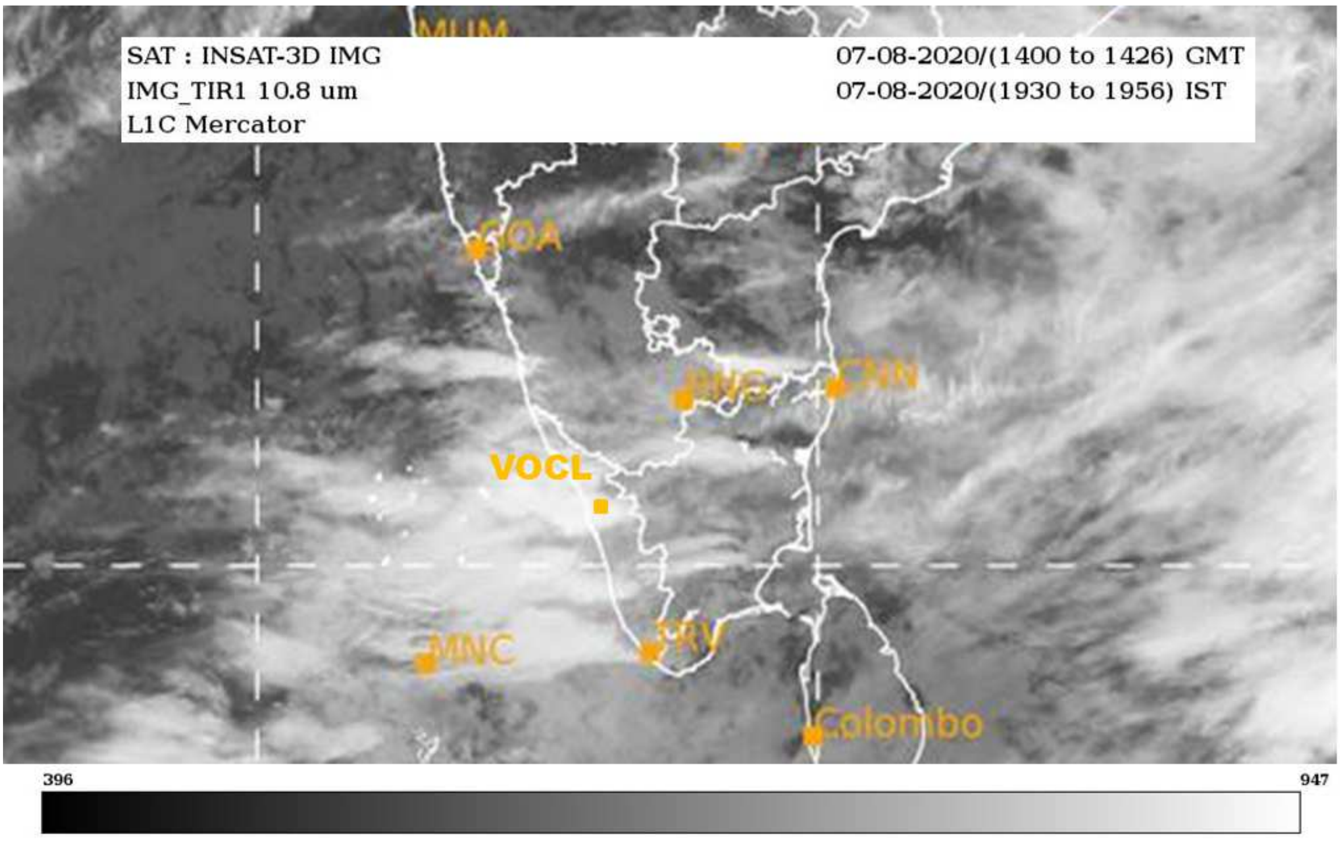


Figure 11: Satellite Image at Time of Accident.

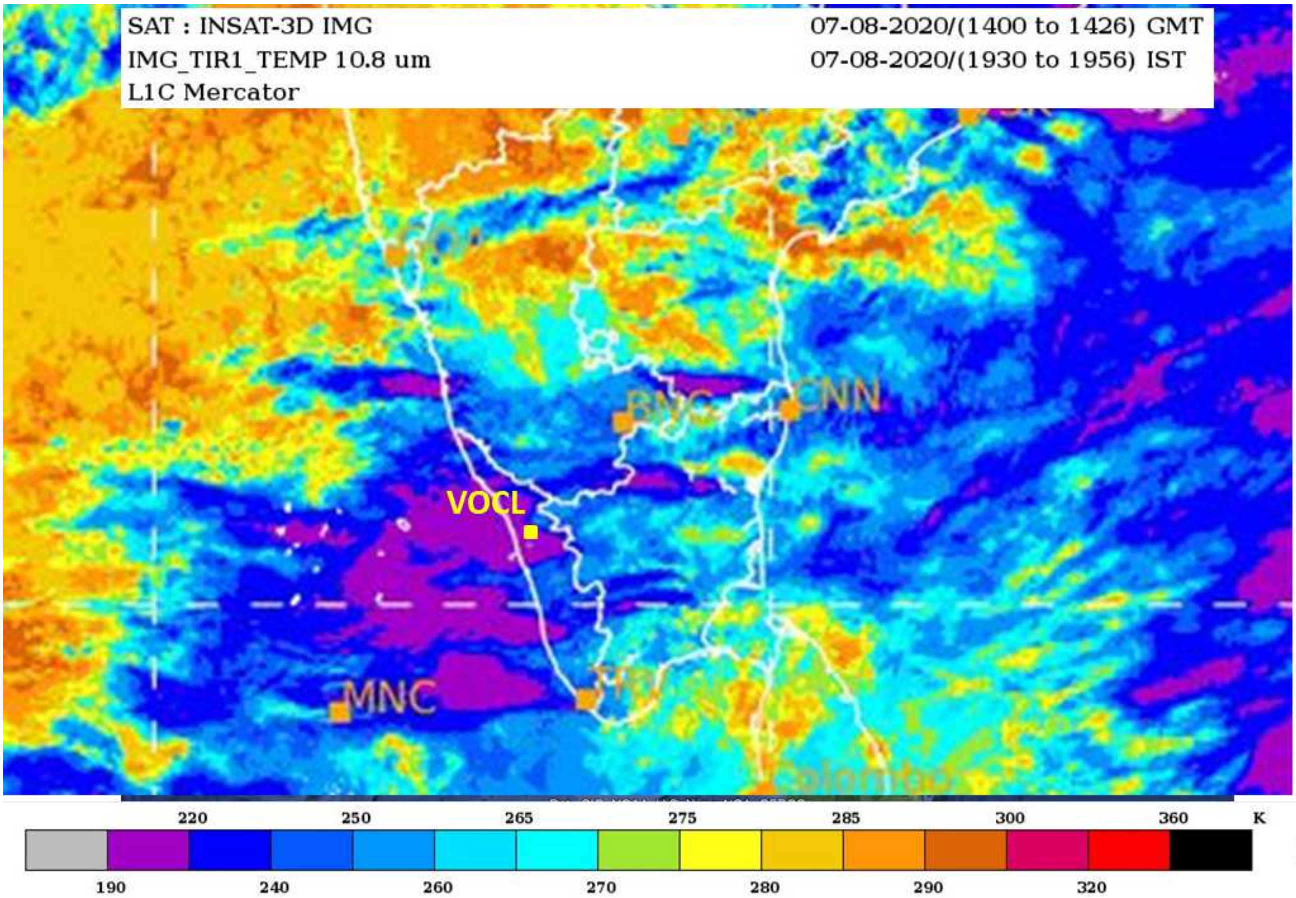


Figure 12: IR Satellite Image at the Time of Accident

1.7.3 AVAILABILITY OF MANPOWER AND INFRASTRUCTURE AT AVIATION MET OFFICE, KOZHIKODE AIRPORT

The manpower and infrastructure at Met Office, Kozhikode Airport is provided under the agreement between the Airports Authority of India (AAI) and Indian Meteorological Department (IMD). The total number of Met personnel posted at Kozhikode Airport is 09. Apart from the normal infrastructure provided in the Met Department Office, a separate work station is also provided for the Tower Met Officer (TMO) in the ATC tower.

1.7.3.1 TOWER MET OFFICER (TMO)

The primary duty of Tower Met Officer is to continuously observe and report in real time the meteorological parameters affecting landing and take-off operations at the aerodrome. The TMO is expected to keep a constant vigil on possible development of adverse weather situation and issue appropriate reports/warning.

The TMO is required to consult with Duty Met Officer while issuing any report. At aerodromes where space is allotted to IMD personnel in the ATC Tower, TMO has to issue METARs, Met Report and Special Report from ATC. However, on investigation, it was revealed that the TMO was not present in the ATC Tower of Kozhikode Airport at the time of the accident.

1.7.3.2 DISTANT INDICATING WIND EQUIPMENT FOR RUNWAY 10

Aviation Met Station (AMS) Kozhikode is equipped with MET report display and dissemination system. The half hourly Met Reports are updated on the portal provided in the ATC tower (in front of the ATC personnel). The Distant Indicating Wind Equipment (DIWE) display for runway 10 and 28 is available in ATC tower.

As per CAR issued by DGCA (CAR Section 9 - Air Space and Air Traffic Management, Series M, Part I, Issue II, 24 March, 2017, Rev. 2, 08 November, 2018) and ICAO Annex 3, the height of the Anemometer for reporting surface wind and directions shall be 10 m (+/- 1 m). However, the height of anemometer for Runway 10 is 6 m and it is installed on a platform 2.5 m below the runway surface. Hence, the effective height of the Anemometer above the runway surface for runway 10 is just 3.5 m. The same is depicted in the figure 13.

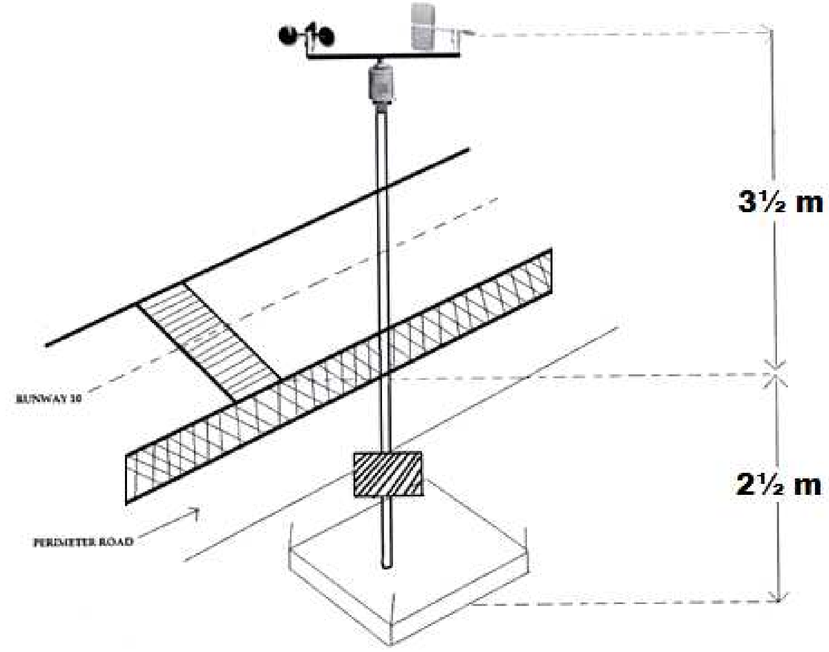


Figure 13: Anemometer installation for Runway 10

During investigation, it was found that the hand held master wind speed measuring equipment used for calibration of Anemometer was not calibrated as per prescribed calibration schedule. There were no records of its maintenance schedule. Further, as per the records made available by Met Office, it was observed that the wind instrument (DIWE) at runway 10 often remained unserviceable for prolonged periods, particularly since December, 2019 and was under NOTAM intermittently.

Post accident, the status of Wind Sensor of Runway 10 was repeatedly sought by the investigation team. It was observed that serviceability of wind sensor remained erratic and NOTAMs were regularly issued informing stakeholders of its unavailability. Finally, in Jan 2021 the sensor was declared unserviceable and remained so till it was replaced with new equipment in May 2021.

1.7.3.3 VISIBILITY REPORTING CRITERIA

It was decided by IMD to install Integrated Aviation Weather Observation System with RVR measuring instrument at Kozhikode as per their upgrade program. The site selection was carried out by AAI in consultation with IMD and two sites were identified. Due to topographical constraints at Kozhikode Airport, the identified sites did not meet the norms of AAI and hence a proposal was sent to AAI

HQ for formal approval. RVR was not available at Kozhikode Airport and visibility is reported using Visibility Polar Diagram.

Visibility reporting markers on the visibility polar diagram were last updated on 28 November, 2018 and were valid up to 27 November, 2020. During the visit of the Investigation Team, it was observed that many reporting markers had become inconspicuous over a period of time due to changes in the city skyline of the surrounding area. Further, the criteria for selecting the visibility reporting markers were found to be arbitrary. For instance, Chammani Prabhu House, a private property outside the airport perimeter wall on a radial 265 at a distance of 2.3 km is being used for assessing visibility at night. During the visit to ATC Kozhikode Airport, the Investigation Team found that there were no lights "ON" in the building during the night, indicating that this marker may or may not be available as an indicator for measuring visibility on all nights. Therefore, it cannot be considered as a dependable visibility marker.

1.7.4 WEATHER PASSED TO THE AIRCRAFT BY ATC

The DATCO reported the surface winds for runway 10 and 28 from the display panel provided in the ATC Tower by MET office. As per statement of DATCO, information regarding any significant change in the mean surface wind direction and speed shall be passed to the crew. The DATCO did not see any significant change in winds on the display panel until the aircraft had passed the threshold.

The MET reports are disseminated to the aircrafts through ATIS on frequency 127.0 MHZ. AXB 1344 had obtained weather of Kozhikode and its alternates, Cochin and Coimbatore, through ACARS during cruise before contacting Kozhikode ATC tower.

1.8 AIDS TO NAVIGATION

The following Navigational Aids and instrument approaches are available at Kozhikode Airport:

Type of Navigation Aids	Identification	Frequency
LOC 28	ICAC	109.500 MHz
LOC 10	ICLB	110.700 MHz
GP 28	ICAC	332.600 MHz
GP 10	ICLB	330.200 MHz
DME ILS 28	ICAC	CH32X
DME ILS 10	ICLB	CH44X
DVOR/DME	CLC	116.500 MHz CH112X

Approach Radar is not available at Kozhikode. All the Navigation Aid equipments were functioning properly on 07 August, 2020.

There were occasional reports of Runway 28 ILS malfunction below 600 feet in 2018 and also flagged by DGCA auditors. AAI had taken corrective action by providing an artificial ground plane of 4.2m x 330m constructed with a wire mesh counterpoise resulting in improvement of Lower Half Sector Width.

The ILS calibration for Runway 28 and Runway 10 which includes localizer, glide path and collocated Distance Measuring Equipment (DME) along with PAPI was last done on 08 January, 2020 and was found compatible with glide path. The next calibration was due on 08 July, 2020 but had not been carried out till the date of the accident. As per existing procedure, in case calibration cannot be carried out within the stipulated time, the following actions are required to be taken:

(a) The weekly and monthly maintenance schedule is to be carried out on a bi-weekly and fortnightly basis respectively. In case ILS calibration is overdue by more than three months, the frequency of maintenance schedule may be increased to daily and weekly basis.

(b) At least one de-briefing report is to be obtained every week.

(c) Any aberration/deviation in the readings of parameters to be intimated as per laid down procedure.

(d) CAR compliance certificate is required to be sent to concerned authority on weekly basis.

All above actions were being carried out satisfactorily at Kozhikode till the day of accident. The de-briefing reports obtained from different flights reported the performance of ILS, including glide path, to be satisfactory for both runway 10 and 28.

1.9 COMMUNICATIONS

The details of ATC and Communication facilities available at Kozhikode are as below:

Service Designation	Call sign	Channel(s)	Hours of operation	Remarks
APP	Calicut Tower/ Calicut Approach	119.150 MHz	H24	DLY BTN 0130-0730 AND 1330-1630 INDEPENDENT APP UNIT (STANDBY)
APP	Calicut Tower/ Calicut Approach	122.950 MHz	H24	DLY BTN 0130-0730 AND 1330-1630 INDEPENDENT APP UNIT MAIN
TWR	Calicut Tower	123.350 MHz	H24	Primary
ATIS	Calicut Information	127.000 MHz	H24	-

Due to curtailed operations owing to Covid-19 pandemic, aircraft movement was restricted and Covid-19 contingency roster was in force for the DATCOs. Therefore, tower and approach units were combined and were being manned from the Control Tower. A NOTAM was issued in this regard.

AXB 1344 was in contact with Kozhikode Tower on frequency 123.35 MHz. There was always two way positive communication between the aircraft and ATC. The transcript for the period 13:33 UTC to 14:12 UTC of said frequency was obtained from ATC and relevant extracts from the transcript are given below:

Time	To	From	Conversation
13:33:11-13:33:44	AXB 1344 came in contact of Kozhikode Tower on frequency 123.35 MHz at 52 NM from CLC passing FL181 descending to FL170.		
13:33:44-13:34:09	AXB1344	TWR	AXB ROGER CLEAR OF WEATHER PROCEED DIRECT CLC DESCEND TO SEVEN THOUSAND FEET TRANSITION LEVEL FLIGHT LEVEL ONE ONE FIVE QNH 1007
	TWR	AXB1344	QNH 1007 ONCE CLEAR OF WEATHER DIRECT CLC AXB1344
13:34:10-13:34 :25	AXB1344	TWR	VISIBILITY ONE THOUSAND FIVE HUNDRED METERS FEEBLE RAIN WITH THUNDERSTORM
13:41:19-13:41:55	TWR	AXB1344	CALICUT TWR AXB1344 PASSING NINE THOUSAND ONE ONE MILES CLC ON A STEADY RADIAL TWO EIGHT FIVE
	AXB1344	TWR	AXB1344 ROGER CONTINUE VIA TWO EIGHT FIVE RADIAL CLC DESCEND TO THREE THOUSAND SIX HUNDRED FEET CLEARED ILS ZULU APPROACH RUNWAY TWO EIGHT REPORT PASSING CLC FOR APPROACH
13:42:21-13:42:36	TWR	AXB1344	CALICUT TWR AXB1344 IN CASE OF MISSED APPROACH DUE WEATHER WILL LIKE TO MAINTAIN RUNWAY HEADING AND THEN TURN RIGHT TO AVOID WEATHER
	AXB1344	TWR	ROGER APPROVED
13:42:41-13:43:44	TWR	AXB1344	ANY CHANGE IN THE VISIBILITY AXB1344
	AXB1344	TWR	AXB1344 LATEST VISIBILITY TWO THOUSAND METER IN LIGHT RAIN
13:44:00-13:44:18	TWR	AXB1344	CALICUT TWR AXB1344 OUTBOUND LEAVING CLC FOR OUT BOUND ZERO NINE ONE
	AXB1344	TWR	AXB1344 ROGER DESCEND AS PER PROCEDURE REPORT ESTABLISHED ON ILS RUNWAY TWO EIGHT
13:47:46-13:49:07	AIC 425 sought permission for Pushback and Startup		
13:49:24-	TWR	AXB1344	CALICUT TWR AXB1344 ON ILS RUNWAY

13:49:55			TWO EIGHT
	AXB1344	TWR	AXB1344 RUNWAY SURFACE WET LIGHT RAIN OVER THE FIELD WIND TWO EIGHT ZERO DEGREE ZERO FIVE KNOTS RUNWAY TWO EIGHT CLEARED TO LAND
	TWR	AXB1344	RUNWAY TWO EIGHT CLEARED TO LAND AXB1344 AND WHAT IS THE VISIBILITY AXB1344
	AXB1344	TWR	VISIBILITY TWO THOUSAND METER IT MAY LIKELY TO… DECREASE… TO ONE THOUSAND FIVE HUNDRED METER
13:53:03-13:53:09	TWR	AXB1344	TWR AXB1344 GOING AROUND
	AXB1344	TWR	ROGER
13:54:54-13:55:35	AXB1344	TWR	AXB1344 REQUEST REASON OF GO AROUND
	TWR	AXB1344	DUE WEATHER AXB1344 HEAVY RAIN
	AXB1344	TWR	ROGER
	TWR	AXB1344	REQUEST FURTHER CLIMB AXB1344
	AXB1344	TWR	ROGER CLIMB TO ONE ZERO THOUSAND FEET
13:55:52-13:56:17	TWR	AIC425	CALICUT AIC425 WE ARE READY FOR TAXI AND WE APPRECIATE IF YOU CAN GIVE ONE ZERO FOR DEPARTURE
	AIC425	TWR	ROGER EXPECT ONE ZERO TAXI VIA CHARLIE ENTER BACK TRACK LINEUP RUNWAY ONE ZERO
	TWR	AIC425	VIA CHARLIE ENTER BACK TRACK LINEUP RUNWAY ONE ZERO AIC425 THANKYOU SIR
	AXB1344	TWR	AXB1344 TWR OBSERVED WIND TWO SEVEN ZERO DEGREE EIGHT KNOTS CONFIRM LIKE TO MAKE APPROACH FOR ONE ZERO
13:56:28-13:57:01	TWR	AXB1344	HOW IS THE VISIBITY FOR RUNWAY ONE ZERO
	AXB1344	TWR	BOTH RUNWAY TWO THOUSAND METER SIR WITH LIGHT RAIN
	TWR	AXB1344	OK… I THINK AND WHAT IS THE SURFACE WINDS
	AXB1344	TWR	SURFACE WIND NOW TWO SIX ZERO DEGREES ZERO FIVE KNOTS
	TWR	AXB1344	COPIED
	TWR	AXB1344	CAN WE LEVEL OUT AT LEVEL SEVEN ZERO PLEASE
	AXB1344	TWR	ROGER LEVEL OUT AT SEVEN ZERO INTERCEPT TWO EIGHT FIVE RADIAL ONE FIVE DME FIX
	TWR	AXB1344	ROGER
13:57:19-13:58:03	AXB1344	TWR	AXB1344 CONFIRM LIKE TO MAKE APPROACH FOR ONE ZERO

	TWR	AXB1344	WE… LIKE.. TO TRY GIVE US UPDATE ON THE VISIBILITY FOR RUNWAY ONE ZERO
	AXB1344	TWR	VISIBILITY IS SAME SIR TWO THOUSAND METER AND WE WILL INFORM ANY FURTHER IMPROVEMENT AND NOW WIND IS TWO SIX ZERO DEGREES ZERO FIVE KNOTS
	TWR	AXB1344	AND ANY CB JUST …. (NOISE) AIRPORT ON APPROACH PATH FOR RUNWAY ONE ZERO
	AXB1344	TWR	SAY AGAIN
	TWR	AXB1344	IS THERE ANY REPORTD CHARLIE BRAVO ON THE APPROACH PATH RUNWAY ONE ZERO
	AXB1344	TWR	REPORTED CHARLIE BRAVO TWO THOUSAND FIVE HNDRED FEET TOWARDS NORTH, NORTH WEST, WEST EAST, SOUTH EAST
	TWR	AXB1344	COPIED THANK YOU
13:58:16-13:59:11	AIC 425 Departure Clearance		
13:59:32-14:00:02	AXB1344	TWR	AXB1344 REPORT POSITION
	TWR	AXB1344	WE ARE POSITION ON RADIAL TWO EIGHT FOUR LIKE TO DESCEND TO THREE THOUSAND SIX HUNDRED
	AXB1344	TWR	AXB1344 ROGER DESCEND TO THREE THOUSAND SIX HUNDRED FEET INTERCEPT TWO EIGHT FIVE RADIAL CORRECTION TWO EIGHT FOUR RADIAL CORRECTION TWO EIGHT FOUR RADIAL ONE FIVE DME FIX FOR ILS APPROACH RUNWAY ONE ZERO
14:00:16-14:00:27	TWR	AIC425	READY FOR DEPARTURE AIC425
	AIC425	TWR	AIC425 WIND TWO SIX ZERO ONE ZERO KNOTS RUNWAY ONE ZERO CLEARED FOR TAKE OFF
14:01:31-14:02:19	AXB1344	TWR	AXB1344 APPEARS YOU ARE GOING OUTBOUND SIR INTERCEPT INBOUND TWO EIGHT FOUR RADIAL
	TWR	AXB1344	WE ARE TURNING LEFT TO INTERCEPT AXB1344
	AXB1344	TWR	ROGER
	TWR	AIC425	TURNING RIGHT HEADING ONE TWO ZERO AIC425 DUE WEATHER
	AIC425	TWR	ROGER APPROVED
	TWR	AIC425	ROGER
	AIC425	TWR	AIC425 AIRBORNE ZERO ONE REPORT ESTABLIHSED ZERO FIVE FIVE RADIAL CLC
	TWR	AIC425	WILCO AIC425
14:03:30-14:04:37	AIC425	TWR	AIC425 CONFIRM TURNING LEFT TO INTERCEPT ZERO FIVE FIVE RADIAL

	TWR	AIC425	WE ARE SLOWLY TURNING LEFT DUE WEATHER AIC425
	AIC425	TWR	ROGER
	AXB1344	TWR	AXB1344 CONFIRM MAKING APPROACH FOR ONE ZERO
	TWR	AXB1344	AFFIRM AXB1344
	AXB1344	TWR	ROGER CLEARED ILS ZULU APPROACH RUNWAY ONE ZERO VIA TWO EIGHT FOUR RADIAL ONE FIVE DME FIX REPORT ESTABLISHED ON LOCALIZER RUNWAY ONE ZERO
	TWR	AXB1344	CLEARED ILS FOR ILS ZULU APPROACH RUNWAY ONE ZERO VIA TWO EIGHT FOUR DME FIX CALL YOU ESTABLISHED ON LOCALIZER AXB1344
14:04:46-14:05:31	AIC425	TWR	AIC425 CONTINUE CLIMB FLIGHT LEVEL TWO FIVE ZERO
	TWR	AIC425	CONTINUE CLIMB TWO FIVE ZERO
	AIC425	TWR	AIC425 REPORT LEVEL
	TWR	AIC425	PASSING LEVEL ONE ZERO ZERO AIC425 ONE ZERO THOUSAND
	AIC425	TWR	AIC425 ROGER CONTACT COCHIN CONTROL ONE TWO EIGHT DECIMAL THREE
	TWR	AIC425	ONE TWO EIGHT DECIMAL THREE AIC425
14:06:26-14:06:48	TWR	AXB1344	CALICUT TWR AXB1344 ON LOCALISER RUNWAY ONE ZERO
	AXB1344	TWR	AXB1344 ROGER DESCEND TO TWO THOUSAND TWO HUNDRED FEET AS PER PROCEDURE REPORT FULLY ESTABLISHED ILS RUNWAY ONE ZERO
	TWR	AXB1344	DESCEND TO TWO THOUSAND TWO HUNDRED FEET WILL CALL YOU FULLY ESTABLISHED ILS RUNWAY ONE ZERO AXB1344
14:08:03-14:08:28	TWR	AXB1344	CALICUT TWR AXB1344 ON ILS RUNWAY ONE ZERO
	AXB1344	TWR	AXB1344 ROGER LIGHT RAIN OVER THE FIELD RUNWAY SURFACE WET WIND TWO FIVE ZERO DEGREE ZERO EIGHT KNOTS RUNWAY ONE ZERO CLEARED TO LAND
	TWR	AXB1344	RUNWAY ONE ZERO CLEARED TO LAND AND WHAT IS THE VISIBILITY AXB1344
	AXB1344	TWR	VISIBILITY TWO THOUSAND METER WITH LIGHT RAIN
	TWR	AXB1344	COPIED SIR AXB1344
14:11:17-14:12:44	Tower gives repeated calls to AXB1344, but got no response.		

1.10 AERODROME INFORMATION

Kozhikode International Airport is also known as Calicut International Airport or Karipur Airport. Its IATA code is CCJ and ICAO code is VOCL. It is located at Karipur in Malappuram district of Kerala, India and became operational in April, 1988. It was declared an International Airport in February, 2006.

The geographical co-ordinates of Kozhikode Airport are 110816N, 0755702E. Airport elevation is 343 ft. Aerodrome reference code is 4D. The airport is located on a tabletop terrain with a steep fall on both sides. There is high ground on all sides and a hill on the left hand side of the inbound track for ILS for runway 28.

After issue of CAR Section 4, Series F, Part I in 2006, wherein requirements for issue of licenses to civil aerodromes were laid down, the airport was provisionally licensed by DGCA for public use category for all weather operations on 20 June, 2007 for a period of six months. Further extensions were granted based on actions taken for compliance with DGCA regulations. The license was subsequently renewed from time to time and the present validity of aerodrome license is up to 28 June, 2021.

Kozhikode airspace jurisdiction extends up to 25NM around Kozhikode ARP (Aerodrome Reference Point) with vertical limit from Ground to Flight Level 145 (14,500 ft). Towards the west sector it further extends to approximately 55NM and in the east sector about 30NM. Cochin, Coimbatore and Kannur ATC are adjacent to Kozhikode Airspace.

Details of aircraft movement and passenger traffic from Kozhikode are given in the table below:

Kozhikode Airport		**2019-20**	**2018-19**
		April - March	**April - March**
Passengers	Domestic	5,29,354	6,12,572
	International	27,00,556	27,48,275
	Total	32,29,910	33,60,847
Aircraft Movements	Domestic	6,695	7,897
	International	18,660	18,841
	Total	25,355	26,738

Due to curtailed operations owing to Covid-19 pandemic, only 26 flights were scheduled in and out of Kozhikode on day of the accident compared to an average of 70 daily flights that were operating before Covid-19 restrictions set in. The satellite map image of aerodrome is given below:

Figure 14: Aerodrome Layout

(PDP: Pre Determined Point for CFT during Aerodrome Warning)

Initially Kozhikode Airport was planned for Aerodrome Reference Code-4D with A300 type of aircraft as the critical aircraft for operations. Wide body (code D/E) aircraft operations were taking place from Kozhikode since 2002, but were stopped by AAI in May, 2015 due to extensive damage to the runway surface.

Subsequently, runway strengthening and re-carpeting work was done and was completed in February 2017 and the PCN of the runway was upgraded to PCN 71/F/B/W/T. After completion of work, there was demand from airlines to resume operations of wide body aircraft. A safety assessment and compatibility study was carried out by AAI along with Airlines and following mitigation measures were proposed for wide body operations:

(a) Restriction of maximum permissible crosswind component of 20kt on dry runway and 15 kt on wet runway if visibility is less than 2000 m.

(b) All thrust reverse should be operative.

(c) On-board ground proximity warning system should be operative.

(d) Anti-skid system should be operative.

(e) No assisted take-off and landing, all operations by PIC.

(f) Restriction for wide body aircraft operation during night for initial period of 06 months and review after six months.

(g) Imposition of additional restrictions on experience requirements for PIC.

(h) Higher operating minima for Code E operations during monsoon period.

(j) Availability of accurate and updated MET information for ATC and timely dissemination of such information to the flight crew.

(k) Reporting of wind-shear and special weather phenomena in the vicinity of aerodrome. Advance equipment to facilitate such reporting.

(l) Installation of Transmissometer equipment for RVR reporting.

(m) Sensitization of pilots about the newly installed simple touchdown zone lights for its purpose.

AAI forwarded the safety assessment and compatibility study to DGCA with request to permit wide body operations at Kozhikode in July 2018. DGCA issued no-objection for the operation of wide body aircraft and the wide body aircraft operations resumed on 05 December, 2018 subject to compliance with the proposed mitigation measures of the safety assessment and compatibility study. In addition following measures were to be incorporated in SOP/Ops Manual of the airport and airline operators:

(a) All take-offs to be carried out at RTOW restricted to sector fuel. RTOW for B777- 200LR not to exceed 260 tons. The same should be incorporated in operational manual/ SOP by the airline to avoid any inadvertent overloading.

(b) Operations restricted to day time only for an initial period of 06 months and to be reviewed thereafter for night operations.

(c) AAI to include personnel with operations background from Emirates in their Runway Safety Team (RST).

(d) Frequency of runway friction test and removal of contaminants to be carried out periodically to ensure that the friction coefficient is kept above μ 0.50. One friction test to be carried out before the onset of monsoons

Note *– As per the e-AIP, India Part AD 1.1, the Aerodromes are required to have Maintenance Planning Level of 0.47 μ, below which corrective maintenance action are required to be initiated. The Minimum Friction Level accepted is 0.34 μ and a NOTAM is required to be issued if friction value falls below 0.34 μ. At Kozhikode, DGCA had prescribed a higher Maintenance Planning Level of 0.5 μ before permitting re-commencement of Wide Body Operations after Runway re-carpeting and strengthening at Kozhikode.*

(e) Runway and taxiway markings to be kept conspicuous and AGL serviceable along with availability of secondary power supply.

(f) AAI to carry out calibration of ILS within specified period and the critical and sensitive area of ILS to be protected.

(g) Aircraft turns on runway/taxiway, to be executed by PIC only, using judgemental over steering defined in aircraft manual. Taxiing speed to be minimum while negotiating turns.

(h) As a long term solution, AAI to provide additional fillets to meet the requirement for such operations. AAI to plan strengthening of taxiways and apron at par with the runway.

(j) Since the distance between runway centre line and apron taxi lane is only 136m, the SOP for movement of Code E aircraft to be strictly followed.

(k) AAI to ensure that ARFF Category 9 is made available for the proposed operations of Code E aircraft.

(l) Disabled aircraft removal plan for B777 to be developed jointly by M/s Emirates and AAI and the same to be tested for its functionality before commencement of flights.

1.10.1 RUNWAY DESCRIPTION

The Runway Characteristics as per the e-AIP, India is given below:

Designations	**Runway Dimensions in (m)**	**Threshold elevation and highest elevation of TDZ of precision Approach runway**	**Slope of runway and associated Stop way**	**Dimensions of strips in (m)**	**Dimensions of RESA in (m)**
10	2860 x 45	Threshold :315.0FT TDZ: 339.0FT	0.30%	2980 x 150	240 x 90
28	2860 x 45	Threshold :326.0FT TDZ: 328.0FT	-0.30%	2980 x 150	240 x 90

Strength of pavement (PCN and associated data) and surface of runway and associated stop-ways is published as 71/F/B/W/T Concrete/Asphalt. The declared distances at Kozhikode Airport are as below:

Runway Designator	**Take-off run Available TORA (m)**	**Take-off distance available TODA (m)**	**Accelerate distance available ASDA (m)**	**Landing distance available LDA (m)**
10	2700	2700	2700	2700
28	2700	2700	2700	2700

The runway at Kozhikode was re-carpeted and strengthened in February, 2017. Analysis of the runway gradient and texture was carried out in detail. The runway has a transverse slope of 1.5 % on each side of the centreline along the length of the runway in addition to 0.30% longitudinal slope in both directions. An up sloping runway impedes acceleration and results in a longer ground run during takeoff. However, landing on an up sloping runway typically reduces the landing roll. A down sloping runway aids in acceleration on takeoff resulting in shorter takeoff distances. The opposite is true when landing, as landing on a down sloping runway increases landing distances.

Cross Section of the runway is shown in the diagram below:

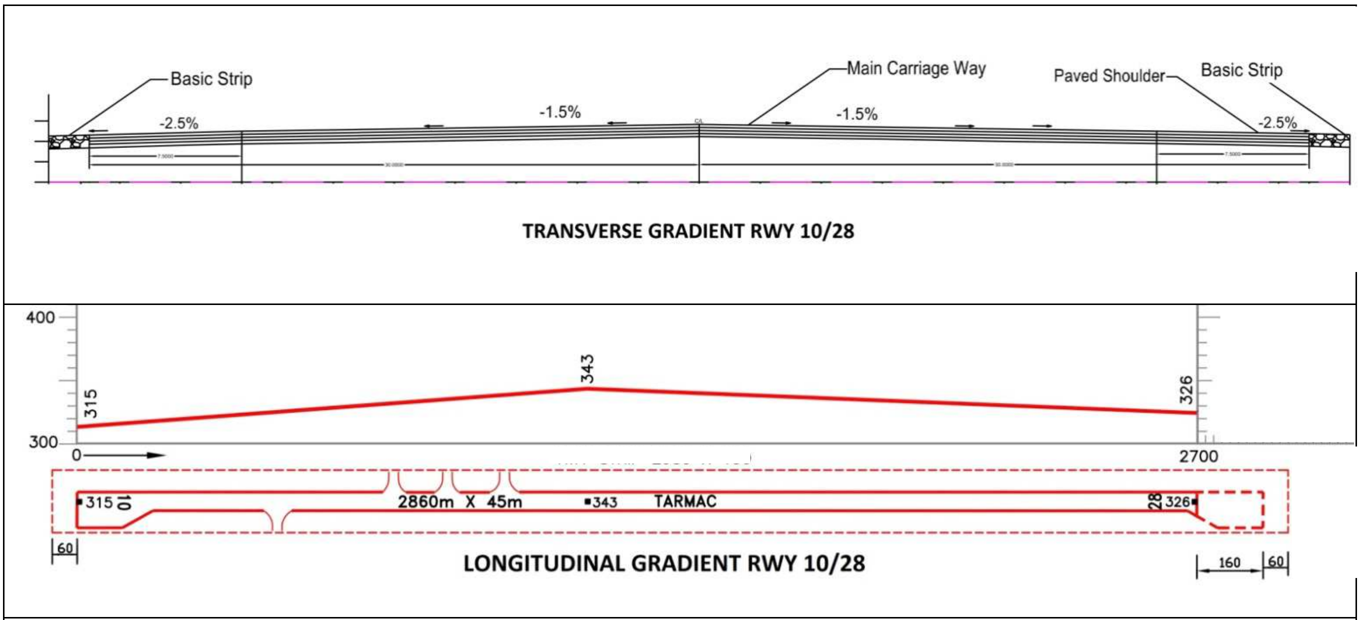


Figure 15: Gradient of Runway 10/28

The runway texture depth is measured by Grease Patch method and depth obtained by this test shall not be less than 1.5mm. The texture depth was checked at three locations and obtained as 2.15 mm during acceptance of the runway.

1.10.2 RUNWAY END SAFETY AREA (RESA)

CAR Section 4, Series B, Part I mandates provision of Runway End Safety Area of 90m x 90m. Being a table top runway, there is constraint with respect to availability of land. Due to unavailability of land the last 3.6 m length of Runway 10 RESA had a width of 85.6m and the last 9.7m length of Runway 28 RESA had a width of 71.2 m. In accordance with Annex 14, Attachment ‘A’ Para 10.2 which states “*Where provision of a runway end safety area would be particularly prohibitive to implement, consideration would have to be given to reducing some of the declared distances of the runway for the provision of a runway end safety area and installation of an arresting system*”. The Runway declared distances were therefore reduced by 10 m to comply with this regulatory requirement.

Consequent to directions by DGCA to implement recommendation of the Court of Inquiry (COI) on another aircraft accident at Mangalore in 2010, the RESA dimensions for Table Top Runways were required to be increased to 240m X 90m. Hence, the declared runway distances were further reduced by another 150 m, during re-carpeting work carried out in 2017, to provide for additional RESA to implement the recommendation.

As the recommendation was complied with by reducing the Runway Declared distances by another 150 m, the RESA dimension became 240m X 90m but soft ground area dimensions remained unchanged. The following table shows the RESA dimensions before and after implementation of Court of Inquiry recommendation of Mangalore accident of 2010.

Comparison of RESA before and after implementation of recommendation of the Investigation Report

Parameter	Before	After
RESA in Overshoot Area of Runway 10	10m reduced Runway surface 91.1 m X 90.8 m Soft Ground Area except last 3.6 m length which has width of 85.6m	160 m reduced Runway surface 91.1 m X 90.8 m Soft Ground Area except last 3.6 m length which has width of 85.6m (Figure. 16)

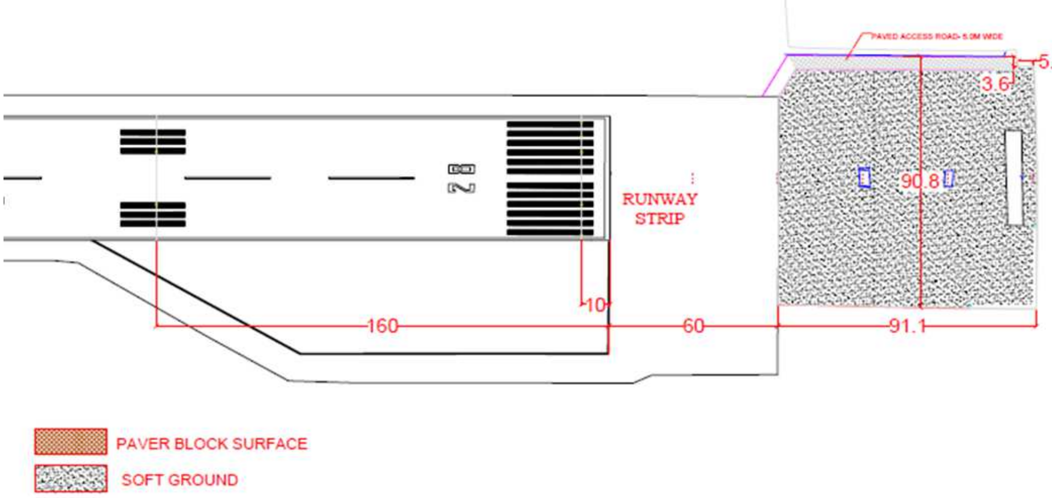


Figure 16: RESA Overshoot Area-Runway 10

Parameter	Before	After
RESA in Undershoot Area of Runway 10	90.7 m X 90.7 m Soft Ground Area except last 9.7 m length which has width of 71.2 m	90.7 m X 90.7 m Soft Ground Area except last 9.7 m length which has width of 71.2 m (Figure. 17)

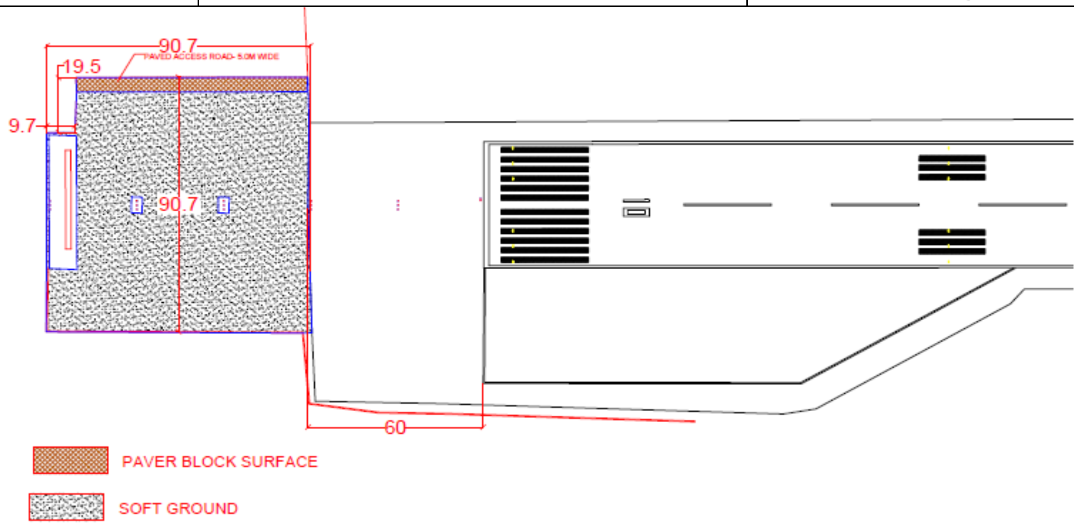


Figure 17: RESA Undershoot Area-Runway 10

Parameter	Before	After
RESA in Overshoot Area of Runway 28	10 m reduced Runway surface 90.7 m X 90.7 m Soft Ground Area except last 9.7 m length which has width of 71.2 m	10 m reduced Runway surface 90.7 m X 90.7 m Soft Ground Area except last 9.7 m length which has width of 71.2 m (Figure.18)

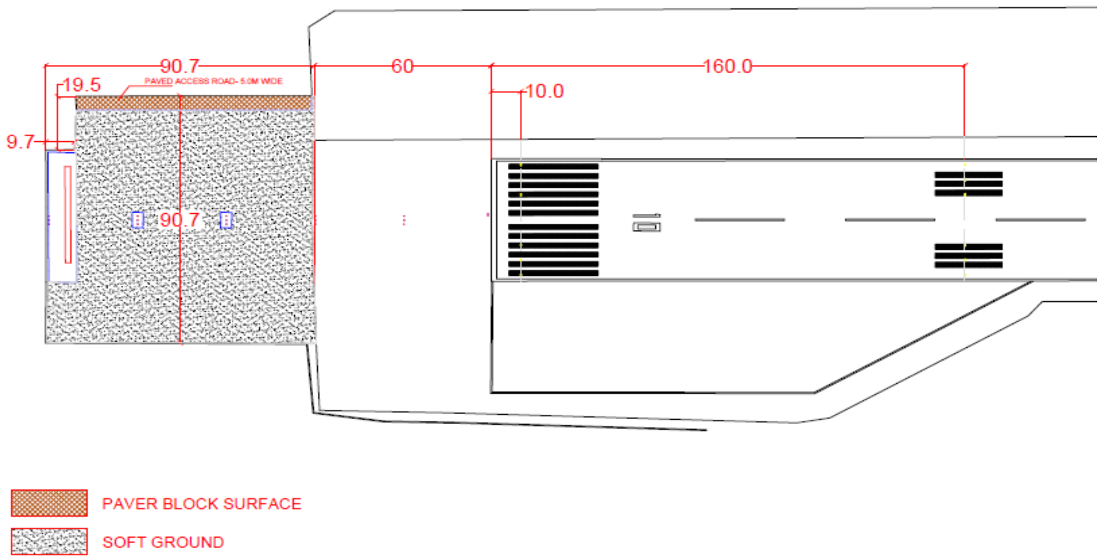


Figure 18: RESA Overshoot Area-Runway 28

Parameter	Before	After
RESA in Undershoot Area of Runway 28	91.1 m X 90.8 m Soft Ground Area except last 3.6 m length which has a width of 85.6m	91.1 m X 90.8 m Soft Ground Area except last 3.6 m length which has a width of 85.6m (Figure. 19)

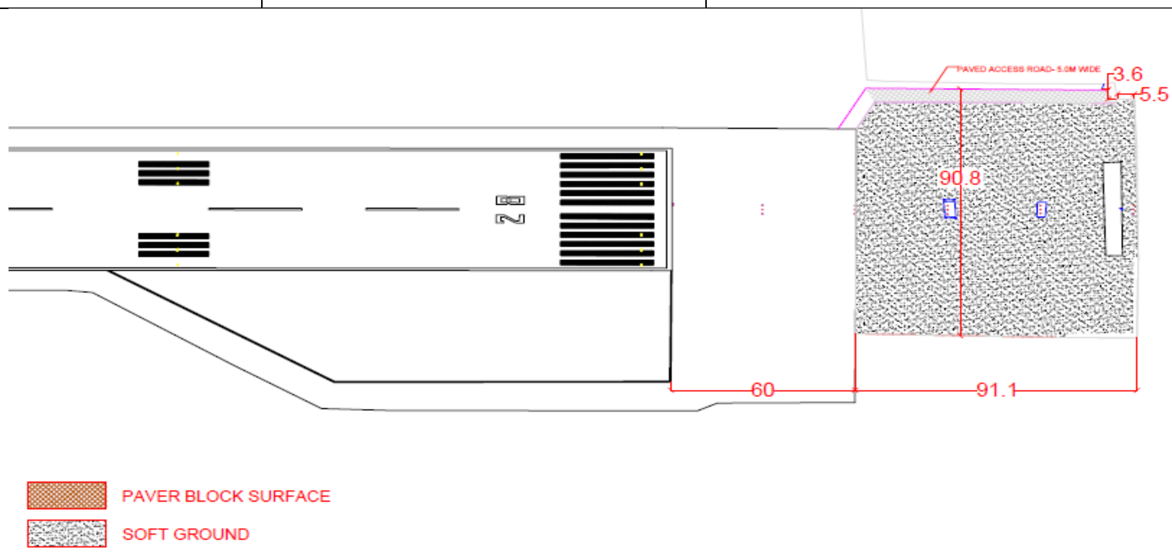


Figure 19 : RESA- Undershoot Area-Runway 28

The portion of runway length beyond 2700 m, even though a part of RESA is also available for taxiing and is being used as a turn pad. There is no physical change in dimension of unpaved RESA overshoot/undershoot area with soft ground for both runways subsequent to implementation of recommendation of CoI. The Soft Ground portion of RESA had a CBR of 16.2 as per the details provided by AAI.

In order to implement a Safety Recommendation given by the Court of Inquiry in Mangalore air crash of 2010, AAI had considered installation of Arresting System in accordance with Annex 14, Attachment 'A' Para 10.2 and carried out a study in consultation with DGCA to install Engineered Materials Arresting System (EMAS)

EMAS is a special engineered material which gets crushed with the impact of the aircraft and decelerates the aircraft to bring it to a halt at a shorter distance. Hence the same can be an alternative to the required RESA length. The manufacturers of EMAS claim that a EMAS provides a level of safety that is equivalent to a full RESA built to the dimensional standards in Chapter 3 of DGCA CAR Section 4, Series B, Part-I.

The matter was deliberated by AAI in consultation with DGCA and the proposal was found operationally unviable due to constraints including but not limited to those given below:

(a) The EMAS performance evaluation is based on the assumption that the aircraft runway exit speed should not more than 70 knots. In case of higher speeds the facility is not suitable.

(b) It was informed that the width of the EMAS bed would be equal to the width of the runway. The EMAS bed was proposed to be installed approximately 161 m from the runway end with the presumption that all aircraft shall be following extended runway centre line after runway excursion without considering the lateral deviation of the aircraft due to braking effect or any other reason.

(c) As per the proposal, the total length of the land required for installation of the EMAS is 225.25 m from runway end. There was only a marginal gain of 75 m against the full length requirement of RESA.

(d) The repair time for replacement of the concrete blocks of the EMAS was proposed to be 45 days. It was further recommended to aerodrome operators in the FAA Circular on EMAS, to promulgate the NOTAM intimating the operators for reduced performance of the EMAS. Further, the repair activities and presence of men and material in the EMAS area for repair were considered an added hazard. Under such situations, during the unserviceable period, the runway would be without adequate RESA/EMAS.

(e) Para 16 b of the FAA circular in the subject matter implies that the provision of EMAS may contribute to fire which would be three dimensional in nature due to the rutting and breakup of the EMAS material.

(f) It will be a challenge for the movement of CFTs (ARFF Vehicles) in that area, further the blockage by being immovable for seven days and 50% maintenance of stock (repair material) are also additional challenge for such installations.

1.10.3 RUNWAY STRIP

Runway Strip of 75 m is available on both sides of the runway centreline. This is in variance with DGCA CAR which lays down a requirement of 140 m Runway Strip on either side of the runway centre line for Code 4 precision approach, CAT-I runway. AAI had sought exemption from this requirement from DGCA. In response AAI was advised to include the effect of crosswind component on aircraft veering off and mitigation thereof. Thereafter, AAI carried out hazard identification and risk analysis during safety assessment in Aug 2016 and mitigation measure for cross wind hazard were proposed. After acceptance of proposal, it was decided in consultation with airlines to suspend aircraft operations whenever the visibility is less than 2000 m and the crosswind speed is 15 kt or more on a wet runway and 20 kt or more on a dry runway. This was informed to all concerned vide AAI/VOCL/ATM/2018/O-1/OPNS dated 19 July 2018.

AAI submitted a combined proposal to DGCA seeking exemption for non standard Runway Strip at various airports on 28 Sep 2018. DGCA, on the same date, gave fresh guidelines for Safety Assessment for Non-Compliant Runway Strip. As per guidelines issued by DGCA, AAI was required to undertake further mitigation measures to be included in the Safety Assessment. One of the mitigation measure suggested by DGCA at Para 4 (XII) of DGCA letter stated, "*Aircraft operations not to be undertaken above cross wind of 15 Kt for dry runway and 10 Kt for wet runway which may vary according to category of aircraft*".

AAI submitted revised proposal in Dec 2018 to DGCA for seeking exemption after carrying out Safety Assessment in view of DGCA letter dated 28 Sept, 2018 but the stricter DGCA crosswinds guidelines for Non-Compliant Runway Strip were not incorporated in the mitigating factors by AAI.

In response to the revised proposal submitted by AAI, DGCA advised AAI vide its letter dated 11 February, 2019 to seek exemptions directly from Ministry of Civil Aviation (MoCA). Accordingly, AAI wrote to MoCA seeking exemption on 15 Apr 2019. MoCA, however, advised DGCA to take the decision on exemption in light of Rules and Procedures laid in CAR Section 4, Series B, Part I and IV on 20 September, 2019 AAI followed up with DGCA vide reminder letter dated 17 September, 2020 and again on 12 January, 2021 but no such exemption has so far been granted by DGCA and the matter remains pending.

Five months after VT-AXH crash of 07 August, 2020 at Kozhikode, the cross wind limit for aircraft operations has been reduced at the airfield. This was promulgated vide AAI/VOCL/ATM/2021/O-1/OPNS dated 08 January, 2021. It states, "*Aircraft operations not to be undertaken above cross wind of 15 Kt for dry runway and 10 Kt for wet runway which may vary according to category of aircraft*".

This stated exactly the same limits what were given in DGCA guidelines on 28 Sep 2018 but were not incorporated by AAI.

1.10.4 RUNWAY LIGHTINGS

Details of Approach and Runway lights at Kozhikode Airport as per published e-AIP, India is given below:

Runway Designator	Type, length and intensity of approach lighting system	Runway threshold lights, color and wing bars	Type of visual slope indicator system	Length, spacing, color and intensity of runway edge lights	Color of runway end lights and wing bars	Simple Touch Down Zone Lights	Runway Threshold Identification Light
10	SALS 150 M Abridged LIH	Green	PAPI LEFT/3.00 DEG MEHT (65.06FT)	2700 M 60 M White LIH	Red	Steady White A pair on either side of CL 922.8 M from Threshold	Flashing White Lights
28			PAPI LEFT/3.20 DEG MEHT (70.47FT)				

As per the maintenance schedule, the PAPI Calibration at Kozhikode Airport is carried out twice a month. The last bi-monthly calibration before the accident was carried out on 22 July, 2020.

Runway centreline lights are not available at Kozhikode as the width between the runway edge lights is 48.5 m. In case the width between the runway edge lights is more than 50m only then centre line lights are a mandatory requirement for Cat 1 precision approach runway. Two circuits for Runway Edge Lights are available. Runway Guard Lights are available on Taxiway A, B and C. Blue Taxiway Edge Lights are provided on all taxiways and runway turn pads.

04 Lead-in Lights, each consisting of a group of three sequential flashing white lights in a linear configuration are installed in the Final Approach track of runway 28 at a distance of 6193 m, 4721 m, 3128 m and 1826 m respectively from threshold of runway 28. The light at 3121 m is offset by 16.5 m to the right side of the extended runway centre line. There are no Lead-in Lights on runway 10.

1.10.5 RUNWAY INSPECTION AND TESTS

The surveillance inspection of Kozhikode airport was carried out by DGCA as per their Annual Surveillance Plan and the observations made therein were being addressed by AAI from time to time. Surveillance inspection was carried out by

DGCA from 24 to 26 April, 2017 after the re-carpeting and strengthening work. It was observed that the overall average coefficient of friction was below the minimum acceptable level. The observation was categorized as level 1 observation, which required immediate corrective actions. It was further observed that there were rubber deposits around the touchdown zone of Runway 28 and 10 for which a regular rubber removal schedule was also required to be put in place.

In response AAI took the following actions with intimation to DGCA in mid May, 2017:

(a) Rubber deposit from the runway was removed from 06 to 09 May, 2017 with a closure NOTAM for three hours and during other lean traffic periods including at night.

(b) Runway friction was re-evaluated using runway friction tester continuously. As soon as the friction value obtained was above the minimum level, NOTAM regarding the friction was cancelled.

(c) Rubber removal was continued till 12 May, 2017 and the overall friction value obtained were above the maintenance level.

AAI also assured DGCA that in future, the condition of runway pavement would be assessed at regular intervals by measuring the friction coefficient to keep the runway friction values above the minimum acceptable value of 0.34µ. In addition, friction survey through visual inspection as prescribed in ICAO Airport Service Manual Part 2 would also be carried out once in 03 months. Further, corrective action for rubber removal would be considered immediately, whenever friction values fall below the maintenance planning level.

Later, a special inspection of Kozhikode airport was carried out from 04 to 05 July, 2019 by DGCA. In view of the prevailing monsoon season and based on the significant safety concerns, a show cause notice was issued by DGCA on 11 July, 2019 to Airport Director Kozhikode Airport, seeking an explanation as to why the facilities had not been maintained in accordance with the regulatory requirements set out in CAR Section 4,Series B, Part 1. In response to the show cause notice, the Airport Director Kozhikode submitted an ATR (action taken report) along with the necessary documentary evidence on the observations made by DGCA.

The action taken on the significant observations was as follows:

Observations	***Action taken***
1. Runway surface friction values are found to be below maintenance friction level.	*I. Soon after the friction test, and on receiving the report, the rubber deposits have been removed from the above areas using RDR machine.* *II. In touchdown areas, on runway 10 & 28 specifically, RDR was deployed for around 20 hrs covering total of around 1500sq.m area after the friction testing on 08 June, 2019 and rubber deposit*

	removal has been carried out regularly. After last friction test on 08.06.2019, one bag of volume 300 ltr full of rubber has been discharged.
2. Excessive rubber deposit are observed from runway C/L to 3m on both sides of runway 28 TDZ also being runway C/L markings of TDZ of runway 28 and runway 10.	*I. As observed by auditor from DGCA, during said inspection, rubber deposits were observed on centreline which was immediately taken care of by deployment of RDR machine along the centreline throughout the length of runway.* *II. Rubber deposits on centre line to 3m on both sides of runway 28 TDZ and also along runway C/L markings of TDZ of runway 28 &runway 10 have been removed by deploying RDR machine.* *III. Subsequent to DGCA inspection on 04.07.2019, RDR has been deployed for a total of 14 hrs and 12,275 sq meter area has been covered including the segments along the centre line as well as 3m to either side of runway centre line as per DGCA observations.*
3. Water stagnation of about 1.5 m length was observed on the area between runway edge and intermediate turn pad on runway 28.	*Rectification carried out*
4. Cracks are observed at runway 28 TDZ and along runway C/L markings at runway 10 TDZ.	*The cracks were filled with polymer modified emulsion. The material was applied at high pressure to the cracks, thereby filling the cracks. With time, the material hardens and seals the crack thereby preventing further intrusion of foreign materials into the crack observed.*
5. Runway strip transverse slope at about 1000m from runway 28 THR (on LHS) is found exceeding the limit of 2.5%.	*Grading of the area completed as per CAR.*
6. A steep downward slope of approx. 5ft depth is observed immediately after the apron behind Aircraft Stand No. 1; which needs to be levelled and graded.	*The area was graded, levelled and compacted to give a gradual drop from the edge of Apron.*
7. Several cracks are observed at Aircraft Stand	*Temporary sealing is being done on cracks observed at Aircraft stand No. 5 PDC 31.08.2019.*

No. 5 A portion of Apron surface of about 111 m is found damaged.	*Portion of Parking surface of about 111m – Action for dismantling re construction as per the structural expert is being initiated PDC 31.03.2020*
8. The digital MET display DIWE (Distant Indication Wind Equipment) installed for runway 10 is found unserviceable and is under NOTAM since many days; which is not in compliance with the mitigation measures committed for Code E Operation.	*The DIWE equipment for runway 10 has been made serviceable by MET department on 09/07/2019 from 1200 UTC.*
9. Shortage of reserve stock of 6630 litres AFFF and 140 Kg DCP complementary agent was observed at ARFF station to maintain ARFF Cat-9 for Code E operations.	*As per AAI FS Manual; 200% extinguishing media available at Fire Station. AFFF requirement 9400 litres available 9880 litres* *DCP requirement 1200kgs available 1425 kg*

Subsequent to action taken by AAI, the Audit findings were closed and the same was confirmed by DGCA during subsequent surveillance inspection of 2019/2020.

Inspection of Operational Area by aerodrome airside personnel is carried out as laid down in Operation Circular 5 of 2011/SOP for airfield inspection (Doc No.ASM/SOP/007) and MATS Part I- 7.18, 7.16 (Attachment III & IV). Detailed runway inspection as per the runway inspection checklist was carried out on 07 August, 2020. The details of the runway inspection carried out in the morning and evening are as follows:

Date: 07/08/2020 Time In: 0125 UTC	**Out: 0135 UTC**
Facility	**Status**
Foreign object of Damage (FOD)	Nil
Surface	WET
Threshold lights	Ok
PAPI	Ok
runway Lights	Ok
Approach Lights	Ok
Runway Guard Lights	Ok
Aerodrome Beacon	Unserviceable
WDI	Ok
Birds	No. and position Nil
Taxi way	Ok
Apron	Ok
Signage	Ok

Date: 07/08/2020	Time In: 1320 UTC Out: 1335 UTC
Facility	**Status**
Foreign object of Damage (FOD)	Nil
Surface	WET
Threshold lights	Ok
PAPI	Ok
runway Lights	Ok
Approach Lights	Ok
Runway Guard Lights	Ok
Aerodrome Beacon	Unserviceable under NOTAM
WDI	Ok
Birds	No. and position Nil
Taxi way	Ok
Apron	Ok
Signage	Ok

Besides the above detailed runway inspection the routine runway inspection on 07 August, 2020 was carried out as follows:

From	To	Report as logged
0010 UTC	0018 UTC	runway clear and normal, WET
0114 UTC	0125 UTC	runway clear and normal, WET
0428 UTC	0438 UTC	runway clear and normal, DAMP
1015 UTC	1025 UTC	runway clear and normal, WET
1105 UTC	1115 UTC	runway clear and normal, WET
1325 UTC	1335 UTC	runway clear and normal, DAMP
2335 UTC	2350 UTC	runway clear, normal and WET

Rubber deposit removal was last carried out on 30 July, 2020. Runway co-efficient of Friction is regularly monitored and periodic friction check was done on 07 August, 2020 during the day. The average value of coefficient of friction was above the required value. Friction Test was carried out on 08 August, 2020 and again on 12 August, 2020 in the presence of AAIB team. The values were satisfactory on both occasions. The details of Friction Test are as below:

Date	Speed	Friction of Coefficient	
		03 m from Centre Line	06 m from Centre Line
07 Aug 2020	95 Km/hr	0.57	0.58
07 Aug 2020	65 Km/hr	Could not be done due to rain	
08 Aug 2020	95 Km/hr	0.63	0.65
08 Aug 2020	65 Km/hr	0.69	0.72
12 Aug 2020	95 Km/hr	0.61	0.66
12 Aug 2020	65 Km/hr	0.67	0.76

As per the feedback on braking action reported by the pilots of Flight ABY454 and Flight SEJ9026, which landed before AXB 1344 on 07 August, 2020 (in similar runway conditions), the braking action was reported to be 'Good' and 'Satisfactory' respectively.

In addition, the Investigation Team interacted with the AIXL pilots seeking their feedback on braking action while landing on a wet Kozhikode runway. The AIXL pilots too reported that the braking action was satisfactory. The results of Friction Test carried out in presence of AAIB Go-Team on 12 August, 2020 and Investigation Team later were also satisfactory.

1.10.6 SECURITY CAMERAS

Kozhikode Aerodrome is equipped with CCTV system consisting of 35 cameras covering all ANS areas and another 313 cameras covering terminal, tarmac and other areas. One of the CFTs is equipped with an infrared camera but the same was not functional on the day of the accident. Some relevant screenshots from the CCTV footage made available to the Investigation Team are shown in the following figures.

Figure 20: Screenshot from CCTV footage at 19:22 IST

The above figure shows low clouds in the direction of Runway 28 approach. The aircraft had made a missed approach on Runway 28 at around this time.

Figure 21: The Screen Shot from CCTV Installed in Front of Taxiway 'C'

The above figure shows the aircraft while crossing Taxiway 'C', and still floating. The location of camera and final touchdown point is also shown.

Figure 22: Screenshot from CCTV footage showing VT-AXH landing

The above figure shows visibility conditions at the time of landing on Runway 10. VT-AXH is also seen in the frame.

1.10.7 AIRPORT EMERGENCY PREPAREDNESS

1.10.7.1 AIRPORT EMERGENCY PLAN

Airport Authority of India has published Airport Emergency Plan 'DOC NO.VOCL/ATM/2011/000001/EMER-PROCD' for Kozhikode Airport. Airport Emergency Planning is the process of preparing an airport to cope with an emergency occurring at the airport or in its vicinity. The Airport Emergency Plan had been revised in August, 2019 but had references to redundant portions of Aircraft Rules, 1937 and repealed Aircraft (Investigation of Accidents and Incidents) Rules, 2012.

The actions required to be performed by various agencies in case of an accident are listed in Chapter III of the Airport Emergency Plan. It is the duty of ARFF Shift In-Charge to establish a command post at the site and to man it. Airport Director will take over the operational command once ARFF and City Fire Brigade are in attendance. As per statements given by airport personnel, although the Airport Director was present at the crash site, however, there was neither a Command Post Vehicle available nor was the mandatory formal Command Post established at the site of the accident. Video recording of the rescue operations was not done, which is a mandatory requirement under ASC 04 of 2013. This requirement is not included in the Kozhikode AEP which is in direct contravention of ASC 04 of 2013 and is a serious lapse. There is no observation made during any of the Mock Exercises till date, regarding violation of this mandatory requirement (ASC 04 of 2013) wherein no video recording was being done or regarding this aspect not being incorporated in the AEP. In the absence of crucial video footage, the investigating team had no option but to rely solely on the version of available witnesses to reconstruct the sequence of events of the entire rescue operation.

The Airport Clinic is managed by a local private hospital as per a Memorandum of Understanding between the airport and that hospital. Duty doctors at the Airport Clinic are deputed by the hospital on rotational basis. These duty doctors are not thoroughly briefed or trained for their role during an aircraft accident as enumerated in the AEP. According to the statement of the Airport Duty Doctor, on the day of accident, the medical cover during an accident was to be provided by APHO and he did not have any specific role to play at the accident site. He stated to have received information regarding the aircraft crash from his hospital colleagues and not through the channel prescribed in the AEP. The Airport Duty Doctor did not reach the crash site immediately. He also had to walk some distance on foot to reach the crash site due to traffic congestion on the narrow airport perimeter road. Causalities were not triaged at the accident site by the airport doctor before being transported to the city hospitals. Hence, the casualties were not prioritised (as I/II/III or colour coded) according to the severity of injuries and their clinical condition. All available means of transportation like airport ambulances, taxis and even private vehicles were used for transporting the injured passengers to various hospitals and a large number of passengers were transferred to nearby hospitals even before the ambulances from the hospitals could reach the crash site.

In another statement, submitted at a later date, in response to the questions from the Investigation Team, the Airport Doctor changed his version and claimed that all actions were undertaken as per the published AEP. This is in total variance with the initial deposition and written statements submitted by the Airport Doctor.

1.10.7.2 FIRE AND RESCUE SERVICES AND INFRASTRUCTURE

ARFF station is located north of the runway approximately 1000 m from the beginning of runway 10, adjacent to international terminal building. ARFF Service is responsible for responding to all aircraft incident/accident up to 05 km on approach path and 2.5 km across the runway, with full complement and in accordance with the category of the aircraft.

The ARFF services at Kozhikode are determined as per DGCA CAR Section 4, Series 'B', Part I and ICAO Annex-14. Accordingly, as per e-AIP, Fire and Rescue services, Category VIII is being maintained between 03:30-11:30 UTC and Category VII between 11:31-23:59 UTC and 00:00-03:29 UTC.

ARFF Kozhikode is equipped with 03 CFT, 01 RIV and 04 ambulances. The airport has a 4.9 m wide perimeter road which surrounds the airport. During a DGCA audit in May 2016, a CFT met with an accident while trying to manoeuvre through the narrow perimeter road to demonstrate the emergency response time. DGCA commented in the Audit report that *"the existing perimeter road is not capable of supporting the heavy Fire Fighting vehicles, the same should be strengthened and to be widened"*. However, the work to widen the perimeter road had not commenced till the date of this accident.

During the rescue operations, on the day of accident, the narrow perimeter road was blocked with emergency vehicles, airport vehicles and taxis that were put in to use during the rescue, leading to serious delays.

1.10.7.3 TRAINING OF ARFF PERSONNEL

The ARFF personnel are required to undergo appropriate training prior to induction and also at station level to ensure professionally trained manpower for provision of ARFFS is available. Training programs are conducted at designated training establishments and also at station level. The ARFF personnel undergo the following training at Authorised AAI Training Establishments in accordance with laid down AAI training and operational requirements:

(a) Four Months Basic Training Course

(b) Six Weeks Advanced Refresher Course –I

(c) Six Weeks Jr. Fire Officer Course

(d) Six Weeks Fire Officer/Advanced Refresher Course –II

(e) Eight Weeks Senior Fire Officer Course

On being posted to a station, ARFF personnel are required to undergo following trainings within the defined timelines:

S. No	Subject	Week	Duration
(a)	Familiarisation of Fire Station SOPs	1st Week	2 Hours
(b)	Familiarisation of Fire Orders	1st Week	2 Hours
(c)	Fire Safety Procedures	2nd Week	2 Hours
(d)	Familiarisation of Operational Area	2nd Week	2 Hours
(e)	Familiarisation of Fire Fighting Equipment and ACFTs	2nd Week	2 Hours
(f)	Practical Class on Rescue Methods	2nd Week	2 Hours
(g)	Familiarisation of Emergency Medical Centre and Ambulance	2nd Week	2 Hours

In addition they also undergo recurrent training at station level, which includes the Aircraft Familiarisation Training. The training has two modules, a Theoretical Training which is carried out half yearly and Practical Training which is carried out yearly.

DGCA, through its Audits, had flagged the absence of training records for recurrent trainings in 2016. In 2018, DGCA observed that ARFF personnel had not undergone mandatory Aircraft Familiarisation Training.

Thereafter, regular e-mails were written by the Head of Fire Department, Kozhikode requesting assistance from airline operators, APD, AAI Regional Headquarter and AAI Headquarter for Aircraft Familiarisation Training. No arrangements were made despite a series of e-mails from Head of Fire Department dated 11 Jan 2019, 29 Mar 2019, 12 July 2019, 16 Aug 2019, 19 Aug 2019 and 16 March 2020.

Later, when DGCA carried out the Annual Surveillance Inspection of Kozhikode Airport from 01 April, 2019 to 03 April, 2019, it was mentioned in the Audit Report that the ARFF personnel had undergone Aircraft Familiarization Training as per ICAO Doc. 9137-AN/898 Part-1, Chapter-14, Para 14.5.2 and this training was recorded as 'Satisfactory'.

During visit of Investigation Team to Kozhikode, Head of Fire Department gave a written statement and deposed before the Investigation Team that no familiarisation training for ARFF personnel on aircraft operating at Kozhikode Airport has been carried out. The same was also confirmed by other fire crew members.

However, lately, records of Aircraft Familiarisation Training were provided to the Investigation Team to state that training was being regularly conducted over the years. This is contrary to the proof given by the HOD Fire Dept and the deposition and written statements of Head of Fire Department and other Fire Crew.

1.10.7.4 EMERGENCY MOCK EXERCISE

A full scale mock exercise of the Airport Emergency Plan was carried out at Kozhikode in November, 2019 in which all the agencies working at the airport as well as other local agencies like City Fire Brigade etc. participated in the drill. Following issues were flagged by the observers who participated in the mock exercise:

(a) Coordination of agencies with Command Post was not proper at initial stage.

(b) Movement of ambulances can be more organised and handling of casualties should be done in a professional manner.

(c) The perimeter road requires to be widened for safe movement of emergency vehicles.

(d) There should be proper security arrangement / police presence at Survival Reception Centre (SRC), Friends and Family Reception Centre (FFRC) and Reunion Area.

1.11 FLIGHT RECORDERS

The aircraft VT-AXH was equipped with Flight Data Recorder and Cockpit Voice Recorder in accordance with CAR Section 2, Series I, Part V. The details of the Flight Recorders installed on the aircraft are as below:

Flight Recorders	Make	Part No.	Sr. No.
DFDR	Honeywell	980-4700-042	18034
CVR	Honeywell	980-6022-001	120-04885

Airlines are required to carry out 100% monitoring of DFDR data in accordance with CAR Section 5, Series F, Part II. The data from these devices are also used for analyzing system performance.

In addition AIXL carries out download of CVR data to cover 50% of aircraft in the fleet per month as per policy laid in its CAME.

1.11.1 COCKPIT VOICE RECORDER (CVR)

The airplane was equipped with a Honeywell solid-state CVR capable of recording 120 minutes of digital audio. Specifically, it contains a 2-channel recording of the last 120 minutes of operation and separately contains a 3-channel recording of the last 30 minutes of operation.

The CVR was retrieved from the wreckage on 08 August, 2020. The CVR did not have any apparent damage and was in good condition. The download of CVR recordings was carried out at DGCA flight recorders laboratory.

Audio information was extracted without difficulty using the normal procedure. The extracted 02 hour, 05 minutes and 23 seconds recording consisted of 5 channels of useable audio information. Good quality audio was obtained from all the 5 channels that comprises of cockpit area microphone, Captain, First officer, Observer and combined audio information from all the individual flight crew positions. The start of CVR recording corresponded to 12:05:32 UTC while the airplane was in cruise flight during the Dubai–Kozhikode sector and ended at 14:10:56 UTC. A transcript was prepared starting at 13:11:52 and relevant extract from the transcript is given at Appendix 'C'.

1.11.2 DIGITAL FLIGHT DATA RECORDER (DFDR)

The airplane was equipped with a Honeywell solid-state FDR that records airplane information in a digital format using solid-state flash memory as the recording medium. The DFDR unit was retrieved from the wreckage on 08 August, 2020 in good condition without any apparent damage.

The DFDR was sent to the DGCA recorder laboratory for readout. The DFDR data could be extracted normally from the recorder. The downloaded data was converted into engineering parameters with assistance of NTSB. The DFDR recorded about 25 hrs of aircraft data.

The graphical plots for various parameter obtained from the DFDR are placed at Appendix 'D'. A kinematic consistency (KinCon) analysis was conducted on the DFDR data to correct inherent inconsistencies often present in recorded data from different sensors because of the presence of instrumentation biases due to misalignment in inertial measurements, contamination of pressure and altitude measurements due to flow separation, and sample rate differences. The KinCon process uses integrated acceleration data to ensure that the basic inertial parameters such as altitude, ground speed, and drift angle are compatible and comparable. The output is a kinematically consistent set of data with acceleration biases removed, allowing calculations of wind data and ground track information.

Figure 23: Approach Path Followed by AXB 1344 for both Runways

The aircraft on arrival from Dubai was cleared for ILS Z approach for RWY 28 from overhead the VOR (CLC) by Kozhikode ATC. On the first attempt the FDR data shows that the airplane was established on the ILS at 3269 ft PA (13:49:18 UTC) with Autopilot and Autothrottle engaged, landing gear selected down and speed brakes armed. Landing flaps 30 were selected at 1917 ft PA (13:51:07 UTC) and the aircraft was fully configured for landing. At 13:52:39 UTC, approximately 729 ft PA the ILS approach was discontinued, TO/GA switch was pressed and the Autopilot disconnected at a CAS of 155 kt and GS of 145 kt. This was followed by a missed approach procedure where the undercarriage was selected 'Up' and flaps were retracted and the aircraft climbed to 3600 ft. The Autopilot was re-engaged at 3324 ft PA with a CAS of 226 kt.

Thereafter the aircraft continued on the missed approach track and the Mode Control Panel (MCP) altitude was changed to 10000 ft however, the aircraft leveled out at 7000 ft and turned left on an inbound course at 14:01:54 UTC at a distance of 27 NM from CLC VOR. The aircraft was cleared for ILS RWY 10 (ILS frequency 110.7 MHz).The aircraft captured the ILS localizer at 14:06:21 UTC at 3359 ft PA with a CAS of 168 kt. The landing gear was selected 'Down' and speed brake was armed for landing at 14:06:38 UTC. The Glide slope was captured at 14:07:58 UTC at 2369 ft PA with a CAS of 157 kt. Landing flaps '30' were selected at 14:08:48 UTC at 1667 ft PA with approach speed of 150 Kt selected on the MCP.

From approximately 1100 ft Radio Altitude (RA), the recorded winds were out of the west (~250 degrees) at an average speed of 26 kt. Given the runway true heading of 100.9 degrees, the airplane would have been experiencing a tailwind component of approximately 22 kt and a crosswind from the right of approximately 13 kt.

The airplane gross weight during approach was 62,908 kg. The 'VAPP' speed was initially set to 149 kt on MCP at 14:08:42 UTC and at 14:08:52 UTC selected 'VAPP' speed was changed to 150 kt. During the same time the GS was approximately 175 kt and the ROD was 750 fpm. Throughout the approach, CAS was between 05 and 10 Kt above the approach speed. The aircraft was on the localizer, and within 0.2 dots of the glideslope.

Auto Pilot was disengaged at 14:09:45 UTC as the aircraft descended through 500 ft RA. At 14:09:50 UTC the rate of descent began to increase momentarily reaching 1500 fpm. Around this time glideslope deviation began to increase towards 1.7 dots below the beam as the aircraft approached the runway threshold. EGPWS alert was also triggered in the process. Auto throttle remained engaged till touchdown.

The aircraft crossed the threshold at 92 ft RA. At 14:10:13 UTC after crossing the threshold when the aircraft was at a RA of 20 ft the engine power was increased manually by the PF to 83% N1 despite autothrottle command to reduce thrust, the CAS at this time was 156 Kt and finally went up to a maximum of 160.9 Kt, corresponding to ground speed of 174 Kt.

At 14:10:15 UTC the aircraft sink rate decreased to between 2 and 3 fps and for the next 05 seconds remained at this value, during this period, radio altitude decreased from approximately 20 to 12 ft, indicating that the aircraft floated.

At time 14:10:25 UTC (19:40:25 IST) the aircraft likely touched down. This is based on weight on wheels input, decrease in longitudinal acceleration and an increase in normal load factor. About 0.7 seconds after touchdown, the left commanded brake pressure began to increase and reached to 3000 psi. The right commanded brake pressure was recorded as constant (-) 165 psi due to an unserviceable pressure transducer. The automatic brake discrete parameter remained disengaged throughout the rollout, indicating that manual brakes were applied.

At 14:10:26 UTC, auto-speed brakes were fully deployed and at around the same time, longitudinal deceleration (negative longitudinal acceleration) increased to an average value of 0.22 G. At 14:10:28.5 UTC, the auto-throttle was disengaged.

At 14:10:29.9 UTC, thrust reversers were momentarily deployed for approximately 02 seconds before reverse thrust levers were stowed and returned to forward idle positions. Thereafter, at 14:10:34.3 UTC, the left commanded brake pressure temporarily reduced to approximately 600 psi before increasing back to 3000 psi. Subsequently, longitudinal deceleration momentarily decreased to 0.1 G during this time.

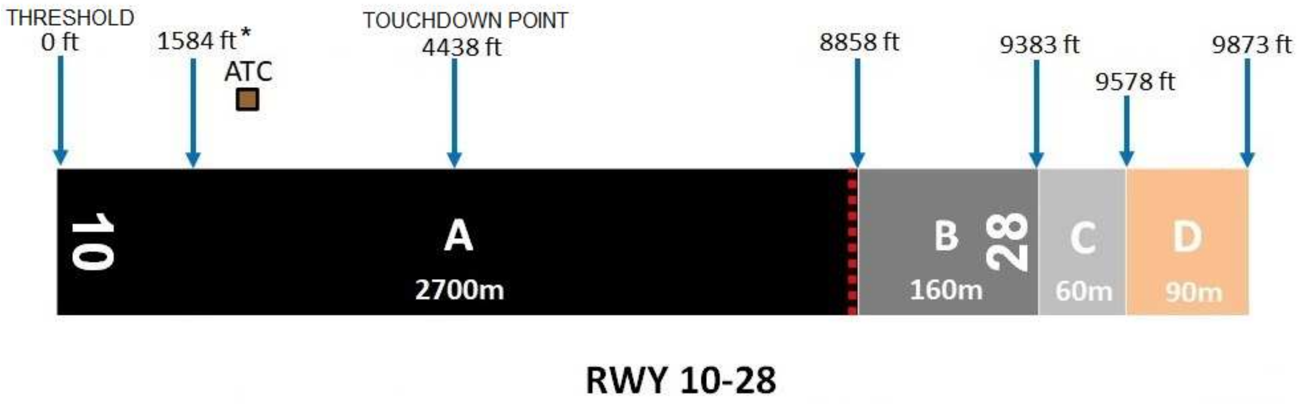
At 14:10:39.4 UTC, the thrust reversers were deployed for the second time, the throttle resolver angles (TRAs) were decreased to 6.0 degrees (i.e. maximum reverse thrust). Soon after, the engines began to spool up following the maximum reverse thrust command. At 14:10:46.7 UTC, the thrust reversers were stowed and returned to forward idle. Subsequently, longitudinal deceleration began to decrease from approximately 0.2 G to 0.05 G before increasing again as the aircraft entered the soft ground of RESA.

At 14:10:53 UTC, pitch attitude began to decrease drastically, indicating this was likely the point when the airplane began to travel down the embankment of the table top runway. Ground speed was approximately 50 kt at this time. Just prior to the last recordings on DFDR, the ‘landing gear proximity sensors’ recorded ‘air mode’, for approximately two seconds. This indicates that the main wheels of the aircraft had left the ground during its descent from the edge of the table top runway to the perimeter road, where it impacted nose first and in a wings level attitude.

The last recorded parameters on DFDR have been considered as the point of first impact of the aircraft with ground after it fell from the runway edge. At this point, the last recorded ground speed was 41 kt and the engine power of LH engine as 25.75% and RH engine was 12.12%. The last recorded manual brake pressure was 1915psi.

1.11.2.1 GROUND TRACK ANALYSIS

DFDR data was used to carry out ‘Ground Track Analysis’ to show the airplane path in relation to the runway during the approach and landing rollout. The pertinent longitudinal and lateral-directional parameters were plotted versus distance to the runway threshold and centre line, respectively. The ground track analysis was done for approximately 325 ft beyond the end of runway 10 (prior to the embankment), which has a length of 9383 ft and a width of 148 ft. Longitudinal and lateral distances were calculated using a combination of inertial data (ground speed, drift angle, heading), glide-slope/localizer deviation, and airport information (runway dimensions, taxiway dimensions, etc.). The distances relative to the airplane’s CG were then referenced to the runway based on the airplane location as it crossed runway 28 threshold. Actual locations of tyre marks on RESA were also taken into account to construct the ground track analysis in order to estimate the trajectory of the airplane.



NOTE – DIMENSION NOT TO SCALE

DSGN	NOMENCLATURE
A	LANDING DISTANCE AVAILABLE
B	RESA-PAVED PORTION OF RUNWAY
C	RUNWAY STRIP
D	RESA-SOFT GROUND

* The aircraft achieved maximum speed of 160.9 kt at 1584 ft after crossing the threshold.

DISTANCE ft	C.A.S kts	G.S kts
0	151.6	169
1584	160.9	174
4438	149	165
8858	69.5	84.5
9383	62.3	74.1
9578	57.9	69.6
9873	45	42

Figure 24 : Aircraft Speeds at Various Distances on Runway and RESA

The aircraft touched down at 4438 ft from the runway threshold. Speed brakes were deployed while aircraft was at 4800 ft past threshold and were initially the main contributor to the total longitudinal deceleration. However, as the aircraft had touched down just short of the beginning of the downward slope of the runway, speed did not decrease much until the application of wheel brakes at 4716 ft. The wheel brakes also provided a significant component of the overall longitudinal deceleration, which initially stayed relatively constant at approximately 0.1 G after commanded brake pressure was applied after touchdown.

TR deployment was initiated while the aircraft was at 5193 ft and was fully deployed at 5992 ft. The TRs provided a deceleration component of approximately 0.05 G when they were deployed momentarily the first time after touchdown. However, a brief relaxation of commanded brake pressure to approximately 2200 psi coincided with the momentary TR deployment, which likely offset the deceleration provided by the TR at that time (i.e., overall longitudinal deceleration did not change significantly).

Further, thrust reversers were commanded to stow at 6203 ft, while the thrust reversers were stowing, brakes were released momentarily. The recorded metered brake pressure reduced from 2910 psi to 573 psi (between 6650 ft and 7100 ft) causing a decrease in deceleration. Thrust reversers were stowed by 6466 ft. The average $\mu_{airplane}$ from the touchdown point to approximately 7100 ft beyond the threshold was approximately 0.07. Once the maximum commanded brake pressure application resumed, the brakes then provided the majority of the longitudinal deceleration, however, the effectiveness of the speed brakes continued to decrease with decrease in aircraft speed.

At 7615 ft, the thrust reversers deploy command was given and thrust reversers were again fully deployed by 8192 ft. Both engines N1 had by that time, decreased to approximately 27%. As a result, the longitudinal deceleration contribution from the thrust reversers was small (approx. 0.01 G). At 8950 ft, stow command was again given and at 9104 ft, the Thrust Reversers were fully stowed.

At the time when the thrust reversers were stowed for the second time both engines N1 were reaching a peak value of approximately 80%. This resulted in a momentary positive longitudinal acceleration contribution of approx. 0.05 G from the engines. The total longitudinal deceleration hence decreased. As the airplane approached the end of the runway, the wheel brakes provided the majority of deceleration. On both the occasions when reversers were stowed, the Engine RPM was trending to increase and hence negated the deceleration provided by other devices.

From 7100 ft till the end of the runway, the average $\mu_{airplane}$ increased to approximately 0.14. At the time when the aircraft crossed the end of the runway, longitudinal deceleration increased rapidly, along with the calculated $\mu_{airplane}$. However, this was not sufficient to stop the aircraft and it plummeted down the table top runway embankment.

Figure below shows the deceleration level achieved by the aircraft along the runway length vis-a-vis deceleration level required to stop on runway or pavement (RESA).

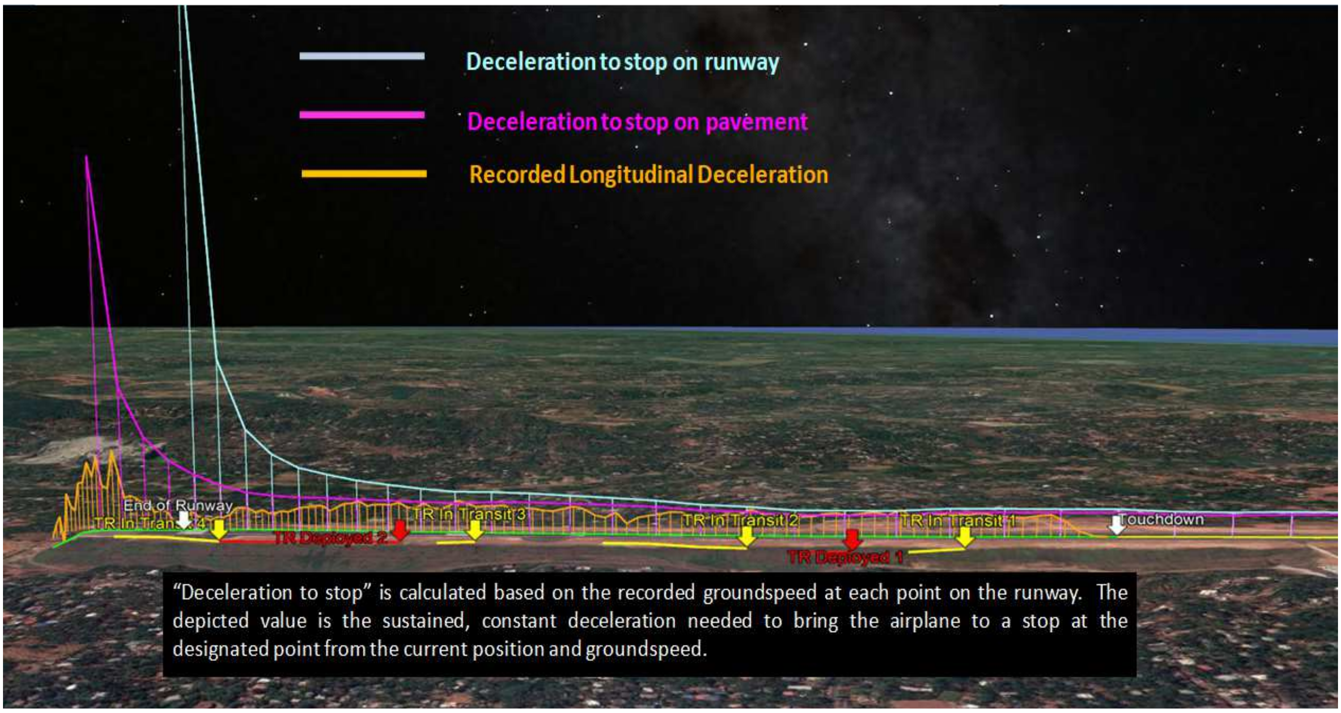


Figure 25: Deceleration to Stop

1.12 WRECKAGE AND IMPACT INFORMATION

The aircraft touched down at 4438 ft from the threshold of runway 10. Airport Safety Investigation Co-ordinator and the AAIB investigators did not observe any distinct tyre marks on the Runway during runway inspection as Aerodrome was experiencing continuous rains during the accident and later throughout the night.

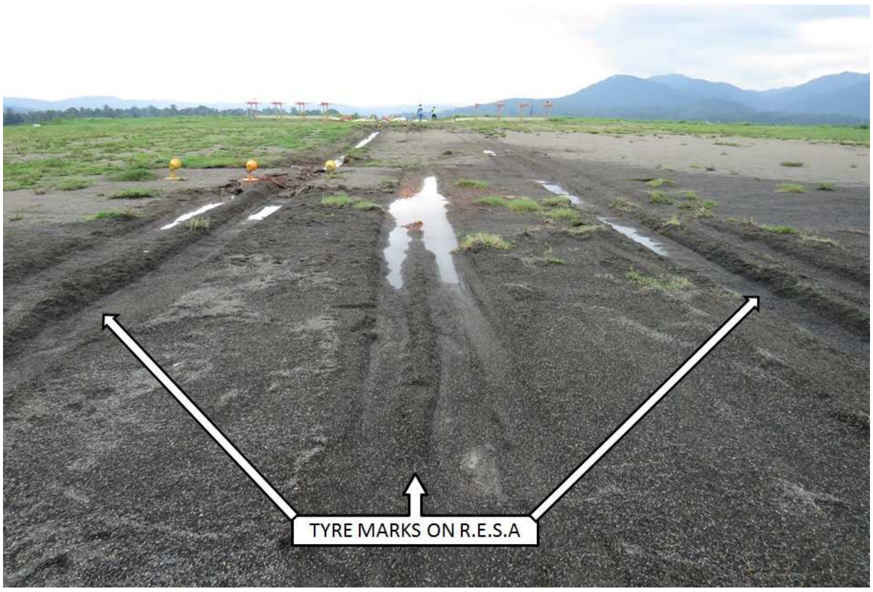


Figure 26: Tyre Marks on RESA.

Tyre marks on the unpaved surface of RESA showed that the aircraft had almost maintained the centreline and was slightly right of the centreline when it entered the RESA. The aircraft was briefly in air mode as recorded in DFDR as it exited the edge of RESA after breaking the ILS localiser antenna array and runway area horizontal fence.

Immediately thereafter the aircraft pitched nose down before the DFDR stopped recording. The aircraft went down and impacted the perimeter road at an angle of about 30° nose down. The fuselage separated into three sections on impacting the perimeter road. The forward section of the aircraft came to rest on a heading of 080 degrees magnetic, 74 ft forward of the centre section. The centre section was on a heading of 110 degrees magnetic and the aft section on a heading of 120 degrees magnetic.

Figure 27: Layout of Wreckage.

1.12.1 FORWARD SECTION

The initial impact separated the forward section from the centre section, it moved forward in the direction of the perimeter wall next to Gate No. 08. Impact and separation dissipated a part of the total energy and the rest was consumed by friction with road/soft ground and impact with the perimeter wall.

Figure 28: Forward Section Impact Profile.

Figure 29: Forward Section Debris

The impact profile observed on the forward section was at an angle of 30° to the corresponding water line. The initial impact severely damaged the forward section and all the structural members including forward pressure bulk head, floor beams and skin. The nose landing gear folded back and separated on impact. It was part of the debris that was found underneath the forward section. Lower nose compartment door and E&E compartment door separated and damaged the electronic equipment compartment.

1.12.2 CENTRE SECTION

The centre section after separating from the forward section continued plunging into the road at an approximate angle of 30° (as confirmed by the observed impact line). The structural members in section 44 bore the brunt of impact with the ground, the floor beams were shattered, the lower lobe skin, cargo and cabin floor crumpled and separated. Attached cabin equipment including seats, overhead bins, passenger service units and side wall panels fragmented and were scattered over an area of approximately 300 square yards forward of the centre section. The passenger seat headrests were bent forward due to impact with the loaded overhead bins that separated and fell down with a forward momentum.

Figure 30: Passenger Seats with damaged Headrests

The centre wing box including the centre tank structure was exposed and severely damaged. The air conditioning system components were crushed and damaged. Section of the fuselage skin, cargo floor panel, generator cables and system tubing showed signs of a rippled pattern resembling corrugated sheet.

Figure 31: Centre section impact profile

Figure 32: Centre Section Debris

1.12.3 AFT SECTION

The aft section separated from the centre section between STA 727D and STA 727J during the fall and impact. The centre section was supported on the belly by the edge of the perimeter road embankment. Due to momentum the aft section continued moving down and separated from the centre section. It was supported at the forward end by the base of a storm drain and at the aft end by the runway embankment. Due to this orientation it was at a relative angle of 10-12 degrees with the centre section.

Figure 33: Layout of Centre & Aft Section Wreckage

The cabin floor structure was damaged but did not separate cleanly. Due to the height difference between the cabin floor levels of the two sections, the cabin floor rotated from horizontal to near vertical position between seat rows 23 to 26 with the seats still attached causing the passenger seats to pile up at this location. The empennage was relatively intact other than a few post impact damages.

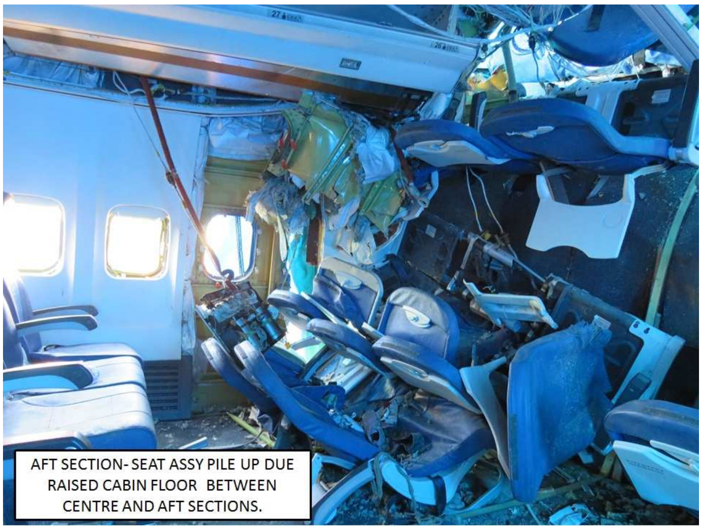


Figure 34: Aft Section Seat Pile up

Figure 35: Separation Between Centre and Aft Section

1.12.4 ENGINES

The two CFM 56-7B27 engines were completely separated from their respective wing struts after hitting road embankment beside the perimeter road. They separated cleanly from the engine mounts and the series of fuse pins which connect the strut to the wing fittings were intact. Engine separation dissipated a part of the total energy in that section. The engines were examined on site.

The engines were embedded in the soft ground at an approximate angle of 30°. The left engine came to rest at a distance of 10 ft behind the strut and the right engine was at a distance of 17 ft behind the strut. Both engines suffered extensive impact damage.

Figure 36: Left Engine

Figure 37: Right Engine

Engines ingested lot of debris, mud and a portion of the air-intake which had crushed on impact. The pieces from crushed section got stuck beneath the fan blade tips. This along with the ingested debris resulted in the arresting of engine rotation. Nacelles of both the engines were also destroyed.

Both Engines had the thrust reverser actuators retracted, and the translating cowls of both were in the stowed position, indicating that the thrust reversers were stowed before impact. This information conforms to the recorded DFDR data. There was no evidence of pre-impact anomalies noticed during the examination.

Figure 38: Engine Thrust Reverser Sleeve Alignment Marks

1.12.5 LANDING GEAR

1.12.5.1 NOSE GEAR

The nose gear was folded back and separated by impact forces and its inner cylinder cracked due to impact. The DFDR indicated that it was down and locked before impact. The wear on the tyres was typical of in-service tyres, and showed signs of abrasions on the side wall sustained during its contact with concrete base structures in RESA. Both tyres showed signs of impact damage and were found deflated.

1.12.5.2 MAIN LANDING GEAR

1.12.5.2.1 LEFT MAIN LANDING GEAR

The left main landing gear was embedded in the road embankment soft soil with the gear strut fully extended. The DFDR indicated that it was down and locked before impact. The wear on the tyres was typical of in-service tyres and showed signs of abrasions on the side wall sustained during its contact with concrete base structures in RESA. The outboard tyre tread was ripped apart probably due touching down on a boulder in the storm drain. The inboard tyre was intact and the tyre pressure recorded was 202 psi.

Figure 39: Left Main Landing Gear

Both the brakes were intact and no damage was observed. No hydraulic leaks were observed at the brake pistons. Examination of brakes and its associated hardware was carried out; no pre-impact anomalies were noticed during the examination.

1.12.5.2.2 RIGHT MAIN LANDING GEAR

The right main landing gear folded back under the right inboard flap. It separated from forward trunnion pin assembly and side beam hangar fitting with a dislocation from the aft trunnion pin. It did not separate cleanly and was covered by debris and partially submerged in water. The DFDR indicated that the right main landing gear was down and locked before impact.

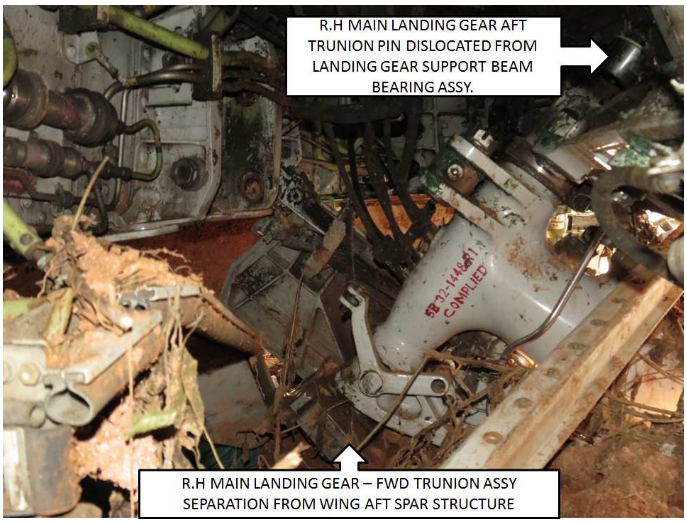


Figure 40: Right Main Landing Gear Separation

Figure 41: Right Main Landing Gear

The wear on the tyres was typical of in-service tyres. They showed signs of abrasions on the side walls sustained during their contact with concrete base structures in RESA. The outboard tyre had circumferential cracks on the sidewall due to impact and was deflated. The inboard tyre was intact and the tyre pressure recorded was 210 psi. Both the brakes were intact and no damage was observed. No hydraulic leaks were observed at the brake pistons. Examination of brakes and its associated hardware was carried out; no pre-impact anomalies were noticed during the examination.

1.12.6 DOORS

1.12.6.1 FORWARD ENTRY DOOR (L1)

The forward entry door designated L1 was found unlocked, with the door handle in vertical position. The coat closet aft of the door had dislocated and leaned forward blocking the door handle operation beyond vertical position. The caution strap was found snapped in position above the viewing window. The escape slide was armed and inflation cylinder pressure in the gauge was in green band.

1.12.6.2 FORWARD SERVICE DOOR (R1)

The forward service door designated R1, was found jammed in the door frame due to impact and the door handle was slightly lifted from the locked position. The caution strap was found snapped in position above the viewing window. The escape slide was armed and inflation cylinder pressure in the gauge was in green band.

1.12.6.3 AFT ENTRY DOOR (L2)

The aft entry door, designated L2, was found open and the door handle was in the open position. The caution strap was found snapped in position above the viewing window. The escape slide was disarmed with the girt slightly pulled and inflation cylinder pressure in the gauge was in green band.

1.12.6.4 AFT SERVICE DOOR (R2)

The aft service door, designated R2, was found open and the door handle was in the open position. The caution strap was found snapped in position above the viewing window. The escape slide was found deployed but deflated with the girt bar attached to the floor brackets.

1.12.6.5 OVERWING EMERGENCY EXIT DOOR

All four over-wing emergency exit doors were found open. The escape straps for all of them were found in their stowed positions.

1.12.7 FLIGHT DECK

The flight deck suffered extensive damage during the initial impact. The forward pressure bulkhead, the sidewall frames and the skin were fractured/deformed. The cockpit floor beams had cracked and the flight deck floor was buckled upwards. There was a separation in the floor forward of the cockpit door.

The Captain and the First Officer seats were subjected to high 'G' forces during impact. The seat structure was deformed and cracked at some locations. Seat mounting tracks had cracked and a few seat mounting bogies were disconnected. The Captain and the First Officer seat harnesses were found cut at four locations in order to extricate and rescue the pilots. The operation of quick release rotary buckle to release all the harnesses was checked and found satisfactory. The second observer seat bottom pan separated from the bulkhead and was stuck between Captain seat back and P18-3 circuit breaker panels. The first observer seat was stuck in the closed position.

Figure 42: Control Cabin P5 Fwd Overhead Panel

Figure 43: Control Stand

Figure 43 shows the image of Control Stand P10 as observed during the wreckage examination.

The forward instrument panels P1, P2 and P3 separated at the top from the structure and rotated forward away from the pilot's view. The P5 forward overhead panel lock and mount brackets were pulled apart. The panel had opened and was hanging only on aft right hinge.

The flight deck door buckled between the floor and the ceiling and separated from the door hinge. The upper and the lower blow out panels were open and supported on the hinges.

Figure 44: Front View of the Damaged Nose Section.

Both the forward windshield glass shattered. The window frame and its support structure was damaged. LH windshield wiper motor converter was retrieved from the wreckage with superficial damage. RH windshield wiper motor converter and arm assembly separated from its location and were retrieved from the debris. Both wiper arm assemblies were found slightly deformed.

The left sliding window dislodged from the frame and hung on the damaged window track. The right sliding window was intact in the frame but its unlocking mechanism from the external handle was damaged on impact. Both LH and RH # 3 fixed windows were intact.

The control wheel and column on both sides were severely damaged. The rudder pedals were raised up and had jammed in the adjoining structure. The rudder forward control rods, rudder forward quadrants, the elevator forward control quadrants, the elevator forward input toque tube, the aileron and spoiler control drum below the floor were extensively damaged.

The throttle lever position did not correspond to the last recorded position in the DFDR data before impact. The Engine Throttle Levers were found jammed at the full forward position with the stop plate bent forward. This was attributed to impact damage sustained by the Thrust Lever Resolver Assemblies and Control Rods causing it to move back thereby forcing the throttle lever forward with such a force that it resulted in bending the stop plate. Both the throttle levers were jammed and could not be moved.

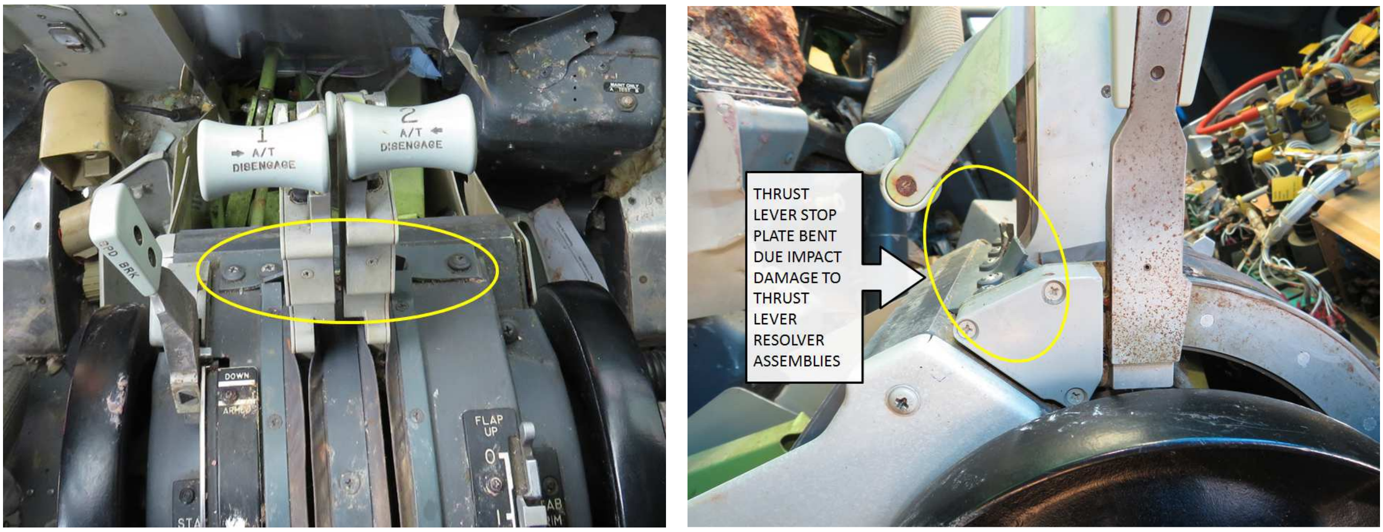


Figure 45: Engine Thrust Lever

Speed brake lever was found in the down detent position but because of the impact, the control rod transmitting the lever movement to speed brake forward drum was broken and the lever was free to move without any frictional load.

1.12.8 FLAP LEVER SELECTION

The Flap lever was found to be at Flap 40 selection and free to move without any frictional load. This position did not corroborate with the Flap 30 selection last recorded in the DFDR. The actual Flap position was confirmed by physically measuring the flap jack screw length which is shown in the following figure and table. The measured length corresponds to the Flap 30 selection as in DFDR.

Figure 46: Trailing Edge Flap Jack Screw Measurement

The individual jack screw dimensions are as below:

MEASUREMENT AS PER BOEING DESIGN DIAGRAM FOR FLAP AT 30 DEGREE POSITION				
FLAP POSITION	STANDARD DIMENSION 'A'	MEASURED DIMENSION 'A'	STANDARD DIMENSION 'B'	MEASURED DIMENSION 'B'
1	8.33"	8.31"	1.72"	1.75"
2	9.73"	9.56"	2.02"	2.06"
3	10.69"	10.75"	2.17"	2.12"
4	10.69"	10.62"	2.17"	2.31"
5	10.69"	10.62"	2.17"	2.12"
6	10.69"	10.68"	2.17"	2.25"
7	9.73"	9.68"	2.02"	2.06"
8	8.33"	8.31"	1.72"	1.75"

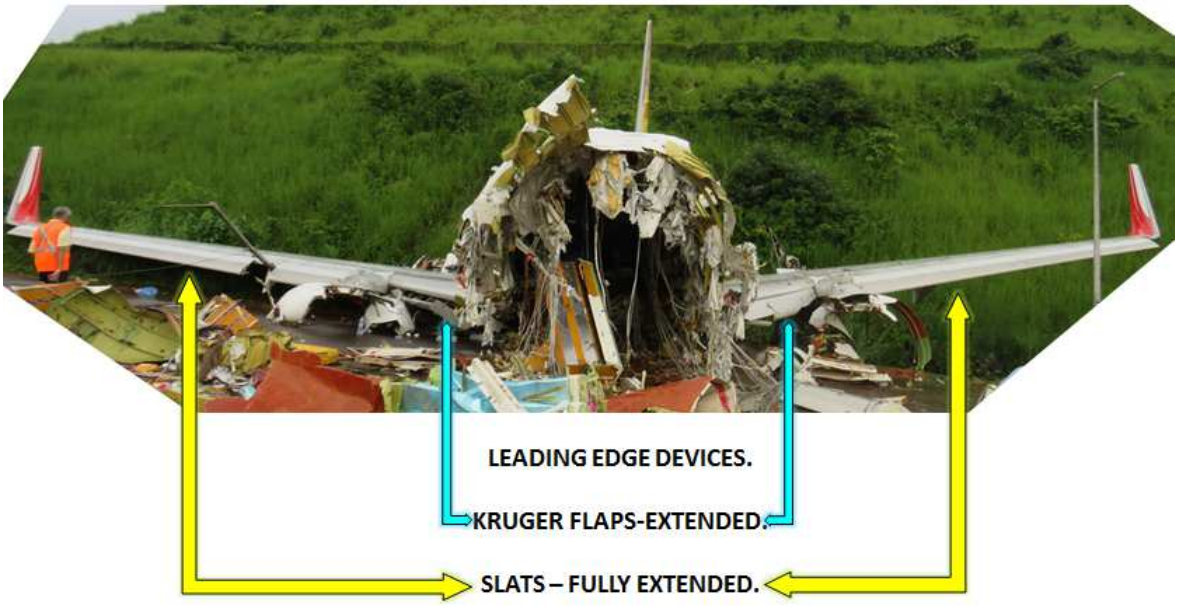


Figure 47: Leading Edge Devices

1.12.9 WING SECTION

Both the wings suffered damage near the forward wing root attachment. RH wing root leading edge along with the centre section impacted the perimeter road before coming to a halt. This resulted in cracking of the right forward pickle fork attachment (bracket that joins wing to fuselage) and damage to the wing internal structure. The impact resulted in the breaking apart of a 70 square inch piece from wing lower skin. This opening was near the forward wing root attachment. # 2 (RH) FWD fuel booster pump canister mounted inside the wing structure on the wing front spar was damaged due to the impact and its mounting flange at 6 o' clock position was bent. This resulted in a gap between the fuel pump canister mounting flange and the wing front spar. LH and RH wing tips were at a height of 13 ft and 5 ft from the ground respectively.

Fuel leak from the left and the right wing was confirmed from the separated engine fuel supply line at both of the engine pylons. Both fuel spar valves upstream of the fuel supply lines were found to be in open position corresponding to the engine start levers in idle position and the engine fire handles not pulled. In addition to this, the impact damage on the right forward fuel boost pump canister and fuel supply lines in the right wing led to a complete fuel leak from the right wing main tank. The fuel leaked through the opening created on the lower wing skin. On the left wing the fuel leaked from the separated fuel supply line on the pylon and it continued to leak until the fuel level inside the tank decreased below the level of the separated line. Approximately 650 litres of fuel was later drained from the left wing main tank.

Figure 48: Right Wing

Trailing edge flaps (inboard and outboard) were substantially damaged by the engine separation. RH inboard trailing edge flap had separated due to the RH engine shearing from the aircraft wings. The outboard flap track at transmission #6 separated along with the transmission from the wing attachment and was supported by the RH engine inboard thrust reverser sleeve. Due to this the Flap transmission gearbox at position #5 was pulled and rollers were found cocked.

Leading edge flaps were found to be in extended position and slats were found to be in “full extend” position. The kruger flaps were damaged and leading edge slat #5 on the right wing impacted a light pole resulting in separation of a 30 inch piece from the outboard end.

Physically all spoilers were found in the stowed position, corresponding to the recorded position in the DFDR before impact.

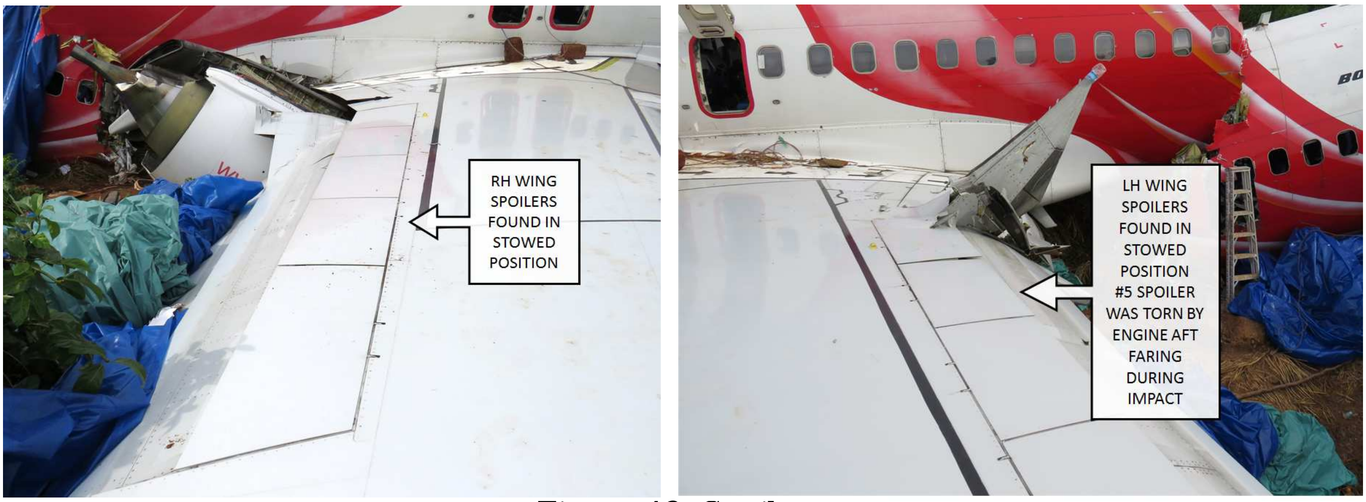


Figure 49: Spoilers

Flight spoiler # 5 was hit by the LH Engine Aft fairing which broke apart during Engine separation. The spoilers were stowed and pressurised at this point, as indicated by the damage pattern on the spoiler.

The flight spoilers were extended during landing which was recorded in the DFDR by the speed brake lever movement and corresponding flight spoiler angular movement. The ground spoilers were extended during landing as recorded in DFDR. The spoilers were stowed back by the cockpit crew when the aircraft entered RESA as recorded in the DFDR by speed brake lever movement and corresponding angular position/status of the spoilers.

The wreckage from the crash site was shifted to a secure area within the Kozhikode airport. The wings were cut and stabilizers removed for transporting the wreckage. It was rearranged resembling an actual aircraft for investigation. The re-arranged wreckage is shown in the figure below.

Figure 50: Rearranged Wreckage

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

The autopsy for the deceased passengers and the crew was conducted at Government Medical College and Hospital Kozhikode on 08 Aug 2020. The reports were made available to the Investigation Team. It was found that the post mortem examination and collection of specimens for toxicology analysis were not done as per the provisions laid down in DGCA Air Safety Circular (ASC) 06 of 2010 dated 15 December, 2010. There was no Aerospace Medicine specialist present at Kozhikode during the conduct of autopsies to assist in sample collection and preservation for toxicology analysis to be done at Institute of Aerospace Medicine, Bengaluru. On perusal of the Pilot Medical Record (PMR) files, autopsy reports, toxicology reports etc provided to the Investigation Team the following facts emerged.

1.13.1 CAPTAIN (PIC)

PIC was diagnosed with Type 2 Diabetes Mellitus (Type 2 DM) in April 2016 and was prescribed a single anti-diabetic medication (Plain Metformin) in accordance with extant AIC on the subject. Since the diagnosis of Type 2 DM was established, the pilot was being reviewed every six months at IAF boarding centres only. He was upgraded to 'P1' medical category with effect from 10 January, 2017 after review at IAM Bengaluru. He was prescribed reading glasses for presbyopia since his initial Class1 medical assessment dated 17 June, 1998. His pre-flight medical examination was conducted at the Kozhikode airport at 0355 UTC (09:25 IST) on 07 August, 2020. He did not undergo breath analyzer test, however, he had submitted a declaration stating that he had not consumed alcohol in the last 24 hours. This was in accordance with the DGCA directions to safeguard against Covid 19 infection during breath analyzer test.

The autopsy was conducted at Government Medical College and Hospital Kozhikode on 08 Aug 2020 afternoon. The cause of death as per the post mortem report is head injury and cervical spine injury. He had sustained multiple injuries caused due to severe deceleration forces resulting in inertial movement of the head and contact with the cockpit structures. The cervical vertebral fracture with dislocation at multiple levels is also pathognomonic of high deceleration forces causing neck injury. He had fracture of both the bones of right forearm along with contusion over right palm and outer aspect of right wrist joint, which indirectly connotes that he had his hand firmly placed on the throttle levers at the time of crash impact.

The gastric contents were examined and approximately 400 ml of the contents consisting of partially digested food items consumed as lunch were present. As confirmed by the cabin crew, the PIC routinely consumed only bland, low calorie food which was specially prepared for him for in-flight meals as well as at the hotel. At Dubai, at around 12:50 UAE time (08:50 UTC) before take-off for Kozhikode, the PIC had his special meal followed by a cup of black coffee (without sugar) in-flight. Hence, by the landing time i.e. at around 14:10 UTC, he had been fasting for approximately five hours. Also, the circumstantial evidences suggest that the PIC had not consumed anything from the 'Snack Box' on the return flight.

The gross and histopathological examinations of the vital organs did not reveal any evidence of pre-existing disease process. His blood samples were analyzed at the Aviation Toxicology Laboratory at IAM Bengaluru. The test results revealed 'zero' alcohol level. Also, there were no traces of Lactic Acid and CO. In addition to the routine toxicology tests, the Investigation Team requested for anti-diabetic drugs testing. The toxicology study was carried out on the limited quantity of blood samples preserved at IAM, Bengaluru. The results revealed presence of Metformin as well as Pioglitazone in the blood sample.

The PMR of PIC revealed that the he was prescribed Tab Metformin (Plain) 500 mg twice a day for Type 2 DM. The Investigation Team carried out a search for the prescribed drug at the crash site and at his hotel room. His personal bag recovered from the crash site contained four different types of anti-diabetic drugs viz. Metformin Sustained Release (Biguanides), Glimepride (Sulfonylureas), Piloglitazone (Thiazolinedindione) and Dapagliflozine (SGLT 2 inhibitor). These drugs were in blister packs and a few tablets were missing from each strip (two, five, one and one respectively). In addition, a partly consumed bottle of an Ayurvedic tablet formulation namely '*MadhuKalpVati*' was recovered from his personal baggage at his hotel room at Kozhikode. '*MadhuKalpVati*' is an ayurvedic anti-diabetic medication.

1.13.2 FIRST OFFICER (CO-PILOT)

Co-pilot had a valid Class I medical assessment without any limitations. His pre-flight medical examination was conducted at the Kozhikode airport at 0312 UTC (08:42 IST) on 07 August, 2020. The alcohol breath analyzer test conducted at that time revealed 0.000 reading.

Co-pilot received fatal injuries in the accident. The post mortem examination was conducted at Medical College on 08 Aug 2020 afternoon. The cause of death was Traumatic Brain Injury with Contusion Cordis as per the post mortem report. The injuries are pathognomonic of high deceleration forces, as the sternum was found fractured at the level of 3rd rib. He had sustained multiple injuries caused due to inertial movement of the head and contact with cockpit structures. The gross and histopathological examinations of the vital organs did not reveal evidence of any pre-existing disease process. His blood sample was also analyzed at the Aviation Toxicology Laboratory at IAM Bengaluru. The test results revealed 'zero' alcohol, Lactic Acid and CO.

1.13.3 INJURY PATTERN

Out of the total 190 on board, 19 passengers and two pilots died in the crash. 75 passengers and 01 cabin crew sustained serious injuries. 33 passengers and 01 cabin crew had minor injuries while 57 passengers and 02 cabin crew did not sustain any injuries due to the crash.

Most of the injured passengers sustained multiple injuries, mostly musculoskeletal (72%). Amongst these, approximately 70% had various fractures of the lower limbs. There were 18 passengers with spinal fractures and three passengers had associated neural injuries resulting in paraplegia. Six passengers survived head injuries other than minor scalp lacerations/aberrations.

The injuries (mainly fractures) of the lower limbs occurred due to direct impact and compaction between the passenger seats that moved forward due to frontal impact. Most of the passenger seats were dislodged from the floor mounting. Head injuries were caused most likely due to impact from the loaded overhead baggage stowage bins that separated and fell on the seats with a forward momentum. In addition, some injuries were caused due to the head and face hitting the aircraft structures due to inertial movement of trunk and head due to frontal impact. Also, the aircraft experienced significant damage between seat row numbers 2 to 10, following the impact and separation of the nose portion of the aircraft. Almost all the passengers seated in this area (54 passengers) suffered serious or fatal musculoskeletal injuries and head injuries except passengers on 3C, INF/3C, 3E 5A, 8F and 9E (six passengers) who sustained minor injuries. Also, the rows 22 to 26 suffered extensive damage due to the fact that the aircraft split up around this location. 05 out of 30 passengers seated in the area suffered fatal injuries and one suffered serious injuries. Remaining 24 passengers suffered minor injuries.

The injury pattern analysis of the deceased passengers reveals that, these 19 passengers were distributed in two clusters, each in the vicinity the aircraft fuselage breaks i.e. from row numbers 2 to 10 and 22 to 26. Figure 51 depicts the injuries to the passengers as per seat layout.

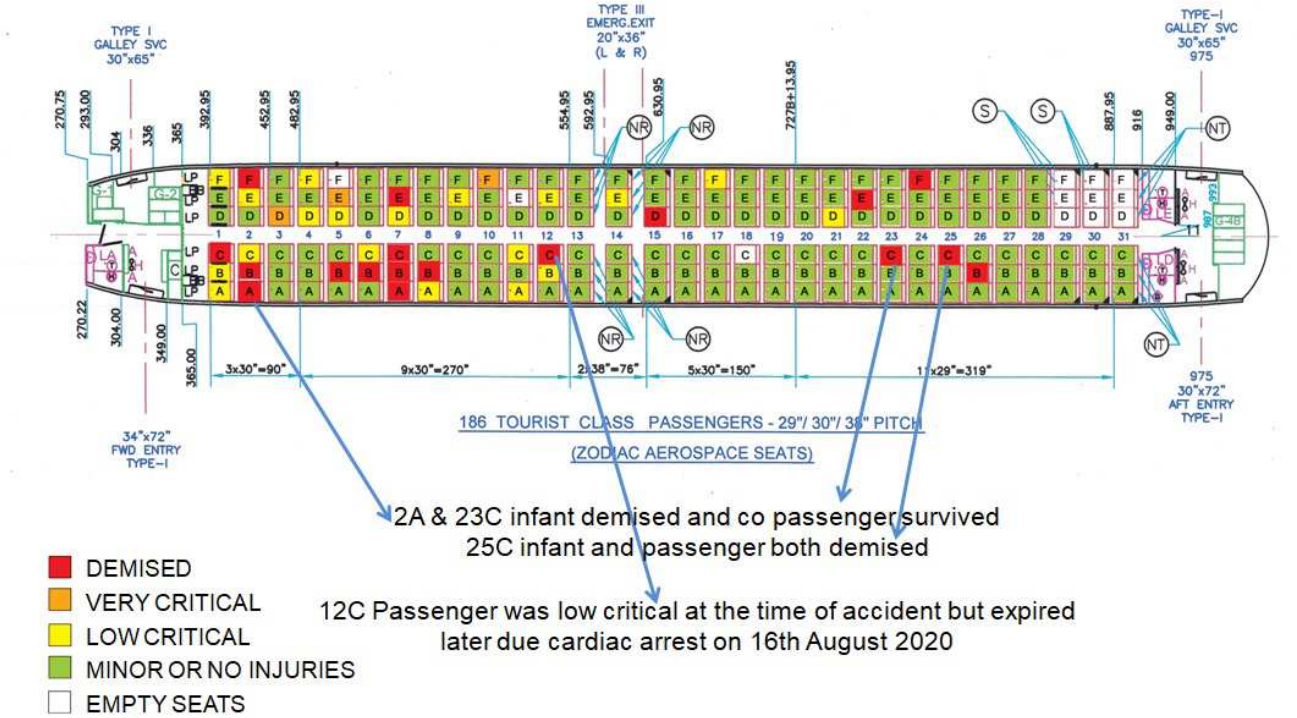


Figure 51: Fatalities and Injuries to passengers depicted on Seat Layout

16 passengers are presumed to have died immediately on impact and three passengers died during the course of their medical treatment later. The analysis of 'Cause of Death' on post-mortem pathological examination revealed that 14 passengers suffered severe head injuries. Of these, 05 passengers had fatal chest injuries as well. There were total seven fatal chest injuries, but only one passenger had severe chest injury in isolation, the rest had other associated fatal injuries. One passenger (and the PIC) had cervical spine injuries resulting in death. The fourth leading cause of death was multiple visceral injuries. Out of the three passengers who died later in hospital, two passengers had pulmonary embolism and one suffered cardiac arrest during management of serious multiple injuries.

There were 10 infants on board who were less than 2 years of age and were not allotted independent seats. These infants were seated on the lap of their guardians during takeoff and landing. Of these 10 infants on laps, three sustained fatal injuries and three had serious injuries while four escaped unhurt. The primary cause of death in all three fatalities (on seat 2A, 23C and 25C) was head injury. The passengers with the infants seated on seat 2A, 23C and 25C suffered a fractured right ankle, no injuries and fatal head injury respectively.

1.14 FIRE

As per the DFDR data, the aircraft had approximately 3200 litres of fuel on board at the time of impact. There was fuel leakage from both wings after impact. The presence of a drain nearby allowed the fuel to flow down the slope along with the rainwater, away from the aircraft. Investigation Team also retrieved 650 litres of leftover fuel from left wing. The CFT reached the accident site nearly 08 minutes after the crash and sprayed foam on the aircraft to avoid any chance of fire. As it was raining at the time of the accident, chances of fire were further diminished.

CFT approached the aircraft from the north side perimeter road and arrived at left side of the aircraft. The CFTs could not cross over the wreckage and hence tried to carry out foaming on the right side of the aircraft while the CFT was parked on the left side.

67 respondents out of the 80 passengers who responded to queries of the Investigation Team, reported seeing no fire, but 20 respondents did report seeing some kind of smoke. Investigation team did not find any signs of fire at the wreckage. There was no evidence of in-flight fire as well.

Both engines were detached from the aircraft and fuel lines were ruptured downstream of the spar valve, hence cutting fuel supply to the engines. After impact and separation the engines were embedded into soft ground. Debris including soft soil got ingested into the engines which arrested the engine rotation.

Four CFTs from ARFF were put into service during the rescue operations. Six fire tenders from State Fire Department also joined the ARFF team. As per details available from ARFF personnel, 800 litres of foam was used for blanketing during the rescue. 4.5 Kg of CO_2 extinguisher was used on the wreckage to prevent any likelihood of post crash fire. Nearly 20000 litres of water was also reported to have been used by the ARFF for cooling.

1.15 SURVIVAL ASPECTS

1.15.1 RESCUE

At Kozhikode airport the ARFF station is located north of the runway, approximately 1000 m from the beginning of runway 10, adjacent to International Terminal building. As per letter No.19014/4/99/AR dated 16 Nov 1999 from the AAI Headquarters, it is mandatory for airport ARFFS to respond to all aircraft incident/accident up to 5 Km on approach path and 2.5 Km across the runway, with full complement and in accordance with the category of the aircraft.

The provision of ARFF services is determined as per DGCA CAR Section 4, Series B, Part I, Issue II, 26 August, 2015 Rev.4, 08 November 2018/ ICAO Annex-14. At Kozhikode, during the Covid-19 pandemic, the category was reduced to VII due to reduced aircraft movements.

1.15.1.1 INITIAL RESPONSE

Following an 'Aerodrome Warning' issued by the Met Office, weather standby was already in place at the aerodrome at the time of accident. Hence, two CFTs were already positioned at pre-determined points. CFT P01 was positioned at PDP 1 (approach road in front of the ATC) and CFT P06 was positioned at PDP 2 (Fire Station approach road). Total 16 ARFF personnel were on duty at the time of accident. 02 CFTs and 03 ambulances were on duty and 01 CFT and 01 ambulance were on standby.

At time 14:10 UTC, ATC observed that the aircraft had crossed the runway touchdown zone but had not touched down till crossing abeam taxiway 'C' which was well beyond the touchdown zone. ATC immediately asked CFTs, which were holding at PDPs to enter the runway and follow the aircraft. The CFT crew could not locate the aircraft on the runway end and were then directed to proceed via the perimeter road to locate the aircraft. ATC also could not sight the aircraft and made repeated calls to the aircraft. On receiving no response, the Fire Bell and Crash Siren were activated by ATC at 14:11 UTC.

The aircraft had overshot runway 10 and crashed near Gate no. 08 on the airport perimeter road. The CISF personnel posted at Gate no. 08 immediately reported the crash and its location to their SOCC (Security Operations Control Centre) and the information was passed to ATC by SOCC at 14:12 UTC (19:42 IST). CFTs were also given the information by ATC at 14:14 UTC (19:44 IST) and were asked to proceed to Gate no.08. Terminal managers and AIXL operations office was also informed of the crash and its location at 14:17 UTC, 14:19 UTC and 14:23 UTC respectively. CFT P03 reached the crash site at 14:18 UTC and was followed immediately by CFT P01 and P06. At time 14:25, UTC CFT reported that rescue operations were underway and there was no fire. Off-duty ARFF personnel were informed about the crash and were asked to come and assist in the rescue operation.

Aircraft was also equipped with Emergency Locator Transmitter (ELT) in accordance with CAR Section 8, Series O, Part II. The same was registered with the Indian Mission Control Centre (INMCC), Bengaluru in accordance with AAC 01 of 2015. The ELT got activated after the aircraft crash and signal was picked up by COSPAS-SARSAT system. Accordingly, a priority message was sent to rescue coordination centre and the airline giving the details of ELT co-ordinates of the location.

1.15.1.2 CO-ORDINATION WITH EXTERNAL AGENCIES

A CISF patrol party was at Gate no. 8 when the accident occurred. They immediately started assisting the passengers before the ARFF arrived. The CISF personnel have their barracks located within the airport premises at about 800 m from the crash site. The CISF guard on duty at Gate no. 8 right next to the crash site had also informed their SOCC (Security Operations Control Centre). An alarm was raised and around 75-80 off-duty CISF personnel immediately rushed to the crash site and joined in the rescue efforts. A few off-duty CISF personnel and local civilians joined in the rescue efforts after entering from the Gate 08.

Six fire tenders from State Fire Service had reported at the crash site by 20:20 IST (14:50 UTC). Ambulances from external service providers started reaching the crash site by 20:20 IST. The taxis parked outside the terminal building were also pressed into service to ferry the injured passengers to different hospitals in the city.

Information was passed to the Local District Administration, Police and NDRF through APD as well as CISF SOCC.

1.15.1.3 RESCUE OPERATIONS

No video recording of the rescue operation of the air crash was done. The investigating team gathered the details of the rescue efforts by interacting and questioning the ARFF and CISF personnel and the civilians who had gathered at the crash site.

According to ARFF personnel, on reaching the crash site, they saw passengers lying on the ground and a few passengers on the aircraft wings. The ARFF rescued the passengers from over the wings and those lying on the ground. Thereafter, ARFF carried out foaming on the aircraft to prevent any likelihood of fire.

Rescue efforts were soon supplemented by CISF off-duty personnel and local civilians. Rescued passengers were sent to different hospitals in coordination with City Fire Department, Kerala Police, Civil Defence personnel and other civilian volunteers.

The damaged nose portion of the aircraft from where the pilots had to be rescued was in close proximity to the CFTs but the ARFF crew did not make any attempt to access the cockpit through the damaged left side wall portion behind the forward bulkhead or the dislodged left sliding window or the damaged cockpit entry door which had come off the hinge. The airport perimeter wall in front of the wreckage was later broken with the help of an earth mover by the local civilians in order to rescue the cockpit crew. CISF personnel and a local civilian then entered the cockpit through the opening created due to impact damage between the front windshield and the main instrument panel. The rescuers were not familiar with the cockpit emergency exits, cockpit entry door or the operation of the pilot five point seat harness and with the cockpit surrounding. They were not able to unlock the quick release rotary buckle of the pilot's seat harness. After a considerable delay they managed to procure a knife to cut the pilot seat harness.

The ARFF personnel were not present during the rescue of the pilots from the cockpit, hence, there was no guidance provided to the rescuers for unlocking the seat harness. The pilots were finally extricated after almost one hour from the time of the crash. The PIC was taken out of the cockpit by a CISF Inspector while the Co-pilot was taken out by some unknown civilian who could not be identified.

During the course of investigation, it was found that neither the persons who entered the cockpit nor the ARFF personnel, were aware of the procedure for opening the Cockpit Emergency Exit.

The cabin crew who were in the forward galley were trapped and injured, therefore, could not assist in rescue operations. The cabin crew in the aft galley opened the rear exit doors and signaled the rescuers with the help of light from their mobile phones. The right hand side escape slide was deployed but soon got deflated.

ARFF personnel had to cut through the aircraft structure, equipments and seats to assist in removing the trapped passengers from the aircraft. Power driven saws and hydraulic power pack were used during the rescue. The saw is powered using a portable gasoline engine. The operation of this saw emanates fumes and smoke that accumulated in the aft section of the cabin while the seats were being cut. The rescuers had to break open the windows to allow some ventilation, however, the smoke and fumes still caused significant discomfort to the trapped passengers and rescuers as stated by the CISF personnel, who were involved in the rescue as well as the passengers who were rescued.

Row 14 and 15 were over-wing emergency exit rows. All these seats were occupied by able bodied adults aged between 31-63 years. The passengers were able to open the emergency exits. Two passengers received fractures in these rows with one fatality.

The Investigation Team sought responses from surviving passengers on various aspects related to evacuation, fire and rescue activities etc through a structured questionnaire. 80 passengers provided their responses. Out of these 80 respondents, 32 respondents reported that they exited the aircraft from emergency exits and doors, while 32 reported exiting the aircraft from the broken portion of the aircraft, the others could not recall or were unsure. Only 06 respondents reported using the escape slide.

Rescue operations were completed at 16:45 UTC (22:15 IST) after ensuring all passengers had been rescued. The rescue operations were declared over at 16:45 UTC (22:15 IST) by APD after taking stock of the situation.

19 passengers including two un-injured passengers were shifted to the hospital by 04 airport ambulances which made 05 trips to various hospitals. 169 passengers were shifted to hospitals by taxis, private vehicles and ambulances from various hospitals that were also pulled into service. More than 50% of the 80 respondents to the questionnaire from the Investigation Team stated that they were not taken to hospitals by ambulance and also that no first aid was provided to them at the crash site.

1.15.2 AIRCRAFT FACTORS

1.15.2.1 EMERGENCY EXITS AND EQUIPMENT

The L1 door movement beyond unlocked position was blocked by the dislocated forward coat closet which had moved on impact. The cabin floor in this area was found raised due to impact. R1 door was jammed inside the door frame structure and could not be opened.

As per the statement given by cabin crew, R2 door opened normally with the slide in armed position, but the slide did not deploy automatically and had to be deployed manually. The slide did not rest properly on the ground due to uneven terrain making it difficult to be used for evacuation and deflated very soon thereafter.

As per the statement of cabin crew, he was not able to fully open the L2 door with slide armed and hence disarmed the escape slide to open the door. During this operation the girt was slightly pulled but the latch assembly was not released.

The technical records for L2 door escape slide were examined and it was found that it was replaced in March, 2020. The AMM installation procedure requires the latch assembly to be lubricated and a check for latch release is to be carried out. The latch assembly should release with a force of no more than 30 lbs. On further investigation, the condition of latch block assembly (latch brackets on the slide cover/backing pan and latch on girt release strap) was inspected and no sign of corrosion was observed. It was found to be dry without any sign of lubrication. A check of the latch release was carried out and the force required to release the latch was 48 lbs, which is beyond the AMM prescribed limit of 30 lbs. This additional force required, coupled with the fact that the separated aft section was at an abnormal attitude (pitch down with slight rollover to the right), made it difficult for the cabin crew to open the door beyond 25 degrees out of the frame. This was insufficient to release and deploy the slide.

The forward cabin crew were trapped in the forward galley area and could not take part in passenger evacuation and rescue. In fact they had to be rescued by the ARFF. The aft sections cabin crew performed their duty but could not communicate with forward cabin crew over intercom. As the aft section had separated from the centre section, aft cabin crew were neither in visual contact with the forward crew nor could they reach the centre section to help passengers in evacuation. The over wing emergency exits in the centre section were opened by the passengers without much difficulty.

Emergency Lights were switched ‘ON’ by the L2 cabin crew from the aft cabin attendant panel. As the aircraft had suffered extensive damage including breaking down of electrical wires and cabin equipment, the emergency lights were only partially working. They remained operational for about 15 minutes.

1.15.2.2 PASSENGER SEATS

The aircraft had 31 rows, with sets of three seats on each side of the aisle. Layout of Passenger Arrangement (LOPA) for 186 passengers with 29"/30"/38" Zodiac Aerospace Seats was attested by DGCA. 174 seats were occupied by passengers. 12 seats were vacant and were neither allotted nor occupied at the time of the accident. These seats were 5F, 11E, 18C, 29D, 29E, 29F, 30D, 30E, 30F, 31D, 31E and 31F. On examination, most of the passenger seats were found damaged to various extents. Seat belt operation and security of installation of all available passenger seats was checked and found satisfactory. It was found that majority of the seat backrests were deformed and bent forward. Seats in the rows 2 to 10 were dislodged from the aircraft floor due to damage to the aircraft floor or seat tracks. Seat rows in the damaged portion of the fuselage between the centre section and the aft section (rows 22 to 26) were not dislodged from the aircraft floor. However, owing to the extensive structural damage around these seats and its orientation post crash, the seat backrests were pushed forward. The frontal impact caused the floor mountings and the spreader legs of the seat assemblies to dislodge and move forward. As a result, the passengers' lower limbs got wedged between the seats and suffered serious injuries. A large number of injured passengers were stuck between the seats. As a result, these seats had to be cut at the spreaders or at the beams by the ARFF personnel.

1.16 TEST AND RESEARCH

1.16.1 BRAKE ASSEMBLY

All brake assemblies were inspected at the crash site for broken parts, inconsistent appearance/form, distortion, large amount of wear and tear or other damage that could cause a malfunction including any signs of hydraulic fluid leakage. All the assemblies were found to be satisfactory. As the aircraft wheels had dug deep in the mud, the brake assemblies were removed from the aircraft after it was repositioned from the crash site. Signs of corrosion were noticed on all the brake assemblies, which could be attributed to wet and damp surroundings that the wreckage was exposed to over a prolonged period.

The brake assemblies were subjected to shop inspection at a DGCA approved facility. As per procedure, a detailed inspection of all the brake assemblies was carried out including pressurising them to 3000 psi using hydraulic fluid. The brakes were inspected for simultaneous and smooth operation of all pistons and any sign of fluid leak. Brake wear-indicator pins were measured in the pressurised state. The condition and operation of all the brake assemblies was satisfactory, no sign of fluid leak was observed and all brake wear indicator pin measurements were found to be within the specified AMM limits.

BRAKE WEAR PIN MEASUREMENT AT 3000 PSI	
POSITION	BRAKE WEAR INDICATOR PIN LENGTH IN mm.
1	7
2	22
3	4
4	2.5

1.16.2 BRAKE PRESSURE TRANSDUCER

The pressure value of right normal brake system was not being recorded in the DFDR, hence it was decided to carry out detailed investigation of right normal brake pressure transducer. It was physically inspected at the wreckage site before removal and showed no signs of damage. Electrical connector and hydraulic pressure line were examined and found secured. The unit was removed from the wreckage and sent for shop inspection at a DGCA approved facility. Functional check was carried out on the unit in which it was subjected to variable hydraulic pressures up to 3500 psi. There was no corresponding change in output voltage with change in input pressure. This confirmed the faulty status of the right normal brake pressure transducer.

1.16.3 ANTISKID TRANSDUCER

All 04 Antiskid Transducers were inspected as per CMM at a DGCA approved facility. The insulation and resistance check on all 04 units was found satisfactory. One of the Antiskid Transducers could not be completely tested for all frequency range due to shaft binding caused by post impact damage. Other three units were found functional in all frequency range tested at the shop.

1.16.4 WIPER MOTOR CONVERTER

CVR transcript confirms that the windshield wiper on the left (Captain) side stopped after operating for a short period during the first approach on runway 28 and the investigation team believes it may not have operated at the desired speed during the approach on runway 10, therefore the wiper motor converters was inspected and tested as per CMM at a DGCA approved facility.

Although, the Cockpit Instrument Panels P1 and P3, behind which the wiper motor converters are installed suffered extensive impact damage, no damage was observed on the left wiper motor converter (on the Captain side). The unit was tested for all speed conditions and was found satisfactory.

Right wiper motor converter had separated on impact. It was found in the debris to the right side of the cockpit. Its electronic housing cover was damaged and some fasteners were missing. During the testing, its operation was found satisfactory at ‘High’ and ‘Low’ speed selections, however, in ‘Park’ and ‘Intermittent’ speed selection it was found working continuously probably due to crash impact damage.

1.16.5 WIPER SELECTOR SWITCH AND AIRCRAFT WIRING

The wiper selector switches were subjected to continuity check between input and output terminals at all 04 selector positions. The output voltage was within the specified range for both wiper selector switches.

The aircraft wiring check for windshield wiper motor was carried out as per FIM and WDM. No insulation failure, breakage or abnormalities were noticed.

1.16.6 WIPER BLADE ASSEMBLY

Wiper blade assemblies were physically inspected and impact damage was observed on the blades and arms on both sides. Because of the impact damage, the blades were bent and the wiper arms were distorted. Windshields on both sides were also damaged due to impact. Owing to the damage to wiper blade assemblies and windshields, the Windshield Wiper Arm Force Check could not be carried out. Opinion of OEM was sought to devise an alternate procedure to ascertain blade spring tension under these circumstances. It was opined that the spring force cannot be set high enough to cause the wiper motor to stall as the Belleville spring washers (washers installed under the tension adjustment nut to absorb vibration and thermal expansion) would experience plastic deformation before that. Further, as per OEM, since 08 threads of the screw were protruding above the tension adjustment nut and Belleville washer, this is believed to be within expected range based on comparison with other in-service airplane installations.

1.16.7 ANTISKID AUTOBRAKE CONTROL UNIT (AACU)

AACU was retrieved from the wreckage in a substantially damaged condition with the protective housing deformed. The same could not be tested at DGCA approved facility due to the extensive damage during impact. The unit was shipped to the OEM for disassembly and component level inspection. The report received from the OEM revealed the following:

- The circuit cards were significantly bent due to impact damage. Some of the solder pads were observed to be contacting the support structure. A3 card corresponding to Inboard Anti skid came out easily. The visual inspection revealed no anomalies. All other cards could not be removed because of the loading of the deformed case. The motherboard was removed to relieve this load and the other cards could then be recovered. The A1 card corresponding to Outboard Antiskid was found cracked at the top, A5 card corresponding to Auto brake and A2 BITE card were found bent.

- The circuit cards were fitted on a known good unit and subjected to bench check. After power was applied, smoke was observed near the A5 card and A1 card was found to be faulty, presumably due to the post impact damage. A fault was found to be registered in the NVM downloaded from the BITE card. This fault could be attributed to fault generated during initial power up during bench check or the accident flight. If this fault was present during accident flight, it would have illuminated the *Antiskid Inop* light in the flight deck. *Antiskid Inop* light is not recorded in the DFDR, however 'Speed Brake Arm light' & 'Speed Brake Do Not Arm' are recorded in the DFDR. Based on the recorded state and logics for illumination of the lights it can be inferred that at least one wheel card was operational (multiple wheels were sensed to rotate greater than 60 knots within 4 seconds of landing and remained that way till deceleration through 70 knots ground speed.)Further during analysis of CVR recording no call of '*antiskid inop*' was recorded during landing rollout.

- The unit was fitted with known good A1 and A5 cards and subjected to full acceptance test procedure. The test was completed with no fault found.

1.16.8 ANTISKID VALVES

Anti skid valves were inspected for condition before removal from the wreckage, all units were found to be in satisfactory condition. The units were sent to OEM for detailed inspection. Acceptance Test Procedure ATP 39-353 was performed on each unit by the OEM. All valves were found to be below the acceptable envelope, however, it was not considered to be a significant performance problem. The observed valve drive characteristics for all four valves would not have an effect on the anti skid behaviour during friction limited braking, as the control laws will adjust the current to the antiskid valve to achieve maximum effective brake force for the runway condition.

1.16.9 BRAKE METERING VALVE

Brake metering valves were sent to the OEM for detailed investigation, various tests were conducted as per CMM for normal, alternate and de-spin (gear retract braking) function. Since during landing normal system was active (as confirmed by DFDR), test results for only normal system are discussed.

1.16.9.1 RIGHT BRAKE METERING VALVE

Right brake metering valve passed all the tests except the following,

(a) During Input lever deflection versus hydraulic pressure test, a slight exceedance was observed below 0.1 inch input deflection and on decreasing pressure input.

(b) During Input deflection versus input lever force test a slight exceedance below 70 lbs on decreasing load was observed.

These were not considered to be a significant performance problem.

1.16.9.2 LEFT BRAKE METERING VALVE

Left brake metering valve passed all tests except the following:

(a) Internal leak test.

(b) Input lever deflection versus hydraulic pressure.

(c) Input deflection versus input lever force test.

In view of the above observations, left brake metering valve was disassembled for further analysis. The mechanism providing the input deflection to the normal brake system (side crank) was found to be broken due to impact damage. The failure of the above tests was attributed to the impact damage sustained by the component. However, the max metered pressure 3000 psi during test was achieved with deflection at 70% of the full travel. The metered pressure downstream of the valve was also recorded by the left brake pressure transducer.

1.16.10 TYRES

The aircraft tyres were subjected to detailed inspection and testing at a recognised lab to ascertain if tyre condition could have been a factor in the accident. The aircraft was equipped with Nose landing gear tyres of 27 x 7.75-R15 with a 12 radial ply rating and main landing gear tyres of H44.5 x 16.5-21 with a 28 bias ply rating. All tyres showed signs of damage including punctures and circumferential/radial cuts on the tread, shoulders and sidewalls. This damage was primarily due to contact with approach lights, protruding approach light concrete platforms in RESA and damage sustained during the impact. During inspection no physical signs of reverted rubber hydroplaning like, skid burn, tread rubber reversion marks and tread flat spots were observed on any of the tyres. Material failure was also ruled out based on the test results.

The average tread groove depth of tyres as observed during physical inspection is tabulated below:-

Position	Nose Wheel Tyre # 1	Nose Wheel Tyre # 2	Main Wheel Tyre # 1	Main Wheel Tyre # 2	Main Wheel Tyre # 3	Main Wheel Tyre # 4
Average Groove Depth	3.67 mm	7.49 mm	4.25 mm	8.89 mm	5.86 mm	7.15 mm

Except #2 & #3 main wheel tyres, all tyres had deflated due to the damage sustained during crash. On #1 main wheel tyre, a portion of the tread was completely peeled off. The pressure of #2 and #3 main wheel tyres was measured after retrieval from the wreckage, the readings were 202 psi and 210 psi respectively, which were within the required pressure range of 205 psi +/- 5.

1.16.11 ESCAPE SLIDE

1.16.11.1 R2 DOOR ESCAPE SLIDE

Since, the slide had deflated during evacuation, it was sent for shop inspection to ascertain the cause of deflation. During the shop inspection, air retention test was carried out and a puncture was detected on panel friction tension assembly.

1.16.11.2 L2 DOOR ESCAPE SLIDE

The slide was sent for shop check in a packed condition to check for its deployment capabilities. During the flat fire functional test, pull force required to deploy was 25 lbs as against the limit of 30 lbs. Over pressure test, aspirator leakage test and air retention test were satisfactory.

1.17 ORGANISATIONAL AND MANAGEMENT INFORMATION

1.17.1 M/S AIR INDIA EXPRESS LTD (AIXL)

M/s Air India Express Limited, a subsidiary of M/s Air India Limited was issued Air Operator Certificate (Scheduled/Passenger) No. S-14 valid up to 21 April, 2023. Initially, Air India Express Limited was issued Air Operator Certificate No.S-14 in the name of M/s Air India Charters Limited on 22 April 2005. The name was changed to Air India Express Limited on its Air Operator Certificate on 03 November, 2017. The Organisation was re-certified as per Air Operator Certification Manual (CAP 3100) on 10 March, 2016. The Organisation Chart of the Airline is given below:

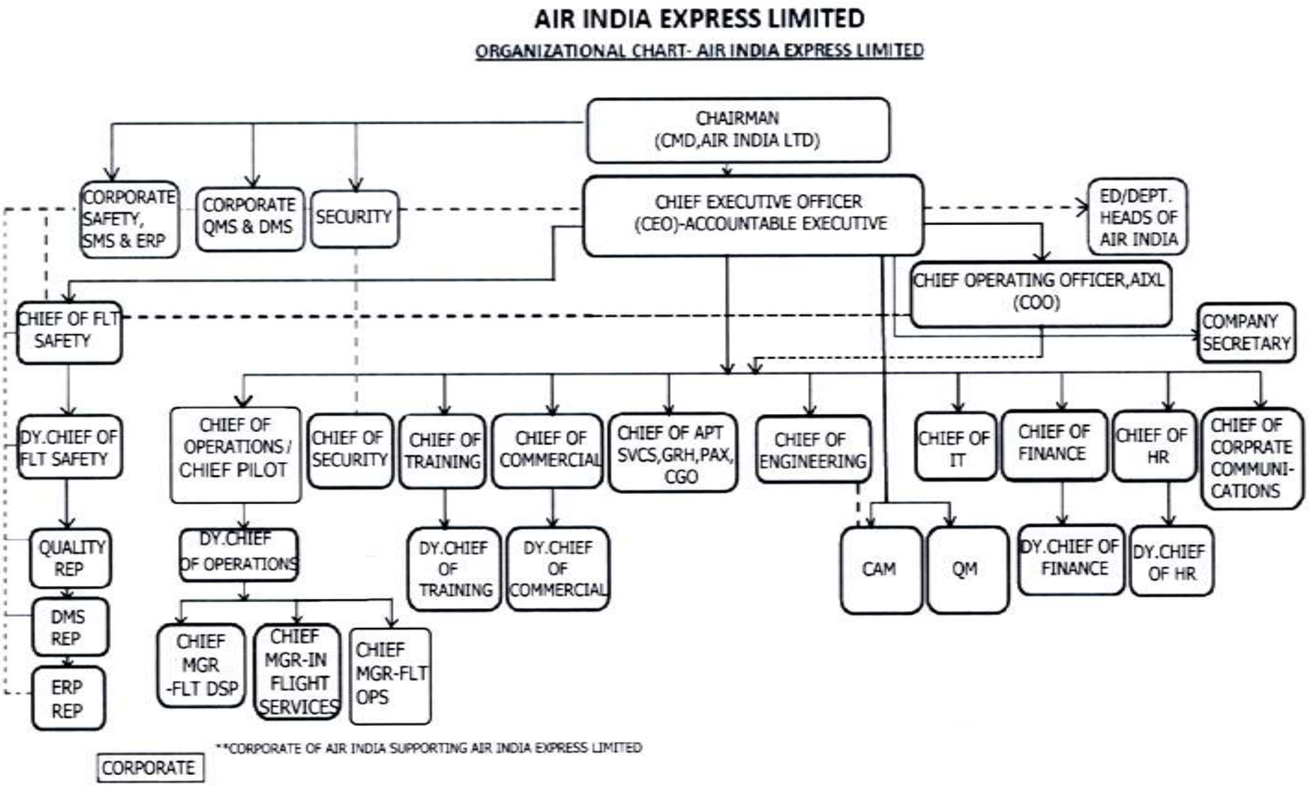


Figure 52: Organizational Chart of AIXL

The Chief Executive Officer is the 'Accountable Executive' of AIXL and reports to the Chairman & Managing Director of parent company i.e. Air India Limited. He is assisted by a team of post holders as shown in the Organisation Chart. The Chief of Operations, the Chief of Flight Safety and the Chief of Training are required to be approved by DGCA.

The review of the organisation chart revealed that the chief of flight safety in addition to reporting to the CEO (Accountable Executive), also liaison with the Chief Operating Officer and the Air India Corporate Safety, SMS & ERP. Further it was observed that the vertical of flight safety also liaison with corporate safety, SMS & ERP. Para 1.17.2 VT-AXV Mangalore accident report 2010 is quoted below:

"*It was evident from the above that although Air India Express had a separate AOP it did not function as a separate entity. During the interaction with post holders, the demarcation of responsibility between Air India and Air India Express was not clearly evident*".

The Corporate Office of AIXL is based in Cochin, Maintenance Head Office is at Thiruvananthapuram while Offices of Chief of Operations, Chief of Training and Chief of Safety are at Mumbai. The Chief of Engineering and CAMO are based at Thiruvananthapuram, which is also the primary base for maintenance. The Investigation Team observed that although the office set up and facility of Operations and Training (including the company flight simulator) are located at Mumbai, the Chief of Operations and the Chief of Training have been assigned home base at Chennai and Delhi respectively.

AIXL Operations Manual (OM) PART – A 1.1.7 defines the Responsibilities and Duties of Operations Management Personnel - Chief Operating Officer. *The Chief Operating Officer (COO) is responsible to the Accountable Executive for the day to day functioning of all activities of the company. COO has the supervisory and advisory role in the company activities.* This post is held by a senior Air India pilot who is also on active flying duties with the parent company.

The airline was operating 651 scheduled departures per week before Covid-19 restrictions were imposed. The total number of AIXL flight departures in the country on the day of accident was 35. The number of AIXL flight departures from Kozhikode had dropped from average 12 daily departures during pre Covid-19 time to just 03 departures on the day of accident. Air India Express was a major player in Vande Bharat Mission to repatriate Indian citizens who were stranded abroad due to closure of airspace during Covid-19 lockdown. Under Vande Bharat Mission, the international flight schedules were decided in accordance with requirements projected by the Ministry of External Affairs. Scheduling and network planning of AIXL introduced flights based on the requirements projected by MEA and no fixed international schedule was available on the day of the accident.

1.17.1.1 AIXL OPERATIONAL PROCEDURES

1.17.1.1.1 FLIGHT DUTY TIME LIMIT (FDTL)

FDTL scheme of Air India Express is approved by DGCA vide letter no AV.22036/8/2013-FSD dated 31 October, 2019. As per OM Part A, Chapter 2, Para 4.5, airlines are required to publish the flight crew roster sufficiently in advance and at least for an eight day period. Each crew member is assigned a home base based on high degree of permanence from which the crew member normally starts and ends a flight duty or a series of flight duty periods. AIXL also has a temporary home base policy, wherein crew can be assigned temporary home base for a period of 07 days to 28 days. The number of pilots available at different station as on 30 July, 2020 is given in the table below:-

Base	P1	P1 U/T	P2	P2 U/T	Total
Mumbai	34	01	17(AIX)+1(AI)	03	56
Delhi	40		27		67
Kozhikode	1	03	26		30
Cochin	23 (AIX)+2(AI)	03	27		55
Mangalore	12		17		29
Chennai	15		11	01	27
Thiruvananthapuram	14 (AIX)+2(AI)		19		35
Kannur	04	01	13		18
Off-Line	20				20
Total	167	8	158	04	336

Apart from 08 bases on their network in India, AIXL has also posted 20 Captains to off line bases (locations from where AIXL does not operate any flight). The airline HR policy allows the Captains to choose their home base as per their choice and convenience but First Officers are posted as per operational requirements. There are 04 Captains and 01 First Officer on deputation from Air India posted at Cochin, Thiruvananthapuram and Mumbai.

As per the approved FDTL scheme, the maximum flight time and flight duty period during any 24 Hrs for 02 pilot operations are given below:

Maximum Flight Time	**Maximum Flight Duty Period (in Hours)**	**Maximum No. of Landings**
08 Hrs	11:00	6
	11:30	5
	12:00	4
	12:30	3
09 Hrs	13:00	2
10 Hrs	13:00	1

The minimum rest, which must be provided before undertaking a flight duty period, shall be at least as long as the preceding duty period or, as follows (whichever is greater):

(a) Minimum rest of 12 hours

(b) 18 hours for crossing more than 3, up to 7 time zones

(c) 36 hours for crossing more than 7 time zones.

FDTL CALCULATION FOR THE PIC OF AXB 1344

The following FDTL time period was applicable to the PIC of AXB 1344 before he could undertake the earliest next flight:

FDTL Calculation	Duration in Hours
Post Flight Duty Time	00:15
Minimum Rest Period Before Next Flight Duty Period	12:00
Reporting Time Prior to Next Departure at Kozhikode	01:00
Travel Time to and from Kozhikode Airport	00:45 + 00:45
Total	14:45
Reference: AIXL Ops Manual Part 'A' Chapter 2	

From the above, it is can be observed that the PIC of AXB 1344 could have operated the next departure only after a minimum period of 14 hours and 45 minutes after his arrival at Kozhikode on night of 07 August, 2020.

1.17.1.1.2 FLIGHT PLANNING AND CREW POSITIONING

AIXL has only 01 Captain permanently based at Kozhikode. Initially only 02 scheduled departures were to be operated on 08 August 2020, One flight from Kozhikode to Abu Dhabi and another from Kozhikode to Doha. Accordingly AIXL operations department had positioned 02 additional Captains at Kozhikode to operate these flights. Covid-19 protocol had to be strictly followed by the Operations Dept, wherein all operating flight crew were subjected to prescribed Covid-19 test schedule before undertaking any flight. The Covid-19 test was repeated every five days.

On 06 August, 2020, an additional daily flight starting 08 August, 2020 from Kozhikode to Dubai was introduced in ARMS portal. As another Captain for the newly introduced additional flight could not be arranged at short notice, the planned roster of PIC of AXB 1344 positioned at Kozhikode was changed as below:

Date	Planned Roster	Changed Roster
PIC of AXB 1344		
05.08.2020	Covid-19 Test	Covid-19 Test
06.08.2020	BOM-CCJ	BOM-BLR-CCJ (Dead Heading)
07.08.2020	CCJ-DXB-CCJ	CCJ-DXB-CCJ
08.08.2020	Standby crew	1373/74 CCJ-DOH-CCJ
09.08.2020	CCJ-DXB-CCJ	
10.08.2020	Movement back to 'Home Base'	
P1 Permanently based at Kozhikode		
07.08.2020	1351/54 CCJ-SHJ-CCJ	1351/54 CCJ-SHJ-CCJ
08.08.2020	1348/63 CCJ-AUH-CCJ	1343/1344 CCJ-DXB-CCJ
P1 'positioned' at Kozhikode		
07.08.2020	Standby	Standby
08.08.2020	1373/74 CCJ-DOH-CCJ	1663/1348 CCJ-AUH-CCJ

On the morning of 07 August, 2020 at 03:26 UTC, before departure of AXB 1343 for Dubai, the PIC was informed that he was being pulled out for Flight AXB 1373/74 (Kozhikode-Doha-Kozhikode) with departure 04:30 UTC/10:00 IST to be operated on the morning of 08 August, 2020 instead of the earlier Standby duty that he had been rostered for. Since the scheduled arrival of flight AXB 1344 on 07 August 2020 was 19:10 IST, applying the FDTL period as above, he could not have operated the next flight the following day before 09:55 IST. As he was the only PIC available for operating the Doha fight on 08 August 2020 hence this flight was rescheduled from 08:30 IST to 10:00 IST.

1.17.1.1.3 ILS APPROACH CHARTS

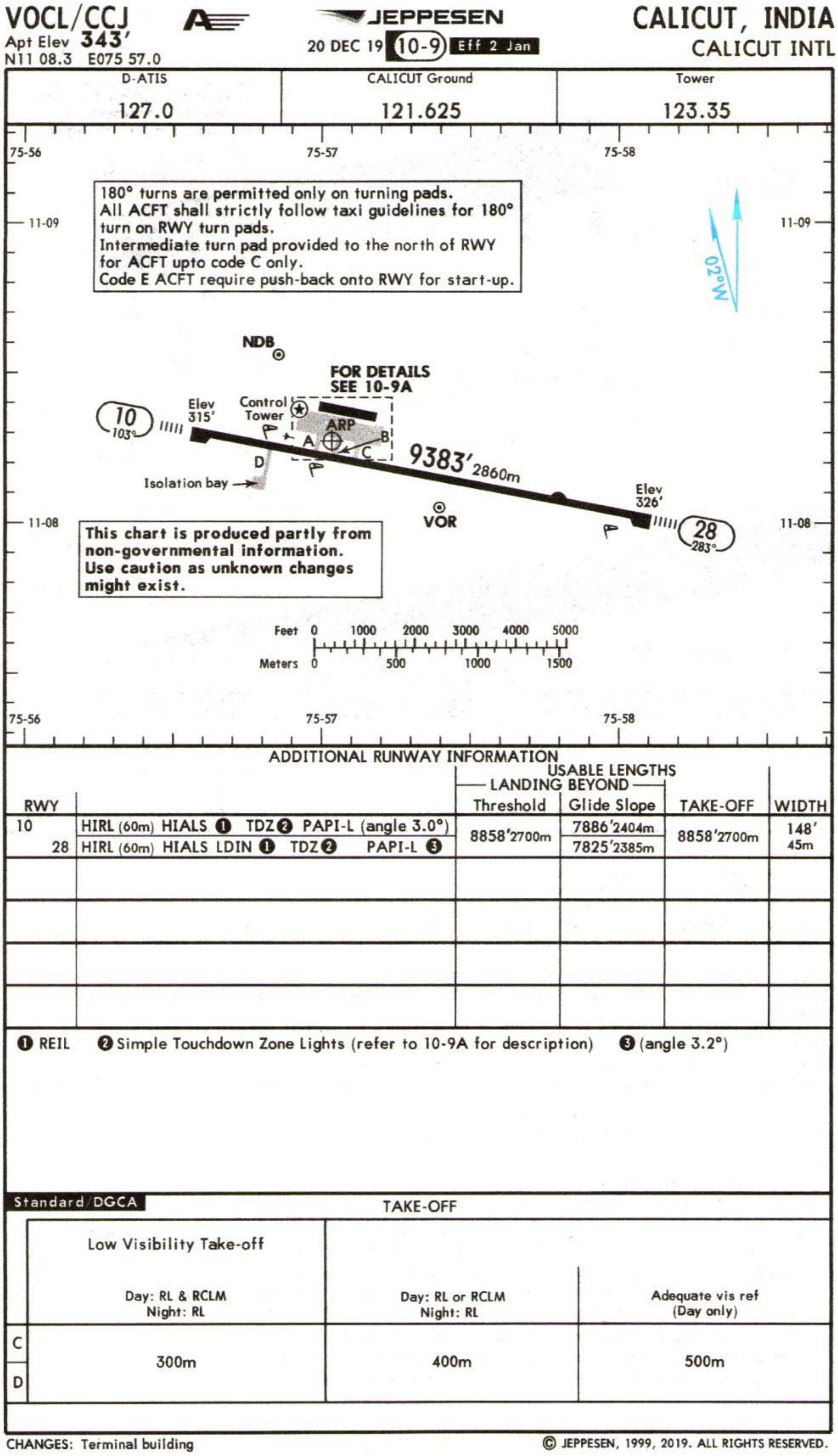
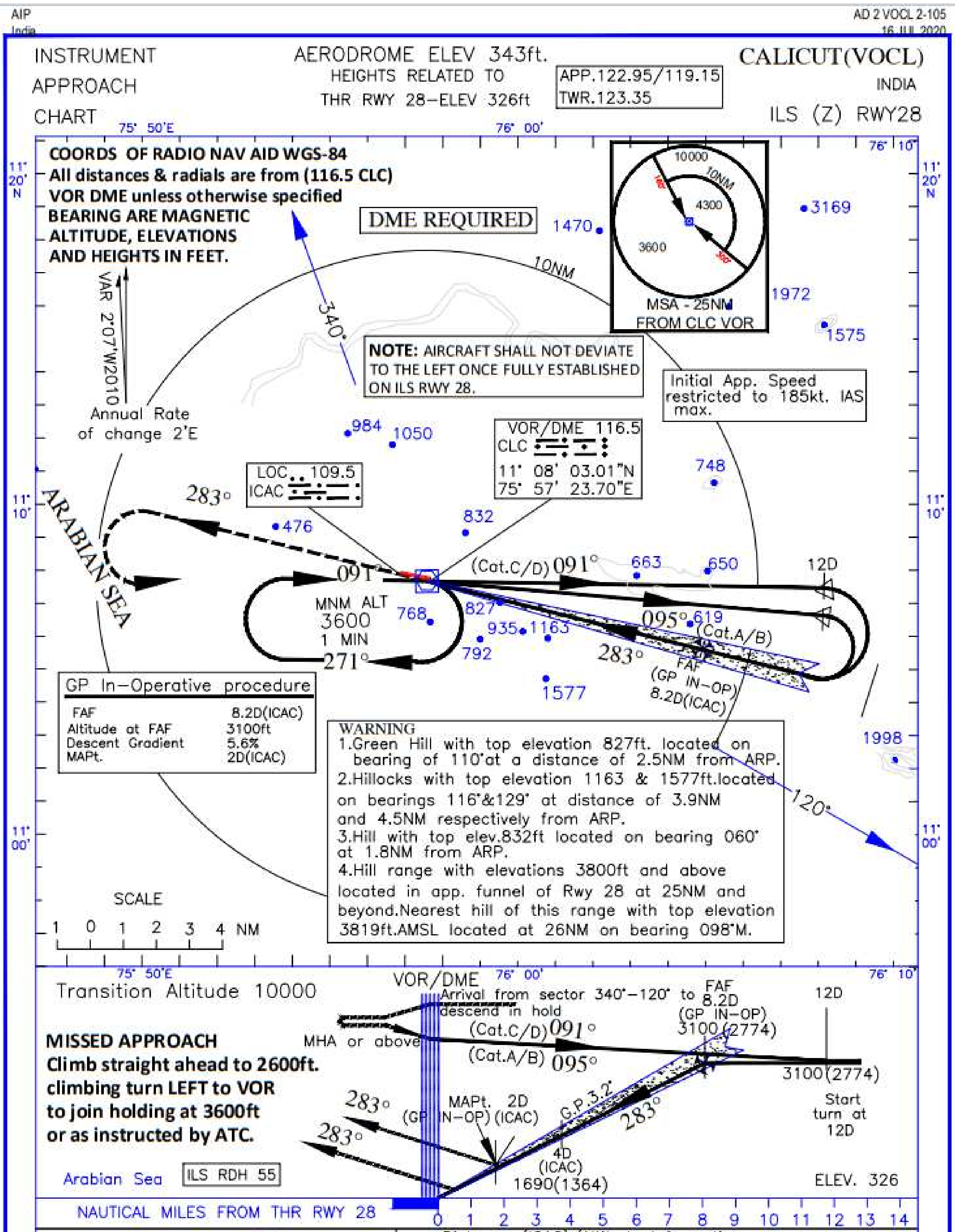


Figure 53: Calicut Airport Chart



O C A (H)			Distance (ICAC)/Altitude Information						
Categ. Of Acft.	A/B	C/D	Distance(NM)	8.2D	7D	6D	5D	4D	3D
STRAIGHT–IN	576(250)	576(250)	Altitude (ft.)	3100	2710	2370	2030	1690	1360

G P INOPERATIVE PROCEDURE			Rate of descent./Ground Speed Information						
			Ground speed (kt.)	80	100	120	140	160	180
Stright–IN	1080(754)	1080(754)	Rate of descent (ft/min)	450	560	680	790	905	1020

DRG. NO. AAI/08–IALC/2002/16–07–2020

Airports Authority of India　AMDT 02/2020

Figure 54: Instrument Approach Chart: Runway 28

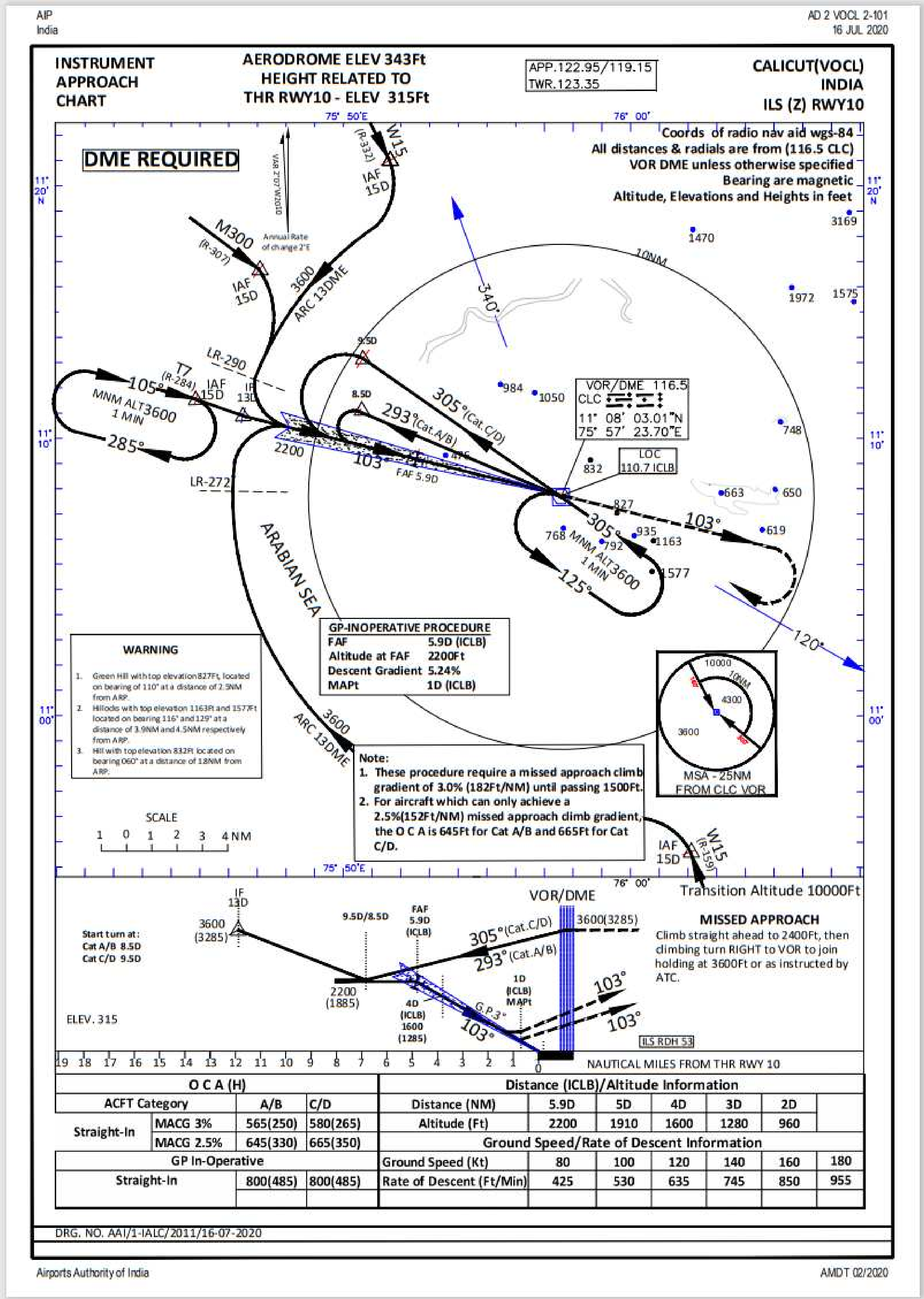


Figure 55: Instrument Approach Chart: Runway 10

1.17.1.1.4 ILS APPROACH PROCEDURE

ILS Approach Procedure as per the FCTM is shown in the figure below:

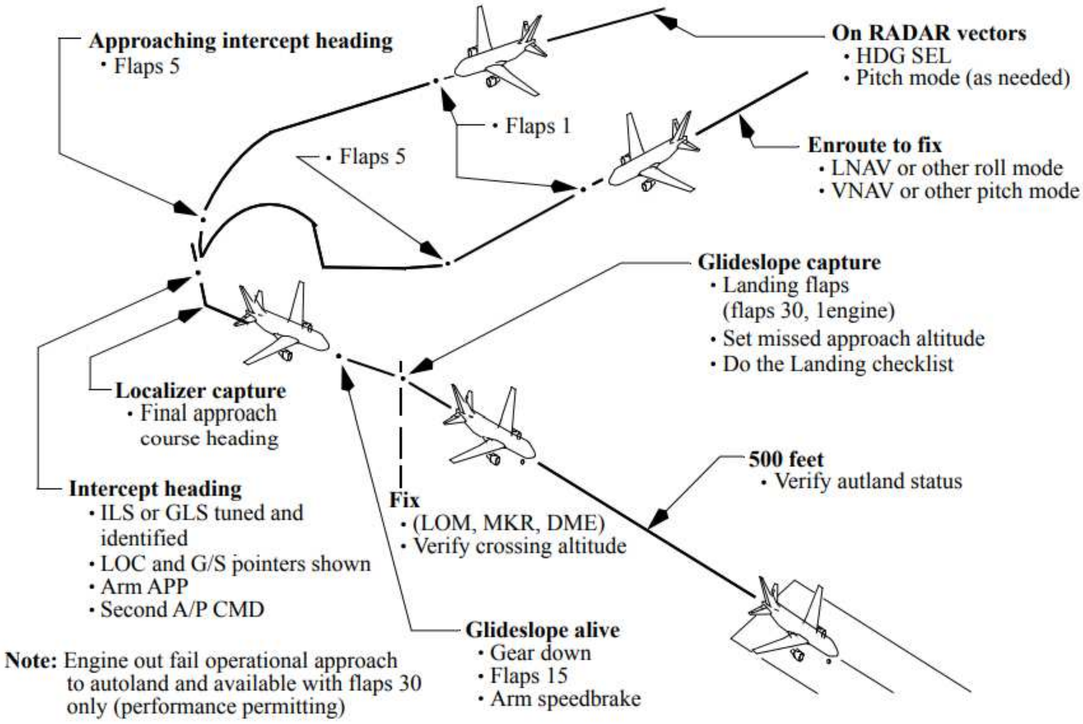


Figure 56: ILS Approach Procedure

Procedure for ILS as per FCOM is given in the table below:

Pilot Flying	***Pilot Monitoring***
Initially *• If on radar vectors* *• HDG SEL* *• Pitch mode (as needed)* *• If enroute to a fix* *• LNAV or other roll mode* *• VNAV or other pitch mode*	
	Notify the cabin crew to prepare for landing. Verify that the cabin is secure.
Call "FLAPS ___" according to the flap extension schedule.	*Set the flap lever as directed. Monitor flaps and slats extension.*
When on localizer intercept heading: *• verify that the ILS is tuned and identified* *• verify that the LOC and G/S pointers are shown.*	
Arm the APP mode. *If a dual channel approach is desired, engage the second autopilot.*	
Note: When using LNAV to intercept the final approach course, LNAV might parallel the localizer without capturing it.	

Use LNAV or HDG SEL to intercept the final approach course as needed.	
Verify that the localizer is captured. *Verify the final approach course heading.*	
	Call "GLIDESLOPE ALIVE."
At glideslope alive, call: • *"GEAR DOWN"* • *"FLAPS 15"*	
	Set the landing gear lever to DN. *Verify that the green landing gear indicator lights are illuminated.* *Set the flap lever to 15.* *Set the engine start switches to CONT.*
Set the speed brake lever to ARM. *Verify that the SPEED BRAKE ARMED light is illuminated.*	
At glideslope capture, call "FLAPS ___" as needed for landing.	*Set the flap lever as directed.*
Set the missed approach altitude on the MCP.	
Call "LANDING CHECKLIST."	*Do the LANDING checklist.*
At the final approach fix (LOM, MKR, DME), verify the crossing altitude.	
Monitor the approach. *If an autoland is planned, verify the autoland status at 500 feet AGL.*	
For a single channel approach, disengage the autopilot and autothrottle no later than the minimum use height for single autopilot operation. For a dual channel approach, disengage the autopilot after touchdown.	

While configuring for an ILS approach, the landing gear and flap 15 are to be selected once glide slope becomes alive i.e. just before intercepting the glide slope. Landing flaps are to be selected on intercepting the glide slope and descent initiated. In the case of flight AXB 1344, the PF delayed the selection of landing flaps while executing ILS approach on runway 28 as well as on runway 10. This practice of delayed flaps is only recommended during good weather and good visibility conditions on non-critical airfields (OM Part A Para 25.8). This option is only a fuel saving measure and is not mandated in adverse weather conditions.

1.17.1.1.5 PUBLISHED STABILIZED APPROACH CRITERIA

The criteria for Stabilized Approach to be adhered by the pilots of AIXL as given in the OM Part A, Chapter 25, Para 25.4 are quoted below:

"i. All appropriate briefings and checklists should be accomplished before 1000' height above threshold (HAT) in instrument meteorological conditions (IMC), and before 500' HAT in Visual Meteorological conditions (VMC).

ii. The airplane is on the correct flight path.

iii. Only small changes in Heading, Pitch and Thrust are required to maintain that path.

iv. The airplane speed is not more than Vapp + 10 knots IAS and not lower than Vapp – 05 knots trending to Vapp and not lower than Vref.

v. The airplane is in the correct landing configuration (with Speed brakes retracted)

vi. The sink rate is no more than 1000 feet/minute. If an approach requires a higher sink rate, a special briefing is required.

vii. The power setting is appropriate to the configuration.

viii. All briefings and checklists have been performed.

***Note:** If the approach is not stable by 1000 feet or 500 feet AGL (depending on weather conditions), or if the approach becomes unstable below these altitudes, the pilot should initiate a missed approach/go-around. The pilot may initiate a go around at any time above or below these altitudes if deemed necessary. It is possible for a pilot to initiate a go around even after touchdown on the runway, but not after the thrust reversers have been deployed."*

1.17.1.1.6 MANDATORY "GO-AROUND"

Mandatory Go-Around Criteria laid in Para 25.5 of OM Part A is quoted below.

"Adhere to the instructions given in the paragraph on "Mandatory Missed Approach" in FCTM, Chapter 5.

In addition:

i. If the above criteria for a Stabilized Approach cannot be established and maintained, initiate a go-around.

ii. The "Go-Around" call can be given by either PF or PM.

iii. Once "Go-Around" is called, it is mandatory to execute the "Go-Around"."

Para 1.3.26 (d) of SOP IX-OPS-001-SOP Sec 2 Issue-4 Rev.0 dated 11 November, 2019 contains the approach briefing to be given by Pilot Flying and the same is quoted below:

"Call deviations as per SOP, and if no verbal response received after a second call or flight path not stabilised you shall call "Un-stabilised! Go-Around". If I do not go-around after the 'go-around' call you will take over control and initiate the go-around."

As per records made available in the last two years 21 Go-Around were carried out at Kozhikode below minima due to unstabilized approach/adverse weather condition.

1.17.1.1.7 PROCEDURES OF AIXL IN ADVERSE WEATHER/MONSOON OPERATIONS

PROCEDURE FOR APPROACH PREPARATION

As per Para 2.1.31(k & m) of the AIXL SOP IX-OPS-001-SOP Sec 2 Issue-4 Rev.0 dated 11 November, 2019, approach briefing shall include the following (in addition to other routine briefing points):

(k) Approach and Landing.

(ii) Data pertaining to Approximate (Estimated) Landing Distance (ALD), Landing Distance Required (LDR) and Landing Distance Available (LDA) for the prevailing conditions must be discussed in the approach briefing.

(v) Strictly comply with stabilized approach criteria. Do not hesitate to go around if approach is un-stabilized or visual reference is temporarily lost below DA/DDA, or when it is not possible to land in the touchdown zone.

(vii) Plan a flap 40 landing to minimize the landing distance.

(m) Missed Approach.

After weather related missed approach, only one subsequent approach is permitted. Before commencing another approach, the captain should be confident that the next approach has a high probability of success and there is adequate fuel to divert in case the second approach too ends in a missed approach. After two missed approach due to weather, it is mandatory to divert.

Also, as per Para 7.12 of the OM Part A, only one subsequent approach is permitted after a weather related missed approach and it is mandatory to divert after two missed approach. AIXL follows a non-punitive policy of a 'go-around' that is carried out in the interest of safety. 'Go-around' call can be given by Pilot Flying or Pilot Monitoring and it is mandatory to 'Go-around' once the call has been given. A Go-around can also be initiated after a touchdown but not after deployment of thrust reversers. The destination alternate for Kozhikode, during adverse weather as per OM are Tiruchirappalli (VOTR), Coimbatore (VOCB) and Kannur (VOKN).

General requirements for Monsoon Operations are stated in Para 17.34.1 of OM Part A and some salient requirements are given below:

"(c) Approach Briefing prior to top of descent shall include wet/contaminated Actual Landing Distance required calculation. A quick analysis table for wet/contaminated ALD is available to crew PI-QRH to cross check landing distance requirement.

(e) Greater emphasis on stabilized approaches

(h) Full Flap landing and adequate use of Reverse Thrust and consideration of extra en-route/terminal fuel computation shall be adhered to."

As per Para 17.34.2 of OM Part A, the following equipment must be serviceable during adverse weather/monsoon condition operations:

(a) Anti-skid System
(b) ***Wind Shield Wiper System***
(c) Weather RADAR system
(d) Flap system
(e) Reverse Thrust system
(f) GPWS

The above policy is in line with the CAR Section 8, Series 'C' Part I, Issue I, Rev 10 dated 01 April, 2017 on 'All Weather Operations' (AWO), which at Para 9 lays down the minimum equipment for low visibility operations. Para 7.3.2 of Annexure 1 of said CAR states that unserviceable windshield wipers, could be accepted to return direct to base station for maintenance (i.e. one landing only) subject to acceptable weather conditions at departure and destination station and, subject to the PIC side (LHS) being serviceable.

This implies that in case the windshield wiper on the side of the PIC is unserviceable, it is mandatory to divert to an alternate airfield where no rain is being reported/forecast.

LANDING PROCEDURES (FCTM 737 (TM) Chapter 6)

Landing Roll

Advisory on selection of Brake setting/Manual Braking is given in Chapter 6 of FCTM and is quoted below.

"Use an appropriate auto brake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Use of the auto-brake system is recommended whenever the runway is limited, when using higher than normal approach speeds, landing on slippery runways, or landing in a crosswind. For normal operation of the auto-brake system, following deceleration setting can be selected.

- ***MAX:*** *Used when minimum stopping distance is required. Deceleration rate is less than that produced by max manual braking*
- ***3:*** *Should be used for wet or slippery runways or when landing rollout distance is limited. If adequate rollout distance is available, auto-brake setting 2 may be appropriate*
- ***1 or 2:*** *These settings provide a moderate deceleration suitable for all routine operations.*

Braking during Landing Roll

"Immediate initiation of reverse thrust at main gear touchdown and full reverse thrust allow the auto-brake system to reduce brake pressure to the minimum

level. Since the auto-brake system senses deceleration and modulates brake pressure accordingly, the proper application of reverse thrust results in reduced braking for a large portion of the landing roll".

"After touchdown, the crew members should be alert for autobrake disengagement annunciations. The PM should notify the PF anytime the autobrakes disengage. If stopping distance is not assured with autobrakes engaged, the PF should immediately apply manual braking sufficient to assure deceleration to a safe taxi speed within the remaining runway,"

PF of AXB 1344 resorted to manual braking immediately on touchdown and the autobrakes got disengaged. The CVR transcript confirms that this was called out by the PM as per the SOP but was not acknowledged by the PF.

"Although immediate braking is desired, manual braking techniques normally involve a four to five second delay between main gear touchdown and brake pedal application even when actual conditions reflect the need for a more rapid initiation of braking. This delayed braking can result in the loss of 800 to 1,000 feet of runway, as compared to the calculated PI-QRH landing distance which allows for a two second delay."

Landing On Wet/Slippery Runway

PI Chapter of the QRH states, *"When landing on slippery runways contaminated with ice, snow, slush or standing water, the reported braking action must be considered. Advisory information for reported braking actions of good, medium and poor is contained therein. Also provided, in the QRH, are the stopping distances for various auto-brake settings and for non-normal configuration. Pilots should use extreme caution to ensure adequate runway length is available when poor braking action is reported."*

Wind Limitations

In order to comply with DGCA OC 03/2015 and SSP 01/2012, AIXL has stipulated limitations for maximum headwinds, tailwinds and crosswinds and is contained in Para 5.1.1 of OM Part B Chapter 5. The same is tabulated below:

Maximum wind component for Take-off/Landing			
Braking Action	***Runway Condition***	***Wind Component***	***Limits***
- - - -	*Dry*	*Crosswind* *Tailwind*	*25 Knots* *10 Knots*
Good	*WET runway with good surface condition*	*Crosswind* *Tailwind*	*20 knots* *10 Knots*
Medium	*Moderate/ Heavy Rain on clear runway*	*Crosswind* *Tailwind*	*15 Knots* *10 Knots*
Poor	*Slush, Snow, Ice, Standing Water, Freezing rain, drizzle on dusty runway*	*Crosswind* *Tailwind*	*Landing Prohibited*

As per SOP for Kozhikode laid in Para 6.3.3.14 of Part C of Operations Manual, aircraft operations will be suspended when visibility is less than 2000 m and cross wind speed is 15 kt or more on a wet runway and 20 kt or more on a dry runway.

Aircraft Operational Limits as per Airplane Flight Manual are, Runway Slope ± 2% and Maximum Take-off & Landing Tailwind Component 15 kt (AIXL has restricted the maximum tailwind component to 10 kt).

Calculation of Landing Distance

Advisory information for normal and non-normal configuration landing distances is contained in the PI chapter of the QRH. The following aspects are highlighted in the QRH regarding landing distances:

"*Actual stopping distances for a maximum effort stop are approximately 60% of the dry runway field length requirements. Factors that affect stopping distance include height and speed over the threshold, glide slope angle, landing flare, lowering the nose to the runway, use of reverse thrust, speed brakes, wheel brakes and surface conditions of the runway.*

Note: *Reverse thrust and speed brake drag are most effective during the high speed portion of the landing. Deploy the speed brake lever and activate reverse thrust with as little time delay as possible.*

Note: *Speed brakes fully deployed, in conjunction with maximum reverse thrust and maximum manual antiskid braking provides the minimum stopping distance.*

Floating above the runway before touchdown must be avoided because it uses a large portion of the available runway. The airplane should be landed as near the normal touchdown point as possible. Deceleration rate on the runway is approximately three times greater than in the air.

Height of the airplane over the runway threshold also has a significant effect on total landing distance. For example, on a 3° glide path, passing over the runway threshold at 100 ft altitude rather than 50 ft could increase the total landing distance by approximately 950 ft. This is due to the length of runway used up before the airplane actually touches down.

Glide path angle also affects total landing distance. As the approach path becomes flatter, even while maintaining proper height over the end of the runway, total landing distance is increased.

The CVR transcript confirms that during the approach briefing prior to descend, no ALD calculations were done by the crew of AXB 1344. The thumb rule for calculating Required Landing Distance is given in the Quick Reference Table provided in the AIXL SOP.

APPENDIX – 1

QUICK-REFERENCE TABLE

Estimated and Required Landing Distance

(Factor of 1.15)

Flaps	Ldg Wt >		66.3 T		65 T		60 T		55 T	
	Braking	AB	ELD	RLD	ELD	RLD	ELD	RLD	ELD	RLD
30	Good	3	6,440	**7,670**	6350	**7,310**	6,000	**6,900**	5,650	**6,500**
30	Good	**2**	8,080	**9,290**	7,960	**9,150**	7,480	**8,600**	7,000	**8,050**
30	Med	3	7,670	**8,820**	7,180	**8,260**	6,780	**7,800**	6,380	**7,340**
30	Med	**2**	8,880	**10,210**	8,280	**9,520**	7,790	**8,960**	7,300	**8,390**
40	Good	3	6,280	**7,220**	5,900	**6,790**	5,580	**6,420**	5,260	**6,050**
40	Good	**2**	7,970	**9,160**	7,430	**8,550**	6,990	**8,040**	6,550	**7,540**
40	Med	3	7,200	**8,280**	6,730	**7,740**	6,450	**7,300**	5,970	**6,860**
40	Med	**2**	8,290	**9,530**	7,740	**8,900**	7,290	**8,380**	6,840	**7,860**

ELD: Estimated Landing Distance is derived from QRH PI and includes air distance of 1,000 ft from threshold to touchdown.

RLD: Required Landing Distance determined by applying a factor of 1.15 to the ELD.

Parameters:

PA	**1,000 ft**	Slope	**1% down**	Winds	**Calm**
Temp	**SA + 20°C**	**Auto speedbrakes**		**Both reversers**	

To accurately apply prevailing parameters, refer ***PI-QRH.11.2/11.3***

Figure 57: Quick Reference Table for Landing Distance

However, after accurately considering the prevailing weather conditions available to the crew of AXB 1344 from the information received from ATC at Kozhikode as per PI-QRH.11.2/11.3,the ALD calculations should have been as follows:

ALD calculations for Kozhikode Airport with weather info available to the crew before commencing approach.	
Elevation : 343 feet Temp : +24° C QNH : 1007 hPa Landing Wt : 63000 Kg LDA : 2700m (8858 feet)	
Winds in Kt	10 Tail
Flap Settings	30
Autobrake Selection	3
Braking Action *	Good
Approach Speed (V_{app})	150
ALD	6785
ALD with factor of 1.15 as per SOP	**7803**
Reverser Advantage(SOP)	Both
The final ALD Data is obtained after adjusting corrections for weight, altitude, wind, slope, temperature, approach speed and reverse thrust.	

*Braking Action for Light Rain and Wet runway condition is taken as GOOD as per Para 5.1.1 of OM Part B Chapter 5**.**

1.17.1.1.8 TRAINING FOR ADVERSE WEATHER/MONSOON

The crew operating to monsoon affected aerodromes are required to be qualified for Adverse Weather/Monsoon Operations as per Annexure 1 of CAR Section 8, Series C, Part I. The detailed training program is mentioned in the OM Part D which includes ground and simulator training as below:

1. ***Ground Training*** *(shall cover, but not be limited to):*

(a) Aircraft Performance during take-off and landing with specific emphasis on wet and contaminated runway conditions.

(b) Calculation of take-off and landing field lengths and impact of individual failure events (type specific).

(c) Use of weather radar (type specific)

(d) Techniques of weather avoidance.

(e) Indian Monsoon climatology

(f) ALAR (Approach and Landing Accident Reduction) and Adverse Weather Tool Kit

2. ***Simulator Training***

(a) One hour simulator training (in the form of LOFT) for adverse weather operations covering all aspects of adverse weather conditions likely to be encountered en-route and in terminal areas covering aircraft performance

related to wet/ contaminated runway conditions combined with MEL dispatch. Increased emphasis on landing performance should be given including assessment of landing distance required in reduced braking effectiveness vs. actual LDA (Safety Margins).

(b) One hour simulator check for adverse weather operations.

1.17.1.1.9 LANDING AT CATEGORY "C" AERODROME

Kozhikode is categorized as a Category C Aerodrome as per Para 24.2.2 of Part A of OM in accordance with the DGCA Operations Circular 2 of 2012. The following are the salient procedures for landing at Category 'C' airports:

(a) As per Para 24.2.1 of Part A of OM, Take-off and Landings at Category C Aerodromes are done by PIC only and no Supervised Take-off and Landing is permitted.

(b) As per the Para 1.4.7.1 of Part D of OM, the PIC should have 100 hrs of minimum flying experience and should have undergone 01 Supernumerary Observer Flight and 01 Route Check before being released for operating to Kozhikode.

(c) As per the Para 1.4.7.1 of Part D of OM, if the PIC has not flown to Category C airfields for a period exceeding 12 months, he is to undergo a route check.

(d) Aerodrome Specific SOPs for Kozhikode are contained in Para 6.3.3 of Part C of OM. Para 6.3.3.3 states the Aircraft Operating Limitations, *'Landing up to the maximum landing weight is permitted. Flaps 40 landing is preferred. Auto brake setting will be at the discretion of the PIC as per SOP. Flaps 40 have the following advantages:*

(i) 8 kt lower landing speed which results in less strain on the brakes and thrust reverser. (Engine and fuel benefit)

(ii) Higher drag will prevent a prolonged flare.'

1.17.1.1.10 USE OF AUTO THROTTLE

Since Kozhikode airport is classified as 'Category C' (critical) airfield by AIXL, it is not cleared for auto-land operations. Whenever manual landing is planned, auto throttle has to be disconnected when auto pilot is disengaged as per AIXL SOP Para 2.2.9. During the final approach on Runway 10, the PIC disengaged the auto pilot at 794 ft PA but did not disconnect the auto throttle. The aircraft landed with auto throttle engaged.

1.17.1.2 TRAINING OF AIXL PILOTS

The Investigating team visited the Ground training and simulator complex of AIXL located at Mumbai. The ground classes were being conducted online due to the prevailing Covid-19 conditions. Simulator was being used to impart mandatory recurrent training. In order to get a first-hand account of the simulator maintenance and training standards being followed in AIXL, the Investigator-in-charge observed their Training and Check sessions. In order to make a comparative study of the simulator training standards and simulator maintenance, the IIC also monitored a training session conducted by another Boeing 737-800 operator on another simulator facility. The two aspects that stood out were the poor maintenance of AIXL simulator and steep authority gradient amongst the cockpit crew.

CAR section 8, series C Part I Para 4.2 states that "*An operator shall establish, for each aerodrome planned to be used, aerodrome operation minima. The method of determination of such minima must be approved by DGCA and shall be consistent with the provisions of this CAR and ICAO Doc 9365 Manual of All Weather Operations*". During scrutiny of flight documents it emerged that LVTO minima in the Jeppesen Chart 10-9 of Calicut (Kozhikode) airport contained in Para 1.17.1.1.2 of this report is mentioned as 300m/400m/500m which is in variance with the limits mentioned in CAR.

During discussions with Chiefs of Training of various airlines it emerged that there is a discrepancy in procedures being followed for PIC training on aircraft between AIXL and other Boeing 737 operators in the country. This discrepancy was observed during the crucial phase of takeoff roll regarding handling of thrust levers by trainee captain.

The IIC also observed an AIXL line flight by travelling in the cockpit on a quick return flight on Mumbai-Kozhikode-Mumbai sector. The runway used for landing at Kozhikode was Runway10, which was also the runway used by AXB 1344 on 07 August 2020. During the course of the flight the IIC observed lack of good CRM and at times deviation from standard call-outs and use of non-standard terms, especially in the Approach phase. The crew were not familiar with the simple touchdown zone lights at Kozhikode, which are a pair of steady white lights on either side of the centreline at 3000 ft from threshold. The details of Simulator and Ground training of AIXL are as follows:

1.17.1.2.1 SIMULATOR TRAINING

AIXL conducts simulator training for its pilots on Boeing 737-800 Simulator (S.No.8810) at CTE Mumbai. There is a MOU under which the Boeing 737 simulator is maintained by Air India and used for training by AIXL as Air India does not have B-737 aircraft on its inventory. Simulator and Line Training are conducted by approved B737-800 DE/TRI/LTC/SFI of AIXL. The Investigation Team during its visit to the AIXL Simulator Complex observed that the maintenance of simulator was not up to the acceptable standards. After observing simulator training sessions, scrutinising the records and interacting with the pilots, the team found that there were deficiencies and repetitive snags in the simulator, resulting in negative transfer of training. Some of the deficiencies observed are enumerated below:

(a) The contaminated runway condition cannot be simulated during the training sessions, however, as per B737 Flight Crew Operations Manual (PI.10.6) and AIXL SOP SEC 2, Issue-4, Rev-0, dated 11 Nov 2019 the pilots are authorised to operate on up to 3 mm of contaminants during line operations.

(b) All AIXL B 737-800 aircraft have a feature of Auto-relight in case of an Engine-failure but the trainees cannot practice/experience this malfunction in the simulator as the instructor cannot simulate this emergency. This feature is not available on the IOS (Instructor Operating Station).

(c) Flap gauge indicator shows significant split.

(d) Manual extension of Landing Gear was found unserviceable.

(e) Thrust levers moved freely and lacked resistance or feel.

(f) Observer seat cannot be locked in any position.

The snags of Landing Gear and Flaps were not consistently documented, as they do not come under the purview of MMI. Taking into account the wear and tear of the simulator, there is scope for upgrade of the interface to facilitate higher environmental fidelity and making the simulator more interactive.

It was observed during simulator briefing/debriefing sessions that First Officers were not able to accurately calculate the LDA/LDR, especially for wet and contaminated runway conditions. A steep authority gradient between the crew was evident, wherein the First Officers tended to look over their shoulder even for routine SOP actions.

Simulator training was carried out on a routine basis with snags which do not come under the purview of MMI. The trainers had to devise risk mitigation methods in order to conduct and complete the training sessions. Even the contaminated runway condition, the feature which is not available in the simulator, is simulated by random permutation and combination by the trainers. This ad hoc simulator environment leads to negative training.

On random scrutiny of the simulator training documents/forms, the investigating team found that some of the mandatory exercises were not done during the tests conducted by the Designated Examiners. The tests were shown completed to satisfactory standard without completing all mandatory exercises and this had gone unnoticed in the scrutiny/audit done by the company and the regulator.

1.17.1.2.2 CREW RESOURCE MANAGEMENT (CRM) TRAINING

Operations Manual Part-A, Vol-2, Chapter 17 Para 17.12, states that CRM is the effective utilization of all available resources (e.g. Crew members, aircraft systems and supporting facilities) to achieve safe and efficient operations. The objective of CRM is to enhance the communication and management skills of pilots. Emphasis is placed on the non-technical aspects of flight crew performance. Initial

CRM training is specified in the Training Manual. The following elements of CRM are integrated into all appropriate phases of the recurrent training and are covered over a period not exceeding two years:

(a) Statistics and examples of Human Factor related accidents

(b) Human perception, learning process

(c) Situational awareness

(d) Management of workload, tiredness or fatigue, and vigilance management of stress.

(e) Company 'Standard Operating Procedures'

(f) Personality type, delegation, leadership, effective communication skills

(g) The CRM Loop

(h) Effective communication and coordination within the flight crew and between crew members & other operational personnel

(j) Error chain and taking actions to break the error chain

(k) Implications of automation on CRM

As per the Operations Manual Part-D, Chapter 1, a specific modular CRM training programme has been established by AIXL such that all major topics of CRM training are covered over a period not exceeding three years as follows:

(a) Human error and reliability, error change, error prevention and detection.

(b) Company Safety Culture, SOPs, Organisational Factors.

(c) Stress, Stress Management, Fatigue and Vigilance.

(d) Information acquisition and processing, Situation Awareness, Workload management.

(e) Decision Making,

(f) Communication and Co-ordination inside and outside the cockpit.

(g) Leadership and Team Behaviour, Synergy.

(h) Automation and Philosophy of use of Automation.

(i) Specific Type related differences.

(j) Case based studies.

(k) Additional Areas which warrants extra attention, as identified by the accident prevention and the flight safety program.

The AIXL has established procedures to update their CRM Recurrent Training Programme. Revision of the Programme is conducted over a period not exceeding three years. The revision of the programme takes into account the de-identified results of the CRM assessments of crew and information identified by the accident prevention and flight safety programme.

AIXL has ensured that elements of CRM as outlined in the DGCA Operations Circular 03 of 2004, dated 28 July, 2004 are integrated into all appropriate phases of the initial / recurrent / transition training on ground and simulator.

Each flight crew member undergoes specific modular CRM training during annual refreshers. Joint CRM of flight crew and cabin crew is to be conducted during annual refreshers whenever feasible. AIXL makes efforts to conduct joint CRM along with recurrent CRM during all annual ground recurrent training whenever feasible. However, AIXL has ensured that all flight crew undergo Joint CRM once in two years. The validity of Joint CRM is two years.

PIC had undergone Joint CRM training during annual refresher on 30 June, 2020 (valid for two years i.e. up to 29 June, 2022 and the Co-Pilot underwent Joint CRM training as part of annual refresher on 17 September, 2019 (valid up to 16 September, 2021).

1.17.1.2.3 GROUND TRAINING

AIXL through MOU with parent company Air India, conducts the training of its crew predominantly through AI, CTE which is a DGCA approved ATO and has set up elaborate training infrastructure by acquiring necessary simulators, training aids and various established training sections covering all areas of aviation at Mumbai and Hyderabad. The ground training in the B737-800 performance, NAV and SPL OPS, and technical subjects is conducted by approved Ground Instructors of AI, CTE and AIXL. SEP Training is conducted by DGCA approved SEP Instructors. DGR training is conducted by DGCA approved DGR Instructors. AIXL through MOU with parent company Air India, utilizes classrooms, CBT and training materials/aids of AI CTE, for conducting the training of its flight crew by trainers of AI CTE and AIXL.

The Investigation Team visited the ground training facility of AIXL in Mumbai from 06 - 08 Oct 2020. In line with Covid-19 protocols, face-to-face classroom teaching had been discontinued at the training facility and all training was being conducted online. Owing to these limitations, it was not feasible to conduct a thorough assessment of the quality of training being delivered. However, during the visits, the Team was able to interact with a few aircrew who were undergoing simulator checks. The team was also able to speak to aircrew during meetings conducted through the course of this investigation and onboard flights taken during the investigation. These meetings revealed that aircrew training records were at variance with the on-ground reality and capability of the aircrew.

While a majority of the aircrew had done well on paper, as per the records available with the training department, the level of proficiency displayed by a large number of aircrew was much below the acceptable level. Routine calculations which are required to be done by the aircrew before each takeoff and landing were not carried out properly and there was confusion regarding basic protocols and procedures.

1.17.1.2.4 ELECTRONIC FLIGHT BAG (EFB)

The induction of 'A' series of B737-800 aircraft in AIXL started in 2006. AIXL had projected EFB as a part of configuration specification from OEM. Subsequently, the initial batch of 17 'A' series aircraft (including VT-AXH) were delivered with OEM fitted EFBs. The system is manufactured by M/s Astronautics Corporation of America. It consists of EFB Electronic Unit and Display Unit, two each per aircraft. Navigational Charts and other Operational Information from QRH have to be uploaded on this EFB system for it to be used effectively as an On-Board Performance Tool (OPT). The process of uploading and updating of information on the EFB requires close coordination between Operations and Engineering. This activity, however, has not been undertaken at all by AIXL. At present, the aircraft mounted EFBs are used for camera surveillance only. Specific DGCA approval for the use of these EFBs has not been obtained. Instead, DGCA approval has been obtained for using portable EFBs (iPad®) loaded with Jeppesen and ARMS. The OEM fitted EFB is capable of being used for calculation of critical parameters which enables flight crew to perform real-time take-off and landing calculations but only if equipped with the necessary OPT application. The portable EFBs (currently being used) are also not equipped with this application.

During interaction with pilots of AIXL the Investigating Team found that the landing data calculations done by the crew while in air, especially under challenging conditions, was often inaccurate and some of the cockpit crew were unable to calculate ALD accurately even in class room conditions.

On 07 August, 2020, before the top of descent for the approach for runway 28, the flight crew of AXB 1344 did not perform ALD calculations as part of their approach briefing. After carrying out the missed approach, the briefing for the approach on runway 10 also did not include ALD calculations. Such calculations were absolutely vital for landing on a table-top runway in rain with tailwinds near the company limit of 10 Kt.

1.17.1.3 AIXL FLIGHT SAFETY

Air India Express Flight Safety Manual, Issue 05 dated 01 February, 2018 was approved by DGCA on 28 May, 2018 and was applicable on the day of the accident.

1.17.1.3.1 FOQA MONITORING BY AIXL

Since all operators are required to prepare their exceedance limits of FOQA parameters within the prescribed laid down limits in Annexure-A of CAR Section 5- Air Safety, Series F, Part II dated 30 September, 1999 (Rev 1 dated 26 July, 2017) on 'Monitoring of DFDR/QAR/PMR Data For Accident/Incident Prevention', AIXL prepared the list of their exceedance limits and obtained approval from DGCA as part of their Flight Safety Manual Issue-05, Rev 0, dated 01 February, 2018 (approved by DGCA on 28 May, 2018).

On the date of the accident, there were 85 parameters that were being monitored for exceedance by AIXL. Out of these, 36 parameters pertained to 'Approach and Landing Phase' of flight including 'Prolonged Flare during Approach and Landing'. AIXL was not monitoring 'Landings beyond Touchdown Zone' (Long Landings), as this was not required as per their DGCA approved Flight Safety Manual. Some of the salient exceedance limits for assessing stabilized approach are enumerated below:

Event Description	Possible Reason	Exceedance Limits		
		Green	Yellow	Red
Low power on short final below 500 feet	Incorrect thrust management	**N1-40.2%**	**N1-40.1%**	**N1-40%**
High ROD(1000ft to 500ft)	Unstabilized Approach	**1300 ft/min**	**1400 ft/min**	**1500 ft/min**
High ROD (500ft to touch down)	Unstabilized Approach	**1100 ft/min**	**1200 ft/min**	**1300 ft/min**
Prolong Flare	Incorrect Flare Technique	**10 sec**	**11 sec**	**12 sec**

The exceedance limits were categorised into green, yellow and red wherein, green and yellow exceedance are only monitored and the red exceedance are taken to generate trends for crew awareness and performance improvement.

Air Safety Directorate, DGCA-HQ after detailed discussions with the industry and Flight operations experts standardized the list of FOQA parameters and sent a list of 68 exceedance parameters for Boeing 737 Series to all Boeing 737 operators via e-mail on 28 July 2020. All operators were asked to update their Flight Safety Manual and configure their FOQA software at the earliest.

Monitoring of Long Landing (>3000ft or 30% of the LDA) was clearly documented by DGCA for first time in the standardized list issued vide e-mail dated 28 July 2020. AIXL started monitoring Long Landing Exceedance vide its Flight Safety Bulletin (FSB 2020-1001) dated 01 September 2020. However, this bulletin was not effective on the date of the accident.

Later, exceedance limits for assessing stabilized approach parameters for B737 family aircraft (High Rate of Descent) issued on 28 July, 2020 were revised vide email dated 07 December, 2020 by Air Safety Directorate, DGCA HQ. All B737 operators were again asked to update their Flight Safety Manual and configure their FOQA software accordingly. AIXL was not consulted regarding these changes.

Although, monitoring of Landing beyond Touchdown Zone was advised as a measure for reduction in Runway Excursion by DGCA in its National Aviation Safety

Plan (2018-2022) issued in August 2018, there was no specific communication or any instructions/guidelines from DGCA to the airlines for its implementation. Hence, neither was the FOQA parameters changed in the software nor was the FSM amended by AIXL until Sept 2020.

The investigating team asked for the records of long landing from DGCA for all Indian airline operators from 2018 to 2020. Subsequently AIXL was also asked the details of long landings. The two records are at complete variance with each other. The comparison of data provided by DGCA and AIXL is given below:

	Prolonged Flare		**Long Landing**	
Period	**Data from DGCA**	**Data from AIXL**	**Data from DGCA**	**Data from AIXL**
Jan 2018 to Dec 2018	29	92	29	Not monitored
Jan 2019 to Dec 2019	22	85	22	Not monitored
Jan 2020 to Nov 2020	33	33	14	14 (Out of 33 Prolonged Flare)

The Investigation Team observed the following regarding this monitoring:

(a) It is evident that only 'Prolonged Flare' was being monitored by AIXL till August 2020. The reason given for this was that 'Landings beyond Touchdown Zone' (Long Landings) were not required to be monitored as per their DGCA approved Flight Safety Manual. Based on DGCA e-mail of 28 July, 2020 on "Exceedance parameters for Boeing 737 Series" AIXL started monitoring the FOQA exceedance parameter of 'Landings beyond Touchdown Zone/Long Landing" from September 2020 vide their Flight Safety Bulletin (FSB 2020-1001, dated 01 September 2020).

(b) In the absence of AIXL not monitoring Long Landing for 2018 and 2019, the DGCA provided data of AIXL for 2018 and 2019 still show that all extended flare resulted in Long landing.

(c) It was observed that the present FDM software does not have automatic pop-up capability to monitor exceedance of 'Long Landing' beyond touchdown zone

(d) The DFDR monitoring for exceedance of 'Prolonged/Long Flare' is being calculated/correlated manually by the available DFDR data.

(e) Manual calculation of Long Landing is being done by taking the time taken by an aircraft from 30 ft RA till touchdown on the runway, assuming the average aircraft speed to be 250 ft/sec. It was confirmed by AIXL safety department that present method is not very accurate but they are in the process of purchasing software which would give 100% monitoring of Long Landing.

(f) DGCA communicated standardized FOQA parameters for B-737 Indian Operators on 28 July, 2020 (which included 'Long Landing'). On 01 September, 2020, this was incorporated in the Flight Safety Bulletin No. FSB

2020-1001. However, this Bulletin was not effective on the date of the accident.

1.17.1.4 DGCA AUDITS, CHECKS AND EVALUATIONS OF AIXL

Mumbai Base audit of AIXL carried out from 14 to 22 September 2011 covered all its weak areas in detail, highlighting AIXL inability to function as a separate identity. On examination of the safety audit reports of AIXL carried out for the period from 2018 to 2020 by DGCA, it was observed that some of the findings and observations have appeared repeatedly over the years. These observations were closed by Air India Express each time, however, the core concern of the audit observations remained and surfaced again in the subsequent audit by DGCA. Some of the areas of concern are highlighted below:

(a) **DFDR Monitoring**

The following is the breakdown of the quantum of data analysed by AIXL in the last three years as found during DGCA audits:

(i) **2018**: *Software not functioning properly. Frequent breakdowns observed. 100% DFDR monitoring NOT being done* (It was only 88.65%).

(ii) **2019**: *100% monitoring of DFDR is NOT being done* (It was only 89.67%).

(iii) **2020**: *DFDR Monitoring NOT 100% as per CAR.* (It was only 94% upto August).

In order to obtain the DFDR data for FOQA monitoring, AIESL downloads the data for AIXL from the DFDAU PCMCIA Cards. The data is uploaded on the FTP server as per the SOP issued by AIXL. This download and upload onto the server is done for 100% flights. If any card is found corrupted, the CAMO office is informed and the card is replaced. As per the AIXL FSM Para 6.3.1, *'missing data for each month to be checked after 15th of following month and same to be informed to the Engineering Department'*. In the event of some missing data on the uploaded files, the missing data is provided from the backup with AIESL. The backup data is only preserved with AIESL for a period of 60 days. The details of the uploaded data is not regularly checked and confirmed by AIXL contrary to what is clearly prescribed in their FSM. Their delayed requests beyond 60 days cannot be fulfilled by AIESL as the data is not preserved beyond 60 days. Scrutiny of data by investigating team revealed that this issue has never been resolved by Safety Audit of AI Express as well as DGCA. In summary, although 100% DFDR data was downloaded, however, analysis for FOQA monitoring was not done for 100% data.

(b) **Flight Simulator**

Evaluation of the AIXL Simulator was carried out on 28 September, 2020 at CTE Mumbai by DGCA. 18 deficiencies were found during this evaluation and the same were notified to M/s Air India for rectification. Subsequently, one month approval (till 27 October, 2020) was granted.

During this period, M/s Air India could not get the snag pertaining to the landing gear rectified and requested for another four months period for the repairs. However, since the snag impacted training, DGCA did not approve the extension and suspended training from 28 October, 2020 to 06 November, 2020. During this period M/s Air India submitted the risk mitigation measures with regard to unserviceable landing gear. This was approved and an extension of six months was granted (till 03 May, 2021).

On perusal of the defect report register provided by AIXL for the period Feb 2018 - Jan 2021, by the Investigation Team, it was found that majority of the deficiencies highlighted by DGCA in its Audit in 2020 had persisted at least since 2018.

(c) **Flying Checks**

DGCA is required to carry out frequent flying checks on sectors involving flights to Critical Airfields and also during 'Red-eye' flights involving 'Window of Circadian Low'. The data obtained from DGCA for the period from January, 2019 to June, 2020 indicates that DGCA did not carry out any surveillance checks on the above mentioned flights/airfields during this period.

(d) **SMS Training**

In 2018, DGCA Surveillance Inspection revealed that the AIXL personnel who are involved with the SMS had not undergone appropriate SMS Training as prescribed in the SMS manual. AIXL was to carry out five day training for their Nodal Managers directly handling SMS. However, the five day course was cut short down to three days. This aspect was highlighted by DGCA in their audit. AIXL in its response committed to DGCA that it will carry out the required training for Nodal Officers as per Approved SMS Manual within 6 months. However, no action was taken to provide necessary training and in 2019 DGCA again flagged the issue during Audit. The reasons stated by AIXL for this reduction was unavailability of SMS trainers, and again it was committed to DGCA that AIXL would ensure required training as per approved SMS Manual by May 2019.

AIXL did not carry out any action on the findings of 2018 and 2019 till the date of accident. However, after the accident of AXB 1344, AIXL amended their SMS Manual for the duration of training which was reduced from five to three days for Nodal Officers and submitted for acceptance of DGCA on 17 Aug 2020. As per AIXL the revised manual is under scrutiny with DGCA and they have not received acceptance of the same from DGCA.

1.17.1.5 CONTINUED AIRWORTHINESS

AIXL CAMO is a CAR-M, subpart-G approved organization for Aircraft fleet of Boeing 737-800NG aircraft which is structured under the management of Accountable Manager of AIXL. A Quality System is established, which works independently and monitors all activities on the continuing airworthiness management system to ensure that it remains in conformity with the applicable CAR M requirements. As per CAR M, subpart G, AIXL CAMO holds the privilege to manage the continuing airworthiness of commercial air transport aircraft as listed on the approval certificate and on its Air Operator Certificate (AOC) S-14.

Maintenance Program of AIXL meets requirements of DGCA as laid down in CAR M and is developed by CAMO of AIXL to satisfy the requirement and approved by DGCA. All maintenance activities carried out by the maintenance personnel on AIXL fleet are to be performed in accordance with the policies outlined in CAME.

The main CAMO facility of AIXL is located at Thiruvananthapuram and is approved by DGCA vide Letter No. F/KOCHI/AICL/1887 dated 18 December, 2015. AIXL currently operates independently of any other organization.

AIXL has contracted its line, base and shop maintenance activities for B737-800NG aircraft to Air India Engineering Services Limited (AIESL) which is a wholly owned subsidiary of Air India Limited, and a CAR 145 AMO approved by DGCA. The major checks are being carried out at AIESL Base Maintenance facilities located at Thiruvananthapuram and Mumbai.

At all Line Stations operated by AIXL, AIESL performs maintenance activities with its own infrastructure which may include Tools & Equipment or its contracting agencies to provide the same.

1.17.1.6 AIR INDIA ENGINEERING SERVICES LTD (AIESL)

Air India Engineering Services Limited (AIESL), a wholly owned subsidiary company of Air India Limited was formed on 11 March, 2004. AIESL is approved by DGCA as an MRO under the purview of CAR-145. AIESL comprises of infrastructure to cater to Line Maintenance, Base Maintenance, Engine Overhaul, Accessories Overhaul and Component Overhaul activities as per capability at main bases and line stations. AIESL provides Base Maintenance facilities at Mumbai, Delhi, Kolkata, Hyderabad, Thiruvananthapuram and Nagpur Airports.

Air India Express utilizes the services of AIESL for carrying out Line Maintenance and Base Maintenance of its aircraft. Certain issues were observed by the Investigation Team in the maintenance practices followed by AIESL. These are enumerated below:

(a) **DFDR**: The personnel checking and certifying the mandatory DFDR parameters being recorded during Annual Checks, Quarterly Checks and Phase Checks failed to identify the illogical values of Brake Pressure being recorded in the data.

(b) **Maintenance Standards**: An unserviceable brake pressure transducer remained installed on aircraft VT-AXI without being identified during Annual, Quarterly or Phase checks. The same unit was cannibalized and installed on VT-AXH in December, 2018. The fault again was not detected during installation as the maintenance activity was not completed as per the laid down AMM procedure before certification.

(c) **Record of Calibrated Tools:** It was observed during the investigation that the record of calibrated tools used or to be used for a specific maintenance task was not documented in the Defect Rectification Card (Job Sheet).

(d) **Positioning of Calibrated Tools**: During the Investigation it was observed that aircraft components were positioned at various locations in the network without giving due consideration to the availability of the special/calibrated tools required for removal/installation of those component. In such a scenario, if a component is to be replaced, the task cannot be completed without resorting to an unsafe practice of using non-calibrated or non-standard tools to do so. In addition, the requirement for special tools or calibrated tools is not documented in the Defect Rectification Card (Job Sheet) for component replacement.

1.17.1.7 AIR INDIA APPROVED TRAINING ORGANISATION (ATO)

Air India Express does not have its own ATO and has a Memorandum of Understanding to utilize the training facilities of Air India CTE, which has an ATO approval by DGCA. ATO approval was last renewed vide DGCA letter dated 08 June, 2016. Under this arrangement, AIXL uses the training facilities of AI, CTE to conduct training of its Flight Crew by Trainers of Air India CTE and AIXL. The simulator facilities are located at Mumbai in Air India Training Centre. Training and Procedure Manual Issue 1, Rev 3 of ATO is approved by DGCA on 02 May, 2019.

1.17.1.8 MEDICAL DEPARTMENT OF AIR INDIA EXPRESS

AIXL does not have an independent medical department. The Air India Medical Department is responsible for routine pre-flight medical examination, cabin crew periodic medical assessment and special medical assessments of the AIXL flight crew. The ab-initio and recurrent training of first aid is provided by Air India. At present, there is no Aerospace Medicine specialist in the medical department of Air India as well as Air India Express. There is also no participation of medical department during Human Factors and CRM training.

The need for employing an Aviation/Aerospace Medicine Specialist for all scheduled & non-scheduled operators and at Airport Medical Setup has been highlighted in the DGCA General Advisory Circular No. 01 of 2011 dated 17 December, 2011. However, AIXL and Air India have not employed any Aviation/Aerospace Medicine Specialist. Air India had one specialist from Indian Air Force on deputation prior to 04 February, 2015. Thereafter, there has been neither deputation nor employment of a specialist.

1.17.1.9 OCCURRENCES INVOLVING AIXL AIRCRAFT

Following are the list of occurrences involving AIXL aircraft.

- Accident involving B737-800 aircraft VT-AXV at Mangalore on 22 May 2010.
- Serious Incident involving B737-800 aircraft VT-AXE at Mangalore on 14 August 2012.
- Accident involving B737-800 aircraft VT-AYB at Cochin on 4 September 2017.
- Accident involving B737-800 aircraft VT-AYD at Tiruchirappalli on 11 October 2018.
- Serious Incident involving B737-800 aircraft VT-AYA at Mangalore on 30 June 2019.
- Accident involving B737-800 aircraft VT-AXH at Kozhikode on 07 August 2020.
- Accident involving B737-800 aircraft VT-GHE at Vijayawada on 20 February 2021.

1.17.2 DIRECTORATE GENERAL OF CIVIL AVIATION (DGCA)

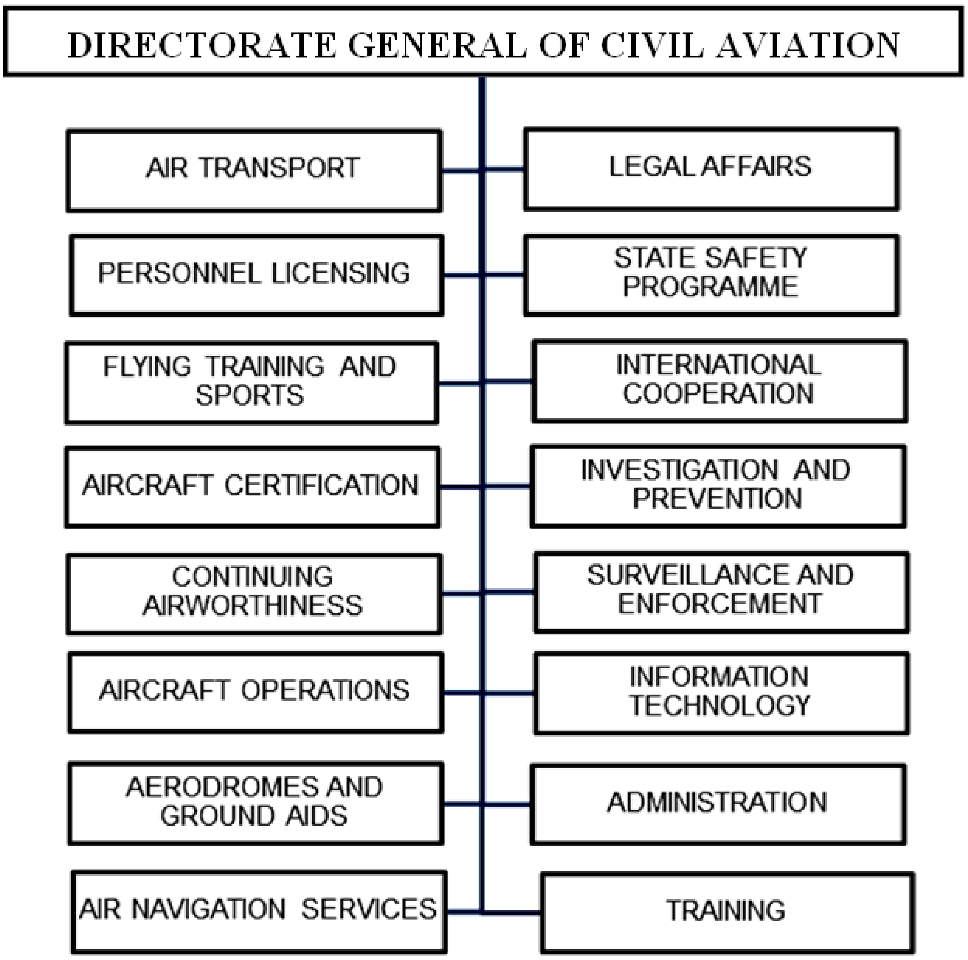


Figure 58: Organisation of DGCA HQ

DGCA is an attached office of the Ministry of Civil Aviation and is the regulatory body in the field of civil aviation in India. It is responsible for regulation of air transport services to/from/within India and for enforcement of Civil Air Regulations, Air Safety and Airworthiness Standards, in coordination with International Civil Aviation Organization (ICAO). DGCA headquarter is located in New Delhi with regional offices in various parts of India. DGCA is further divided into different Directorates and Divisions (Fig 58) that perform duties and functions as provided in the DGCA Organization Manual.

Rule 133A of Aircraft Rules 1937, empowers DGCA to issue directions not inconsistent with the Aircraft Act, 1934 (22 of 1934) or rules relating to the operation, use, possession, maintenance or navigation of aircraft flying in or over India or of aircraft registered in India. These directions may be issued through Notices to Airmen (NOTAMS), Aeronautical Information Publication, Aeronautical Information Circulars (AICs), Notices to Aircraft Owners and Maintenance Engineers and publication entitled Civil Aviation Requirements (CAR).

DGCA has issued CAR Section 1, Series A, Part I, Issue 2 dated 08 January, 2010 on the subject *'Issuance of the Civil Aviation Requirements and revisions thereof etc. - Requirements to be complied with'*. As per the said CAR, Civil Aviation Requirements are issued to specify the detailed requirements and compliance procedures so as to:

"(a) Fulfil the duties and obligations of India as a Contracting State under the Convention relating to International Civil Aviation signed at Chicago on the 7th day of December, 1944.

(b) Standardize and harmonize the requirements taking into account the rules and regulations of other regulatory authorities.

(c) Implement the recommendations of the Courts of Inquiry or any other committee constituted by the Central Government/ Director General.

(d) To address any other issues related to safety of aircraft operations as may be considered necessary by the Director General."

DGCA issued a CAR on 'Flight Safety Awareness and Accident/Incident Prevention Programme' (CAR Section 5, Series F, Part I dated 28 June, 1996) that requires all airline operators to prepare their Flight Safety Manual (FSM) and obtain approval of DGCA for the same. The CAR specifies the essential chapters to be included in FSM. Flight Operations Quality Assurance (FOQA) is to be included in the airline FSM as per this CAR.

The Investigation Team requested to have a formal meeting with The Air Safety Directorate of DGCA to discuss the various aspects of flight safety including FOQA monitoring. Accordingly, a meeting was convened on 16 December 2020 and a few of these aspects were discussed with them. However, the required information was not provided in writing during the meeting and it was informed that the same will only be provided through e-mail in a questionnaire form, although as per Rule 10(1) (a) and (b) of the Aircraft (Investigation of Accidents and Incidents) Rules, 2017 it is binding on any person called for discussion to give a written statement to the Investigation team if and when required to do so.

Subsequently some information was mailed to the IIC but on scrutiny it was observed that the information provided to the Investigating team regarding various safety issues including FOQA monitoring by DGCA was ambiguous.

In order to clarify those issues, the Investigation Team again invited officials of DAS, DGCA HQ for another meeting for clarifications and discussion on the data provided by them. DAS officials did not come to meet the Investigation Team in violation of the Aircraft (Investigation of Accidents and Incidents) Rules, 2017 Rule 10(1) (a) and (b).This was despite the best efforts of the Investigation Team to sit together and discuss various safety issues including the ambiguities in the FOQA monitoring parameters provided by them.

Thereafter, the Investigation Team held detailed meetings/discussions with the Chiefs of Safety of all major scheduled airline operators on their safety procedures and FOQA monitoring parameters. This report has been prepared based on information made available to the investigation team by the stakeholders.

1.17.2.1 CAR SECTION 5, SERIES F, PART II: 'MONITORING OF DFDR/QAR/PMR DATA FOR ACCIDENT/INCIDENT PREVENTION'

In 1999, DGCA issued CAR on 'Monitoring of DFDR/QAR/PMR Data for Accident/Incident Prevention' (CAR Section 5, Series F, Part II Issue I, dated 30 September, 1999). This CAR highlighted the fact that decoding and analysis of the DFDR/QAR/PMR is one of the major tools to identify hazards and system deficiencies in aircraft operations to prevent an accident. This CAR laid down the requirements for all operators to develop procedures, establish facilities and monitor data of all flights to determine exceedance of flight parameters within the stipulated limits. Para 4.5 of this CAR clearly mentions that "*Exceedance limits of various parameters* ***SHALL*** *be established by the operators for each type of aircraft* ***WITHIN THE LIMITS*** *given in* ***Annexure-A****. These* ***SHALL*** *be stipulated in their Flight Safety Manuals*".

Annexure-A to this CAR is a general list of 67 parameter exceedance limits which include all the phases of flight viz. general, take off, climb, cruise/descend and approach and landing.

There was a major air crash of an Air India Express Boeing 737-800 at Mangalore on 22 May, 2010, killing 158 passengers including six crew members on board. A Court of Inquiry (COI) was ordered to investigate this accident. The primary cause of this accident was aircraft landing off an unstabilized approach followed by a long landing past middle of the runway, resulting in runway overrun. Considering the cause of this accident, one of the important recommendation of the COI was that *"CAR, Section-5, Series 'F' Part II, Issue I dated 13 September, 1999 needs to be amended, to remove any ambiguity regarding the exceedance limits"*. The first and only revision of this CAR was done on 26 Jul, 2017 but the amended CAR did not address or remove any ambiguity regarding the exceedance limits. Also, the amendment did not address monitoring of 'Long Landing' by the operators, which was the major cause of the 2010 Mangalore accident. All 67 exceedance monitoring parameters enumerated in the Annexure-A of the CAR except parameter of '*High Normal Acceleration*' remained unchanged.

The investigation team studied the exceedance parameters of the "Approach & Landing" portion of the CAR. Few of the Approach and Landing phase exceedance of Annexure A of the CAR are enumerated below along with the standard stabilised Approach criteria:

CAR Parameter	***CAR Exceedance***	***Existing Stabilized Approach parameters***
Late landing flap (Flaps not in Landing position)	*Selected at <=600 feet*	*One of the important published stabilized approach criteria stipulates that aircraft on approach for landing should be in landing configuration by 1000 ft above airfield elevation.*
Deviation below Glide slope (< 600 feet Alt)	*>= ½ dot*	*Deviation of up to 1 dot is acceptable in a stabilized approach criteria.*
Deviation above Glide slope (< 600 feet Alt)	*>= ½ dot*	
High ROD (1000-500 feet)	*>700 to 800 feet/min*	*ROD of up to 1000 feet/min is within the accepted limit of a stabilized approach criteria.*
High ROD (500-100 feet)	*>600 feet/min*	*ROD of up to 1000 feet/min is within the accepted limit of a stabilized approach criteria.*

On the date of the accident, there were 85 parameters that were being monitored for exceedance by AIXL. Out of these, 36 parameters pertain to 'Approach and Landing Phase' of flight including 'Prolonged Flare during Approach and Landing'. AIXL was not monitoring 'Landings beyond Touchdown Zone' (Long Landings), as this was not required as per their DGCA approved Flight Safety Manual. Rate of Descent criteria for assessing Stabilized Approach followed by AIXL on the date of accident are enumerated below:

Event Description	**Exceedance Limits**		
	***Green**	***Yellow**	***Red**
High ROD(1000ft to 500ft)	1300 ft/min	1400 ft/min	1500 ft/min
High ROD (500ft to touch down)	1100 ft/min	1200 ft/min	1300 ft/min
Prolong Flare	10 sec	11 sec	12 sec

*Green: Monitored

*Yellow: Monitored

*Red: Exceedance are taken to generate trends for crew awareness and performance improvement.

DGCA in consultation with the airlines finalised a new list of FOQA exceedance parameters for B-737 aircraft on 28 Jul 2020 (ROD parameters from the revised list are presented in the table below). This new revised list was emailed to all B737 operators in India on 28 Jul 2020 for its implementation. AIXL completed all safety/training activities, modified their software and started monitoring the new FOQA exceedance vide their Flight Safety Bulletin (FSB 2020-1001, dated 01 September, 2020). This, however, was not effective till the crash of AXB 1344 on 07 August 2020. Few relevant parameters revised on 28 July 2020, effective from 01 Sep 2020 are enumerated below.

S No.	Parameters	Exceedance value (Yellow/Amber/Red)
1.	High ROD (1000 feet - 500 feet)	1300/1400/1500 feet/min
2.	High ROD (500 feet -100 feet)	900/950/1000 feet/min
3.	Long Landing	Green: >2500 feet from runway threshold Yellow: >2750 feet from runway threshold Red:>3000 feet from runway threshold/30% of LDA

Thereafter, DGCA finalised another list of FOQA exceedance parameters for B737 aircraft on 07 Dec 2020 (ROD parameters from the revised list are presented in the table below). AIXL was not consulted on these changes.

S No.	Parameters	Exceedance value (Yellow/Amber/Red)
1.	High ROD (1000 feet-500 feet)	1200/1300/1400 feet/min
2.	High ROD (500 feet -100 feet)	1000/1050/1100 feet/min

The events of AXB 1344 crash replicated the Mangalore crash of 2010 that had triggered the requirement of removing exceedance ambiguities in the CAR. Ten years later, on 07 August, 2020, it was once again a similar tabletop aerodrome, the same airline, the same type of aircraft that landed off an 'Un-stabilised Approach' and touched down past half the runway and resulted in another major disaster. Parameter for monitoring Long Landing, the other most critical factor for runway overruns, still does not find a mention in the CAR.

It was only in 2018, with the introduction of the five year (2018-2022) National Aviation Safety plan (NASP) by DGCA that reduction in number of *'Runway Excursions and Overruns'* was included in its 'Safety Objectives' and *'FOQA monitoring of landings made beyond the touchdown zone of the runway (Extended/Long flare)'* was mentioned in the Safety Action Plan.

1.17.2.2 NATIONAL AVIATION SAFETY PLAN 2018-2022

As part of the State Safety Program, DGCA introduced the first State Safety Plan in the year 2015 by conducting an array of meetings and discussions with the stakeholders and assessing the worldwide safety priorities. The effectiveness of the

State Safety Plan was evaluated and performance for the year 2015 and 2016 was published in the Annual Safety Review of 2016 and 2017, which provided the basis for the development of the National State Safety Plan to outlay Safety Objectives for 2018-2022.

National Aviation Safety Program (Edition II) was issued in August, 2018. Though the National Aviation Safety Plan is for five years, the targets were fixed for the first two years (i.e. for 2018 and 2019). In the subsequent years (i.e. for 2020, 2021 & 2022), targets were to be fixed based on the performance of the previous years. This five year plan (2018-2022) had eight key 'Safety Priorities'. The investigation team focussed on Serial No. 3 on *"Runway Excursions and Overruns"*.

In the action plan to implement the Safety Objective of "*Reduction in number of Runway Excursions at all Indian Airports at all times of the year*", a new FOQA parameter was added viz. *"FOQA monitoring of landings made beyond the touchdown zone of the runway (Extended/Long flare)"*. Air Operators were marked as 'Stakeholders' but no specific instructions/guidelines followed thereafter on its implementation. The following is the extract of the Safety Action Plan formulated by DGCA for the operators to achieve the above Safety Objective:

SAFETY ACTION PLAN FOR AIRLINE OPERATORS
a. *All air operators shall provide a training module to includes:* *i. CRM Class:* • *Increased emphasis on coordination between two pilots with respect to traffic clearances given by ATC* *ii. Flight Safety Class:* • *Causes of runway excursions* • *Increased emphasis on situational awareness with respect to traffic on approach/ departures/ taxiing on runways* *iii. Simulator Training:* • *On performance limited airfields* • *Stabilized approaches* • *Training on cross-wind landings to a level required for operations* ***b.*** *Continuous periodic monitoring through route/ in-flight checks* ***c. FOQA monitoring of landings made beyond the touchdown zone of the runway (Extended/long flare).*** ***d.*** *In case of non-precision approach, the operators are encouraged to carryout Continuous Descent Final Approach Technique (CDFA)* *Specialized ALAR Tool Kit training on visual illusion faced while transitioning to visual segment of approach*

Safety Performance Indicators (SPI) were developed for each State Safety Priority as laid in the NASP. As per the safety report published by DGCA for its 'Annual Safety Review of 2019', the targets for 2018, highlighted in red, could not be achieved. The performance for year 2019 has not been published and neither the targets nor the action plan for 2020 - 2022 has been revised. The performance measure along with target and measured performance for various periods for the objective of "*Reduction in number of Runway Excursions at all Indian Airports at all times of the year*" is given below:

SPI	Metrics	Achieved in 2017	Target for 2018	Achieved in 2018	Target for 2019
3.1	Number of unstabilized approaches per 10,000 approaches	6.28	6.1	**7.79**	5.91
3.2	Number of unstabilized approaches that continue to land per 10,000 approaches	6.65	6.45	**7.04**	6.25
3.3	Number of unstabilized approaches when performing a precision approach per 10,000 approaches.	3.52	3.41	**4.26**	3.31
3.4	Number of unstabilized approaches when performing a non-precision approach (no vertical guidance) per 10,000 approaches.	1.92	1.86	1.82	1.8
3.5	Number of unstabilized approaches when performing a visual approach per 10,000 approaches	0.76	0.73	**1.69**	0.71
3.6	Number of 'near' runway excursions per 10,000 approaches	0.01	0.01	0.01	0.01
3.7	Number of runway excursions per 10,000 approaches	0.07	0.06	0.02	0.05

While compiling AIXL flight safety data, it was observed that in spite of NASP guidelines of August 2018, FOQA parameter of Long Landing was not monitored till September 2020. As a follow-up, Directorate of Air Safety (DAS), DGCA HQ was requested to provide information on Regulatory procedures on CARs, NASP, Approvals on Flight Safety Manuals (FSM), implementation details of FOQA monitoring by all airlines in India, and also, information on Action Taken Report on Mangalore Air crash of 2010.

1.17.2.3 FOQA MONITORING

The information provided to the Investigating team regarding various safety issues including FOQA monitoring by DGCA is ambiguous

Some of the salient facts which emerge from the available data and on steps taken for accident prevention are as given below in chronological order:

(a) DGCA issued a CAR on Monitoring of DFDR/QAR/PMR data for Accident/Incident Prevention CAR Section 5, Series F, Part II Issue I, dated 30 September, 1999.

(b) Court of Inquiry after Mangalore air crash in 2010 recommended that ambiguities of the Exceedance parameters of the above CAR be removed. The accident involved runway overrun because of Unstabilised Approach and a Long landing.

(c) The CAR was revised in 2017 but Approach exceedance limit ambiguities were not addressed and they remained same as in 1999 CAR on accident prevention. The revised CAR does not have Long Landing Exceedance parameter added for accident/incident prevention.

(d) National Aviation Safety Plan (2018-2022) was issued by DGCA in October 2018. It was the first time that FOQA monitoring of Long landings made beyond the touchdown zone of the runway (Extended/long flare) was documented as a safety objective.

(e) This safety objective of Long landing is ambiguous. Long landing and Long/extended flare are shown synonymous. Long landing is measured by the distance between runway threshold and aircraft touchdown point. Long/extended flare is the time taken by the aircraft from 30ft RA (pre-determined aircraft height) till it touches down on runway. Therefore, both need not necessarily be same.

(f) DGCA issued NASP (2018-2022) in October 2018 with an action plan wherein all the airlines were advised to monitor long landings made beyond the touchdown zone of the runway. As per the statements given by the airline operators, this was not followed with any specific guidelines/instructions regarding its safety objective of monitoring Long landing exceedance. Hence, AIXL did not add Long landing as a new FOQA parameter.

(g) 2019 was a year of runway misadventures. Four of the five runway excursions reported in 2019 happened within 72 hours. On 28 July 2020 DGCA communicated revised FOQA exceedance limits for implementation to all B737 operators, including revised ROD on Approach. Long landing was added as a new FOQA exceedance parameter (>3000 ft from runway threshold/ 30% of LDA). AIXL implemented monitoring of Long landing from September 2020 (post AXB 1344 crash of 7 Aug 2020) after receiving new FOQA parameters for all B737 operators from DGCA.

(h) There is a discrepancy between the data regarding Long Landings that was provided to the investigation team by DGCA and the data provided by the airline operators. The DGCA data for most airlines tabulate exceedance limit of all Long flare same as long landing. This clearly indicates that the regulator does not distinguish between Long flare and Long landing. This was also confirmed by all operators that there is a clear distinction between the two and all long flare need not necessarily result in long landing.

(j) Only one B737 operator has the capability to correctly filter long landings automatically from the DFDR data. It has been monitoring long landings since 01 January, 2020. This operator uses GPS coordinates of runway threshold and aircraft touchdown point to calculate long landings i.e. beyond 3000 ft or 1/3rd of the runway, whichever is less.

(k) AIXL does not have the required software to automatically filter long landings from the DFDR data. Long Landing distance is being calculated from the time taken by the aircraft from a height of 30 ft RA till touchdown, at an average speed of 250 ft/sec.

(l) Another operator, in its FOQA monitoring for A-320 operations identifies long flare distance as any touchdown beyond 1050m (3444ft) on the runway irrespective of the runway length. For B787 which has been in operation for nearly 10 years, they do not have any measure as IGS (integrated ground software) software has not been configured for monitoring landing exceedance.

(m) A new B787 operator in its FOQA monitoring, has monitored both Long Landing and Extended flare using AGS (analysis ground station) software since the day the aircraft was inducted in May 2020.

(n) There is ambiguity in the DGCA approved criteria for defining the touchdown point to calculate long landings for different fleets of aircraft.

1.17.3 AIRCRAFT ACCIDENT INVESTIGATION BUREAU (AAIB)

In accordance with the 'Standard and Recommended Practices (SARPS)' contained in Annex 13 to the Chicago Convention, Ministry of Civil Aviation, Government of India established an independent Accident Investigation Committee vide Order No. AV. 15029/002/2008-DG on 26 May, 2011.

Aircraft (Investigation of Accidents and Incidents) Rules 2012 were formulated and notified on 05 July, 2012 through a Gazette Notification and subsequently, Aircraft Accident Investigation Bureau was formed vide order AV-11012/01/2011-DG dated 30 July, 2012 superseding the earlier order.

It was envisaged that formation of AAIB would ensure independence of investigation function from the regulatory function. This was also in line with recommendation of the Court of Inquiry that investigated an earlier accident at Mangalore in 2010.

Aircraft Accident Investigation Bureau, India (AAIB, India) is an attached office of the Govt of India, Ministry of Civil Aviation. Twenty One posts of Investigators were created to enable AAIB to carry out its functions and the posts were filled on temporary and ad-hoc basis. For investigations that may require subject matter expertise, AAIB strengthens its Investigation Team by appointment of subject matter experts from the industry. AAIB also has an agreement with DGCA for utilizing the services of DMS (Civil Aviation) wherever expertise in the field of Aviation Medicine is required as part of Go-Team or during investigation.

In accordance with amendments in ICAO Annex 13, rules notified in 2012 were amended in 2017. As per sub-rule (3) of Rule 8 of Aircraft (Investigation of Accidents and Incidents) Rules, 2017, AAIB carries investigation of Accident and Incidents as part of India's obligation towards ICAO as per Annex 13 and also discharge various functions stated in the said rules which includes the following.

"(e) to formulate safety recommendation on the basis of safety studies, including induction of new technology to enhance safety, conducted from time to time;

(f) to establish and maintain an accident and serious incident database for effective analysis of information on actual or potential safety deficiencies;"

Although, AAIB has carried out more than 150 Investigations in accordance with Annex 13 so far, no Safety Study has been carried out so far owing to shortage of manpower.

Further, the sub-rule 4 of Rule 8 gives AAIB the power to make procedures, not inconsistent with the provisions of the Act and the rules made there under to carry out the purposes of these rules and the functions referred to in sub-rule (3).

Consequent to Aircraft (Amendment) Act, 2020 (13 of 2020) dated 19 September, 2020 Aircraft Accidents Investigation Bureau was made responsible for carrying out the functions in respect of matters relating to investigation of aircraft accidents or incidents specified in the Act or the rules made there under.

AAIB has prepared and issued Procedure Manual based on guidance available in ICAO Annex and ICAO Documents 9756, 9973, 9156 etc. Procedure Manual lays down detailed guidance on qualification and experience requirements for investigators, notification of accidents/incidents, planning and conduct of investigation, preservation of evidence, testing of components, empanelment of subject matter experts etc. Training requirements for investigators are also laid in accordance with ICAO Circular 298.

Even though the investigation function shifted to AAIB in 2012, AAIB is dependent on the facilities and regulations of DGCA for discharging its obligations defined in Aircraft Act, 1934 and Aircraft (Investigation of Accidents and Incidents) Rules, 2017.

As per said rules, on the day of accident, AAIB did not have any powers to issue directions to any stakeholders on any matter related to accident investigation. AAIB was dependent on DGCA to issue any such directions to operators or any stakeholder. Some of the directions issued by DGCA which help AAIB in carrying out its functions are as below:

- CAR Section 2, Series I, Part V - Flight Data Recorders, Combination Recorders, Data link Recorders, Airborne Image Recorders, Airborne Image Recording System and Aircraft Data recording System
- CAR Section 5, Series C, Part I - Notification of Incidents and Investigation thereof.
- ASC 04 of 2013 - Role of Aerodrome operator in preservation of Evidence following an Accident/Incident
- ASC 06 of 2010 - Action required by Police Authorities in case of aircraft accidents
- ASC 05 of 2009 - Classification of Aircraft Proximity
- ASC 09 of 2009 - Off rostering of pilots
- ASC 05 of 2014 - Preservation and Replaying of ANS and Aerodrome related Recording Media for Investigation of Accidents /Incidents /Occurrences.
- AAC 3 of 2019 - Routine Readout and maintenance of Flight Data Recorders units installed on Aircraft.
- AAC 4 of 2019 - Routine Readout and maintenance of CVR units installed on Aircraft.

Consequent to issue of amendments in Aircraft (Investigation of Accidents and Incidents) Rules, 2017 issued vide **G.S.R. 222(E) dated 30 March 2021,** The DG, AAIB has been given powers under these rules to issue directions to

"*Authorize any person or persons to take measures –*

(a) to protect the evidence and shall include the preservation, by photographic or other means, of any evidence which might be removed, effaced, lost or destroyed;

(b) to maintain safe custody of the aircraft and its contents and shall include protection against further damage, access by unauthorized persons, pilfering and deterioration;

(c) for preservation of the aircraft for such a period as may be necessary for the purposes of an investigation.

(d) for arranging a suitable place and facilitation of transportation of wreckage to such a place.

AAIB has MoU with various agencies to get the wreckage components examined and tested. MoU with DGCA to utilise the Flight Recorders Lab of DGCA for investigation also exists. However, the lab was found to be poorly equipped and not fit to handle majority of cases as there has been little or no infrastructure update in the Flight Recorders Lab since 2012, when investigation function was taken over by AAIB.

1.17.4 AIRPORT AUTHORITY OF INDIA (AAI)

Airport Authority of India (AAI) was constituted by an Act of Parliament and came into being on 01 April 1995 by merging erstwhile National Airports Authority and International Airports Authority of India. The merger brought into existence a single organisation entrusted with the responsibility of creating, upgrading, maintaining and managing civil aviation infrastructure both on ground and air space in the country.

The main functions of AAI inter-alia include construction, modification and management of passenger terminals, development and management of cargo terminals, development and maintenance of apron infrastructure including runways, parallel taxiways, apron etc. Provision of DVOR/DME, ILS, ATC radars, visual aids etc. Along with it AAI provides air traffic control (ATC) services, provision of passenger facilities and related amenities at its terminals thereby ensuring safe and secure operation of aircraft, passengers and cargo in the country.

1.18 ADDITIONAL INFORMATION

1.18.1 IMPLEMENTATION OF RECOMMENDATIONS OF PREVIOUS CRASH INVESTIGATIONS

The Investigation Team found glaring similarities between the Mangalore air crash and the accident that took place in Kozhikode on 07 August, 2020. The Mangalore Accident Report and the recommendations made by the Court of Inquiry were studied at length.

As per the information provided by DGCA, all the actionable recommendations of the COI have been implemented and no action is pending. However, the Investigation Team observed that some salient recommendations from the Final Report of VT-AXV crash have not been wholly addressed. Relevant recommendations and the Action taken/status is tabulated below along with the observations of the Investigation Team in the context of AXB 1344 crash:

Para of COI	Recommendations of COI	Action taken/Status provided by DGCA	Observations by the Investigation Team
4.1.1	**Air India Express Should Operate as a Separate Entity** The DGCA regulations mandate that a separate AOP holder like	Operations, Training and Flight Safety are managed by Air India Express with full time Post Holders.	It was observed that the 'Post Holders' have been appointed independently for Air India Express.

	Air India Express should operate as an independent organization instead of being operated by part time Post Holders on deputation from Air India. The philosophy of operations of Air India Express is vastly different from Air India. While Air India is a legacy airline which operates on long haul international routes, Air India Express is a low cost airline operating to destinations in the Middle East, South and South East Asia. Air India Express also operates from multiple bases which make its operations vastly different from Air India. Functions of marketing, commercial, administration and even some aspects of engineering and logistics support can be synergized with the parent company. However, those of operations, training and flight safety should be independently managed by Air India Express.	AICL has entered into an MOU with Air India for use of TRTO and Simulator and ground facilities.	The Operations and Flight Safety are independently managed but even after a decade, AIXL has been unable to establish an independent TRTO.
4.1.2	**Need for Calibrated Growth of Air India Express** Since its inception in 2005, Air India Express had grown rapidly from a mere 3 aircraft to 25 aircraft in a short span of 4 years. It had also done well to increase number of flights from 26 to about 210 per week in 2009. It is given to understand that there would be further induction of aircraft and operations on new routes including domestic sectors. In order to connect more cities with international routes, AI Express also plans to operate form additional bases. There would also to be an independent	Presently out of 21 aircraft, AICL is operating 17 B737-800 aircraft. Keeping the other 04 aircraft as spare and in maintenance. Therefore for a fleet strength of 17 we have adequate number of pilots and AMEs. We have more than the required 06 sets of crew per aircraft. Current strength: PIC:104 (Required 17x6=102) First Officer: 108 (Required 17x6=102	04 Captains and one Co-pilot of Air India Ltd are still working with Air India Express Ltd on deputation.

	engineering setup to be started at Thiruvananthapuram shortly. While such growth has its merits, there is a need to ensure that alongside other resources, infrastructure and in particular induction of duly qualified manpower also takes place. While inducting flight crew to cater to this increased requirement, issues such as training and flight safety should be given prime importance.	PIC under Training:27 First Officer Under Training:09 We also have sufficient Engineers for the maintenance of aircraft. As and when we increase our fleet strength we will increase our qualified manpower to the satisfaction of DGCA. We have the required infrastructure in Operation, Training, Flight Safety and Engineering. Certain activities such as Ground Handling, Flight Dispatch, Technical Documentation, Medical etc. have been outsourced to the parent company. Being a Government owned company we have to abide by the directions of the Government in this regard. The COI report also accepts that certain functions may be synergized with the parent company.	
4.1.5.1	**FOQA and CVR Analysis in Multi-Base Operations** The mandatory analysis of CVR is presently being carried out only for flights operating into Mumbai. Such sample checks also need to include flights operating from different bases and for monitoring performance of crew operating from bases other than Mumbai. In view of the multiple base operations,	DFDR data is being made available by IOD to Flight Safety within a week's time. DFDR and CVR monitoring as per CAR is being done.	DFDR monitoring is not 100% and is well below acceptable standards. Monitoring percentage for last 03 years i.e. 2018-2020 are: 88%, 89%, and 94% respectively. The Exceedance

	100% FOQA analysis of DFDR takes up to 3 weeks. For faster monitoring of various parameters, this duration could be cut down by Computerization and Networking.		parameters are not measured as per DGCA approved FSM.
4.1.6	**Training** Air India Express has a mixed intake of Pilots. While there are Captains and First Officers employed directly on contract, First Officers from Air India are also sent to AI Express for Command conversion. In addition, a number of foreign pilots have also been employed, who need to be given familiarization training for operating in Indian conditions. There is also a need for recurrent training including various clearance and checks. There is a shortage of TRI and TRE which needs to be addressed urgently. The emphasis should be on a common SOP for such a mixed crew. During training, endeavour should also be made on inculcating a common company culture amongst the crew. Aspects such as CRM, actions during unstabilized approach, use of Vertical Situation Display (VSD), identification of false Glide Slope etc., should be covered in ground training and where possible, in simulator. In addition to this large requirement of training, Air India Express needs to develop its own infrastructure for carrying out training especially in view of the constraint of Multi-base operations. Since AI Express operates on shorter sectors, criteria for various qualifications should be more on numbers of take-offs	Strength of Examiner/ Instructor in Air India Express increased to 32 including 03 trainers awaiting DGCA approval. Efforts are on to further increase of training captains. The SOP is standard (common) for all crew. During training aspects such as common company culture, CRM, action during unstabilized approach use of VSD and identification of false Glide Slope are covered during classes and simulator training. Special LAR, TEM Risk Assessment Classes are being conducted for Air India Express Pilots. The SOP is standard (common) for all crew. During training aspects such as common company culture, CRM, action during unstabilized approach use of VSD and identification of false Glide Slope are covered during classes and simulator training B737 TRTO belongs	Steep authority gradient was observed to persist between the Captains and Co-pilots during simulator sessions. Simulator maintenance is poor with lot of recurring defects leading to negative training. Despite regular DGCA audit as per Annual Surveillance Plan, the same defects have persisted over the years.

	and landings and not on total hours flown. The ground training should include aspects of Aviation Medicine including fatigue management, effects of alcohol, self-medication etc.	to Air India. AICL has an MOU with Air India to carryout complete Ground Training (WET) of Cockpit and Cabin Crew. The Simulator Training (DRY) is conducted on Air India b737 simulator by AICL Instructors. AICL has applied to DGCA for approval to use Air India TRTO. The training flow chart has been revised accordingly. AIE presently has 31 trainers. Action has been initiated to enhance our strength of training captains in a phased manner. Training syllabus has been revised as per recommendations.	
4.1.7	**Training on Simulator** Air India Express has a simulator for Boeing 737-800 aircraft. However this simulator suffers from maintenance problem and frequent breakdowns. In view of vast requirement of training, the simulator should have a much better state of serviceability.AI Express operates to some of the critical airfields such as Mangalore, Calicut and Pune. The simulator should be able to generate synthetic displays of these airfields. With availability of enhanced fidelity these days, the flight crew can be given better training.	A- AICL already has an arrangement with Jet Airway and CAE for use of 737 Simulator whenever Air India 737 Simulator is not available. B- VISUALS of critical airfield- The new visuals of Mangalore and Calicut have been procured. C- Emphasis is given during training on Go-around procedures from both stabilised and unstabilized approach	The maintenance of Air India B737 simulator is a major issue. The throttle movement was found to be absolutely free, undercarriage emergency lowering did not work and the trailing edge flaps indicator displayed a large split on selection. All these snags and inadequacies of the simulator result in negative transfer of training.

	Apart from normal emergencies, emphasis during simulator training should also be given to 'Go Around' procedure from both stabilized and unstabilized approach conditions.	conditions.	The option of simulating contaminated runway (upto 03mm) condition is not available in the Simulator.
4.1.9	**Crew Resource Management (CRM)** Crew Resource Management training and refreshers for all flight crew should be conducted as required by DGCA vide Operations Circular No 2 of 2001 dated 10th May 2001 and other circulars in this regard. This should include both classroom and simulator training. Workshops to include, inter alia, training on assertiveness by First Officers should be conducted. Specific issues regarding multi-cultural crew composition should also be covered during the CRM training. Flight crew should be sensitized to implications of nil or little communication on the flight deck during cruise phase. Flying supervisors and TRE/ TRI should observe all CRM issues including the Trans-Cockpit Authority Gradient by occupying Observer's seat. This would allow them to assess the responses of both Captain and the First Officer, functioning as a team. In addition, airline should ensure a system whereby relevant details about the personal particulars and flying experience of the Captain and First Officer are available to each other, before commencing a flight together. This would help the flight crew in establishing a quick rapport. Flow of such information would	ALAR/TEM training conducted by Chief of Flight Safety for 130 cockpit crew,6 SFI and 2 CRM instructors. ALAR, TEM Risk Management and CRM class presentation DVD copy submitted to DAS (HQ). OTPPC is completed for all line, Commanders. CRM LOFT Simulator Assessment form amended including the points trans cockpit gradient and openness of Commander to take input from First Officer. Cockpit Surveillance- This is emphasised in ALAR/CRM training classes.	It is observed that training on assertiveness for First Officers has not yielded any qualitative results. The steep cockpit authority gradient continues to be managed poorly. TRIs/DEs are not rostered as Observers for CRM monitoring on flights as recommended by the COI.

	be possible after computerization and networking of activities at all bases, from which AI Express operates.		
4.1.11	**Crew Scheduling** Computerisation of crew scheduling should be ensured by the airline at the earliest in accordance with CAR Section 3, Series 'C' Part II (Revised 2009) issued by DGCA. This non-compliance had also been brought out by the DGCA Audit carried out from 30th October to 3rd November 2007. In multi-base operations, adequate number of flight crew (including Standby flight crew) should be based permanently at all such bases. Instead of moving the crew repeatedly to other bases, the permanent basing will allow unhindered operations of scheduled flights from all bases.	Computerised Crew Scheduling system has been introduced in AIX being done though ARMS software. OM of AIX was revised in April 2012 to amend policy for posting of Crew.	Adequate crew are not based permanently to undertake unhindered operations at all bases. A case in point is Kozhikode, where there is only one Captain on the posted strength against 26 First Officers, in spite of maximum number of flights of AIXL operating out of this base.
4.1.13	**Aviation Medicine Specialist** Airline should consider employing a full-time Specialist in Aviation Medicine. Such specialist should conduct initial and refresher training of flight crew and cabin crew in sleep physiology, circadian disruptions and methods to reduce effects of fatigue (including controlled rest in seat and use of prescription medication for sleep induction and alertness enhancement). This specialist may, in addition, be utilised to conduct regular classes in Aviation Medicine including Hypoxia, Spatial Disorientation and Aviation Psychology. In addition, such a specialist should be utilised to	Aviation medicine Specialist appointed. He conducts classes for all crew on aviation medicine aspects.	There is no Aviation Medicine Specialist posted in Air India Express/Air India since 04 February 2015.

	counsel the flight crew on their regular licensing medical examination and measures to be adopted to increase wellness and thereby a full and healthy flying career.		
4.2.3	**Need for Frangible Structures on the Overshoot Areas** It is mandatory for all structures protruding above the Runway Safety Areas, to be frangible. These would include approach lights in the overshoot and undershoot area, signage, ILS Localizer Antenna mountings etc to name a few. At Mangalore, the ILS Localizer Antenna is mounted on a concrete structure. Although, this structure is in-frangible, as recommended at Para 4.2.2 above, once the downward slope of overshoot area for R/W 24 is brought to the same level of the runway surface, this concrete structure will also get embedded in the ground.	As per AAI supporting structure of Localiser antenna has been buried and the RESA an overrun area has been graded as per CAR specification.	At Kozhikode also, the concrete support structure of the Localiser Antenna and the Approach Lights were found protruding above the ground level, within the soft ground arrester area.
4.2.4	**Maintenance of RESA** Maintenance of RESA at Mangalore needs improvement. There were not only a number of shrubs growing all over, but some of the Approach Lights had their concrete mountings jutting out above the surface. Requisite refilling of sand and its periodic maintenance needs to be ensured.	As per AAI Periodic maintenance ensured. SOP on maintenance of RESA is in place.	At Kozhikode, lot of shrubs were seen growing on RESA.
4.2.5	**EMAS and Soft Ground Arrester Barrier** Considering the large number of runway excursions leading to hull loss accidents, ideally an arresting system like the Engineering Material Arresting System (EMAS) should be	As per AAI Soft Ground Arrester Barrier 174x90m has been provided at Mangalore Airport.	At present RESA of 240mx90m as per ICAO guide lines is available at Kozhikode. However sufficient land required at the runway end for EMAS is not

	installed on the runway overshoot areas, especially for Table Top airports like Mangalore. However, at all other runways, the overshoot areas could incorporate a Soft Ground Arresting (SGA) system to retard the exiting aircraft, in case the cost of EMAS is not viable. It may be pertinent to mention that such SGA are maintained at almost all the Indian Air Force (IAF) airfields with regular ploughing and filling of sand, as required.		available. Soft Ground Arresting (SGA) system to retard the exiting aircraft is not maintained as required with regular ploughing and replenishing with sand. Photos of SGA before the accident and at present are presented in the report.
4.2.11	**Continuity Training of RFF Crew Including Simulators** Due to operational constraints, the RFF crew lack opportunity of practical training and crash drill on actual aircraft. On the other hand, recurrent training for all activities related to aviation is required to enhance the level of professional skill and flight safety. It is, therefore, recommended that the RFF crew should be sent for training on simulators on regular intervals. In this connection, more number of simulators, large scale aircraft models and training films should be made available regionally.	Incident Command Management System ICMS and ARFFV Driving Simulator have been established and commissioned at FTC, New Delhi. The simulator is designed to create various emergency scenarios and practice emergency response. It has also a Driving Simulator here fire personnel can be trained to drive on difficult terrain.	The ARFF crew at Kozhikode has not been given actual aircraft familiarisation training. The ARFF crew was not conversant with operation/opening of the aircraft doors, emergency exits, cockpit emergency exit and unlocking of pilot seat belt. The issue was raised by the Head of Fire Department with the higher authorities repeatedly but this crucial safety concern was not addressed till the day of AXB 1344 crash.
4.3.1	**Post Accident Initial Actions** There is a need for the DGCA to designate in co-ordination with Airports Authority of India, a post holder at each airport who will be the Single Point of Contact in case of an aircraft accident. Such official should	ASC 04 of 2013 has been issued by DGCA	ASC 04 of 2013 has been issued by DGCA in this regard. However, the same is not reflected in any Policy Manuals of AAI. Video recording of

	initiate immediate actions required to facilitate investigation, while the search and rescue operations are still underway. All immediate actions need to be initiated and properly recorded till the arrival of Inspector of Accident, who will be appointed by DGCA. It is recommended that the initial actions should include video recording of the wreckage for better understanding of the situation, while the rescue operations are underway. There is also a need to bring out a Check List enumerating immediate initial actions. This Check List should be available at all airports and incorporated on the DGCA website.		the rescue operations was not done.
4.3.2	**Aviation Medicine Specialist in the Initial Team** There is a need for including a Specialist on Aviation Medicine in the initial team of DGCA officials, who visit the site of accident, especially in the case of fatalities/injuries. The Aviation Medicine Specialist should liaise with the local Police Authorities for implementation of Air Safety Circular No 03/84 issued by DGCA, Govt. of India. He should also liaise with local Medical Authorities for the post mortem, especially those of flying crew. This will ensure a thorough autopsy including post-mortem Xrays that can help in corroborating the cause of the accident and establishing the cause of injuries/fatalities. Also this Specialist will ensure timely toxicology investigation to rule out consumption of alcohol or other drugs.	Letter issued to JDGM (Aviation), DGCA to nominate one aviation specialist as nodal officer to be part of investigation Go-Team and also participate in the investigation. A confirmation letter regarding the same has been received.	AAIB to take necessary actions. No doctor was nominated as member of the Go-Team. Also, there is no Aviation Medicine Specialist with Air India Express or Air India who could have assisted in the initial part of accident investigation through participation in post-mortem or sample collection for toxicology analysis.

	Aviation Medicine Specialist should also be facilitated to go through personal effects of the deceased/injured flight crew and interview their family and colleagues. This will help to investigate the possibility of self-medication and any life stress events that may have contributed to the cause of the accident.		
4.3.11	**Flying Checks by the Flight Inspectors of FSD** Flight Inspectors of FSD need to carry out frequent flying checks on sectors involving flights to Critical Airfields and also during 'Red-eye' flights involving Window of Circadian Low. This will help them in ascertaining for themselves, flight crew proficiency during such flights.	Circular has been issued by DGCA and checklist for Surveillance has also been developed.	The information received for the period from January, 2019 to June,2020 show that FOI from FSD carried out random flying checks for AIEL but the Critical Airfields and 'Red-eye' flights were not covered during these check flights.
4.3.12	**Clarification on Flying Procedures** In view of this accident, there is a need for DGCA to bring out a Standard Operating Procedure to be followed for the following:- a) Unstabilised approach and actions to be taken by the First Officer, in case the PIC does not initiate a timely 'Go Around'. b) Identification of False ILS Glide Slope and procedure to be followed for a safe landing. In view of a number of points raised by Operators and Participants during the Public Hearings, DGCA needs to clearly and unambiguously bring out the limits, which do not warrant any Operational Incident Reports (OIR) to be raised or punitive action to be initiated against the	DGCA had issued OC 15 of 2010 and OC 01 of 2013 wherein procedures for Go-around/Missed Approach were given and non-punitive policy towards every Go-around was promulgated. CAR Section 5, Series F, Part II was amended in 2017 to make FDM non-punitive.	The subject CAR has not been revised since 30 September, 1999 to remove the ambiguities in the exceedance limits for parameters prescribed in this CAR till the date of this accident. The last revision was done on 26 July, 2017, which made Missed Approach non-punitive but did not address the serious concerns of exceedance limits highlighted in the Court of Inquiry recommendations.

	pilot for following incidents: a) Hard landing. b) Go Around. CAR, Section-5, Series 'F' Part II, Issue I dated 13 September, 1999 needs to be amended to remove any ambiguity regarding the exceedance limits.		
4.3.16	**Publication of Flight Safety Journal** Since DGCA is a repository of all the current information on Flight Safety, a centrally published Journal on matters of Flight Safety will greatly help in spreading awareness on safe operations. DGCA has information on periodic initiatives by ICAO and has access to data on worldwide accidents/incidents. The recommendations from such data can be shared with the operators through this journal. The publication could be monthly/bi-monthly and could incorporate a variety of issues which have bearing on Flight Safety, such as Meteorology, Aviation Medicine, new ATC procedures etc, to name a few. The proposed Flight Safety Journal could also include 'Good Show' in respect of crew members as well as technical, ATC and all other personnel connected with aviation for an 'individual action' which might have resulted in avoiding an accident/ incident.	As per DGCA, Organisations are required to issue Flight Safety Journals and DGCA issues Annual Safety Review.	The Annual Safety Reviews for 2019 and 2020 have not been published.
4.4.1	**Setting up of Indian Civil Aviation Safety Board** The Court of Inquiry also recommends setting up of an independent Indian Civil Aviation Safety Board (ICASB),	Aircraft Accident Investigation Bureau has been set up by Govt in 2012.	Aircraft Accident Investigation Bureau has been set up by Govt in 2012. 21 posts were sanctioned by the Govt of India in

	on the lines of NTSB, USA. This independent body will help in focusing on all the flight safety related issues, so as to make timely recommendations to DGCA and Ministry of Civil Aviation for speedy implementation. The recommended proactive measures will help in minimising accidents and incidents. Such an independent organisation is much needed in view of rapid growth of aviation in the country including General Aviation.		2015 to staff AAIB. Various posts in AAIB are still vacant. MoU has been signed with DGCA to use its Flight Recorders Lab for Investigation. The lab was found to be ill-equipped to handle investigation work owing to non-availability of equipment and software to download and analyse latest flight recorders for investigation. MoU have also been signed with various labs and agencies for providing facilities for testing and defect investigation.

1.18.2 OTHER ACCIDENTS AND INCIDENTS AT MANGALORE AND KOZHIKODE

It is pertinent to mention that Kozhikode and Mangalore share similar weather phenomenon, topography and operational constraints. In addition to the VT-AXV accident at Mangalore in 2010, the Investigation team also studied Investigation Reports of other accident and incidents that happened at Mangalore and Kozhikode. The following was observed.

1. In 2012, a B737-800 NG aircraft VT-AXE operated by Air India Charters Ltd was involved in an undershoot incident at Mangalore on 14 Aug 2012. Committee of Inquiry in its Investigation report had recommended installation of Runway Centre line Lights at Mangalore in view of tabletop operations, topography of surrounding area and frequently changing weather. AAI had accepted the recommendation and submitted in its ATR to DGCA that Runway Centre Line Lights will be installed at Mangalore during re-carpeting. However, as per the e-AIP, Runway Centre Line Lights are not installed at Mangalore Airport till date.

2. In 2019, an Airbus A320 aircraft operated by Etihad Airlines struck Runway Edge Lights while landing at Kozhikode on 20 June 2019. The investigation report had flagged the absence of Runway Centre Line Lights at Kozhikode in its findings.

3. In 2019, a B737-800 aircraft operated by Air India Express was involved in a Runway excursion at Mangalore due to unstabilized final approach and extended flare over runway.

1.18.3 RUNWAY OVERRUN AWARENESS AND ALERTING SYSTEM (ROAAS)

Runway overruns upon landing are largely considered as one of the greatest operational risks in commercial air transport and to date they are still a major contributor to accidents. Over the last 10 years significant rule making efforts and industry activities have been committed to reduce runway excursions.

Description

EUROCONTROL's European Action Plan for the Prevention of Runway Excursions of January 2013 states that "*on-board real time performance monitoring and alerting systems that will assist the flight crew with the land/go-around decision and warn when more deceleration force is needed should be made widely available*". There are a number of commercial solutions available to address this need and have developed solutions like the Runway Overrun Awareness and Alerting system (ROAAS), which acts as a safety enhancement tool to flight crew during the approach and landing phases of flight operations in order to prevent runway excursions. EASA ED 2020/001/R mandated the implementation of ROAAS on commercial aircraft.

Contributory Factors for Overrun

The contributory factors on the flight deck which are mostly responsible for runway overruns upon landing are related to the lack of awareness that:

(i) The current aircraft energy state (i.e., height above glide slope and ground speed) may lead to an overrun.

(ii) The current autobrake setting may lead to an overrun.

(iii) The aircraft braking capabilities on the actual runway conditions are different from the planned and may lead to an overrun.

(iv) The aircraft is approaching the wrong (shorter) runway or that the approaching runway is shorter than planned and an overrun is pending.

An additional contributory factor to runway overruns has to do with the wrong or late decisions to adjust the aircraft energy state and/or configuration, and/or wrong or late decision to conduct a go-around or apply maximum deceleration.

The ROAAS Solution

ROAAS with the intended function to provide an aid to:

(i) Flight crew awareness of aircraft stopping-points relative to the approaching runway, based on real-time aircraft energy state.

(ii) Flight crew decision making for go-around and for timely use of all available stopping devices during a pending runway overrun situation.

ROAAS uses the selected runway conditions from the FMS to perform calculations and it requires no additional flight crew inputs.

1.18.4 COMPETENCY BASED TRAINING AND ASSESSMENT (CBTA)

With reference ICAO Doc 9868 (PANS TRG) ICAO task force worked on the concept of CBTA in 2017 and 2019. As per ICAO the CBTA is training and assessment that are characterized by a performance orientation, emphasis on standards of performance and their measurement, and the development of training to the specified performance standards. EASA also developed as CBTA manual in fourth quarter of 2019

Competency Based Training and Assessment as recommended by ICAO are assessed on the nine competencies listed below: -

(i) Communication

(ii) Aircraft Flight Path Management – Manual Control

(iii) Aircraft Flight Path Management – Automation

(iv) Leadership and teamwork

(v) Problem Solving and Decision making

(vi) Application of procedures

(vii) Work load Management

(viii) Situational Awareness

(ix) Knowledge

1.18.5 SIMULATOR OPERATIONS QUALITY ASSURANCE MONITORING (SOQA)

In the recent past there has been development in Information Technology which permits simulator flight data also to be downloaded like the flight data from the aircraft. Simulator data can be used to standardise the training exercises, ensure flight crew are flying stabilised approaches and touching down within the touchdown zone. Like FOQA has been a non punitive proactive programme similarly programme like SOQA can also bring in value and enhance safety in operations.

1.18.6 CHILD RESTRAINT SYSTEMS

AIXL does not have provision for child/infant restraint system and they rely solely on lap-held infants without any supplemental restraint. Out of the 10 infants on board AXB 1344, three sustained fatal injuries, three had serious injuries and four escaped unhurt.

Doc 10049, Manual on the Approval and Use of Child Restraint Systems First (Edition, 2015) approved by and published under the authority of the Secretary General, ICAO, states that statistically, the global aviation accident rate is notably low, which makes it challenging to gather enough evidence or data on infant and child safety in aviation accidents. Also, there is very limited scientific literature available on the aircraft accidents resulting in serious or fatal injuries to infants or children. Therefore, research data on dynamic seat/restraint system testing, is the only available source of information to understand the issues relating to infant and child safety during an air crash. There is no doubt that infants and young children are entitled to the same level of protection afforded to adults, both in flight and during emergency landings.

The provision of seats and restraint systems on board commercial passenger aircraft is a requirement of Annex 6 - Operation of Aircraft. The current SARP require that a seat or berth be provided for each occupant over a certain age. This age is determined by the State. Additionally, Annex 6 currently states that restraint systems (e.g. seat belt) must be provided for each seat or berth. Paragraph 6.2.2 of Annex 6, Part I - International Commercial Air Transport - Aeroplanes, states that, *"An aeroplane shall be equipped with a seat or berth for each person over an age to be determined by the State of the Operator; a seat belt for each seat and restraining belts for each berth; and a safety harness for each flight crew seat*".

Chapter 3 para 3.5 of ICAO Doc 10049 on 'Methods of Restraining Infants/Children on board Aircraft' lists out the methods of restraining infants/children on board aircraft (which are to be clearly outlined by the State). The manual states the following points related to double-seat occupancy: -

(a) Lap-Held Infants without Supplemental Restraint.

(b) Supplemental loop belt.

1.18.7 BLACK HOLE APPROACH

A visual illusion known as "black hole effect" is another inherent risk of night visual approaches. The black hole conditions exist on dark nights (usually with no moon or starlight), when there are no ground lights between the aircraft and the runway threshold. The black hole illusion, sometimes called Featureless Terrain Illusion, deceives pilots into thinking they are higher than they actually are, causing them to fly low approaches.

Apart from the terrain illusion, an upslope runway provides the illusion of being too high during a straight-in approach. This results in a strong tendency to descend prematurely. Additionally, peering through a rain-soaked windshield can convince a pilot (because of refraction) that the aircraft is too high. Viewing an airport through an intervening rain shower makes the runway lights seem bigger than they are, causing a pilot to believe the aircraft is too high.

1.19 EFFECTIVE INVESTIGATION TECHNIQUE

Investigation team carried out performance analysis for different hypothetical scenarios to assess conditions in which the aircraft could have stopped within the available runway length including RESA or been able to carry out a safe balked landing from actual touchdown point. Investigation Team also analysed the behaviour of Speed Brake Lights recorded in the DFDR data to check possibility of locked wheel/hydroplaning. The results are discussed as following.

1.19.1 LANDING ROLLOUT AND TAKE-OFF ROLL DISTANCES ANALYSIS

A performance analysis was conducted to calculate the required landing rollout distance and takeoff roll distance under different hypothetical scenarios to identify the conditions under which the aircraft could have been stopped within the available Runway and RESA. Hypothetical scenario of a balked landing was also analysed.

Available distance was calculated based on the actual touchdown point of AXB 1344, which was taken as 4438 ft from the threshold of runway 10. All variables used for this calculation were taken as per the prevailing conditions at this point. The values of variables used for analysis are given in the table below:

Flaps	Landing Weight (Kg)	Temp (degrees Celsius)	Runway 10 Declared Distance Remaining (feet)	Runway Paved Distance Remaining (feet)	Winds (knots)	Runway Elevation at Touchdown (feet)	Touchdown Airspeed/ Ground Speed (knots)	Runway Slope (%)
30	62908	24	4420	4945	-15	343	150/165	-0.3

Winds, touchdown speed, weight and flaps settings were taken from DFDR data. Runway slope and elevation were taken from the published AIP and temperature was taken from the actual METAR.

Different scenarios were assumed based on sequence for application of Brakes and Thrust Reversers derived from DFDR and its combination with hypothetical scenarios where Brakes were applied at 02 seconds from touchdown and continued till the end and Max Thrust Reversers were deployed at 5.5 seconds from touchdown and retained till the end. Speed brakes were assumed ‘UP’ at 01 sec and deployed till the end in all scenarios.

The calculations were carried out for Airplane Braking Friction Co-efficient value of 0.13, which is the average Airplane Friction experienced by the aircraft from point of touchdown till end of RESA and replicated for Airplane Friction Co-efficient value of 0.15 which is the average value experienced by the aircraft during the later part of runway beyond 7181 ft from threshold when the Thrust Reverser was deployed for the second time. The different scenarios are listed in the table below:

Scenario #	Manoeuvre	Airplane Braking Friction Coefficient	Speedbrakes Sequence At Time After Touchdown (sec)	Brakes Sequence At Time After Touchdown (sec)	Thrust Reverser (TR) Sequence At Time After Touchdown (sec)
1	Landing- Normal TR Deployment	0.13	Up @1s	On @2s -> Off @8.5s -> On @10.2s	TR-MAX @5.5s
2	Landing- Normal TR Deployment	0.15	Up @1s	On @2s -> Off @8.5s -> On @10.2s	TR-MAX @5.5s
3	Landing- Normal TR Deployment	0.13	Up @1s	On @2s	TR-MAX @5.5s
4	Landing- Normal TR Deployment	0.15	Up @1s	On @2s	TR-MAX @5.5s
5	Landing- Multiple TR Deployment	0.13	Up @1s	On @2s -> Off @8.5s -> On @10.2s	TR On @5.5s-> Stowed @6.5s -> TR-MAX @16s -> Stowed @20.5
6	Landing- Multiple TR Deployment	0.15	Up @1s	On @2s -> Off @8.5s -> On @10.2s	TR On @5.5s -> Stowed @6.5s -> TR-MAX @16s -> Stowed @20.5s

Similarly, two different hypothetical balked landing scenarios were evaluated assuming a non-normal scenario in which a go-around is attempted after thrust reversers are deployed and stowed before rotation and a scenario where a go-around is performed soon after touchdown occurs, assuming that thrust reversers were never deployed.

The calculations were carried out for Airplane Braking Friction Co-efficient value of 0.13 and 0.15 giving four balked landing scenarios shown in the table below.

Scenario #	Manoeuvre	Airplane Braking Friction Coefficient	Speedbrakes Sequence At Time After Touchdown (sec)	Brakes Sequence At Time After Touchdown (sec)	Thrust Reverser (TR) Sequence At Time After Touchdown (sec)
7	Balked Landing With TR Deployment / Stowage	0.13	Up @1s-> Down @7.5s	On @2s -> Off @6.5s	TR On @5.5s -> Stowed @6.5s

8	Balked Landing With TR Deployment / Stowage	0.15	Up @1s-> Down @7.5s	On @2s -> Off @6.5s	TR On @5.5s -> Stowed @6.5s ->
9	Balked Landing Without TR Application	0.13	Up @1s-> Down @6.5s	On @2s -> Off @5.5s	-
10	Balked Landing Without TR Application	0.15	Up @1s-> Down @6.5s	On @2s -> Off @5.5s	-

All four of the balked landing scenarios evaluated below assumed that flaps are retracted from flaps 30 to a flaps 15 configuration after deceleration devices are retracted or stowed. The scenarios also assume that the engine was stabilized, the stabilizer trim was reset, and throttles were advanced to go-around thrust followed by rotation and lift-off, which occur at slightly different times for the different scenarios.

The distance required by the aircraft to come to a full stop, to lift-off and to achieve V_R is given in the table below.

Scenario #	**Touchdown to Stop Distance (feet)**	**Touchdown to VR Distance (feet)**	**Touchdown to Liftoff Distance (feet)**
1	5363	-	-
2	5011	-	-
3	5213	-	-
4	4849	-	-
5	6641	-	-
6	6023	-	-
7	-	5215	5860
8	-	5234	5879
9	-	4885	5529
10		4904	5549

From the above analysis it can be concluded that the aircraft would not have stopped within the declared runway distance of 8858 ft in any of the scenarios. In Scenario 4 the aircraft would have stopped on the paved surface of the Runway i.e. 9383 ft. In Scenario 2 the aircraft would have overshot the Runway but stopped on the paved Runway Strip and in scenario 1 and 3 the aircraft would have stopped within the RESA soft ground area. Required Landing Roll-out Distance in case of Scenario 5 and 6 which closely replicate the sequence of actual events that occurred during the accident was more than the total Runway Length, Runway Strip and RESA put together.

Similarly, for balked landing the aircraft could have achieved V_R on Runway Strip in scenario 9 and 10 only. The aircraft could not have reached Lift-off height in any of the analysed scenarios.

In addition to the above, additional hypothetical scenarios (# 11 to # 14) were also analysed. With all other conditions including the touchdown point (4438ft from threshold) remaining the same, if the pilot had opted/decided to land on runway 28, 15 kt of tailwinds experienced on runway 10 would have been 15 kt of headwinds, thereby resulting in a reduction of actual ground speed from 165 kt to 135 kt. The different scenarios are listed in the table below:

Scenario #	Manoeuvre	Airplane Braking Friction Coefficient	Speedbrakes Sequence At Time After Touchdown (sec)	Brakes Sequence At Time After Touchdown (sec)	Thrust Reverser (TR) Sequence At Time After Touchdown (sec)
11	Landing - Normal TR Deployment	0.13	Up @1s	On @2s	TR-MAX @5.5s
12	Landing - Normal TR Deployment	0.15	Up @1s	On @2s	TR-MAX @5.5s
13	Balked Landing w/ out TR Application	0.13	Up @1s-> Down @6.5s	On @2s -> Off @5.5s	-
14	Balked Landing w/ out TR Application	0.15	Up @1s-> Down @6.5s	On @2s -> Off @5.5s	-

The touchdown to stop distance, touchdown to VR distance, touchdown to Lift-off distance as per the above scenarios is given in the table below:-

Scenario #	Touchdown to Stop Distance (feet)	Touchdown to VR Distance (feet)	Touchdown to Liftoff Distance (feet)
11	3488	-	-
12	3257	-	-
13	-	3986	4523
14	-	3995	4531

With all other conditions remaining unchanged, had the aircraft landed on runway 28 it would not have faced any problem in the above scenarios and would have stopped or gone around safely even after touchdown at 4438 feet.

1.19.2 SPEEDBRAKE LIGHT ANALYSIS

The wheel speeds are not recorded in the DFDR. In order to rule out if Antiskid System functioned properly and no wheel locking happened, behaviour of 'SPEED BRAKE ARMED' light and 'SPEED BRAKE DO NOT ARM' light in cockpit was analysed. 'SPEED BRAKE DO NOT ARM' (SBDNA) light and the 'SPEED BRAKE ARMED' (SBA) light signal is recorded on the DFDR. The SBDNA and SBA light logic are based on parameters from multiple different sources, including speed brake lever position, throttle position, air/ground relays, antiskid module health, and individual wheel speeds on the landing gear.

During landing, the auto speedbrake operates when all these conditions are met.

- The altitude is less than 10 feet from the flight control computers to the R/A<10 ft relays,
- The MLG is on the ground or the MLG wheels spin up,
- The speed brake lever is in the armed position,
- Both left and right thrust levers are at idle.

SBA and SBDNA light logic within the Speed Brake Module monitors the four main wheel speeds for spin rates above 60 kt. Signals from the left outboard (wheel 1) and right inboard (wheel 3) are paired, and the left inboard (wheel 2) and right outboard (wheel 4) are paired.

Speed Brake Arm (SBA) Light

The SBA light will illuminate during landing roll when the speed brake system is armed or extended with valid system inputs. Under normal circumstances and with the aircraft on ground for more than four seconds, the SBA light will be illuminated when all of the following conditions are met:

- Both throttle angles are less than 44 degrees (Reference: 36 degrees corresponds to forward idle)
- Sensed wheel speed is greater than 60 kt on at least one even numbered and at least one odd numbered wheel
- Speed brake lever is NOT in the DOWN position

Speed Brake Do Not Arm (SBDNA) Light

During landing roll, the SBDNA will illuminate when there is a disagreement between the paired wheel spin determinations (>60 knots sensed on one or both wheels within the pairing).

Under normal circumstances after landing with the aircraft on ground for more than four seconds, the SBDNA light will be illuminated when any of the following conditions are met:

- [(Wheel 1 Speed > 60 knots) OR (Wheel 3 Speed > 60 knots)] AND [(Wheel 2 Speed < 60 knots) AND (Wheel 4 Speed < 60 knots)] AND Speed brake lever NOT in the DOWN position
- (Wheel 1 Speed < 60 knots) AND (Wheel 3 Speed < 60 knots) AND [(Wheel 2 Speed > 60 knots) OR (Wheel 4 Speed > 60 knots)] AND Speed brake lever NOT in the DOWN position
- (Wheel 1 Speed < 60 knots) AND (Wheel 3 Speed < 60 knots) AND (Wheel 2 Speed < 60 knots) AND (Wheel 4 Speed < 60 knots) AND Speed brake lever NOT in the DOWN position AND Auto Speed brake Actuator remains extended

As covered in condition (2) enumerated above, under normal circumstances as the aircraft decelerates below 60 kt after landing, the SBDNA light will illuminate if the auto speed brake actuator has not yet been retracted.

Above 70 kt ground speed data for the SBDNA and SBA lights during the event approach and landing are shown in Figure 59 below.

Figure 59: SBDNA and SBA Lights Graph (above 70 Kts)

It can be seen from the Figure 59 that the SBA light was recorded to illuminate when the speed brake lever was set to ARM on approach. The SBA light remained illuminated until after the aircraft landed and decelerated below 70kt ground speed. Based on this observation, it can be inferred that multiple wheels (at least one even number wheel and one odd number wheel) were sensed to rotate greater than 60 knots within four seconds of landing and remained that way during deceleration through 70 knots of the PIC side recorded ground speed.

The behaviour of the SBDNA light as seen in the figure 59 indicates that SBDNA light was recorded on the DFDR to be OFF on the event flight until the aircraft was below 70 knots groundspeed. The recorded state of the SBDNA light indicates that the paired wheel spin determinations (Greater than 60 knots sensed on one or both wheels within the pairings) were in agreement following touchdown and while above 70 knots groundspeed during the landing deceleration.

From the recorded behaviour of the SBDNA and SBA lights, for Ground Speed above 70 knots, it can be concluded that multiple wheels were sensed to be spinning greater than 60 knots and that there was no disagreement between the paired wheel speed determinations for the majority of the landing roll. Due to a four second time delay in the SBA and SBDNA logic after touchdown, no conclusions about wheel speed during the first four seconds after landing can be drawn from the behaviour of the lights.

The behaviour of SBDNA and SBA lights during the final portion of landing roll below 70 knots is shown in figure 60 below.

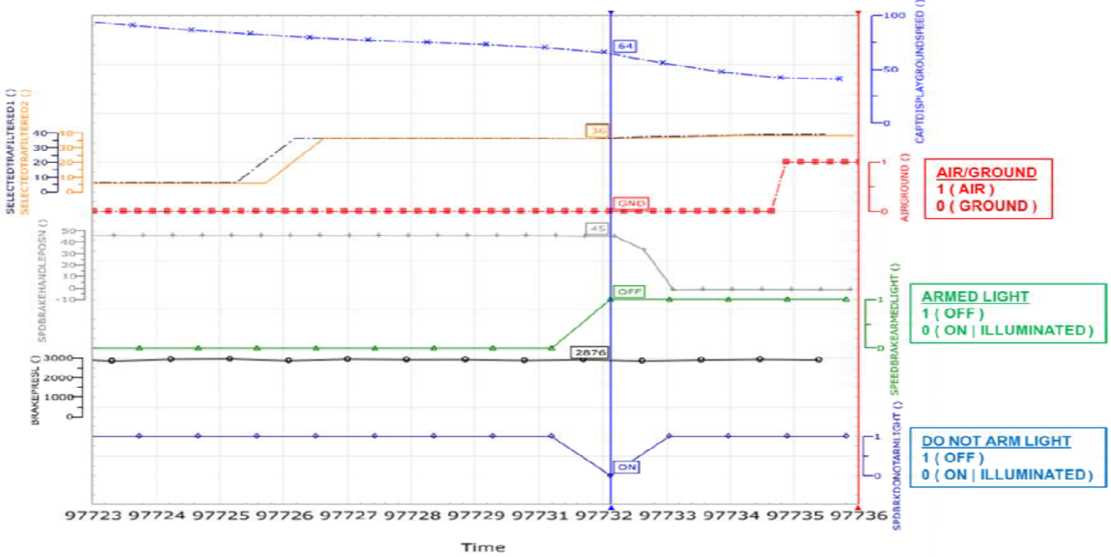


Figure 60: SBDNA and SBA Lights Graph (below 70 Kt)

The SBDNA light was recorded to be illuminated for one FDR data frame with the aircraft position: Latitude 11.13327, Longitude 75.969257. The aircraft recorded ground speed was 66 knots at the time and the recorded position is approximately 105 feet beyond the runway hard surface. Below 70 Kt ground speed The SBDNA light would have illuminated in a scenario where there is disagreement between the sensed wheel speeds (i.e. Wheel speed greater than 60 knots sensed on one wheel of a pair, with both wheels on the opposite pair sensed at less than 60 knots).

This scenario is considered likely reason for SBDNA light behaviour as the aircraft was on a soft surface and ground speed was approaching 60 Kt at the time the SBDNA light was recorded. The speed brake lever was stowed shortly after the SBDNA light was recorded. The SBDNA light was turned OFF after the speed brake lever was stowed consistent with expected system behaviour.

The behaviour of SBA and SBDNA lights during the previous flights was also studied and was observed to be consistent with expected system behaviour. The runway length over which multiple wheels (at least one even number wheel and at least one odd numbered wheel) were inferred to be spinning during the event landing based on behaviour of SBA and SBDNA lights is shown in the figure 61.

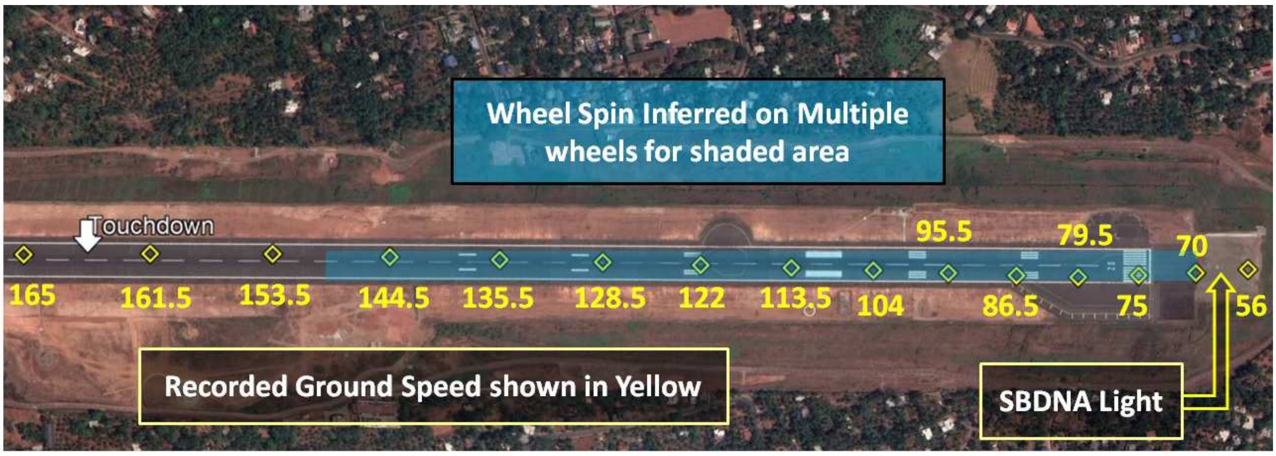


Figure 61: Wheel Spin Analysis

2 ANALYSIS

2.1 AIRCRAFT

The aircraft (VT AXH) held a valid certificate of airworthiness and was maintained as per the DGCA approved 'Aircraft Maintenance Programme (AMM)'. Aircraft remained grounded for more than two months, from 21 March, 2020 to 26 May, 2020, due to closure of airspace during Covid-19 pandemic and curtailed airline operations. The aircraft was preserved in accordance with the procedures laid down in AMM. It was released for service and operated its first flight after de-preservation on 01 June, 2020. It had flown 156.12 hrs after resumption of flights till the day of the accident and there were no deferred maintenance item on the aircraft before operating the flight AXB 1343/1344 on 07 August, 2020.

The flight report book has two sections. Section 'A' contains all additional information such as MEL/CDL status NTC etc and section 'B' contains technical log/voyage report. Section 'B' that was recovered from the wreckage site was found to be in order however, Section 'A' was not recovered from the wreckage. As per the pre-flight briefing documents presented to the PIC, the aircraft had CDL for 'missing static discharger on RH horizontal stabilizer tip'. Technical records for the same were investigated, it was found that the CDL was invoked in October 2019 and after rectification it was revoked in November 2019, however, because of an error in updating the status of deferred defect by AIXL MCC, it continued to reflect in the Daily Deferred Maintenance Status over a period of 09 months. AIXL Despatch updates the MEL/CDL status on the CFP after referring to the status provided by MCC. This CDL continued to remain in effect and was also reflected in the CFP presented to the PIC on the day of the accident. The MEL/CDL status of the whole fleet is accessible to maintenance as well as Despatch/Operations department however, the discrepancy was not identified by any of these departments during the entire period.

DFDR recording of flight AXB 1344 was closely examined and it was concluded that the aircraft and all systems, including the ones related to deceleration on landing, were serviceable and airworthy. Since, ability of the aircraft to stop within the remaining runway length was a factor in the accident, all the deceleration devices on the aircraft were examined specifically and no defects could be established.

The aircraft engine exhibited fan blade damage due to ingestion of hard rocks and binding with the air intake lip metal, the leading edge impact damage was consistent with ingestion of foreign object while the engines continued to operate during the impact sequence. Examination of the engines and its associated components from the accident airplane revealed no evidence of pre-impact anomalies. The investigation revealed no mechanical defect in the aircraft or its engines that could have contributed to the accident except the Captain side windshield wiper which, as per the CVR recording, stopped working on the first approach and then on the second approach operated at a speed lower than the selected speed. In addition, the right brake pressure transducer for DFDR was found unserviceable.

2.1.1 DECELERATION DEVICES

The aircraft touched down well beyond the touchdown zone at approximately halfway down the runway with a high ground speed of 165 kt. The capability of the aircraft to come to a full stop within the remaining length of runway under the prevailing wet runway condition was assessed. Analysis of DFDR data along with the results of detailed inspection and testing of associated systems and components was carried out jointly by the Investigation Team and the Accredited Representatives.

After touchdown, the PF immediately resorted to max manual braking overriding the auto brake '3' selection. This provided the best possible deceleration rate under the prevailing wet runway condition, where braking was friction limited. The speed brakes (spoilers) were automatically deployed immediately after touchdown and remained in that state till they were selected 'down' when the aircraft was in the RESA. The thrust reversers were selected to deploy 03 seconds after touchdown and deployed 05 seconds after touchdown for a brief period of only 02 seconds only before being stowed back. The contribution from the thrust reversers could hardly take any effect before they were stowed back.

09 seconds after touchdown during the process of stowing the thrust reversers, the aircraft brake pressure was momentarily reduced by the PF. The thrust reversers were deployed again 15 seconds after touchdown when the aircraft was near the end of runway and max reverse thrust was selected. The engines began to spool up following the maximum reverse thrust command. After being deployed for 07 seconds, the thrust reversers were again stowed back, with the engines still being at a high fan speed (N1).

Other than the instance when the thrust reversers were stowed and the commanded brake pressure was reduced, the brake pressure was maintained close to the maximum system pressure value throughout the landing roll.

The first stowing of the thrust reversers and simultaneous momentary reduction of brake pressure resulted in a decrease in the braking coefficient, thereby further increasing the runway length required to stop the aircraft. The DFDR data also indicated that stowing of thrust reversers while the engines were still at a high RPM, proved to be counterproductive, as it contributed to momentarily accelerating the aircraft, while other devices were decelerating the aircraft. All the above actions by the PF further deteriorated the situation and the aircraft did not stop on the remaining runway length.

The probe into the reasons for RH brake pressure not getting recorded in the DFDR revealed that it was due to an unserviceable brake pressure transducer rather than any failure in the aircraft brake system. The aircraft had not experienced any directional loss during the landing roll and test carried out on AACU, Brake Metering Valve, Antiskid Valves, tyres and brakes did not indicate any pre-impact anomalies, which could have affected the braking performance. All brake wear were found within the AMM specified limits.

Analysis of the event of speed brake lights being recorded in the DFDR was carried out. It was inferred from the behaviour of speed brake light that multiple wheels (at least one even number wheel and at least one odd number wheel) were spinning during roll out. Therefore, it was concluded that during braking, the tyres had adequate contact with the runway surface and continued spinning above 60 kt. Wheel spin is an indication of adequate contact of the tyres with the runway and indicates that there was no hydroplaning.

During inspection and detailed testing of aircraft tyres, tread wear was found within the AMM specified limits with tread groove depth varying from 3.67 to 8.89 mm. No physical evidence of hydroplaning like, flat spot or rubber reversion was observed on the tyres. Correspondingly, during runway inspection, no evidence of tyre marks were observed on the runway surface.

2.1.2 BRAKE PRESSURE TRANSDUCER

During analysis of DFDR data of the accident aircraft, it was observed that right metered brake pressure being recorded was indicating a constant (-)165 psi during all phases of flight. On further analysis of archived DFDR data, it was observed that right brake pressure transducer had been recording the same value since its installation.

Right brake pressure transducer was retrieved from the wreckage and tested at an approved facility. The functional check declared it as 'confirmed failure'. This status of the transducer was being recorded in the DFDR but was not detected. Various occasions where it should have been identified are enumerated below:

(a) At the time of installation when it was required to be tested using hand held - multipurpose interface units/ download units.

(b) During annual check of the flight recorder system, as mandated by CAR Section 2 Airworthiness, Series I Part V, when all mandatory and additional parameters are verified.

(c) During phase 15 inspections, as per the approved maintenance program, wherein, the functional check of parameter being recorded in DFDR, DFDAU and Interfacing Systems is required to be carried out.

The DFDR data showed illogical value for the right brake pressure transducer but it was certified as normal/active on the DFDR readout reports by the AIESL approved engineer. On investigation, it was found that the certifying approved engineer was not able to identify the illogical values and was not conversant with interpreting the recorded readings and its consequences.

The right brake pressure transducer was cannibalised from aircraft VT-AXI for installation on VT-AXH. On analysis of archived DFDR data of VT-AXI, it was observed that the particular brake pressure transducer was providing the same constant (-)165 psi reading during all phases of flight. This indicates that the brake pressure transducer was unserviceable on VT-AXI as well before being installed on VT-AXH.

This reflects the poor standard of maintenance practices of AIESL.

2.1.3 WINDSHIELD WIPER

AXB1343 departed from Kozhikode in the morning with no rain over the airfield. Same was the case during landing in Dubai on the return flight, AXB 1344 departed in CAVOK conditions from Dubai, thereby indicating that the use of Windshield Wiper was not warranted until first approach into Kozhikode. The CVR transcript revealed that the wiper on the Captain side did not work during the approach to land on runway 28. However, during the approach for runway 10, the CVR transcript revealed that the wiper on the Captain side worked, albeit at a speed lower than the one selected. Subsequent to the accident, the wiper motor converter, wiper selector switch and the wiper blade assembly were tested as per CMM for all speed conditions and found to be operating satisfactorily. The aircraft wiring check was also carried out as per FIM and WDM and did not reveal any insulation failure, abnormality or breakage.

There is no technical evidence to support the fact that the wiper on the Captain side did not function. Since, no data for the wiper operation is recorded on the DFDR, the Investigation Team has no other method to conclusively establish the wiper operation. However, the convincing evidence from the CVR transcript cannot be overlooked. Hence, it is concluded here that the wiper on the Captain side stopped working after operating for about 27 seconds during the approach to land on runway 28 and, although during the approach for runway 10, it worked, albeit at a speed lower than the one selected.

2.1.4 COCKPIT CONTROLS AND SWITCH POSITIONS

The impact caused extensive damage to the cockpit. The pilots were rescued through the opening formed between the damaged front windshield and the instrument panel. The frontal impact caused both the pilot seats to move and bend forward with extensive damage to the seat structure and tracks. The overhead switch panel was dislodged and the cockpit floor crumpled upwards, thereby reducing the manoeuvring space in the cockpit. Hence, the rescuers might have stepped on the main instrument panel and controls to gain access to the injured pilots.

Therefore, the post-crash cockpit controls and switch positions cannot be used to draw meaningful conclusions, as these might have been moved during the rescue efforts. The Captain was rescued by the CISF personnel stationed nearby and the First Officer was rescued by unidentified local civilians who managed to reach the crash site from nearby areas. Hence, the position of controls and switch seen in the photographs taken by the 'Go Team' and during inspection by the investigation team cannot be assumed to be same as at the time of accident.

Disagreements regarding position of Thrust levers, Speed brake and Flap selector were resolved by CVR data, DFDR analysis and measurements of relevant control surfaces position and their components.

The throttle lever position at the crash site did not correspond to the last recorded position in the DFDR data just before impact. It was found that the engine throttle levers were jammed at the full forward position with the stop plate bent forward. This was attributed to impact damage to the Thrust Lever Resolver Assemblies and Control Rods, which moved backwards thereby forcing the throttle lever forward with such force that the levers bent the stop plate.

Speed brake lever was free to move without any frictional load as the control rod transmitting the lever movement to speed brake forward drum was broken due to impact. The lever position recorded in the DFDR just before impact was in down detent position and is used for further analysis.

The Flap lever was found to be at Flap 40 selection and free to move without any frictional load. This position did not corroborate with the Flap 30 selection last recorded in the DFDR. The actual Flap position was confirmed by physically measuring the flap jack screw length. The measured length corresponds to the Flap 30 selection as recorded in DFDR.

2.2 AERODROME

2.2.1 RUNWAY AND ITS ASSOCIATED FACILITY

Kozhikode Airport has one runway with designation 10/28. Kozhikode runway is a precision approach Category 1 runway. Physical length of pavement (Distance between the thresholds) is 2860 m. However, in order to implement the recommendation given by Court of Inquiry in the Mangalore aircraft crash of 2010 and directive by DGCA to provide RESA (Runway End Safety Area) of dimensions 240m x 90m, the declared distances were reduced and presently the take off run available/take off distance available/landing distance available is 2700 m. RESA for runway 10 and runway 28 is now provided as 240m x 90m at both the ends of runway. The bearing strength of the runway is PCN 71 F/B/W/T (Flexible pavement, Medium strength sub grade, unlimited tyre pressure and Technical evaluation). The width of the runway is 45 m with 7.5 m paved shoulder. The longitudinal slope of runway 10 / 28 is +0.3 / -0.3% and runway transverse slope is 1.5%. The aerodrome is approved for Code E operations (Wide Body Aircraft Operations). The runway coefficient of friction as measured on 07 August, 2020 and on 08 August, 2020 was found to be 0.6 μ, which is more than the maintenance value i.e.0.5 μ. Rubber deposits were removed periodically. The last rubber removal was done on 30 July, 20. In addition, the feedback from the operating crew also confirmed that the braking action even on the wet runway was 'Satisfactory'. Hence, the Investigation Team firmly believes that the runway surface characteristics were satisfactory.

2.2.1.1 AERODROME GROUND LIGHTS

Kozhikode airport has the requisite Aerodrome Ground Lights as required by the CAR Section 4-Aerodrome, Series B, Part I. The Centre Line lights on the runway are not available on runway 10/28 as the same are not mandatory as per provisions of CAR Section 4 Series B Part I, as quoted below:

> *"5.3.12.1 Runway centre line lights shall be provided on a precision approach runway category II or III.*
>
> *5.3.12.2 Runway centre line lights shall be provided on a precision approach runway category I, particularly when the runway is used by aircraft with high landing speeds or where the width between the runway edge lights is greater than 50 m*."*

*At Kozhikode, width between runway edge lights is 48.5m.

Runway 28 has lead-in lights. There are no lead-in lights available for runway 10. The simple approach lighting system is available for both runways but only up to 150 m whereas, as per the above mentioned CAR, it should extend over 900 m. Due to non availability of land, as a mitigation measure, the 3 m long barrettes have been provided and Visibility Minima for Cat 1 ILS for both runways has been increased from 800 m to 1300 m.

2.2.1.2 RUNWAY END SAFETY AREA

Primary aim of the Runway End Safety Area is to reduce the risk of damage to an airplane undershooting or overrunning the runway (Runway excursion). Due to land constraint, the last 3.6 m length of Runway 10 RESA has a width of 85.6m and the last 9.7 m length of length of Runway 28 RESA has a width of 71.2 m, against mandatory requirement of RESA with dimensions 90m X 90m and 240m X 90m as recommended by DGCA to implement the recommendation of the COI.

In accordance with Annex 14, Attachment A, Para 10.2, the Runway Declared Distances have been reduced to provide RESA. Since a portion of runway has been declared as RESA, the surface of about 160 m of RESA is of the same PCN and characteristics as the runway surface and 60 m after that is graded area. Only, the last approximately 90m X 90m portion of RESA is soft ground. The California Bearing Ratio (CBR) value for soft ground arresting system on RESA was found to be 16.2 as per available records.

During the visit of Investigation Team it was observed that concrete slabs on which the frangible light fittings and ILS localizer antenna are installed, are protruding above the ground which would adversely affect the aircraft deceleration. In addition, wild vegetation was also seen growing on the soft ground portion of RESA. The poor maintenance of Soft Ground portion of RESA will adversely affect the desired deceleration of the aircraft.

The Soft Ground portion of RESA provided an average longitudinal deceleration of -0.40 G with peaks of up to -0.64 G as calculated from the DFDR data. However, it was not enough to stop the aircraft as the aircraft crossed the declared end of runway 10 at a ground speed of 84.5 kt and entered the soft ground portion of RESA at a ground speed of 70 Kt. (Figure 62)

Figure 62: Ground Speed of the Aircraft with reference to RESA

2.2.2 NAVIGATION AIDS

All the Nav-Aid equipments were reported to be functioning properly before the accident. The airport was handling more than 70 flights per day pre-covid but there is no approach radar available at Kozhikode airport. Non-availability of approach radar has also been highlighted by DGCA. ADS-B facility is available at Kozhikode which provides only surveillance and monitoring facility of the aircraft.

The Officer In Charge CNS informed the Investigating Team that there were occasional aircraft reports about fluctuation of glide path runway 28 below 600 ft. Due to land constraints, ILS 28 lacks critical area to the right of the antenna. In response to DGCA audit findings and occasional reports about fluctuation of glide path runway 28 below 600 ft, an artificial ground plane of 4.2m x 330m was constructed with a wire mesh counterpoise resulting in improvement of Lower Half Sector Width. The proposal is underway to extend mesh artificial ground to the required length and breadth to form 21m x 300m metallic structure in level with ground.

Air calibration of the ILS at Kozhikode was due on 08 July, 2020 but could not be carried out due to prevailing Covid-19 restrictions. However, in the absence of calibration, enhanced routine maintenance of ILS was being carried out, as per the specified schedule and there were no reports of ILS malfunction.

2.3 WEATHER

The cockpit crew of AXB 1344 were fully aware of the fluctuating winds, low visibility, rains and runway conditions etc. through the ATC transmissions, METAR and weather report from ATC. DATCO had reported winds from 05kt to 10kt at different instances to the crew. The source of these winds was stated to be the Wind Display Instrument in the ATC tower. Wind speed reported by the ATC was much lower than the actual prevailing winds as evident from DFDR data analysis. The winds information from the DFDR indicated a tailwind of 16 Kt when the aircraft was at 30 ft RA.

The wind measuring instrument is required to be installed at a height of 10m +/- 1m as prescribed in relevant CAR. However, at Kozhikode, height of the wind sensor for Runway 10 was found to be only 3.5 m above the runway surface against the prescribed 10 m and was installed away from the runway, inside the narrow valley created between the table-top runway edge and airport buildings. This anomalous location of the wind measuring instrument would have resulted in the errors in the reported winds compared to the actual.

Further, frequent snags were documented for Runway 10 wind measuring instrument during the preceding six months which reflects an inadequate and poor maintenance practice. Even after the accident the Runway 10 wind measuring instrument was reported unserviceable frequently and stopped functioning after Jan 2021. The equipment was later replaced by serviceable unit in May 2021.

The weather transmitted to the crew on R/T at different timings by the ATC is given below:

Time (UTC)	Weather	Remarks
13:18	Winds 270/14 Kt Visibility 1500 m with Moderate Thunderstorm and Rain.	Passed by ATC to AXB1344
13:33	QNH 1007	Passed by ATC to AXB1344
13:34	Visibility 1500 m, FBL TSRA	Passed by ATC to AXB1344
13:42	Visibility 2000 m in Light Rain	Passed by ATC to AXB1344
13:49	Visibility 2000 m, likely to decrease to 1500 m, Runway Surface Wet, Light Rain, Wind 280/05 Kt	Passed by ATC to AXB1344
13:55	Wind 270/08 Kt	Passed by ATC to AXB1344
13:56	Visibility 2000 m for both runways, Light Rain, Winds 260/05 Kt	Passed by ATC to AXB1344
13:57	Visibility 2000 m, Winds 260/05 Kt, CB at 2500 feet towards N, NW, W, E, SE	Passed by ATC to AXB1344
14:00	Wind 260/10 Kt	Passed by ATC to AIC425, monitored by AXB1344
14:08	Visibility 2000 m , Light Rain, Runway Surface Wet, Wind 250/08 Kt	Passed by ATC to AXB1344

Weather at Kozhikode was rain with CBs all around. The intensity of rain was varying from light to moderate as corroborated from the available witnesses' statements. The visibility also fluctuated between 1.5 km and 2 km. However, at the time of landing of AXB 1344 on runway 10, the reported visibility was 02 km in light rain. Although, the reported sunset time at Kozhikode on 07 August, 2020 was at 18:49 IST, darkness had set in early due to prevailing cloud cover and rain.

The DATCO did not update the cockpit crew of the latest QNH. Three consecutive METARs (1330UTC, 1344 UTC and 1400 UTC) indicate the updated QNH as 1008 but AXB 1344 was not updated with this information by the DATCO.

While Kozhikode airport was under two concurrent weather warnings at the time of accident, statements from the witnesses confirm that the TMO was not available in the ATC tower at the time of the crash in contravention to his prescribed duty as enumerated in CAMD Aviation Circular dated 01 Nov 2018. The duty MET officer was in the MET section. Presence of the TMO in the ATC tower would have certainly aided in monitoring of the dynamic weather situation and provided useful inputs to the DATCO.

2.4 CREW PERFORMANCE AND PROFICIENCY

2.4.1 CREW QUALIFICATION

The cockpit crew as well as the cabin crew were fully qualified to undertake this flight. All crew members were within the FDTL.

2.4.2 OPERATIONAL PROCEDURE

The crew undertook a quick return flight Kozhikode-Dubai-Kozhikode on 07 August, 2020. The flight was uneventful until the approach into Kozhikode on the return sector. Flight AXB 1344 attempted two landings into Kozhikode. The first attempt on runway 28 was unsuccessful and a missed approach was carried out, while the second attempt on the reciprocal runway 10 resulted in the crash.

2.4.2.1 DESCENT

It was active monsoon season in India and the Indian peninsula was experiencing heavy rains, causing wide variations in the visibility and wind patterns. In such weather conditions frequent changes in the runway were expected and the crew was well aware of this fact. Kozhikode being a Class 'C' (critical) airfield (as per the AIXL OM, Part A, Chapter 24), only the PIC can be the 'Pilot Flying' (PF) for operating in and out of Kozhikode. The PF carried out the approach briefing prior to the top of descent, however, the briefing did not cover some very important aspects.

As evidenced by the CVR transcript, the vital aspect of ALD calculation was omitted during the approach briefing. The CFP where the performance calculations are documented could not be retrieved from the wreckage. The AIXL SOP defines how and when the approach briefing should be carried out. Para 1.3.26 of the SOP comprehensively covers this aspect. ALD calculation is of paramount importance especially while landing on a table top runway like Kozhikode during rain. This act of omission may be attributed to a routine practice in the airline, as the PF was familiar with Kozhikode airfield and had adequate experience of operating from this airfield under similar weather conditions.

The PF did not cover the contingency of change of runway from runway 28 to runway 10 in his briefing. Probable reason for this omission could have been the prevailing winds (270/14kt), which were beyond the tailwind limit of 10kt for landing on runway 10.

As part of the descent check list, the crew must confirm the serviceability of all systems by scanning the cockpit and also verify this by checking the automated RECALL function. The CVR recording confirms that no fault was observed by the crew and aircraft was fully serviceable. Descent check list was carried out at 13:35 UTC while descending through 13500 ft.

As per the CVR transcript, the PF did not carry out the arrival briefing for the CCIC. Also, prior to the approach for runway 28, the flight crew did not make the mandatory announcement for the cabin crew to be seated for landing. Although, it is rare for the cockpit crew to omit such an announcement, they were possibly pre-occupied with the approach into the bad weather and due to lack of attention, missed out on making this important announcement, thereby compromising cabin crew safety.

2.4.2.2 FIRST APPROACH

The first approach carried out into Kozhikode was on runway 28. It was flown with autopilot and auto throttle engaged and met the stabilized ILS approach criteria till the prescribed Decision Altitude (DA).

The cockpit conversation recorded on CVR regarding windshield wiper, immediately after establishing on ILS localiser, indicates that the PF was uncertain of its serviceability. As per CVR recording, at 13:48:24 UTC, PF is heard saying "*you just see that it works…remember put it to high…high speed*" indicates PF was already apprehensive about the reliability of the windshield wipers before selecting it for landing. During normal line operations, selection of switches is a routine activity for qualified and experienced PM. PF only cautions/briefs in non-normal and adverse situations or system malfunctions. Therefore, a possibility of verbal briefing to the crew about serviceability of the windshield wiper was suspected.

A non-standard call was again given by the PF to the PM while asking for the wipers to be selected for landing. As per the CVR recording, PF call "*Isko on kar dete hain (let us put it ON)*". Thereafter, the PM selected the wipers for landing, probably at time 13:50:41 UTC at 2258 ft PA on approach. At 13:51:05 UTC, visual contact with the lead-in lights was confirmed by both the pilots.

The wiper on the Captain side worked for approximately 27 seconds and at 13:51:08 UTC, PF observed that the wiper stopped working. On CVR the PF is clearly heard saying *"Isko kya ho gaya (what happened to this)"*. Immediately thereafter, at 13:51:11 UTC, when the aircraft was at an altitude of 1881ft, the PF says *"Oh Shit....wiper is gone..(sound of laughter) what a day for the wiper to go (sound of more laughter)."*

The analysis of CVR transcript leaves no doubt that the windshield wiper on the side of the Captain stopped operating during the first approach. Thereafter, there was no discussion at any point in the cockpit regarding windshield wiper serviceability or mandatory diversion (As per Para 17.34.2 of OM Part A) due to its un-serviceability.

The PF carried out a delayed flaps approach while coming in for landing on runway 28. Flight AXB 1344 continued the approach till 'ILS minimums' on autopilot and then carried out a 'missed approach'. The analysis of CVR transcript does not clearly bring out the reason for this missed approach. As observed from the CCTV footage made available to the Investigation Team, it is evident that drifting low clouds were passing over the airfield at that point of time. Drifting low clouds, active rain, unserviceable windshield wiper on Captain side, in combination with a shorter length of the approach lighting system (which extends only up to 150 m as against the standard length of 900 m) could have been probable factors for not sighting the runway.

At 13:53:03 UTC, PM informed ATC that they were carrying out a missed approach. At 13:54:54 UTC, the DATCO enquired from AXB 1344 about the reason for the go around. The PM asked the PF as to what reason should be transmitted to ATC for this go around, to which, the PF instructed PM to convey *"due weather"*. Thereafter, the PM informed ATC *"due weather AI Express 1344 heavy rain"*.

Due to the prevailing weather the published missed approach procedure for runway 28 was not followed and clearance for the same was obtained from ATC by AXB 1344 before commencing the ILS procedure from overhead CLC VOR.

2.4.2.3 MISSED APPROCH

AXB 1344 was cleared to climb to 10000 ft. PF requested to level out at 7000 ft once the ATC changed the runway in use from 28 to 10 in order to accommodate departure of AIC 425. AXB 1344 had gone 27 NM on outbound course after the missed approach and was cautioned by ATC before the aircraft turned left to intercept radial 284 for 15 DME FIX from CLC VOR. From this point onwards, as evident from the CVR recording, the cockpit activities were rushed and the cockpit authority gradient between the PF and the PM seemed to become steeper. There was confusion and hesitation in finalising the decision to configure the landing flaps. Throughout the missed approach, AXB 1344 maintained a minimum clean speed of approximately 210Kt. The prevailing winds during this time were unusually strong. During the inbound turn the indicated ground speed was 250 Kt. The aircraft established on radial 284 at an altitude of 3359 ft in flap 5 configuration with CAS of 168 Kt and ground speed of 206 Kt indicating 38 Kt of tail winds.

2.4.2.4 SECOND APPROACH

The analysis of CVR transcript reveals that during the second approach, the flight crew was concerned about the serviceability of the windshield wiper. At 14:02:17 UTC, the PF is heard stating, *"I hope this thing works now"*. He was probably referring to the windshield wiper. Again, after five minutes, at 14:07:03 UTC, PF tells PM, *"You put it on properly in the... I will tell you when to put it on. I hope it works"*. Few seconds later, at 14:07:42 UTC, PF asks PM *"Isko Karen (shall we do it)"* and PM states *"Thodi der mein karte hain (let's do it little later)"*. The wiper was probably switched on at around 14:07:47 UTC, when the PF is heard saying *"What is this"*. After four seconds, the PF stated *"...speed toh itni he rahegi (the speed is going to be this much only)"*.

There was a change of runway in use from runway 28 to runway 10 to accommodate the departure of another aircraft namely AIC 425, that was departing at the time. AXB 1344 that had carried out a missed approach on runway 28 was then asked by ATC to confirm if runway 10 was acceptable for landing, PF agreed to the change after repeated enquires regarding the latest weather conditions for runway 10. While, runway 10 was a convenient option for the ATC (as another departing aircraft was using it), the change in runway for AXB 1344 should have been thoughtfully considered by PF, in compliance with the SOP before agreeing for the same.

2.4.2.4.1 LACK OF PLANNING FOR SECOND APPROACH

Critical factors that were not considered or briefed by the cockpit crew for a change in runway included the following:

(a) **Surface Winds**

The headwinds for runway 28 became tailwinds for runway 10. The wind speed as reported by ATC was 250/ 05 Kt at the time of change of runway and 250/08 Kt at the time of landing. The wind speed was varying and AXB 1344 had evidently monitored reported tail winds (270/10 Kt) transmitted by ATC to AIC 425 in its departure clearance. However, actual winds experienced by AXB 1344 at 30 feet RA during landing were approximately 16 Kt tailwinds, as per the DFDR data.

(b) **Selection of Flaps**

The team carried out close analysis of DFDR and concluded that due to the prevailing weather, turbulence was a factor to be considered and PF in his decision chose to opt for flap 30 instead of flap 40. Perturbations observed in key DFDR parameters, such as computed airspeed, vane angle of attack and the acceleration parameters, along with increased control deflections to maintain the desired attitude and small thrust adjustments to maintain the desired speed, are also indicative of a turbulent atmosphere. This decision in itself was justified but delayed flap approach was not correct. Flaps 40 would have helped in reducing the approach speed by 08 kt and offered higher drag which would have aided in faster deceleration. Landing with flap 30 was at variance with the company SOP which recommends landing with flaps 40 at Kozhikode, especially when the available landing distance is marginal under the prevailing conditions.

While making an approach in marginal weather with tail winds, it is emphasized to settle down early with all checks completed in order to focus complete attention on the flight path and monitoring the approach. The PF delayed selecting flaps for landing in both the approaches which he carried out. He remained indecisive whether to go for flap 30 or flap 40. Finally when he did opt for flap 30 it resulted in a delayed flap approach which should have been without doubt avoided. Glide path for runway 10 was correctly intercepted at 2200 ft but landing flaps selection was completed only at approximately 1700 ft. The degree of difficulty increased manifold as PF was attempting a landing in strong tail winds at night with a partially serviceable wiper on his side.

(c) **Auto Brake Setting**

PF opted to use Auto brake 3 setting for landing. A higher auto brake setting should have been considered keeping in mind the prevailing tailwinds. The higher selection available was of "Autobrake MAX", which provides double the deceleration as compared to the one opted (Autobrake 3). However in the actual scenario the PF resorted to manual braking immediately after touchdown by overriding the autobrake selection.

(d) **Calculation of Landing Distance**

The pilots omitted to make the necessary calculation for ALD resulting in a serious and critical lapse. As per SOP, a safety margin of 15% is added to the final calculated ALD, which must be covered in the approach briefing and used for decision making/contingency planning. In Kozhikode, the ATC only provides the information of runway surface condition and the intensity of rain to the operating aircraft. ATC reports braking action on the runway to all aircraft only if any landing aircraft reports unsatisfactory/less than 'GOOD' braking. OM of AIXL considers braking on a wet runway in light rain as "GOOD" and braking in moderate/heavy rain as "MEDIUM". While calculating ALD, the advantage of thrust reversers in 'MEDIUM' braking scenario is not considered, thereby adding an additional safety margin. However, in actual condition both reversers must be selected as per SOP. According to PI-QRH 11.2 dated 21 March 2019, ALD with autobrake 3 and landing flap 30 for 10/15 kt of tail winds with 'GOOD' braking is 7803/8275 feet and with 'MEDIUM' braking is 10085/10730 feet. The Investigating Team is of the opinion that if the crew had calculated the ALD, they might have opted for a safer alternate option.

(e) **Landing with Tailwinds on a Wet Runway**

AXB 1344 accepted to land on runway 10 in haste without taking into account the implications of their decision. The cockpit crew did not have a discussion or briefing with regard to landing with tailwinds on a wet runway. Lack of importance given to correct landing technique, compounded by massive increase of thrust up to 83% N1, after crossing the threshold, resulted in extended flare and a long landing.

(f) **Prevailing Weather Conditions**

AXB 1344 made both approaches in active rain. Approach and landing on runway 10 with a partially serviceable windshield wiper on the Captain side was a violation of the company SOP. The actual tail winds experienced by AXB 1344 were much stronger, almost double than what was reported by ATC. AIXL tailwind landing limit is 10 kt for dry and wet runway conditions, irrespective of the runway length. The landing was made in approximately 16 kt tailwind almost half way down the runway on a safety critical runway.

(g) **Touchdown Zone**

The crew did not give due attention to the importance of a positive and firm touchdown at the correct point on the runway during the briefing. In spite of the availability of Simple Touchdown Zone Lights at Kozhikode marking the end of the touchdown zone (3000 feet), AXB 1344 touched down at 4438 ft up the runway leaving only less than half the runway to stop the aircraft under the adverse conditions.

(h) **Diversions**

The crew did not consider the unserviceability of the windshield wiper that warranted a diversion to an alternate airfield as mandated by the SOP. On the contrary, after the missed approach, at 13:55:47 UTC the PM asked PF *"I will set up?"* to which the PF responds *"…again?…Yeah"* this is acknowledged by PM as *"Yeah"*. This implies that they had initiated preparation towards another ILS approach for runway 28 without heeding to the SOP regarding the unserviceable windshield wiper.

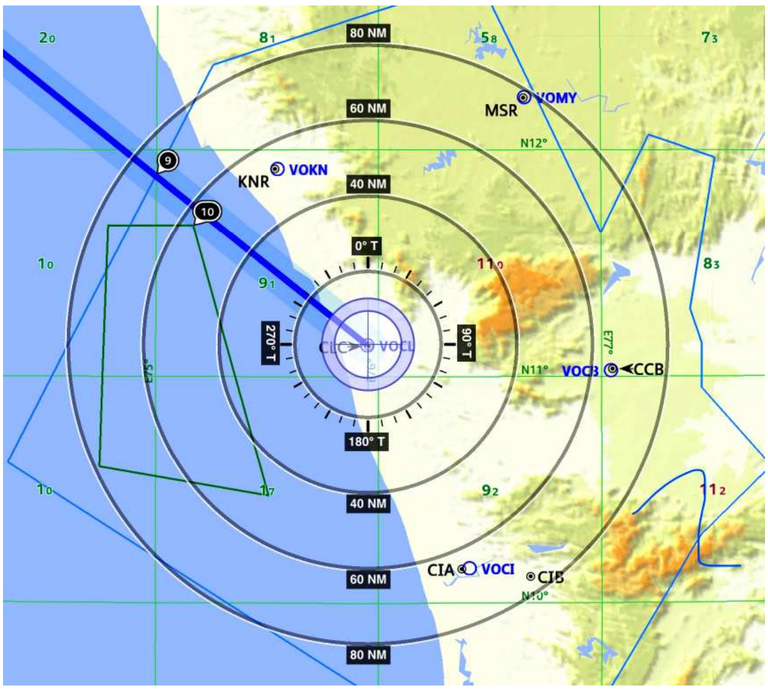


Figure 63: Alternate Airports

As per SOP, Ops Manual and CAR Section 8, Aircraft Operations Series C, Part 1, revision 10 dated 01 April, 2017 on All Weather Operations (AWO), serviceable windshield wiper is a mandatory requirement during monsoon period. In case the windshield wiper on the side of the PIC is unserviceable, it is mandatory to divert to an alternate airfield where no rain is being reported or forecast. As per the weather forecast, there was active rain at Cochin (VOCI) and Kannur (VOKN). Hence, the only alternate airfield available for diversion was Coimbatore (VOCB) which reported no rain at that time. This option of diverting to Coimbatore was not even discussed.

The SOP clearly states that after a second missed approach due to weather, it is mandatory for the aircraft to divert to an alternate airfield. This factor was important, since this aircraft had already carried out one missed approach and considering the prevailing weather and visibility conditions, there was high likelihood of another missed approach. With an unserviceable wiper, even the choice for alternate airfields in case of a second missed approach, was restricted to only those airfields where it was not raining.

(j) **HOLD at 15 DME**

AXB 1344 was cleared for second approach for ILS 10 via 15 DME Fix CLC VOR. The cockpit crew rushed into commencing the second approach for runway 10, consequent to the decision to accept runway 10 instead of 28. Final Approach Fix was the last safety option that would have provided them with additional time to settle and take stock of the current situation. There is a published 'HOLD' at 15 DME. Also, there was enough fuel on board, sufficient for a 'HOLD' over Kozhikode for at least 30 minutes. One or two 'HOLD' at this place, would have provided the flight crew enough opportunity to assess their decision and consider critical factors like calculation of ALD, landing configuration, brake setting and tailwind landing.

(k) **Mode Control Panel (MCP)**

The MCP selected speed was set to 150 kt during first approach and was not changed during the final approach. Selection was 06 Kt above the recorded landing reference speed (V_{REF}) of 144 kt.

2.4.2.5 AUTOPILOT DISENGAGEMENT AND FINAL APPROACH

The DFDR data reveals that the aircraft descended through approximately 1250 ft PA, established on a Flaps 30 ILS approach to runway 10. The Autopilot and Autothrottle were both initially engaged. The Autopilot was engaged in glideslope (GS) and localizer (LOC) modes. Speedbrakes were armed for landing. The aircraft gross weight during approach was approximately 62,908 kg, which was within the maximum landing weight (MLW) limit of 66,360 kg.

The Mode Control Panel selected speed was set to 150 kt, which was 06 kt above the recorded landing reference speed (V_{ref}) of 144 kt. As per the B737 FCTM, the maximum wind additive in the presence of a steady tailwind should not exceed 05 kt. From approximately 1,100 ft RA, the recorded winds were out of the west (~250 degrees) at an average speed of 26 kt. Given the runway true heading of 100.9 degrees, the airplane was experiencing a tailwind component of approximately 22 kt and a crosswind from the right of approximately 13 kt. The airplane was crabbed to the right, in the direction of the crosswind component, at a drift angle of approximately 5.5 degrees. Perturbations observed in key parameters, such as computed airspeed, vane angle of attack and the acceleration parameters, along with increased control deflections to maintain the desired attitude and small adjustments to thrust to maintain the desired speed, are indicative of a turbulent atmosphere.

At time 72 seconds before touchdown, computed airspeed was established at the MCP selected speed of 150 kt. During the same time, ground speed was approximately 175 kt and the calculated descent rate (negative vertical speed) about an assumed mid-centre of gravity (CG) was approximately 750 ft per minute (fpm). Throughout the approach, computed airspeed deviated between 05 kt and 10 kt above the approach speed. Moreover, the airplane was on localizer and within +/- 0.2 dots of the glideslope.

At time 60 seconds before touchdown, descent rate increased to approximately 1000 fpm. At time 40 seconds before touchdown, the Autopilot was disengaged as the airplane descended through 800 ft PA while the Autothrottle remained engaged.

At time 35 seconds before touchdown, the average pitch attitude was reduced and the descent rate began to increase, momentarily reaching 1500 fpm. At time 31 seconds before touchdown (9 seconds after Autopilot was disengaged), the PM also gave a call for *"Rate of Descent"* and PF acknowledged this call with *"Check"*.

Realising that the PF had not reduced the ROD sufficiently, the PM again gave a call *"Rate of Descent… Captain"*. At this stage, they were 0.5 NM from touch-down and were still below the GS. The PF responded to the PM's second call with *"Yeah, Yeah…Correcting… Correcting…Correcting"*.

29 seconds before touchdown, the crew increased the pitch attitude and the descent rate began to decrease, reaching 300 fpm by time 23 seconds before touchdown, before increasing once again towards 1000 fpm. Simultaneously, glideslope alert (caution) from EGPWS "Glideslope…Glideslope" was heard twice at 14:09:58 UTC. This indicates that the aircraft had deviated from the glideslope by more than 1.3 dot. At this point, the DFDR data revealed that the aircraft had deviated by 1.7 dot below the glideslope. The PM attracted the PF's attention to this, by a call of "Check". This was immediately followed by a worried and strained PM's call of "uh..um". Thereafter, the descent was arrested and the aircraft came slightly above the glideslope as both engine thrust increased to around 60% N1.

While the aircraft was at 92 ft RA, it crossed the threshold of runway 10 with a ground speed of 169 kt and thrust on both engines was just above 61% N1.

At time 16 seconds before touchdown, the sink rate (negative vertical speed about the CG) was arrested. Flare initiation was difficult to discern due to variations in column deflection. By time 10 seconds before touchdown, while the aircraft was at 1363 ft from threshold, sink rate had decreased to nearly 02 fps (120 fpm) after thrust was increased manually by the crew up to 83% N1 despite autothrottle commands to reduce thrust. The manual throttle inputs were verified by comparing throttle resolver angle inputs and conflicting throttle rate commands. For the following 05 seconds, sink rate remained between 02 and 03 fps (120/180 fpm). During this period, radio altitude decreased from approximately 20 ft to 12 ft, indicating that the aircraft floated. At 07 seconds before touchdown, while the aircraft was at 16 ft RA, the PM once again tried to catch the attention of the PF by calling "*Just check it*". At this point the aircraft was at 2500 ft beyond the threshold and 500 ft short of end of touchdown zone which at Kozhikode runway is marked by the lights on either side of the centre line. At time 05 seconds before touchdown, the sink rate began to increase gradually towards 12 fps (720 fpm) as the nose was lowered and thrust was reduced. This was followed by a feeble, uncomfortable call of *"…Captain"* by the PM when the aircraft had crossed the end of touchdown zone (3600 ft beyond the threshold). While the aircraft was crossing 10 ft RA, he gave a definite call of *"Go around"*, to which there was no response from the PF. The aircraft touched down in less than 01 second after this call.

The PF continued on unstabilized approach to land in spite of caution from PM and EGPWS. Starting from 35 seconds before touchdown (approximately 700 ft PA on approach) till touch down on the runway the stabilised approach criteria as mentioned in Para 25.4 of company OM part A Chapter 25 mandated a Go Around.

On crossing the end of touchdown zone, which is clearly marked he once again continued with a long landing. Even after a clear Go-around call, where it was imperative on the part of PF to initiate a missed approach, he did not go-around. This was a gross violation of the SOP. On seeing no response from the PF, it was mandatory for the PM to take over controls and initiate missed approach. The PM did not take over the controls and initiate a missed approach when required to do so.

2.4.2.6 TOUCH DOWN AND LANDING ROLL

Touchdown likely occurred at time 14:10:25 UTC (19:40:25 IST), as indicated by a slight decrease in longitudinal acceleration and an increase in normal load factor. At touchdown, normal load factor increased to 1.5 G, gross weight was approximately 63000 kg (138,900 lbs), pitch attitude was approximately 2 degrees nose up, bank angle was 3.8 degrees (right wing down), computed airspeed was approximately 150 kt (VREF+6) and ground speed was approximately 165 kt.

Calculated sink rate was approximately 726 fpm (12.1 fps) at touchdown and calculated closure rate of the right main landing gear (negative vertical speed of the right main landing gear in relation to the runway) at touchdown was approximately 702 fpm (11.7 fps). Closure rate of the right main landing gear is the rate of change of distance between the right main landing gear and the runway and is generated by calculating the sink rate of the right main landing gear and accounting for pitch rate, roll rate, and any runway slope near the point of touchdown. Although Runway 10 has an uphill slope from the threshold to near the midpoint and a downhill slope from the midpoint to the end of the runway, at the segment where touchdown likely occurred, the slope was essentially level.

The level surface and decreasing roll rate at touchdown yielded a similar closure rate with the runway as the calculated sink rate about the assumed mid-CG. The calculated tailwind component at the time of touchdown, derived from the calculated wind speed, was approximately 18 kt while the crosswind component had reduced to nearly 0 kt. The Throttle Resolver Angles (TRAs) had been reduced to 36.5 degrees (idle position) by touchdown.

0.7 seconds after touchdown, the left and right main landing gears compressed enough to transition the air/ground discrete parameters to GROUND. A fraction of a second later, by 0.9 seconds after touchdown, pitch attitude had decreased to 0 degrees and the nose gear air/ground discrete parameter also transitioned to GROUND, indicating that the airplane likely touched down in nearly a 3-point attitude.

Simultaneously, the left commanded brake pressure began to increase towards 3000 psi. The right commanded brake pressure sensor indicated a constant (-)165 psi, due to a failed brake pressure transducer. The automatic brake discrete parameter remained disengaged throughout the rollout, indicating that manual brakes were applied.

At 1.2 seconds after touchdown, autospeed brakes were fully deployed, and at around the same time, longitudinal deceleration (negative longitudinal acceleration) increased to an average value of 0.22 G. Both events were confirmed by the call "*Speed Brakes Up*" at 14:10:27 UTC and "*Autobrake Disarm*" call at 14:10:30 UTC by the PM. However, no call was given for reverser deployment. None of the standard calls given by the PM were acknowledge by the PF, which is a gross violation of the SOP.

The AT disengaged automatically at about 03 seconds from touchdown. Landing with AT engaged is a violation of the procedure laid down in AIXL SOP Para 2.2.9 page 222 and FCTM page 1.41, wherein at airfields where autoland is not allowed (as in Kozhikode), both AP & AT have to be disengaged for landing.

About 05 seconds after touchdown, the thrust reversers were momentarily deployed for approximately 02 seconds before reverse levers (TRAs) were returned to forward idle positions. Later at 09 seconds after touchdown, while the thrust reversers were stowing, the left commanded brake pressure temporarily reduced to approximately 570 psi before increasing back to 2910 psi. Consequently, longitudinal deceleration also momentarily decreased to 0.1 G during this time. This action by the PF coincides with a call by him of "*shit*" on CVR.

At 14 seconds after touchdown, the thrust reversers were redeployed for a second time, the reverse levers (TRAs) were decreased to 6.0 degrees (maximum reverse thrust). Soon after, the engines began to spool up following the maximum reverse thrust command, and then, 21 seconds after touchdown, the reverse levers (TRAs) were returned to forward idle and the thrust reversers were stowed. Subsequently, longitudinal deceleration began to decrease from approximately 0.2 G to 0.05 G by 24 seconds after touchdown before increasing once again when the aircraft entered soft ground.

At 22 seconds after touchdown two calls were recorded on the CVR when the thrust reverser were stowed and the aircraft was about to leave the paved surface of the runway and entered soft ground. Calls from the PF and PM of *"shit"* were recorded within a gap of one second. At 28 seconds after touchdown, pitch attitude began to decrease drastically, indicating that this was likely the point when the airplane plummeted down the embankment. Ground speed was approximately 42 kt at this time. The aircraft remained in 'AIR' mode for approximately 2 seconds before impacting the ground.

To begin with, the approach on runway 10 was 'unstable', yet the PF continued to land and touched down much beyond the designated touchdown zone. Thereafter, the use of deceleration devices by the PF was not adequate. Although on touchdown, he selected the thrust reversers but before they could generate effective deceleration, they were stowed momentarily and simultaneously he eased the brake pressures as well. Probably, he made a fleeting decision to 'go around' by stowing the reversers. However, at no stage, he increased thrust to execute a 'go around'. PF then quickly redeployed the thrust reversers and applied full brakes again, indicating a quick change in his decision. These unsafe actions by the PF further compromised the landing distance on a slightly down-sloping wet runway with strong tailwinds.

The Investigation Team reviewed the nine elements of competency based training and assessment from the facts made available to the committee.

S. No.	Nine Elements of CBTA	Relevant observations for PF (PIC) related to the accident.
1.	Communication	Issues observed
2.	Aircraft Flight Path Management – Manual Control	Issues observed
3.	Aircraft Flight Path Management – Automation	Not observed
4.	Leadership and teamwork	Issues observed
5.	Problem Solving and Decision making	Issues observed
6.	Application of procedures	Issues observed
7.	Work load Management	Issues observed
8.	Situational Awareness	Issues observed
9.	Knowledge	Issues observed (application of knowledge effectively and appropriately)

2.5 AEROMEDICAL ASPECTS

In aircraft accidents, it is imperative to rule out pilot incapacitation in the air, which could be a result of any pre-existing disease or other in-flight aeromedical factors like smoke, hypoxia etc. In order to investigate this aspect in accidents where the cockpit crew are fatally injured, autopsy specimens of the pilot and co-pilot are collected for detailed histological and biochemical/toxicological examination. This examination is carried out at the specialised Aviation Toxicology Laboratory at Institute of Aerospace Medicine (IAM), IAF at Bengaluru. Therefore, at the time of autopsy, relevant organs/tissues/body fluids have to be collected, preserved and forwarded to IAM for the requisite evaluation. Instructions for collection, preservation, storage and dispatch of specimens are given in Appendix 'B' to the Air Safety Circular (ASC) 06 of 2010 dated 15 December, 2010.

The post-mortem examinations of the deceased passengers and the crew of AXB 1344 were carried out at Govt Medical College and Hospital, Kozhikode. ASC 06 of 2010 states: *'Wherever possible, a Specialist in Aviation Medicine shall also be associated with the post-mortem examination'.* However, there was no Aviation/Aerospace Medicine Specialist present during the autopsies conducted on 08 August, 2020. Since AIXL does not have a Medical Department, they are dependent on Air India Medical Department for assistance during such eventualities. Air India too does not have specialists in Aerospace Medicine on their payroll. In addition, AAIB 'Go Team' should have incorporated a medical member for the initial investigation, who would have assisted AIXL and the civil police in the process of autopsies and sample collection. As per the extant arrangement, DMS (CA) at DGCA should have been a member of the 'Go Team' as per AAIB letter no. AV.15013/VT-AXV/2014-AAIB dated 08 January, 2015. However, DMS (CA) was not a part of the final 'Go Team' that left by air from Delhi for Kozhikode on early morning of 08 August, 2020.

Medical Officers from Air India and Alliance Air assisted in the initial handling of the dead and injured passengers and the crew of AXB 1344. However, due to their limited knowledge in Aerospace Medicine and the specific requirements for sample collection for toxicology analysis, only limited blood samples of both the pilots were obtained and sent to IAM, IAF for analysis. The post-mortem reports were also not provided in the format laid down in ASC 06 of 2010.

IAM Aviation Toxicology Laboratory carried out the analysis on the very limited blood samples available and submitted the reports for presence of alcohol, lactic acid, carbon monoxide and later, at the request of the Investigation Team, of anti-diabetic drugs. The test results revealed 'zero' alcohol level. Also, there were no traces of lactic acid and CO. As such, the pre-flight breathalyser test for the FO was negative and the PIC who did not undergo breathalyzer test, had submitted a declaration stating that he had not consumed alcohol in the last 24 hours in accordance with the DGCA directions during Covid 19 pandemic. In addition to the routine toxicology tests, the Investigation Team requested for anti-diabetic drugs testing.

2.5.1 ANALYSIS OF AEROMEDICAL FACTORS

2.5.1.1 HYPOGLYCAEMIA

Hypoglycaemia is an undisputable possibility in diabetics on oral hypoglycaemic agents. ICAO Doc 8984 chapter 4.15 on 'Hypoglycaemia' clearly states a risk of symptomatic hypoglycaemia in Type 2 Diabetes patients of up to 2 percent per annum especially with multiple drugs including Sulfonylureas group of anti-diabetic drugs. Subtle or mild hypoglycaemia may not produce overt symptoms of neuroglycopenia and autonomic neural stimulation as listed in medical literature viz. unconsciousness/coma, palpitation, anxiety, sweating, excessive fatigue, nausea, tingling lips, blurred vision, slurred speech or tremors. It may result in only cognitive effects like mental confusion, light headedness and sluggish psychomotor responses. All this can result in decrement of flying performance, which deteriorates further with the complexity of the task at hand. Researchers have found that complex decision-making skills are specifically disrupted during hypoglycaemia (as per ICAO Doc 8984).

As per the Pilot Medical Records (PMR) of PIC, he was prescribed Tab Metformin (plain) 500 mg twice a day, which is acceptable for flying, as it carries minimal risk of serious hypoglycaemia. However the circumstantial evidences confirm that the PIC was in possession of multiple anti-diabetic drugs in his personal bag and on-person besides this prescribed drug. His personal bag contained four types of anti-diabetic drugs viz. Metformin *Sustained Release* (Biguanides), Glimepride (Sulfonylureas), Pioglitazone (Thiazolinedindione) and Dapagliflozine (SGLT 2 inhibitor). These drugs were in blister packs and a few tablets had been consumed from each strip. This clearly brings out an apparent probability that PIC was not following the prescribed drug i.e. Plain Metformin, rather, he was taking multiple anti-diabetic drugs. The toxicology analysis of the post-mortem blood sample also reveals presence of multiple anti-diabetic drugs viz. Metformin and Pioglitazone. In addition, a partly consumed bottle of an ayurvedic tablets formulation namely '*MadhuKalp Vati*' was recovered from his personal baggage at his hotel room at Kozhikode. Once again, indicating towards a definite possibility of combining ayurvedic medications with non-prescribed allopathic treatment for his diabetes.

The above facts leave no doubt for the Investigating Team to believe that the PIC was suffering from Type 2 Diabetes Mellitus for which he was made fit for flying as P1 (as he was on the treatment with Plain Metformin acceptable for flying). Plain Metformin belongs to the Biguanides group of anti-diabetic drugs that cause minimal hypoglycemia. The team is also certain of the fact that PIC was not only taking sustained release formulation of Metformin but was also consuming multiple unprescribed anti-diabetic drugs including ayurvedic medication (*Madhukalp Vati*) that carry a potential risk of hypoglycaemia as per the available scientific literature and ICAO Doc 8984.

It was confirmed by the cabin crew that the PIC routinely consumed only bland, low calorie food which was specially prepared for him for in-flight meals as well as at the hotel (where he would routinely stay). At Dubai, at around 12:50 UAE time (08:50 UTC) before take-off for Kozhikode, the PIC had his special meal followed by a cup of black coffee (without sugar) in-flight. Hence, by the landing time i.e. at around 14:10 UTC, he had been fasting for approximately five hours. Also, the circumstantial evidences as well as the post mortem findings suggest that the PIC had not consumed anything from the 'Snack Box' on the return flight. It is an established fact, that a diabetic individual, on multiple anti-diabetic drugs, is susceptible to hypoglycaemia. Also, the circumstantial evidence is sufficient to believe that in addition to the prescribed drug i.e. Metformin, the PIC was taking tablet Glimepride (Sulfonylureasgroup), which has a very high potential to cause hypoglycaemia when consumed along with other anti-diabetic drugs.

2.5.1.2 TOXICOLOGY REPORT FOR ANTI-DIABETIC DRUGS

The toxicology analysis of blood sample of the PIC was carried out at the Aviation Toxicology Laboratory at IAM, Bengaluru which revealed the presence of two of the five anti-diabetic drugs found on person of the PIC. The two drugs detected on toxicology analysis were Metformin and Pioglitazone. Dapagliflozine (SGLT 2 inhibitor), being a newer drug could not be tested at IAM. In addition, the laboratory at IAM does not conduct toxicology analysis of Ayurvedic preparations (*MadhuKalp Vati*). Both the detected drugs, in isolation, do not cause hypoglycaemia. However, Glimepride, found in the PIC personal bag, which although not detected in the toxicology analysis, carries the risk of hypoglycaemia. Glimepride is routinely prescribed as once a day dosage either before or after any major meal, as the efficacy of the drug (even at low doses) lasts for 24 hours. The plasma half-life of the drug is 5-8 hours (average 6.5 hours) and depends on numerous factors like age, dose, body built, liver function etc. It takes at least 4 to 5 half-lives for any drug to be completely eliminated from the human body. Considering the pharmacokinetics of this drug, the mean plasma concentration of this drug falls to 30±20ng/ml after 12 hours (with 2mg formulation). Hence, it can be deduced, if the PIC was prescribed 2mg Glimepride with breakfast, at the time of blood sample collection after the accident i.e. more than 12 hours after drug intake, the concentration of Glimepride in plasma of the PIC would have been approximately 30±20ng/ml, which is below the minimum detection capability of the Toxicology Lab at IAM, Bengaluru that can detect Glimepride only if the plasma concentration is more than 50-100ng/ml. Therefore, Glimepride could not be detected during the Toxicology Analysis. However, the efficacy of Glimepride in lowering the blood glucose persists even at lower concentrations and up to 24 hours from drug intake.

2.5.2 SITUATIONAL AWARENESS DURING APPROACH AND LANDING

During the first approach on runway 28, the mandatory PA call to the cabin crew to be seated was not made by the PM which is an unusual lapse. In all probability, the crew was preoccupied and possibly stressed at this point. After carrying out a missed approach, the decision making suffered drastically. The only safe option available to the crew (with unserviceable wiper on the PF's side, during active rain over the runway) was clearly to divert. This option was not even considered, as evidenced by the CVR. The briefing for the second approach on runway 10, did not include LDR calculations. It should have occurred to the flight crew that such calculations were vital, more so for landing on a table-top runway in rain with reported tailwinds. The calculation of landing distance with auto brake 3 and flap 30 would have revealed to the flight crew that they were left with little margin for error under the prevailing weather conditions. The decision to land with such a configuration on runway 10, clearly demonstrated the poor situational awareness of the flight crew, considering the landing conditions and the necessity to decelerate and stop the aircraft as soon as possible after landing (The unavailability of OPT for quick performance calculations added to the error). Despite all indications, the crew did not plan to appropriately configure the aircraft for landing on a wet runway with a tailwind close to the company tailwind limitation.

The decision making of the PF during the final approach clearly suggests that his cognition was further constricted at this time, as evidenced by the lack of discussion about the wet runway, the change in runway (converting the headwinds to tailwinds conditions) and the lack of discussion about a possible 'diversion', especially since the wiper did not work during the first approach. The conversation between the flight crew and the ATC indicated that the flight crew was mainly paying attention to the visibility and the position of CBs in the area.

The Investigation Team is of the opinion that as the flight crew continued the approach, their situational awareness was deteriorating and they were embarking on a more complex and hazardous landing. The unplanned acceptance of the change of runway pushed the crew into an extremely tight situation. The approach plan that was decided upon did not include considerations required for a tailwind landing on a wet runway.

The flight crew, being aware that the windshield wiper on Captain's side did not operate in the previous attempt to land on runway 28, accepted a change in the runway (minutes before landing) without any additional planning for tailwinds in rain on a tabletop runway. Even with limited situational awareness, these events should have triggered a serious warning to the flight crew that a safe landing with 10 kt reported tailwind and a partially serviceable windshield wiper would be marginal. All the elements of situational awareness were adversely affected by the string of events viz. bad weather over Kozhikode, first unsuccessful attempt at landing with an unserviceable wiper, self-imposed compulsion to land back at Kozhikode and last-minute change of runway.

On landing, the aircraft floated for at least 10 seconds between 20ft RA and 10ft RA when the PM called *"Just Check it"* followed by *"...Captain"*. Even this prolonged time lag between 20 feet and 10 feet automated call out and feeble calls by PM to catch his attention, the PF did not appear to appreciate that the landing was going to be long, and it would not be safe to land especially when the runway length available was already limited.

This indicates a complete loss of situational awareness of the PF. The PF continued with the landing while the PM recognised the unstable approach and gave another distinct call of *"Go around"* at around 10ft RA, just before touchdown. The Company SOP also warranted a mandatory go-around. This call was also ignored by the PF and he continued with the landing, touching down immediately thereafter. The response of both PF and PM was not in accordance with the SOP, thereby indicating further loss of situational awareness. The accident could have been averted if there was good CRM or if any of the flight crew had reacted as per the SOP, or if the PF had initiated a mandatory 'go around' after PM's call for the same or if the PM taken over control and initiating a 'go around' himself (in the absence of any response from the PF).

Possibly, the degraded ambient/peripheral vision (because of moderate rain and slow wiper operation) failed to provide PF the required cues to know exactly where he had touched down. Even the 'simple touchdown zone lights' did not attract his attention on late touchdown. During the landing roll, the PF said, "shit", possibly indicating that he had a late realization of his judgement error and therefore made a fleeting decision to stow the TRs (possibly to go around) and then redeployed them quickly and applied full brakes again indicating loss of situational awareness. At no stage during the landing roll did the PM contribute gainfully to control the situation. There was no communication between the flight crew after touchdown reflecting poor CRM.

2.5.3 HUMAN FACTORS ANALYSIS

2.5.3.1 ACTIVE FAILURES: PERCEPTION ERRORS

The environmental factors viz. low visibility due to rain and over cast night sky would have degraded the visual cues for orientation, thereby, exponentially increasing the vulnerability to spatial disorientation. Moreover, the subtle cognitive effects of hypoglycemia might have predisposed the PF to perceptual errors, given the definite reduction in visual cues for orientation especially during second approach for runway 10. The visibility was as low as 2,000 m in rain, as recorded in the METAR issued at 14:00 UTC (19:30 hrs IST).

In the absence of runway centre line lights, together with the halo effect caused by the diffusion of light by rain while viewing runway edge lights through a wet windshield (*as the wiper was not functioning at optimal speed*), would have limited the PF's depth perception and distance estimation cues and probably affected the PF's judgement of the touchdown zone.

The PF's visibility would have been severely impeded by the rain on the windshield, taking into account the slow speed of the windshield wipers. Therefore, it can be presumed that the PF did not have the visual horizon for horizontal as well as vertical reference which must have been further degraded due to absence of cultural city lights beyond the table top runway.

It is a fact that perception of one's own speed can be gauged by the speed of passing imagery in the peripheral vision. The objects that are closer appear to move faster than the ones that are farther away. Observing the runway edge lights going by faster (which appeared to be moving faster because of the higher groundspeed of the aircraft), the PF might have experienced an illusion that led him to perceive that his aircraft was lower than it actually was. This could have possibly caused the PF to misjudge the height resulting in long float.

2.5.3.1.1 BLACK HOLE APPROACH

The Kozhikode runway is a table top runway with minimal cultural lights around the airfield. Also, the Kozhikode runway 10 has a longitudinal slope +0.3% giving an upslope perspective. In overcast-night condition with moderate rains and only the runway edge lights visible, the PF might have experienced a visual illusion called 'black hole approach', wherein the pilot tends to make a shallow approach. Also, the slight up-sloping portion of the runway 10 could have resulted in an illusion of being high on approach, subconsciously forcing the PF to approach low. This would have been aggravated in a 'black hole' like approach that night. This, in part, explains the low approach by the PF that was corrected later. The possible subtle cognitive effects of hypoglycaemia and stress would have certainly added to the likelihood of this perceptual error by the PF.

2.5.3.2 LATENT FAILURES: PRECONDITIONS TO THE ERRORS/ACTIVE FAILURES

(a) **Environmental Factors**

Physical environment at the Kozhikode airfield on the night of 07 August, 2020 significantly influenced the crew's actions by adding stress and created an unsafe situation. Weather (rain) and the ambient environment (night with overcast sky) reduced visibility. The tailwinds along with a wet runway affected the aircraft landing, which is one of the primary contributory factors in this accident.

(b) **Condition of Individual**

The following cognitive, psycho behavioural and physiological factors, with the background of prevailing environmental factors that contributed to the errors committed and the decisions taken by the PF:

(i) **Get-Home-itis and Pressing**

The PF was rostered for a scheduled flight for the following day. Any diversion of AXB 1344 flight would have placed the PF in FDTL and he would not have been available to operate the next day's flight. PF was aware that there were no additional Captains at that base, other than himself to operate that flight. Hence, the PF created a misplaced motivation for himself (to be available for next day's flight) and did not divert after the wiper was found unserviceable during the first approach and pressed on to land during the second approach (as another 'missed approach' would have left him with no option but to divert). According to the statement of the cabin crew, the PIC seemed anxious to return to Kozhikode in time and hence his actions and decisions were steered by a 'misplaced' motivation to land back at Kozhikode as scheduled.

(ii) **Overconfidence and Complacency**.

The PF was a highly experienced pilot and was working in a capacity of Line Training Captain in the company. He had 10848.50 hrs of total flying experience and had operated 36 flights in and out of Kozhikode during the last one year prior to the accident. On close scrutiny of DFDR data of these flights it was observed that majority of these landings were made in headwind condition wherein stopping the aircraft was easily achieved. This experience probably resulted in complacency due to overconfidence that affected his decision making and CRM.

(iii) **Personality**

The emotional state (stress response) of PF is also a contributory factor in this mishap. The earlier documented shortcomings of his degraded performance while under stress came to fore when the PF was confronted with a multitude of adverse factors during the approach and landing at Kozhikode. Also, the PF was known to be 'goal orientated', to have 'cognitive rigidity', 'tendency towards perfectionism' and 'vulnerability to stress'. These traits adversely affect CRM due to the cognitive bias.

(iv) **Coning of Attention**.

During approach for runway 10, which was an 'unstable' one, the PF disregarded the cautionary calls from the PM during the extended flare. He continued with an unsafe long landing in spite of the 'go around' call from the PM just before the touchdown. It seems that the PF had all his conscious attention directed on the stabilization of approach rather than the touchdown point excluding the comprehensive situational information.

(v) **Mental and Physical Fatigue**.

PF had reported for pre-flight medical examination at 09:25 IST and the crash occurred at around 19:41 IST. This amounts to a total 'duty period' of 10:16 hours. As per DGCA CAR Section 7 Flight Crew Standards, Training and Licensing, Series J, Part III on FDTL, the flight duty duration and flight duration was within acceptable limits. Although, a continuous wakefulness of 12 to 14 hours does not affect the cognitive or psychomotor performance of an individual, the effects of cumulative fatigue and chronic fatigue may adversely affect a pilot's flying performance. The PF had arrived at Kozhikode the previous evening on 06 August, 2020 from Mumbai by Air India/Indigo flight that landed at Kozhikode airport at approximately 17:30 IST. He was accommodated at a comfortable location and hotel in Kozhikode city. It is unlikely that his sleep was disturbed the previous night due to any external factor. Hence, it can be stated that there was no cumulative fatigue in the last 24 hours.

(vi) **Hypoglycaemia**.

The potential side effects of the multiple oral hypoglycaemic drugs that the PF was taking for Diabetes Mellitus i.e. hypoglycaemia was a probable contributory factor that impacted his cognition and decision making abilities.

(vii) **Overt Incapacitation.**

The analysis of CVR transcript does not indicate overt incapacitation of the PIC. Calls by the PIC clearly authenticate the fact that both the pilots were conscious and there was no incapacitation of any of the cockpit crew members. Notwithstanding this, the Investigation Team found the medical cause for probable 'subtle' incapacitation of the PIC due to mild hypoglycaemia, especially in view of the established fact that PIC was taking multiple un-prescribed anti-diabetic drugs (including Glimepride and an Ayurvedic preparation). However, it seems unlikely that these anti-diabetic drugs taken by the PIC could have resulted in an 'overt' incapacitation due to hypoglycaemia, resulting in symptoms of substantial neuroglycopenia like unconsciousness, slurring of speech etc.

(c) **Personnel Factors**

Poor Communication, coordinating and planning was another major contributory factor in this crash. Lack of assertiveness by the PM and failure of the cockpit crew to re-assess situations as they began to change, led to the active failures that resulted in the crash. The steep 'authority gradient' in the cockpit certainly degraded the PM's actions. Self-medication by the PIC for control of his clinical condition might have contributed to the errors indirectly by causing hypoglycaemia and affecting the cognition as well as decision making during the demanding second approach. In addition, the crew's 'task-in progress' re-planning was inadequate in managing all safety risks through a thorough reassessment of the dynamic environment.

2.6 EMERGENCY RESPONSE

The first CFT with the ARFF personnel reached the accident site at 19:49 IST and started the fire and rescue activities. ARFF team was supported by CISF personnel. Substantial number of off-duty CISF personnel also reached the crash site as their barracks are in close proximity. Although, as per the AEP, the role of CISF is only to cordon the crash site, they played an active and exemplary role in augmenting the rescue efforts of the ARFF. Large numbers of passengers were shifted to Hospitals for treatment using taxis and private vehicle even before ambulances from different service providers could reach the site.

Notwithstanding the good work done by the CISF, the locals and the private taxis that rushed in to help in the rescue efforts, it was clear that the rescue operations were carried out in an un-coordinated manner. The rescue activities were carried out without an effective central control. Command and Control Post was not established at the site, hence, most of the rescue actions were self-driven and lacked prioritization and proper coordination. The Airport Duty Doctor was not informed of the crash as per the AEP. He tried to reach the crash site after getting the information from his hospital colleagues but had to walk long distance as airport ambulance, taxis and private vehicles that were brought in to augment rescue efforts had blocked/jammed the narrow perimeter road and his vehicle could not reach the crash site. Even after reaching the crash site, he was not very conversant with his role in mass casualty management. Prioritization of casualties was not performed and large numbers of rescued passengers were directly transferred to hospitals by all available means that were put into service without being given First-aid.

The rescue of cockpit crew was carried out by the CISF personnel and civilians who had to put in considerable effort in order to reach the cockpit crew through the broken portion of the nose section of the aircraft. The perimeter wall was broken to gain access to the cockpit. The untrained rescuers could not open the quick release rotary buckle of the safety harness to remove the pilots from their seats as they were unaware of the mechanism to unlock the buckle. Precious time was lost in order to find a sharp object to cut the safety harnesses and rescue the pilots. As per the witness accounts it took almost an hour in this exercise and hence the 'golden hour' was lost.

ARFF personnel did not attempt to open the Cockpit Emergency Exit or guide the local rescuers for the same. On investigation, it was found that the ARFF personnel had not undergone aircraft familiarization training on B737 aircraft and were not aware of the location and opening procedure of cockpit emergency exits. A signed statement to this effect was given by the HOD Fire section and ARFF personnel involved in the rescue to the Investigating team.

The mock emergency exercise carried out in November 2019 had highlighted the need for better co-ordination of rescue agencies, setting up/availability of Command Post and risks associated with narrow perimeter road. The same was not addressed till the date of accident.

2.7 SURVIVAL ASPECTS

The aircraft hit the perimeter road at an angle of approximately 30 degrees. The last recorded ground speed on DFDR was 41 kt. The aircraft nose section first hit the road surface causing the front portion of the aircraft to break. Simultaneously, the engines hit the perimeter storm drain resulting in sudden deceleration of the main fuselage. The tail portion of the aircraft separated due to direct impact over the slope causing the fuselage to split around seat rows 22 to 26. The separated nose portion grazed ahead due to momentum and came to rest just short of the perimeter wall to the left of the crash gate no 08.

From the injury pattern analysis, it was evident that majority of fatalities occurred in the areas where the aircraft fuselage had broken. Approximately 70% of the musculoskeletal injuries were of lower limbs. The primary cause for these injuries can be attributed to the forward movement of the seats due to frontal impact. 20 passengers suffered serious head injuries out of which 16 succumbed to head injuries. The falling of overhead bins with heavy baggage caused these head injuries. The passengers were not prepared for the impact, as the cockpit crew did not caution them with a 'brace' call. Had the 'brace' call been announced, the injuries would have certainly been curtailed.

At least 14 passengers were severely trapped in their seats post impact. These passengers were rescued by cutting the seat structures and the aircraft skin. The use of power-driven saw (gasoline engine powered) in the cramped space led to fumes that caused acute discomfort to the rescuers as well as the crash victims. More hydraulic cutters and spreaders would have reduced this discomfort and improved the efficiency of rescuers.

Both pilots received fatal injuries and were trapped in the mangled cockpit with little surviving space. The post-mortem reports of the pilots reveal that the injuries sustained by both the pilots were fatal.

2.7.1 CHILD RESTRAINT SYSTEMS (CRS)

Out of the 10 infants on board AXB 1344, three sustained fatal injuries, three had serious injuries and four escaped unhurt. The feedback from the parents of the fatally injured infant clearly brought out that as there was no fore warning from the cockpit or cabin crew about the impending impact, the infant although placed on the lap was not held firmly, therefore, during the frontal impact of the crash the infant was displaced from the lap and was thrown in the cabin and as a result received fatal injuries.

AIXL does not have provision for child/infant restraint system and they rely solely on lap-held infants without any supplemental restraint.

The laboratory studies have confirmed that an adult may not be able to hold on to an infant on the lap in sudden decelerations, even when prepared. The infant may then be projected through the cabin and suffer serious injury as a result.

Therefore, the studies have concluded that lap holding of infants without supplemental restraint is not deemed the safest method during air travel.

2.8 ORGANISATION: M/S AIR INDIA EXPRESS LTD

AIXL is a subsidiary of Air India Ltd and is dependent on the parent organisation for various facilities particularly for Training, Maintenance, SMS etc. Maintenance of aircraft is being carried out by AIESL which is a CAR 145 approved Maintenance and Repair Organisation. Training of pilots is being carried out under MoU with Air India Ltd.

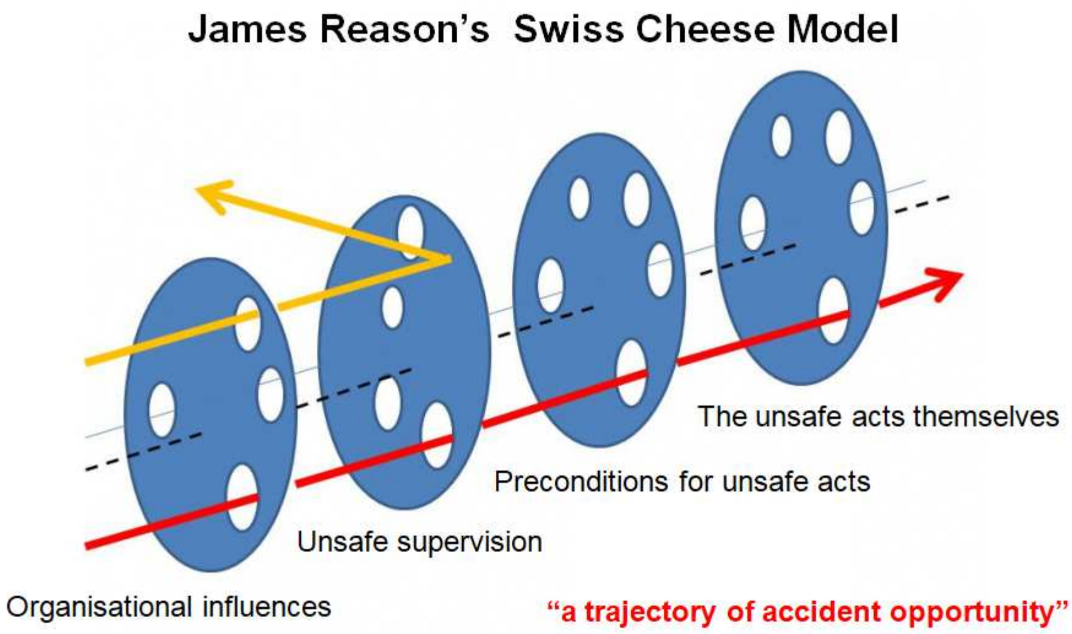


Figure: 64 James Reason's Swiss Cheese Model

If one reviews the James Reason's Swiss Cheese Model of Accident Causation, the first block is Organisational Influences. In the mentioned list of accidents and serious incidents (Para 1.17.1.9 refers), one can see that over the last few years AIXL has suffered serious occurrences also leading to fatalities. This is indicative of the organisation's safety culture and the management practices which are the contributory factors to the occurrences.

Various critical and key functionaries of AIXL are based at different locations, spread over a large geographical area of the country. The headquarters of some of the vital functions of the company are not co-located with their concerned areas of responsibilities which are located away from their respective HQs. To state examples, Head of Training is based in Delhi while all training activities are carried out at Mumbai, Chief of Operations is based in Chennai while Operational Headquarters is located at Mumbai. Also, the Corporate Headquarters of AIXL is at Cochin and the Maintenance Headquarters is at Thiruvananthapuram while major maintenance activities are carried at Thiruvananthapuram as well as Mumbai.

The organisation chart of AIXL reveals that Chief of Flight Safety and his team are also accountable to Air India Corporate Safety. This duality of command &

control leads to ambiguity in execution in order to follow the relevant CAR in letter and spirit. The CoFS and Dy.CoFS of AIXL should preferably be directly responsible only to the CEO/AE (Accountable Executive) as has been done for QM/CAM.

As per OM PART A the responsibilities and duties, the Chief Operating Officer is responsible to the Accountable Executive for the day to day functioning of all activities of the company. The present COO is also employed on active flying duties on wide body aircraft with Air India apart from being deputed for performing the designated duties with AIXL.

To summarize, while a robust organizational structure is in place, the execution of its roles is challenging, leading to a lack of effective supervision, and thereby affecting quality and safety.

The challenge due to geographically dispersed organization extends to flying operations. There are 42 Captains and 29 First Officers based in Delhi in spite of the fact that Delhi accounts for the least number of flights. On the other hand Kozhikode in Kerala that accounts for the maximum number of AIXL flights has only one Captain and 26 First Officers based there.

The home base for Captains has been allotted based on their convenience and not in accordance with operational requirements. This causes wastage of valuable resources in positioning crew on a regular basis, both prior to and after the flights. More importantly, this arrangement leads to a strong urge amongst the Captains to conclude their duties and return to their home base (*get-home-itis*) as early as possible, which may create pre-conditions to an unsafe environment thus compromising flight safety.

Personalised communication is the key element for a good CRM. The free channels for communication may not open unless the senior pilots/Captains interact with the FOs of the airline frequently. Considering the current HR policy of AIXL for assignment of home bases, majority of Captains are not co-located at the bases assigned to the FOs. This leads to limited personal interaction which acts as a barrier in healthy communication and adds to the cockpit steep gradient which was seen in this accident.

2.8.1 FLIGHT OPERATIONS

2.8.1.1 USE OF ON-BOARD EFB

Although a majority of AIXL aircraft are equipped with OEM fitted EFB, these are not being used. The pilots are provided with iPad® in lieu of the on board EFB. These iPad® do not have the requisite On-Board Performance Tool (OPT) application for calculation of critical parameters both for take-off and landing. The OPT enables flight crew to perform quick, real-time and accurate take-off and landing calculations. Apart from other commercial and engineering benefits, it adds to the operational safety. It encompasses all updated relevant information like Jeppesen, Airport Obstacle Database, Airline Policy Data, NOTAMS, Current Runway Atmospheric Conditions, MEL/CDL configurations etc. Important outputs include landing field and climb performance, factored or un-factored landing performance for normal and non-normal configuration, take-off V-speeds etc.

During the course of interaction with senior pilots (including instructors/trainers) and First Officers of AIXL, it was conveyed to the Investigating Team, that the manual on-board landing data calculations while in air, especially done under challenging weather conditions and last minute change of runway, may not be accurate and there is a high likelihood of committing errors. The 'Quick Reference Table' provided as Appendix to the AIXL SOP provides estimated and required landing distances for fixed conditions like calm winds, 1000ft PA, etc. thereby making these calculations too generic and impossible to apply during dynamic weather situations (for which the pilots have to refer to the QRH). Despite this observation by the instructors, the requirement of OPT has never been projected by the Training Department to the upper level management. It needs no emphasis that the crew needs to be trained in the optimal use of all available tools on-board including EFB, in order to assist them in long and complicated calculations while operating in adverse and stressful conditions. This would substantially reduce the mental workload of the pilots and possibly spare their precious cognitive capacity for other more useful activities, especially during the performance of demanding tasks.

As per the briefing carried out on flight AXB 1344, on 07 August, 2020, before the top of descent for the first approach, the flight crew did not perform ALD calculations for landing on runway 28. Also, after carrying out a 'missed approach', the briefing for the second approach for runway 10 also did not include ALD calculations. Such calculations are vital for landing on a table-top runway in rain with tailwinds near the company limit of 10 kt. After interacting with various AIXL pilots, the Investigating Team felt that it is common in the company that prior knowledge of an airfield is considered adequate to carry out landing without calculating the ALD even in adverse weather conditions although this practice is contrary to the company approved procedures.

EFB was projected as part of the configuration specifications in 2006 by AIXL to OEM and the initial batch of 17 'A' series aircraft (including VT-AXH) were delivered with OEM fitted EFBs having OPT as its integral part. The pre-installed EFB was never updated and utilized till date. OPT which provides quick and accurate performance calculations, would have been advantageous and shown that with Auto brake 3 and Flap 30, the landing distance required would be extremely marginal under prevailing weather conditions. This would have made it obvious to the crew that landing on runway 10 was unsafe and they might have opted for landing on runway 28 instead thus averting the tragedy.

2.8.1.2 AERODROME OPERATING MINIMA (AOM)

The Investigation Team reviewed the AIXL company policy of aerodrome operating minima (OM Part A, Vol-2 Para 17.1.5) that mentions that the Jeppesen charts are customized and the value printed on the chart is the applicable minima.

The investigation team reviewed the Jeppesen chart for Kozhikode (Calicut) and observed that as per DGCA CAR Section 8, Series C Part I, at runways where no RVR is reported the takeoff minima cannot be lower than 800 m, however AIXL has filed a takeoff minima of 300 m in violation of the said DGCA CAR.

2.8.1.3 SCHEDULING

After the partial resumption of the flight schedule due Covid-19 pandemic by DGCA, AIXL operated repatriation flights under 'Vande Bharat Mission' as per the directive issued by the Govt of India.

Since international flight schedules were being decided in accordance with the requirements projected by the Ministry of External Affairs, no fixed international schedule was available on the day of the accident. Initially on 08 August, 2020 only two international flights were being operated from Kozhikode, one to Abu Dhabi and another to Doha. Accordingly, two P1 were positioned at Kozhikode in addition to the one P1 for whom, Kozhikode was the home base. On 05 August, 2020, Scheduling and Network Planning planned an additional flight to Dubai from Kozhikode starting 08 August, 2020. This flight was uploaded on the ARMS portal on 06 August, 2020. No additional crew could be positioned at Kozhikode at such short notice and so PIC of AXB 1344, who was to be on standby, was rostered for 08 August morning flight to Doha to cover the newly planned flight. The message from ARMS regarding the change in roster was sent to the PIC on 07 August, 2020 at 03:26 UTC. Therefore, PIC was aware that he had been rostered for the next day flight at 04:30 UTC, before the departure of flight AXB 1343/1344.

The scheduled arrival of flight AXB 1344 at Kozhikode was 13:40 UTC. Delay in arrival of AXB 1344 at Kozhikode would have placed the PIC in FDTL and his next day flight would then have had to be accordingly rescheduled. The urgency to land at Kozhikode so as to operate the flight on 08 August,2020 morning for which he was the only PIC available might have been a reason for him to violate SOP and land with a likely faulty wiper in adverse weather conditions.

2.8.2 TRAINING OF AIXL COCKPIT CREW

Training Facilities of AIXL (including simulator) are located in Mumbai within the Air India Training Centre. Type rating, recurrent training and command upgrades for AIXL cockpit crew is conducted by Air India Instructors at AI Training Centre which has been approved by Flight Standards Directorate (FSD), DGCA. All operational training including simulator training is carried out by AIXL in accordance with the applicable CARs and Operations Manual.

Hard Landings and Missed Approach are adequately documented. However, sufficient follow up action and importance is not given to this vital aspect by the AIXL Flight Safety and Training Department.

Captain under Supervision Training on Aircraft: As per AIXL SOP Para 1.3.21 covering takeoff notes states that... *c) "In case the takeoff is being performed by a F/O or Captain under supervision, the PF must remove the hand from the thrust* *levers after the TOGA switch is pushed. The PIC is to keep his hand on the thrust levers up to V1 to enable immediately RTO if required".* AIXL is following a different training pattern, as compared to other Boeing 737 operators in the country, wherein the trainee captain is not allowed to handle thrust lever during the takeoff roll, this results in negative training during a most crucial phase of the flight. The trainee captain would be handling the thrust levers for the first time during the takeoff roll once released online and flying with a line FO instead of a qualified trainer. The lack of practice in handling the thrust lever could lead to serious repercussion in case of a rejected takeoff.

2.8.2.1 SIMULATOR MAINTENANCE

The maintenance of simulator was found to be unsatisfactory. This results in negative transfer of training. The Investigating Team checked the records and interacted with the pilots and found that there were repetitive snags in the simulator. All snags were not being regularly documented (as they do not come under the purview of MMI). Poor maintenance and frequent break down of the simulator adversely affects training of pilots thereby affecting their performance.

2.8.2.2 SIMULATOR TRAINING

The Investigation Team observed a few simulator sessions in the AIXL simulator at Mumbai Training Centre. Some of the important observations are mentioned below:

(a) The overall Simulator training experience encompassing the existing features and maintenance standards was far from satisfactory. Simulator exercises are often conducted with snags which come under the purview of MMI. Various mitigating measures are resorted to by the trainers to complete the training profile. Frequent interruptions due to mitigating measures to cover poor maintenance results in unrealistic experience of various non-standard events/emergencies by the cockpit crew. The flap indicator displayed a pronounced split which had to be ignored by the trainee and was misleading. Manual extension of the landing gear could not be carried out as the system was unserviceable. The thrust levers moved freely with no 'feel' at all and trainees were unable to set the required thrust values accurately.

(b) The simulator does not have the option of simulating contaminated runway conditions unlike other Boeing-737 simulators available in India. This is a serious deficiency as the simulator cannot be used to highlight to crew the massive difference in braking on wet vs contaminated runway conditions. Various combinations are resorted to by the trainers but it is not realistic.

(c) The non availability of engine Auto-relight feature in AIXL simulator is a big drawback as the cockpit crew is not exposed to this feature which exists in the aircraft. The Instructor can restart the engine quickly from IOS, if he is fast enough, but the normal engine spool-up experience cannot be simulated. The rate of control inputs is different in both cases and can confuse the pilot, thereby compromising aircraft safety, especially in poor visibility with no clear horizon.

(d) The First Officer's role while performing the duties of Pilot Monitoring was restricted to routine procedures and call outs. His participation was not encouraged to promote good CRM. The First Officer, more often than not, waited for a nod of approval from the Captain to carry out routine PM duties. His involvement was bare minimum and restricted to following procedures irrespective of the non standard actions of the Captain. This reflected an extremely poor CRM.

(e) Some Trainers had not filled the required training reports correctly. They were either incomplete or incorrectly filled.

It is very evident from the above mentioned observations that the entire training in the simulator is far from meaningful or realistic. It does not contribute in any way towards enhancing efficiency and safe aircraft operations. More importantly, the aspect of CRM is not addressed effectively resulting in a steep cockpit gradient.

2.8.2.3 COUNSELLING OF AIXL PILOTS

There is no dedicated and trained Counselling Team at the Training Centre. Counselling, an important training aspect, is carried out on an ad-hoc basis by any available Trainer at the centre.

2.8.2.4 CRM TRAINING OF AIXL

Even though the crew were meeting the mandatory CRM training requirements, it was evident from the scrutiny of documents, CVR transcript, simulator sessions attended by the Investigation Team at AIXL training facility at Mumbai and from informal interactions with the company pilots that a steep cockpit authority gradient exists in the company which results in reluctance of junior pilots to positively contribute to decision making and senior pilots acting independently without consultation.

The stiff and closed work environment, where hierarchy and seniority work to the detriment of the airline, contributed towards a breakdown of communication in the cockpit of flight AXB 1344. During the critical phase of planning after the missed approach, preparation of the second approach for runway 10, and at the final phase of landing on runway 10 (onset on deviations towards an destabilized approach and long float) the FO did not offer the required corrective inputs and displayed a meek and unassertive demeanour in the presence of the senior pilot (PIC).

During the alarming extended float period, the FO reluctantly called out for a go around which went unheeded by the PIC. The FO, who was then authorized and required to overrule the PIC and take over controls as per the SOP did not intervene. The FO having correctly anticipated a delayed touchdown and runway excursion was unable to assert his professional role and skill.

The work culture and the prevailing cockpit gradient in Air India Express leading to poor Crew Resource Management was a significant factor that contributed to the crash of AXB 1344 by preventing the FO from being assertive enough to take charge in the cockpit (when required to do so).

The inadequacies in CRM training and the lack of reference criteria propelled the Investigating Team to analyse the CRM training of AIXL crew, especially to determine its efficacy in achieving its desired goals of improving safety.

CRM training should be embedded in the fabric of operational and technical training. An effective CRM training should be able to impart the appropriate operational behaviour, attitude and skill changes as a result of attending the training course, that can be measured in a simulated work environment (like an aircraft simulator).

Although, it was complex to draw firm conclusions on the effects of lack of CRM training on AIXL crew and on the organisation, after interaction with the instructors and aircrew of AIXL, it was evident that there is an unambiguous lack of assertiveness amongst the first officers of the airline. Similar behaviour was also noted during the simulator sessions and during the flight as observer in the cockpit by the IIC. In addition, the authoritarian behaviour of Captains results in their failure to accept inputs from junior crew members.

The annual CRM training is not proving to be meaningful to improve the airline cockpit environment so as to enhance the safety standards. Subsequently, there is a lack of management support for aviation safety and a failure by Line Trainers to reinforce this crucial aspect. This highlights the fact that aviation safety is not being given its due importance by AIXL.

What stood out to the Investigating Team from the CVR recording of flight AXB 1344 was the lack of crew communication and coordination. While the captain communicated often about the weather and made numerous enquiries about it, there was no thoughtful discussion between the crew about it. The safety of a flight is dependent on a cohesive crew that has a shared understanding of their situation and environment.

The Investigation Team also studied the contributory factors in the previous accidents of AIXL. It was found that the 2010 Mangalore crash of flight AXB 812 (VT-AXV) and the 2019 Mangalore runway excursion by flight AIX 384 (VT-AYA) had stark similarities in the accident causation wherein, poor CRM was the primary contributory factor. In both these instances and also in the present accident, the 'Go-Around' call by PM on an unstabilized approach was totally ignored by the PF and resulted in a crash. Although, the airlines have documented the implementation of the recommendations of the Court of Inquiry of 2010 Mangalore accident, the repetition of the same causal factors in 2019 and in 2020, highlight the failure of the company to implement effective CRM training that translates into prevention of future accidents and enhanced safety. Repeated accidents/serious incidents due to proven failure in CRM substantiate that the organisation has failed to make appropriate cultural changes and attitude towards flight safety. No effort is visible in the company to enhance the effectiveness of CRM training. Although the laid down syllabus looks complete on paper, the inability of the company to monitor the methodology of imparting such training has failed to inculcate it in the attitude of the crew attending the CRM training courses.

The 2010 Mangalore Court of Inquiry had made the following recommendation for AIXL:

> *"Flying supervisors and TRE/ TRI should observe all CRM issues including the Trans-Cockpit Authority Gradient by occupying Observer's seat. This would allow them to assess the responses of both Captain and the First Officer, functioning as a team."*

However, on investigation, it was observed that this recommendation was not implemented. This, once again, highlights the inability of the concerned post holders of AIXL to apportion seriousness and weightage to CRM and take the necessary steps to improve flight safety. Senior management pilots and trainers, during random observation flights, could have scrutinized all facets of CRM including the trans-cockpit authority gradient and assessed the responses of Captain and the First Officer as a team.

In addition, CVR monitoring to improve cockpit gradient/CRM/violation of SOPs did not reflect any meaningful outcomes in the past. The reason for this could be an extremely cursory and casual interpretation by the supervisors. In view of the repetitive accidents in the company due to CRM failure, this activity should have been granted higher status and included in their KRAs.

2.8.2.5 STEEP AUTHORITY GRADIENT

Para 1.17.5.4 of VT- AXV Mangalore accident report 2010 of Air India Express states that *"in this accident, the first officer had been able to identify the Unstabilised approach conditions, but a steep gradient had apparently precluded him for taking over the controls or to enforce any corrective actions"*

The 'Steep Authority gradient' in the cockpit of AXB 1344 acted as a barrier to the crew involvement, restricting the flow of feedback from FO especially with regard to threat analysis and problem solving. Only the most assertive and confident FOs would be able to challenge the authority of PIC. Some senior pilots like the PIC of AXB 1344 are likely to consider any type of feedback as a challenge and may respond aggressively. During brief interactions with some of the pilots from AIXL, the Investigation Team discovered that the PIC was known to be goal orientated, to have cognitive rigidity, had a tendency towards perfectionism and vulnerability to stress. Such a personality trait makes the senior pilots vulnerable to denying themselves the available resources (skills, knowledge and support of other crew members), thereby making their actions self-defeating and are unlikely to attain their goals.

The CRM training of AIXL is weak, hence, the Senior Captains of the company do not encourage a working climate in the cockpit where a junior pilot is confident enough to raise concerns, question decisions and also offer solutions. Also, the junior pilots do not possess assertiveness techniques to provide them the confidence to question authority of the PIC and play a full part in the team task.

The comprehensive briefing (such as pre-take-off and top of descent approach briefing) is vital to define limitations and boundaries of each crew member, both in normal and non-normal conditions. In the background of the prevailing safety climate and culture of the company, this lack of clear briefing by the crew of AXB 1344 on 07 August, 2020 (especially after the missed approach) resulted in disintegration of team work in the cockpit and fell prey to the steep cockpit gradient. In that, the PM did not contribute anything to prevent the poor decision making and judgement of the PF during the fast evolving situation in the cockpit *(owing to change in the runway etc)*. Few seconds before touchdown, the aircraft rate of descent increased and the aircraft went below the glideslope. Realising that the PF had not reduced the ROD sufficiently, the PM gave a call *"Rate of Descent"* to which PF responded as *"Check"*. When, the PF did not sufficiently correct the ROD, the PM again gave a call of *"Rate of Descent"* suffixed with *"Captain"*. To this second call of the PM (which was slightly firm), the PIC responded with *"Yeah, Yeah...Correcting... Correcting...Correcting"*, as though, he was conveying his discontent on repeated calls of correction of ROD. The PM responded to this with a feeble and helpless "Uh..mm". Thereafter, the sink rate was arrested but the thrust was increased manually by PF which caused the aircraft to float. At 07 seconds before touchdown, while the aircraft was at 16 ft RA, the PM once again tried to catch the attention of the PF by calling "*Just check it"*. At this point the aircraft was just short of the end of touchdown zone. As the nose was lowered and thrust was reduced further another feeble, uncomfortable call of *"...Captain"* was given by the PM and finally at around 10 ft RA, he gave a definite call of *"Go around"*. The PF did not respond to any of the calls made by the PM.

The PM's response in the cockpit, as captured by CVR, were limited to affirmations to the PIC's calls and not contributory towards enhancing flight safety or preventing errors at anytime. Although, he made a meek attempt at suggesting 'go around' just before touchdown, he did not take a concrete step (as per SOP and CRM training) towards taking over the aircraft controls and executing a missed approach procedure.

Another adverse effect of 'steep authority gradient' in this crash was 'conformity'. The FO could have communicated useful safety actions (to 'go around') but failed to do so assertively. The steep authority gradient played a key role here and facilitated FO's attitude of conformity (which is easier than speaking up against the decision of a Senior Captain).

The steep authority gradient in the company is evident by the very wordings of the Ops Manual. To illustrate this with an example, para 23.13 of OM Part A, states, *"The take-off speeds, V1, VR, V2, the engine power settings etc. are to be derived from the respective FCOM. The first officer will present the same to the PIC for his approval. When the load and trim sheet is presented to the PIC before departure, the take-off data card should be updated accordingly"*. The use of words like 'present for approval' is testimony to the authoritarian status granted to senior Captains in the airline. The FO is clearly made to feel subservient to the PIC and not as part of a team who may be called upon to take crucial decisions if and when required to ensure the safety of the aircraft and its passengers.

Lessons from Previous Accidents: In the last 10 years, AIXL has had 2 major accidents and a number of non fatal accident/serious incidents. On close scrutiny of these accidents and incidents, a very clear and distinct trend emerges.

Most of the above were a result of continuation of unstabilized approach and total disregard to the repeated calls from the First Officer to "Go Around", both being serious breach of SOP. This resulted in long landings in which the aircraft was unable to stop on the runway and terminated in excursion. There was reluctance on the part of the First Officers to take over controls and execute a missed approach, which is the correct procedure, as given in the SOP and is expected to be done without any hesitancy. A steep authority gradient discouraged and prevented participation of the First Officers. Hence, they were extremely reluctant to exercise their duties and responsibilities in emergency/critical situations.

In view of the above it is evident that there is a serious safety concern of steep authority gradient in the company which prevented the PM to make assertive call outs and take actions as stipulated in SOP. This again is one of the major contributory factors to the accident.

The committee observed that there has been no apparent change in managing the Power Distance Index and the CRM programme of the company has not been able to deliver the desired results.

2.8.3 APPOINTMENT OF AVIATION/AEROSPACE MEDICINE SPECIALISTS

In accordance with the DGCA General Advisory Circular No. 01 of 2011 dated 17 December, 2011, all scheduled and non-scheduled operators were advised to employ Aviation/Aerospace Medicine Specialist. However, AIXL as well as Air India do not have any Aviation/Aerospace Medicine Specialist.

As part of promoting Flight Safety, it is the responsibility of all operators to carry out effective maintenance and monitoring of health of their aircrew. In order to achieve this, the operators need to ensure timely medical attendance, specialist consultation and periodic medical assessment of all their crew and implementation of medical policies laid down by DGCA. In addition, the crew members need to be indoctrinated in aeromedical aspects of civil aviation. Training in Human Factors is an integral and vital part of CRM/Joint CRM training for flight crew. Aviation/Aerospace Medicine specialists are medical doctors possessing post-graduate degree in Aviation/Aerospace Medicine. These specialists possess in-depth understanding of aeromedical issues of aviation and their mitigation, which a general physician or a clinical specialist does not possess. This specialized knowledge can be harnessed to scientifically and comprehensively manage various aeromedical stressors inherent to civil aviation that can adversely affect aircrew performance. Not having easy access to an Aviation Medicine Specialist may have led the PIC to take multiple un-prescribed drugs for his diabetes without realising the risks of doing so while operating an aircraft.

The role of Aviation/Aerospace Medicine Specialist is not limited to monitoring of aircrew health and breath analyser testing but also encompasses exploitation of their domain knowledge in managing human factor issues like fatigue management, stress management, CRM, flight automation, mental workload assessment and optimising man-machine interface. These specialists are experts in aeromedical aspects of aircraft accident investigation through structured training during their post graduation.

2.8.4 ORGANISATION CHART

Para 1.17.2 of VT-AXV Mangalore accident report 2010 states, "… *It was evident from the above that although Air India Express had a separate AOP it did not function as a separate entity. During the interaction with post holders, the demarcation of responsibility between Air India and Air India Express was not clearly evident…*".

The review of the current organisation chart reveals that the Chief of Flight Safety in addition to reporting to the CEO (Accountable Executive), also liaisons with the Chief Operating Officer and the Air India Corporate Safety, SMS & ERP. This basically dilutes the authority of Chief of Flight Safety of Air India Express. This is not in line with the DGCA requirement as mentioned in Para 2.5 "Nominated Post Holders" of CAP 3100 and relevant DGCA CAR. It is evident that no change has been made by Air India and Air India Express to clearly demarcate their lines of management and to separate Air India Express as an independent entity.

2.8.5 ORGANISATION CULTURE

The committee reviewed various occurrences (Accidents & Serious Incidents) of Air India Express and it was observed that main stream Air India treats Air India Express differently and the concept of "safety culture" developed by the senior management of Air India and Air India Express does not foster open communication regarding safety related matters. The non implementation of safety recommendations related to the airline which were brought out during various investigations was evident to the committee and inadequate safety oversight by the senior management pushed the entire organisation to be more operation oriented rather than having right balance between operations and safety which in an ideal condition would have given adequate space for development of the right safety culture in the organisation.

2.9 OTHER ORGANISATIONS

2.9.1 DGCA

2.9.1.1 AUDITS BY DGCA

(a) **Monitoring of DFDR Parameter:** The DGCA audits of AIXL 2018-2020 reveal that AIXL was not monitoring 100% DFDR data for FOQA Monitoring. It was at 88.65% in 2018, 89.67% in 2019 and 94% in 2020 (up to Aug 2020). Considering the safety criticality of this programme, neither the airline nor the regulator enforced its strict implementation. Any figure less than 100% (barring MEL) in the safety audits and no strict action being taken against the erring operator depicts the lack of significance being granted to the aviation safety and National Aviation Safety Programme. It needs no emphasis that even a single unmonitored flight operating outside the safety envelope poses substantial risk to its passengers and possible catastrophe. DGCA has been accepting low DFDR monitoring figures and Safety Audits are closed without any follow up action. Flight safety of AIXL continues to be compromised in the absence of any concrete steps by DGCA to ensure compliance of the mandatory required standards of the CAR.

(b) **Audit of AIXL Simulator:** Investigation Team observed various defects in the Flight Simulator of Boeing 737 available at Air India ATO which is being used to provide training to AIXL pilots. Although DGCA audits did bring out certain maintenance issues, there were other defects as well that resulted in negative training. AIXL continued simulator training with defect of 'Manual Main Gear Extension Inoperative, Trailing Edge Flap Asymmetry indication', which do not come under the purview of MMI. AIXL did not address these maintenance issues and they kept recurring.

AIXL simulator audits by DGCA have not highlighted and addressed the important issue of the absence of contaminated runway option which is a mandatory requirement as per AIXL Operations Manual. AIXL follows the manufacture specified limitation of 3 mm of contaminants, however, the company simulator does not have an IOS panel option to allow the instructor to simulate contaminated runway conditions during the training and check sessions of the airline pilots.

(c) **SMS Audit:** Training duration for SMS Nodal officers (operational area) was reduced from five days to three days and the reasons stated by AIXL was, shortage/non-availability of trainers. This was observed by DGCA during the surveillance. However, this observation was not addressed by AIXL till the date of accident. This clearly depicts the safety culture of AIXL and importance that is given to flight safety. After the accident of AXB 1344, AIXL amended their SMS Manual for the duration of training which was reduced from five to three days for Nodal Officers and submitted for acceptance of DGCA on 17 Aug 2020. CAR Section 1 Series C Part 1 on 'Establishment of Safety Management System' lays down the aviation safety related processes, procedures and activities for the establishment of SMS by a service provider. However, the CAR does not specify the minimum duration for the SMS training of operational personnel.

(d) **ARFF Training:** ARFF Crew familiarisation with the aircraft. DGCA in its Audit of 2016 had flagged the non-availability of training records of ARFF crew. Later in 2018 DGCA once again flagged lack of Aircraft Familiarisation training at Kozhikode. The findings were closed based on ATR submitted by AAI and later in 2019, DGCA termed Aircraft Familiarisation of ARFF crew at Kozhikode as 'Satisfactory'. However, during Investigation the team found that aircraft familiarisation training for ARFF crew had not been conducted at Kozhikode.

2.9.1.2 ACTION BY DGCA ON RECOMMENDATIONS OF EARLIER ACCIDENTS

As per the information received from DGCA, all implementable recommendations of COI of 2010 Mangalore air crash have been implemented. However, Investigation Team found that in various instances the recommendations have not been addressed effectively. Some of these observations are elaborated below:

(a) DGCA did not take any action to remove the ambiguities in CAR Section 5-Air Safety, Series F, Part II related to the exceedance parameters for monitoring of DFDR in FOQA program. Various airlines including Air India Express are not complying with the said CAR and have obtained DGCA approval of their Flight Safety Manuals for utilizing exceedance parameters which are not in compliance with the CAR. The list of exceedance parameters for B737 that were arrived at by DGCA after discussion with the Airline Operators and communicated to Airlines for implementation on 28 July 2020 (although not included in the AIXL FSM until the accident on 07 Aug 20) also had some ambiguities. The list of parameters is still being updated and the last update is dated 07 Dec 2020 to address some anomalies.

(b) DGCA Flight Inspectors are required to carry out frequent flying checks on sectors involving flights to critical airfields (including table-top runways) and also during 'Red-eye' flights involving Window of Circadian Low. The data obtained from DGCA indicated that no flying checks were carried out by DGCA FOIs from Jan 2019 to Jun 2020 on any critical airfield or during "Red Eye" flights.

(c) Flying supervisors and TRE/TRI of AIXL did not undertake any observation flights to observe CRM issues.

(d) Permanent bases for Captains of AIXL are not based on the realistic operational requirement. Kozhikode has maximum number of AIXL flights, yet, only one Captain is permanently based there. This arrangement of assigning temporary bases certainly strains the Flight Scheduling.

2.9.1.3 STANDARDISATION AND MONITORING OF FOQA PARAMETERS

The primary objective of CAR Section 5-Air Safety, Series F, Part II is to identify the hazards and system deficiencies in aircraft operations before they result in an accident through a non punitive programme for gathering and analysing DFDR data. Although the objectives stated are robust in preventing future accidents, its requirements and procedures as laid down in 1999 have not been continually revised and updated in order to achieve the desired aim.

The CAR was published on 30 Sep 1999 and has been revised only once on 26 Jul 2017. Since 1999, there have been accidents due to landing off an unstabilized approach and long landings that highlighted the need for strict implementation of the DFDR analysis programme through CAR. However, the accidents continue to happen. To quote examples from AIXL, this accident is the third in the series of runway overruns due to landing off unstabilized approach resulting in long landings. Each of such accidents was a failure of the preventive strategies implemented by DGCA. This should have triggered a need to reinforce the DFDR monitoring. However, even after clear recommendations of CoI of the 2010 Mangalore AIXL crash, the exceedance parameters of the CAR were not revisited until 2017. In 2017, only high normal acceleration on touchdown was revised. The airlines prepared their DFDR monitoring programme based on existing CAR parameter exceedance and included it in their Flight Safety Manuals which was approved by the Regulator.

DGCA published the five yearly National Aviation Safety Plan in 2018 (2018-2022) and all scheduled and non-scheduled operators were pronounced as the stakeholders for the safety programme. The programme once again highlighted the need for monitoring long landings in order to prevent runway excursions. However, this programme was not converted into a policy or requirement. DGCA did not stipulate exact parameters to be monitored for long landings along with their limits. The NASP table 3.8 SP3 Safety Objective [SO 3.1(c)] states, *"FOQA monitoring of landings made beyond the touchdown zone of the runway (Extended/Long flare)"*. Due to the ambiguity in this directive, it was observed that various airlines have been using different parameters to comply with the directive, resulting in inaccurate data that was being forwarded by the operators and accepted by DGCA. The same has been forwarded to the Investigation Team. In the absence of clear cut DGCA requirements, the operators continued to monitor DFDR to identify "extended/long flare" using their own methodology.

The detailed analysis of the FOQA monitoring for approach and landing by the Investigation Team has revealed the following:

(a) The general list of parameter exceedance is listed in Annexure-A of CAR. Para 4.5 of the CAR clearly mentions that "*Exceedance limits of various parameters **SHALL** be established by the operators for each type of aircraft*

WITHIN THE LIMITS *given in* ***Annexure-A****. These* ***SHALL*** *be stipulated in their Flight Safety Manuals*". Although stated as a mandatory requirement for the operators to comply with, it has been found that most of the airlines were not adhering to the laid down suggested alert/tolerance values. The reason stated by DGCA was that Annexure A is 'generic' in nature and is applicable for all categories of aircraft. On the other hand, the operators have clearly stated that the laid down limits were un-implementable. They informed the Investigation Team that the limits laid down in the CAR for approach and landings was not capable of picking up the 'unstabilized approach', as the published criteria for a 'stabilized approach' are at variance with the limits provided in Annexure A to the CAR. The following are some of the exceedance limits of parameters, which need to be reviewed for stabilized approach and landing phase of flight:

(i) **Late Landing Flap** (Flaps not in landing position): DGCA CAR prescribes the exceedance limit for late flap selection as below or equal to 600 feet. However, the stabilized approach criterion starts from 1000 feet (not 600 feet), by which the aircraft has to be in landing configuration, with landing flaps selected and landing checklist completed. Implying that, if the exceedance limit prescribed by CAR is applied, the whole exercise of Exceedance monitoring for this violation would be ineffective as the flaps are to be selected much above 600 feet. Also, all the pilots that defy the stabilized approach criteria i.e. who select flaps in landing position up to 400 ft below the prescribed height of 1000 ft would be denied the mandatory counselling/corrective training to improve flight safety.

(ii) **Deviation from Glide slope:** The CAR lays down the exceedance limitations for deviation from the glide slope as half dot above or below the glide slope. Again, as per the stabilized approach criteria, glide slope deviation of up to one dot is permissible. This implies that, if half dot deviation limit as laid down by DGCA is implemented, a large number of flights shall be violating the exceedance limits.

(iii) **High ROD:** DGCA CAR lays down the limits for high ROD as >700-800 feet/min (between 1000 to 500 feet) and >600 feet/min (between 500 to 100 feet). As ROD is a function of Ground Speed and angle of approach, ROD of up to 1000 feet/min is allowed as per the stabilized approach criteria.

(iv) **Low Power on Short Final:** (Below 500 feet). The FSM of AIXL approved by DGCA lays down the exceedance limits for low power on short finals as below 40% N1. However, in the same manual the limit of 40.2% N1, 40.1% N1 and 40.0% N1 cover the entire thrust monitoring range of Low Power below 500 ft on Approach i.e (Normal, Caution and Exceedance). It is noteworthy, that the range between the Normal, Caution and Exceedance limit is only 0.1% N1, which is practically impossible to monitor in the cockpit.

(b) All operators are required to prepare their exceedance limits of FOQA parameters within the prescribed limits laid down in CAR Section 5-Air Safety, Series F, Part II dated 30 Sep 1999 (Rev 1 dated 26 Jul 2017). AIXL prepared the list of exceedance which was not in conformance with the CAR yet it obtained approval from DGCA as part of their Flight Safety Manual Issue-05 Rev.0 dated 01 Feb 2018 (approved by DGCA on 28 May 2018). This manual was effective at the time of accident i.e. on 07 Aug 2020. On the date of accident, there were 85 parameters that were being monitored for exceedance by AIXL.

(c) DGCA further made frequent changes to the list of FOQA exceedance parameters for B-737 aircraft on 28 Jul 2020 and 07 Dec 2020. The high ROD exceedance limits amended by DGCA are as follows:

Parameter	**High ROD (1000-500 feet)**	**High ROD (500-100 feet)**
Exceedance Limits prescribed by DGCA in the CAR	>700 to 800 feet/min	>600 feet/min
Exceedance Limits prescribed in the FSM of AIXL (on the date of this accident) approved by DGCA on 28 May 2018	>1500 feet/min	>1300 feet/min
Exceedance limits revised by DGCA for all Operators of B-737 on 28 Jul 2020 via e-mail (implemented by AIXL on 01 Sep 2020)	>1500 feet/min	>1000 feet/min
Exceedance limits again revised by DGCA for all Operators of B-737 on 07 Dec 2020 via e-mail	>1400 feet/min	>1100 feet/min

Also, for the first time, parameter for monitoring 'Long Landings' was introduced by DGCA in the exceedance limits on 28 Jul 2020, wherein any landing beyond 3000 feet from the runway threshold or 30% of the LDA was classified as an 'exceedance'. This was implemented by AIXL through their safety bulletin on 01 Sep 2020.

It can be concluded that DGCA revised the exceedance limits at random and frequently without any strong scientific basis and without any consultation with AIXL.

(d) National Aviation Safety Program (Ed II) was issued in Aug 2018. This five year plan (2018-2022) had eight key safety priorities. Serial No. 3 was specific on *"Runway Excursions and Overruns"*. Hence, in the 'Safety Objectives', a new FOQA parameter was added viz. *"FOQA monitoring of landings made beyond the touchdown zone of the runway (Extended/Long flare)"*. For implementation of this new DFDR data, landings made beyond the touchdown zone were being monitored through exceedance of 'extended/long flare'. The investigation team observed that these two terms i.e. landing beyond touchdown and long flare are being used synonymously. It is evident in the data provided by DAS, DGCA that one event leads to another i.e. if there is a long or prolonged flare, the aircraft would touchdown beyond the touchdown zone. However, this may not always be true especially in non-precision approach and visual approach. This aspect leads to a lot of ambiguity and inconsistencies in monitoring parameters by various operators. The DFDR data being used for monitoring of prolonged flare to check long landing by some of the Scheduled Operators is as follows:

(i) One operator uses GPS coordinates of runway threshold and aircraft touchdown point to precisely calculate 'long landings' i.e. beyond 3000 feet or 1/3rd of the runway whichever is less.

(ii) One of the airlines was monitoring 'long flare distance and time' calculated from flare height which was 30 feet RA and using aircraft speed as 250 feet/sec till touchdown.

(iii) An Airbus operator identified 'long flare distance' as any touchdown beyond 1050 m on the runway. The same operator for their Boeing variants uses time taken following flare height of 30 feet and identifies 'prolonged flare' as any touchdown beyond 12 sec after flare for B777 and 11 sec after flare for B747.

(iv) Another operator of Airbus fleet is monitoring 'late touchdown' using algorithms provided by Airbus. This may be valid in precision approaches where the aiming point is defined fairly accurately. But in visual and Non- Precision approaches, where there is no ILS signal, the logic fails.

(e) In July 2020, DGCA issued standardized exceedance parameters for B737. This was communicated to the Operators. Airlines were required to amend their Flight Safety Manuals to include the amended exceedance values. AIXL Flight Safety Bulletin No.FSB 2020-1001 dated 01 Sep 2020 was issued (with the added parameters for 'long landing'), which was after the date of accident i.e. 07 Aug 2020. On the date of the accident, Flight Safety Manual, Issue 5 (Rev.0) dated 28 May 2018 was effective.

The efficacy of strict and correct monitoring of long landings can be seen from the FOQA monitoring data of one of the airlines that had used precise technique in measuring the long landings through GPS coordinates (of threshold and touchdown point from DFDR) and successfully brought down the long landings for B737 aircraft from 303 in January 2020, 105 in February, 2020 to single digits by June, 2020 and the same trend continued thereafter.

To summarize, the Investigation Team believes that prevention of unstabilized approach and long landings through DFDR monitoring is an efficient and effective tool in reducing the number of approach and landing incidents and accidents. DGCA has a vital role in pro-actively and comprehensively identifying the DFDR parameters and defining their exceedance limits that would effectively achieve the goal of preventing runway excursions and over runs through FOQA monitoring by the airlines. Therefore, if the FOQA programme is implemented meticulously, both by the operator and effective supervision by the regulator, it will yield substantial results in preventing such occurrences in future in the form of enhanced flight safety.

In the absence of cooperation from DAS officials DGCA, the analysis of all safety aspects including FOQA parameters has been made taking into account the information provided by Chiefs of Flight Safety of all commercial airlines and detailed discussions and interactions held with office bearers of various airlines.

2.9.2 AIRPORTS AUTHORITY OF INDIA

2.9.2.1 AIRCRAFT FAMILIARISATION TRAINING OF ARFF CREW

It is evident from the statement of witnesses and personnel involved in the fire and rescue activity that considerable effort and time was taken to gain access to the cockpit for rescuing the pilots. These efforts could have been avoided if the ARFF personnel were able to open the cockpit emergency exit or guide rescuers for the same. On further investigation it was found that the ARFF personnel themselves had not undergone aircraft familiarization training on B737 aircraft and were not aware of how to open the cockpit emergency exit door.

According to the organization training policy, all ARFF personnel posted at Kozhikode are required to undergo Aircraft Familiarization Training on aircraft operating scheduled flights to Kozhikode. However, the training manual does not specify any period within which the incumbent should be provided with necessary training nor does it mandate that ARFF personnel should have undergone familiarization before being posted at Kozhikode. This led to a situation where ARFF personnel posted at Kozhikode had not undergone aircraft familiarization training on B737 or other types operating at Kozhikode.

The ARFF crew who deposed before the investigation team after the accident informed them that they have not undergone familiarization training on aircraft at Kozhikode. As per the Head of Fire Department, repeated efforts were made to get ARFF crew familiarized on different aircraft that operate scheduled flights to Kozhikode. Emails were regularly sent to all concerned but the efforts did not materialize and no training was provided to the ARFF crew at Kozhikode.

DGCA had highlighted the absence of training records in its Audit of 2016 and also pointed out lack of Aircraft Familiarization training during 2018. AAI in its Action Taken Report to DGCA later submitted that the familiarization training has been carried out and the finding was closed. The report of Annual surveillance inspection carried out by DGCA from 01 April to 03 April 2019, mentioned that ARFF personnel had undergone Aircraft Familiarization Training as per ICAO Doc.

9137-AN/898 Part-1, Chapter -14, Para 14.5.2 and their performance was recorded as "*Satisfactory*". The Action Taken Report submitted by AAI and DGCA Audit observation of 2019 are in contradiction to the statements of ARFF crew as well as their Head of Department who deposed before the investigation team.

Based on the in-depth interaction and statements of the witnesses as well as by analyzing the actual performance of ARFF crew at the crash site, investigation team is convinced that the ARFF crew had no familiarization training on the type of aircraft leading to delays in the rescue operations.

From the above it is evident that ARFF crew had not undergone familiarization training on type of aircraft which resulted in non standard rescue operation carried out at Kozhikode after the accident.

2.9.2.2 RUNWAY CENTRE LINE LIGHTS

The necessity of providing runway centre line lights at Kozhikode airport has been felt for a very long time. There are various important safety considerations for it. Important ones are:

(a) Kozhikode airport is a safety critical airport (as categorized by AIXL in their OM) with challenging surrounding topography and adverse weather phenomenon during most part of the year. The weather conditions here are very extreme with heavy rain, strong winds and poor visibility during monsoon which extends up to six months in a year.

(b) Kozhikode airport runway is Precision Approach Category -1 but without full Category-1 Approach Lighting System because of non availability of land due to terrain constraints. Present length of approach lights is only 150 m against full-fledged Cat-1 requirement of 900 m.

(c) Runway strip at Kozhikode is non-compliant with the ICAO requirements and is operating under safety mitigating conditions/restrictions. Width of runway strip is only 75 m against minimum requirement of 140 m by ICAO.

As per standards laid down in DGCA CAR and Annexure-14, requirement of runway centre line lights is not mandatory for a standard Cat-1 runway. But Kozhikode airport is a safety critical airport, operating with non-standard approach lighting system and with mitigating factors for non-compliant runway strip.

The criteria of DGCA CAR and Annexure-14 regarding not installing runway centre line lights on a standard Cat-1 runway does not cater for the combined adverse factors that are present at Kozhikode airport. In fact, Kozhikode and Mangalore are two table-top runways in peninsular India which have similar weather and terrain conditions. A Committee of Inquiry while investigating a serious landing incident of flight IX-814 on 14 August, 2012 at Mangalore in their Safety

Recommendations had stated "*AAI may consider the installation of runway centre line lights in view of the table top operation surrounding topography and frequently changing weather phenomenon.*"

The Action Taken Report on 2012 Mangalore Inquiry submitted by AAI, Aviation Safety to DGCA assured that Runway Centre Line Lights will be installed during the next planned re-carpeting work, due to complexity of work on an active runway. However, the Investigation Team was informed that runway at Mangalore was commissioned in 2006 and next re-carpeting would be carried out after 18 years of commissioning in 2024. Mangalore airport continues to operate without runway centre line lights.

An opportunity for installation of Runway Centre Line lights existed at Kozhikode when runway re-carpeting and strengthening work was being carried out. Runway re-carpeting and strengthening work was completed in Feb 2017 but runway centre line lights were not installed.

The occurrence of passing low clouds and sudden drop in visibility after landing of aircraft has resulted in repeated demand from user Airlines for installation of runway centre line light at Kozhikode. Kozhikode airport official prepared a proposal for installation of runway centre line lights at Kozhikode and sent it for perusal of AAI HQ. Again due to complexity of installation of runway centre line lights on an operational runway it was agreed to install the same until next runway re-carpeting in 2022. The demand of runway centre line light at Kozhikode was further re-emphasized by an investigation report into a runway excursion incident of Etihad Airlines aircraft during landing on 20 June, 2019.

Apart from directional advantage in poor visibility and night operations, another major advantage of having Runway Centre Line lights is to ensure the landing distance available for the aircraft through colour coded centre line lighting which consists of alternating red and white lights beginning at 900m from the runway end and these change to continuous red lights for the last 300m of the runway.

Safety enhancements that runway centre line lights could have brought at safety critical airports like Mangalore and Kozhikode were not weighed in during runway re-carpeting and commissioning of runways and AAI management focused on meeting the minimum requirements only. The investigation team understands that the installation of Runway Centre Line Lights at Mangalore and Kozhikode is not a mandatory requirement as per DGCA CAR, however, it can significantly enhance safety of air operations at these safety critical airports.

2.9.2.3 EXEMPTION FOR NARROW RUNWAY STRIP

The purpose of the runway strip is to reduce the risk of damage to an aeroplane running off the runway while providing a clear and graded area which meets specific longitudinal/ transverse slope and bearing-strength requirements. It also protects an aeroplane by providing an area which is clear of obstacles during climb/balked landing except for permitted aids used for air navigation purposes.

The DGCA / ICAO standard requirement for runway strip is 140m on either side of the centreline for Code Number 4 precision approach, CAT-I runway. The requirement of 140m width for runway strip applies to all precision approach Code 3 and 4 runways irrespective of the type of aeroplane operating on it.

The existing runway strip at Kozhikode airport extends laterally to a distance of only 75m from the runway centreline on either side. The presence of steep slopes on all sides of the runway and non-availability of additional land with AAI makes it impracticable to expand the runway strip width from 75m to 140m. The existing runway strip meets all other requirements of DGCA CAR / ICAO Annex 14 except for the width of runway-strip. AAI has been following up with DGCA for grant of temporary/permanent exemption from time to time in this regard.

As a mitigation measure detailed hazard identification and risk analysis along with safety assessment was conducted by AAI in co-ordination with airlines operating at Kozhikode. In accordance with the mitigation measure, all airlines agreed to suspend aircraft operations whenever the visibility is less than 2000m and cross winds exceed 15 kt or more on a wet runway and 20 kt or more on a dry runway and include the same in their SOP. AIXL in their OM Part-C Chapter 6 dated 11 November, 2019 has also limited the crosswind operations at Kozhikode stating '*Calicut Airport will suspend aircraft operations when the visibility is less than 2000m and cross wind speed is 15 kt or more on a wet runway and 20 kt or more on a dry runway*'

DGCA in its response to request for exemption from AAI had asked it to consider additional safety measure and one of them was to restrict aircraft operations when cross winds exceed 15 kt for dry runway and 10 kt for wet runway which may vary according to category of aircraft.

AAI did not take into consideration these limits while submitting the revised proposal in Dec 2018, but in Jan 2021, five months after VT-AXH crash of 07 August, 2020 at Kozhikode, the crosswind limit suggested by DGCA in 2018 were accepted. Notwithstanding repeated requests for permanent exemption by Airport Authority of India, no exemption (Temporary/Permanent) has so far been granted by DGCA.

2.9.2.4 SHARING OF INFORMATION BY AAI DURING AIRCRAFT ACCIDENT

During the course of investigation, the evidence provided by the concerned AAI agencies in the form of statements or answers to the questions by the Investigation Team were contradictory to their own previous statements or other evidence collected by the team. Some of the examples to highlight this aspect are: ARFF training and familiarisation status, Task/duties performed by the Airport doctor, establishment of Command Post at the site as per AEP and providing CCTV footage to the Investigation Team. The statements provided for these aspects have been proven to be contradictory through other material evidence collected by the

Team. Most of the contradictions have been made in an attempt to cover their inadequacies. In order to gather meaningful evidence from various agencies of AAI, the Investigation Team had to spend considerable time and effort. All these evidence bear direct relevance towards enhancing post accident survivability and flight safety.

2.9.3 INDIAN METREOLOGICAL DEPARTMENT

The basic method for reporting vital parameter of weather reports like wind visibility, rain etc are found to be archaic. The proposal for installation of Integrated Aviation Weather Observation System (AWOS) with RVR instrument was agreed in principle, but finalisation of site for installation was still underway on the day of accident and the said system was not installed.

The visibility marker chart was not updated. The wind measuring instrument for runway 10 was not installed as per DGCA CAR and its maintenance was poor. The tower met officer was not available in ATC control tower even during adverse weather on the day of the crash. This is in contravention to the existing CAMD aviation circular dated 01 November, 2018 during adverse weather.

There is no transmissometer available at Kozhikode for reporting runway visual range (RVR) which was to be installed before the re-commencement of widebody aircraft operations after runway re-carpeting and strengthening w.e.f Dec 2018.

2.9.4 AIRCRAFT ACCIDENT INVESTIGATION BUREAU

AAIB was set up in 2012 by the Govt of India in accordance with amendments that came into existence in 'Standard and Recommended Practices (SARPS)' contained in ICAO Annex 13 and ICAO audit findings that aircraft accident investigation should be independent from regulatory body to avoid any conflict of interest. This also helped in implementation of recommendation of Court of Inquiry that investigated an earlier Accident at Mangalore in 2010.

Manpower and Infrastructure at AAIB is not in line with the growth of Aviation in India. 21 posts that were sanctioned in 2015 are inadequate to handle the quantum of Investigation work being carried out. Even these posts have not been filled with permanent full time investigators and presently AAIB is functioning with less than half its sanctioned strength for investigators. With adequate manpower, AAIB should be able to proactively identify potential safety deficiencies from the database of reported occurrences to carry out Safety Studies and give suitable recommendations. The manpower at AAIB is drawn from different agencies having technical expertise that is required for Investigation and mostly in accordance with guidance available at Para 2.4.3 of ICAO Doc 9756 (Part I).

Although Investigators have sufficient powers to carry out their duties under Aircraft (Investigation of Accident and Incidents) Rules, 2017, on the day of accident, AAIB did not have any powers to issue any directions or have control over regulations issued by DGCA or policies laid by the stakeholders in their organisation manuals on matters related to Accident Investigation, Emergency Response, Serviceability of Flight Recorders, Preservation of Evidences etc. Absence of any such control often leads to inadequate or incorrect actions which prove to be hurdle in Accident Investigation. This can be elaborated by the following instances in this particular Investigation.

(a) Serviceability of Flight Recorders and retrieval of wreckage, documents and other evidence play very crucial part in the conduct of Investigation. Airlines, Aerodromes are required to have detailed policies and procedure laid in their Emergency Response Plans and other organisation manuals in this matter as per directions issued by DGCA, however, compliance of these directions was found lacking.

(b) Routine Readout and maintenance of DFDR and CVR units installed on Aircraft was being carried out as per AAC 3 of 2019 and AAC 4 of 2019, however, it was found that an unserviceable Brake Pressure Transducer remained fitted on aircraft for more than a year till the accident. Checks required as per DGCA approved AMP on the DFDR were not carried out by the MRO, but this was not flaged by the Airline CAMO or DGCA. Reason for the discrepancy in DFDR data related to brake could be identified in present case, but lack of recording of a crucial parameter could pose serious difficulties in investigation.

(c) The Flight Recorders were retrieved from the wreckage and downloaded at DGCA lab, however, AAIB or DGCA does not have software capability to analyse the downloaded data. Assistance of Airlines or OEM is taken by AAIB on routine but confidentiality of such sensitive information and data has so far been ensured only by individual actions or chance rather than any clear guidelines or directions in this matter.

(d) Safety Investigation Coordinator (SIC) has been nominated by the Aerodrome in accordance with ASC 04 of 2013, however, his role and responsibilities are not laid down in any policy/organisation manual of AAI.

(e) Even though, the AEP of Kozhikode was last revised in 2019 it had references to the Aircraft (Investigation of Accident and Incidents) Rules, 2012 which have been repealed and replaced by Aircraft (Investigation of Accident and Incidents) Rules, 2017. The AEP also did not have required reference of ASC 05 of 2014 for preservation of CCTV footage.

3 CONCLUSIONS

3.1 FINDINGS

(i) The PIC and the FO of AXB 1344 had valid license and ratings and were fully qualified to undertake the flight.

(ii) As per the extant DGCA policies due to COVID restrictions, 100% pre-flight BA test for the pilots was not being done. BA test was to be done at random. The FO underwent BA test which was negative and the PIC submitted a self declaration for BA test as mandated by DGCA during pre flight medical. PIC was a case of Diabetes and was prescribed a single anti-diabetic drug but was medically fit to undertake the flight as PIC. However the PIC was taking a combination of unprescribed drugs for his diabetes.

(iii) As per the flight schedule, the crew had been given sufficient off duty period prior to the flight in accordance with existing FDTL policy. They were operating a two sector quick return pattern (Kozhikode-Dubai-Kozhikode) which was within the prescribed FDTL limits. The accident took place on the second sector.

(iv) The PIC was to be on standby duty for 08 Aug, 2020 but due to non-availability of Captains at Kozhikode to operate AXB 1373 (Kozhikode-Doha-Kozhikode) flight of 08 Aug 2020, the PIC of AXB 1344 was taken off from standby duty and was assigned to operate this flight. The departure of AXB 1373 on 08 August was also delayed to accommodate the PIC's FDTL as per the scheduled arrival of AXB 1344 at Kozhikode on 07 August. He was informed about this change just before the departure of AXB 1343/1344 on 07 Aug 2020. This last minute assignment of 08th morning flight to Doha put additional pressure on the PIC to land back at Kozhikode in time on 7th evening.

(v) The aircraft VT-AXH had current Certificate of Airworthiness. The necessary inspections as per the approved maintenance programme were carried out. All aircraft systems operated normally. However as per CVR the windshield wiper on the PIC side stopped working during the first approach.

(vi) Kozhikode airfield has been categorised as a category 'C' airfield by AIXL, where assisted take-off and landing is not permitted to be carried out by FO. Hence PIC was the 'Pilot Flying'.

(vii) During the approach briefing before top of descent in to Kozhikode for runway 28, the PIC did not brief or discuss the LDA/ALD and made the Landing Flaps and Auto-brake selection setting without considering this important aspect in violation of the SOP. Before the approach for runway 10 as well, the PIC did not carry out adequate briefing for landing with tailwinds, in rain and poor visibility. The mandatory calculation of landing distances was omitted. Alternate airfields most suited for 'diversions' in case of second missed approach under the prevailing weather conditions and unserviceable windshield wiper were not covered during the briefing. This was a violation of the SOP, and the error magnified on this approach as the landing was made in strong tail wind condition on a wet tabletop runway in active rain.

(viii) The Pilot Monitoring did not make the mandatory announcement for the cabin crew to be seated on the first approach for landing on runway 28 at Kozhikode. This is a very serious omission and compromises cabin crew safety.

(ix) The CVR recording revealed that the PIC carried out an unusually detailed briefing to an experienced FO regarding a routine action for selection of windshield wipers. The CVR transcript points to an apprehension of the PIC regarding the reliability of the operation of the windshield wiper. This undue concern and detailed briefing to FO indicates that the crew probably had prior knowledge of the unreliable windshield wiper. During the approach on runway 28 into Kozhikode, the windshield wiper on the PIC side worked for 27 sec and then stopped. Also, on the approach for runway 10, PIC wiper worked but probably at a slower speed than the selected speed. Both approaches and final landing at Kozhikode were made in active rain without a fully serviceable wiper on the PIC side.

(x) AXB 1344 carried out a 'missed approach' at ILS minimums (DA) while attempting to land on runway 28. The reason for missed approach transmitted to ATC by PM after consulting PF was *"weather, heavy rain"*. However, landing with unserviceable wiper in rain may also have been a contributory factor for not being able to sight the runway.

(xi) The crew were experienced and had often operated in Indian monsoon conditions. They were aware of the adverse weather SOP of AIXL. The PIC took a decision not to divert after the 'missed approach' on runway 28 even though there were alternate airfields available in close proximity and there was enough fuel on board. Subsequently, without any risk assessment, the PIC continued for a second approach into Kozhikode. The FO did not give any input regarding this gross SOP violation to the PIC, indicating a steep cockpit authority gradient resulting in poor CRM.

(xii) In case of diversion of flight AXB 1344, the PIC would have exceeded his FDTL and would not have been available for the following day morning flight. This would have resulted in shortage of PIC at Kozhikode for operating the three scheduled flights ex-Kozhikode the next day.

(xiii) A departing aircraft (AIC 425) from Kozhikode requested for a change of runway from 28 to 10. DATCO immediately accepted his request and changed the runway from 28 to 10. AIC 425 departed in 10 kt tailwinds.

AXB 1344 at that moment was in the process of planning another approach on runway 28 after carrying out a missed approach the first time. The ATC suggested runway 10 for landing to AXB 1344, which the PIC accepted without careful deliberation. The DATCO changed the runway in use in a hurry to accommodate the departure of AIC 425 without understanding the repercussions for landing of AXB 1344 in tail winds on a wet runway in rain. Also, he did not convey the updated QNH settings and also did not caution AXB 1344 of prevailing strong tail winds.

(xiv) The ATC reported visibility of 2000 m in light rain and winds 250/08 Kt while transmitting landing clearance for AXB 1344. Prevailing surface winds were much stronger than the winds reported by ATC. DFDR analysis confirms tail winds of 16 Kt when the aircraft was at 30 ft RA over runway 10.

(xv) The Autopilot was disengaged on approach for runway 10 at 794 ft PA, however, the Auto-throttle continued to be engaged till touchdown. Landing with Autothrottle ON during manual landing is a violation of company SOP.

(xvi) AXB 1344 was established on ILS 10 with autopilot and auto throttle engaged. Within 05 sec after disengaging autopilot, the aircraft went below the glide slope and deviated up to 1.7 dots. The approach became 'unstabilized'. Apart from a deviation call from the FO, EGPWS alert was also recorded on the CVR. The PIC acknowledged the deviation call and initiated the correction but over-corrected in the process. The glide slope deviation had exceeded the company criteria of a 'stabilised approach' and 'missed approach' was not carried out, instead, the PIC continued for landing.

(xvii) The aircraft crossed the runway threshold at 92 ft RA, instead of the correct threshold crossing height of 50 ft.

(xviii) After crossing 1363 ft of the runway at approximately 20 ft RA , the PF opened engine power up to 83% N1. This burst of additional power kept the aircraft afloat and resulted in a long landing with touchdown at 4438 ft on the 8858 ft long runway. The aircraft remained afloat for 16 seconds after crossing the threshold.

(xix) The FO had correctly identified that the approach for runway 10 was an 'unstabilized approach'. After making two unassertive attempts to attract the PIC's attention towards the unstabilized approach, using non-standard vocabulary, he asked the PIC to 'Go Around' just before touchdown. In spite of knowing full well that the approach was unstabilized and the PIC was not responding, the FO did not take over the controls as per the company SOP and initiate a 'Go Around'.

(xx) Immediately after touchdown PF resorted to manual braking over riding autobrake selection and selected thrust reversers. Before the reversers could take effect he momentarily stowed the thrust reversers and simultaneously reduced pressure on the brakes. This abrupt action resulted in reduced deceleration which contributed to increased landing distance required for the airplane to stop. The PIC might have momentarily thought of missed approach but at no stage after touchdown, power was increased to carry out a balked landing (Go Around).

(xxi) During braking, the tyres had adequate contact with the runway surface and continued spinning above 60 kt. Wheel spin is an indication of adequate contact of the tyres with the runway, and indicates that there was no hydroplaning. There was no physical evidence of hydroplaning on any of the tyres in the form of rubber reversion or flat spots or marks on the runway.

(xxii) The aircraft overran the runway including the RESA, impacted the localizer antenna, approach lights and fell down the tabletop runway. The impact with the perimeter road caused the aircraft to separate into three sections. There was fuel leak from both the wing tanks. There was no post impact fire.

(xxiii) The PIC was taking multiple un-prescribed anti-diabetic drugs that could have probably caused subtle cognitive deficits due to mild hypoglycaemia.

(xxiv) Due to degraded visual cues of orientation caused by low visibility and sub-optimal performance of the PIC’s windshield wiper in rain, the PIC probably experienced visual illusions causing errors in distance and depth perception.

(xxv) On mathematical modelling and calculations for all the scenarios for landing at 4438 feet from the threshold of runway 10, with the prevailing weather, runway conditions and tailwind condition at Kozhikode airport on 07 Aug 2020 at around 1410 UTC, it was observed that AIX 1344 could not have stopped on the remaining runway, or carry out a safe missed approach after touchdown. However, under identical weather, runway conditions and same touchdown point, the aircraft would have safely stopped on the remaining runway and even carried out a safe missed approach, if the winds were headwinds instead of tailwinds.

(xxvi) The RESA at Kozhikode airport was not maintained as per DGCA CAR. Vegetation growth was observed in the soft ground area and it was not being ploughed regularly. Also, the concrete base of the frangible equipment installed in the soft ground area was not found buried under the soft ground, but instead jutted out of the surrounding area.

(xxvii) In order to implement recommendation of Committee of Inquiry of 2012 incident in Mangalore, AAI had committed to DGCA that Runway Centre Line Lights will be installed at Mangalore during next re-carpeting. The fact is that the next re-carpeting is due in 2024. Opportunity to install Runway Centre Line Lights at Kozhikode, which shares similar operational constraints as Mangalore, existed in 2017 during re-carpeting and strengthening works but same was not considered and no such action was taken.

(xxviii) The perimeter road at Kozhikode airport was found to be narrow and had sharp turns. This largely affects the speed of the emergency vehicles including CFTs and the overall response time during exigencies. This was also a recurring observation during Mock Emergency exercises as well as during DGCA audits.

(xxix) The Duty Doctor at the Airport Terminal Clinic was not familiar with his role and responsibilities during an aircraft accident as per the published AEP.

(xxx) The post-crash rescue efforts lacked effective command and control. There was no ‘Command Post’ established at the crash site. This was also an observation during the previous ‘Mock Drill’ held in November 2019.

(xxxi) The ARFF crew at Kozhikode were found lacking in aircraft familiarisation training, which resulted in delay in evacuating the pilots from the cockpit.

(xxxii) ARFF crew at Kozhikode have not been provided Aircraft Familiarization training on B737-800. In spite of DGCA audit observation of 2018 on Aircraft Familiarization training and the frequent emails throughout 2019 by Head of Airport Fire Services requesting for training on actual aircraft, no action was taken by any concerned agency in this regard. The DGCA Safety Audit Report of April 2019 assessing Aircraft Familiarization of ARFF crew at Kozhikode as “Satisfactory” is factually incorrect and misleading.

(xxxiii) Policy documents of AAI and Airlines were not found to have relevant provisions to comply with various circulars issued by DGCA on matters related to Accident Investigation like ASC 06 of 2010 and ASC 4 of 2013. The non-compliance of these directions led to avoidable problems with regard to recording of evidence and autopsies not being conducted in prescribed format. Airport Doctor, Airline Doctor and the doctors at local hospital were not aware of the ASC 06 of 2010.

(xxxiv) Responsibilities of Safety Investigation Co-ordinator as per ASC 04 of 2013 is not included in the AEP or any other Policy document of AAI. Photography and Video recording of rescue operations was not carried out.

(xxxv) AAI and airline operators had proposed installation of transmissometer equipment for RVR reporting as a mitigation measure for re-commencing the wide body operations at Kozhikode. DGCA granted permission in 2018 subject to compliance of proposed mitigation measure, however, the transmissometer equipment was not installed till the date of AXB 1344 accident.

(xxxvi) The wind sensor was installed in the valley at a site below the Runway surface level and did not meet the requirements laid down in the DGCA CAR.

(xxxvii) It was observed that the wind sensor for runway 10 at Kozhikode Airport was repeatedly declared unserviceable and had remained non-functional for long durations. There was variance between reported winds and winds recorded on DFDR.

(xxxviii) Tower Met Officer was not available in the ATC tower in the inclement weather conditions at the time of the accident despite requisite arrangements and workstation being available in the Tower.

(xxxix) At Kozhikode airfield, most of the daytime/night time visibility markers as per the available Chart were not distinctly noticeable or dependable.

(xl) It was observed that as per DGCA CAR Section 8, Series C, Part I at runways where no RVR is reported the take off minima cannot be lower than 800 m. AIXL is following the tailor made Jeppesen chart with takeoff minima of 300 m in violation of DGCA CAR.

(xli) AIXL policy of handling of thrust lever during takeoff for PIC upgrade training on aircraft by the Instructor pilot leads to negative training.

(xlii) Permanent posting of Cockpit Crew, especially of Captains, at bases by AIXL does not commensurate with the quantum of flights operating at that particular operational base. There were 26 FOs and only one Captain posted at Kozhikode base. This placed additional pressure on the crew scheduling staff and temporarily positioned Captains to cater to any last minute changes.

(xliii) There was lack of effective supervision in AIXL. The critical post holders were not posted at locations of their respective departments and were found carrying out their duties remotely, leading to supervisory deficiencies.

(xliv) Even though majority of aircraft of AIXL are equipped with OEM fitted EFB, but same was not being used. Portable EFB (iPads) are provided to the crew, but it does not have the required OPT application.

(xlv) There were frequent breakdowns and recurring snags observed in upkeep and maintenance of the simulator. Under the existing MoU with AI, AIXL is not able to exercise influence in the upkeep and maintenance of the simulator.

(xlvi) The actual status of CDL and the one provided to the PIC during pre-flight briefing was not matching. A CDL which was revoked on aircraft in Nov 2019 continued to be reflected in the flight briefing document till the date of accident.

(xlvii) The analysis of the DFDR data of accident flight revealed that Right Brake Pressure was recorded as constant. Further investigation confirmed that this was due to an unserviceable right Brake Pressure Transducer rather than any system failure.

(xlviii) An unserviceable brake pressure transducer was cannibalised from another aircraft and installed on VT-AXH in Dec 2018. The unserviceability was not identified prior to or during installation and also during various maintenance activities and subsequent DFDR readouts owing to poor maintenance and safety practices.

(xlix) An unsafe maintenance practice of briefing snags verbally without recording them in the technical documents was found prevalent in the organization.

(l) SMS training for the SMS Managers/Nodal officers was not being carried out as per AIXL SMS manual. The duration for this training, as specified in the manual, was reduced from five days to three days.

(li) Although, poor CRM emerged as a major contributor in the previous major accident and serious incidents of AIXL, CRM training failed to generate its desired results and continued to be the causal factor in this crash as well.

(lii) AIXL was not monitoring Long Landings in its FOQA program until 01 Sep, 2020 as it was not part of DGCA approved list of exceedance parameters for DFDR monitoring included in AIXL Flight Safety Manual.

(liii) Data on landing exceedance provided by AIXL was at variance with that provided by DGCA. The data provided by DGCA also shows every Long Flare as Long Landing which is factually inaccurate as it need not be true in every situation, more so during non-precision and visual approaches.

(liv) DGCA CAR on monitoring of DFDR data for accident/incident prevention contains ambiguities in values of exceedance parameters. These ambiguities were not addressed in spite of clear recommendations by the previous COI for the Mangalore crash 2010.

(lv) Surveillance of flights operating to critical airfields and red-eye flights was not being carried out by DGCA.

(lvi) In violation of the Aircraft (Investigation of Accidents and Incidents) Rules, 2017 Rule 10(1) (a) and (b), concerned officials of DAS, DGCA HQ did not agree to come and meet the Investigation Team in order to clarify and discuss the ambiguities in the information regarding FOQA monitoring provided by them.

(lvii) Manpower, infrastructure and other resources at AAIB are inadequate in comparison to the growth in aviation due to which AAIB is not able to carry out all its functions as per Aircraft (Investigation of Accidents and Incidents) Rules, 2017. There is shortage of permanent full time investigators and lack of subject matter experts like Aviation Medicine Specialist in cadre strength of AAIB.

3.2 FINDINGS AS TO CAUSE & CONTRIBUTING FACTORS

3.2.1 PROBABLE CAUSE

The probable cause of the accident was the non adherence to SOP by the PF, wherein, he continued an unstabilized approach and landed beyond the touchdown zone, half way down the runway, in spite of 'Go Around' call by PM which warranted a mandatory 'Go Around' and the failure of the PM to take over controls and execute a 'Go Around'.

3.2.2 CONTRIBUTORY FACTORS

The investigation team is of the opinion that the role of systemic failures as a contributory factor cannot be overlooked in this accident. A large number of similar accidents/incidents that have continued to take place, more so in AIXL, reinforce existing systemic failures within the aviation sector. These usually occur due to prevailing safety culture that give rise to errors, mistakes and violation of routine tasks performed by people operating within the system. Hence, the contributory factors enumerated below include both the immediate causes and the deeper or systemic causes.

(i) The actions and decisions of the PIC were steered by a misplaced motivation to land back at Kozhikode to operate next day morning flight AXB 1373. The unavailability of sufficient number of Captains at Kozhikode was the result of faulty AIXL HR policy which does not take into account operational requirement while assigning permanent base to its Captains. There was only 01 Captain against 26 First Officers on the posted strength at Kozhikode.

(ii) The PIC had vast experience of landing at Kozhikode under similar weather conditions. This experience might have led to over confidence leading to complacency and a state of reduced conscious attention that would have seriously affected his actions, decision making as well as CRM.

(iii) The PIC was taking multiple un-prescribed anti-diabetic drugs that could have probably caused subtle cognitive deficits due to mild hypoglycaemia which probably contributed to errors in complex decision making as well as susceptibility to perceptual errors.

(iv) The possibility of visual illusions causing errors in distance and depth perception (like black hole approach and up-sloping runway) cannot be ruled out due to degraded visual cues of orientation due to low visibility and sub-optimal performance of the PIC's windshield wiper in rain.

(v) Poor CRM was a major contributory factor in this crash. As a consequence of lack of assertiveness and the steep authority gradient in the cockpit, the First Officer did not take over the controls in spite of being well aware of the grave situation. The lack of effective CRM training of AIXL resulted in poor CRM and steep cockpit gradient.

(vi) AIXL policies of upper level management have led to a lack of supervision in training, operations and safety practices, resulting in deficiencies at various levels causing repeated human error accidents in AIXL

(vii) The AIXL pilot training program lacked effectiveness and did not impart the requisite skills for performance enhancement. One of the drawbacks in training was inadequate maintenance and lack of periodic system upgrades of the simulator. Frequently recurring major snags resulted in negative training. Further, pilots were often not checked for all the mandatory flying exercises during simulator check sessions by the Examiners.

(viii) The non availability of OPT made it very difficult for the pilots to quickly calculate accurate landing data in the adverse weather conditions. The quick and accurate calculations would have helped the pilots to foresee the extremely low margin for error, enabling them to opt for other safer alternative.

(ix) The scrutiny of Tech Logs and Maintenance Record showed evidence of non-standard practice of reporting of certain snags through verbal briefing rather than in writing. There was no entry of windshield wiper snag in the Tech log of VT-AXH. Though it could not be verified, but a verbal briefing regarding this issue is highly probable.

(x) The DATCO changed the runway in use in a hurry to accommodate the departure of AIC 425 without understanding the repercussions on recovery of AXB 1344 in tail winds on a wet runway in rain. He did not caution AXB 1344 of prevailing strong tail winds and also did not convey the updated QNH settings.

(xi) Accuracy of reported surface winds for runway 10 was affected by installation of wind sensor in contravention to the laid down criteria in CAR. This was aggravated by frequent breakdown due to poor maintenance.

(xii) The Tower Met Officer (TMO) was not available in the ATC tower at the time of the accident. The airfield was under two concurrent weather warnings and it is mandatory for the TMO to be present to update and inform the fast changing weather variations to enhance air safety. During adverse weather conditions the presence of the TMO in the ATC tower was even more critical.

(xiii) The AAI has managed to fulfil ICAO and DGCA certification requirements at Kozhikode aerodrome for certain critical areas like RESA, runway lights and approach lights. Each of these, in isolation fulfils the safety criteria however, when considered in totality, this left the aircrew of AXB 1344 with little or no margin for error. Although not directly contributory to the accident causation, availability of runway centreline lights would have certainly enhanced the spatial orientation of the PIC.

(xiv) The absence of a detailed proactive policy and clear cut guidelines by the Regulator on monitoring of Long Landings at the time of the accident was another contributory factor in such runway overrun accidents. Long Landing has been major factor in various accidents and incidents involving runway excursion since 2010 and has not been addressed in CAR Section 5, Series F, Part II.

(xv) DGCA did not comprehensively revise CAR Section 5, Series F, Part II Issue I, dated 30 Sep 99 (Rev. on 26 Jul 2017) on 'Monitoring of DFDR/QAR/PMR Data for Accident/Incident Prevention' to address the recommendations of the COI of 2010 AIXL Managlore Crash regarding the exceedance limits, resulting in the persisting ambiguities in this matter.

(xvi) DFDR data monitoring for prevention of accidents/incidents is done by AIXL. However 100% DFDR monitoring is not being done, in spite of the provisions laid down in the relevant CAR and repeated audit observations by DGCA. DFDR data monitoring is the most effective tool to identify exceedance and provide suitable corrective training in order to prevent runway accidents like the crash of AXB 1344. However, ATR submitted by AIXL on the said findings were accepted by DGCA year after year without ascertaining its implementation or giving due importance to its adverse implications.

4 SAFETY RECOMMENDATIONS

The safety recommendations have been divided under the following heads: -

(a) Air India Express Ltd

(b) Airports Authority of India

(c) DGCA

(d) AAIB

(e) IMD

4.1 AIR INDIA EXPRESS LIMITED (AIXL)

4.1.1 TRAINING

In view of the failure of the AIXL pilot training program to impart the requisite skills for performance enhancement due to lack of its effectiveness, it is recommended that:

(i) **Simulator Training**

(a) In order to impart training in realistic situations, flight simulators to be used extensively. Emphasis to be laid on the following scenarios during the flight simulator briefing/training:

(aa) To promote assertiveness of the First Officer to take-over control and initiate a go-around on an unstabilized approach when PIC fails to respond.

(ab) Tail wind landing on wet runway.

(ac) Landing on wet/contaminated runway (up to 3mm depth)

(ad) Extended Flare and Balked landing.

(b) Simulator Training Assessment: It is recommended that the Chief of Training to ensure that the assessment reports (CA 40/CA41) done by the DEs are complete in all aspects. All 'training forms' to be scrutinized critically by the AIXL Training Department as well as by DGCA during their inspections.

(ii) **CRM Training**

Trainers of AIXL to undertake random observation flights to assess the critical facets of CRM including the trans-cockpit authority gradient and assess the responses of Captain and the First Officer as a team.

(iii) **PIC Upgrade Training on Aircraft**

AIXL to review its PIC upgrade training procedure for handling of thrust levers by PIC Trainee Captain during the takeoff roll.

4.1.2 ONBOARD PERFORMANCE TOOL (AIRCRAFT)

Majority of aircraft in AIXL are equipped with OEM fitted EFB, capable of Onboard Performance Calculation. It is recommended that Onboard Performance Tool be made mandatory part of the Electronic Flight Bag (EFB) and all pilots to be trained and checked for their proficiency in the use of OPT for accurate aircraft performance calculations.

It is recommended that AIXL may implement the B737 performance module in the EFB (OEM fitted or currently used iPad) to calculate Take-off, Cruise, Landing, Single-engine operations to enhance safety.

4.1.3 SIMULATOR MAINTENANCE

In view of the fact that simulator continued to be used for training by AIXL in spite of maintenance issues and pending defects on the simulator which does not fall in the preview of MMI, it is recommended that the Head of Training of AIXL ensures that at the time of use, the simulator should meet all regulatory requirements.

It should be ascertained that the simulator meets all training objectives as prescribed in the training plan of the airline and no negative training is carried out.

4.1.4 COCKPIT CREW SUPERVISION

In order to ensure compliance of SOPs and CRM principles, it is recommended that AIXL to enhance their observation flight by senior pilots, trainers and carry out additional observation flights during monsoon as recommended by DGCA.

Further all scheduled operators may implement a regular LOSA programme (Line Operation Safety Assessment) to observe system weaknesses.

4.1.5 DFDR DATA MONITORING

DFDR monitoring is the most effective tool to identify exceedance and provide suitable corrective training in order to prevent aircraft accidents; it is recommended that AIXL must ensure that 100% DFDR data is downloaded as per CAR for FOQA monitoring and trend analysis is done so that timely follow up action is taken.

4.1.6 INSPECTION OF FLIGHT RECORDER SYSTEM

In view of the fact that RH Brake pressure transducer unserviceability could not be identified during repeated checks and monitoring, it is recommended that, personnel involved in analysis of data from Flight Recorders as per CAR Section 2, Series I, Part V are provided Technical Training so as to ensure that proper analysis is carried out, discrepancies are identified and timely remedial measures are undertaken.

4.1.7 CVR MONITORING

As a policy AIXL is monitoring CVR. It is recommended that AIXL uses CVR monitoring to effectively analyse and address the established weaknesses in non technical skills including Cockpit Gradient.

4.1.8 AIXL HR MANAGEMENT

(i) To ensure better availability of Crew at all bases, it is recommended that AIXL HR to take into consideration the quantum of flights originating from respective bases and accordingly assign them as 'home base', especially for the Captains.

(ii) AIXL may ensure that all post holders and sub-post holders are available at their designated office to ensure proper supervision of their area of operations. The operator may define clear office days/hours for such post holders and sub post holders as a part of their company HR policy. Their office days must be considered as a part of duty as defined in DGCA CAR Section 8.

(iii) At present AIXL does not have an independent medical department. It is recommended that Aviation/Aerospace Medicine Specialists be employed in accordance with DGCA General Advisory Circular No. 01 of 2011 dated 17 December, 2011. Also, the Aerospace Medicine specialist to take classes during ground training for cockpit crew to indoctrinate aircrew in aeromedical issues.

4.1.9 AIRCRAFT DEFECT REPORTING

The Investigation Team observed that there were instances of verbal briefing for defect reporting in AIXL. It is recommended that verbal briefing for any aircraft defect be strongly discouraged and correct procedures be followed as defined in relevant DGCA CAR.

4.1.10 INTERNATIONAL BEST PRACTICES REGARDING STABILIZED APPROACHES

It is recommended that AIXL should introduce following practices in its flight operations.

(i) Final landing configuration should be selected by 1500 feet AGL for an instrument approach and 1000 feet for a visual approach to be stable by 1000 feet for instrument approach and 500 feet for visual approach.

(ii) The operator may like to introduce a standard call out at 1000 feet AGL during an instrument approach and 500 feet AGL for visual approach "Stabilised/Unstable – Go Around" for better situational awareness of the pilot flying.

4.2 AIRPORTS AUTHORITY OF INDIA (AAI)

4.2.1 AIR TRAFFIC CONTROL

It is recommended that AAI ensures that during the ab-initio training of ATCO and annual refresher the following aspects to be strongly emphasized: -

(i) The impact of tailwind conditions in adverse weather.

(ii) The impact of change of QNH.

(iii) Precautions required to be taken while deciding the change of runway in adverse weather.

4.2.2 TRAINING OF ARFF CREW

The ARFF crew at Kozhikode were not familiar with the type of aircraft, which resulted in poorly coordinated rescue operations and delayed evacuation of the pilots from the cockpit. Therefore, it is recommended that AAI must ensure that mandatory Aircraft Familiarization Training is provided to all ARFF crew at posted station within defined timeline in addition to recurrent training as per the existing requirements.

In order to achieve the same, APD at all airports should coordinate with airline operators for timely conduct of aircraft familiarization training for ARFF crew on all types of aircraft operating through that aerodrome as mentioned in ICAO Doc 9137-AN/898 'Airport Services Manual, Part 1- Rescue and Fire Fighting'. This should be monitored by DGCA through realistic surveillance inspections.

4.2.3 MAINTENANCE OF RESA

Proper maintenance of soft ground portion of RESA offers crucial defence in case of a runway excursion. It is recommended that upkeep and maintenance of RESA be ensured at all times as per the laid down specifications.

4.2.4 AIRPORT PERIMETER ROAD

The Kozhikode airport perimeter road which surrounds the airport should be capable of supporting heavy Fire Fighting vehicles in order to achieve the required response time with adequate safety. In Nov 2019, DGCA during their surveillance had made similar observations however, the observed deficiencies still existed as on the date of accident. It is recommended that the perimeter road should be wide enough to facilitate quick movement of emergency vehicles.

4.2.5 AIRPORT DOCTOR

The Airport Doctor has an important role in the Aerodrome Emergency Plan (AEP). It is recommended that all doctors detailed at the Airport Terminal Clinic must undergo formal and structured familiarisation training for their roles and responsibilities during an aircraft accident as per the published AEP.

The Airport Doctor must participate in the periodic refresher training and mock drills carried out at the airport for the ARFF crew. It is also recommended that the Airport Doctor should train the ARFF crew in respect of prioritization of mass casualties (triage) and casualty carriage procedures.

4.2.6 APPROACH RADAR

Kozhikode airport is one amongst the ten busiest airports in India, has hilly terrain and experiences extended adverse weather conditions. Therefore, it is recommended that for better guidance to the aircraft, Approach Radar be installed at Kozhikode airport.

4.2.7 MOCK DRILL

In Nov 2019, DGCA during their surveillance had made certain observations regarding deficiencies in conduct of Mock Drills. The observed deficiencies still existed as on the date of accident. In order to achieve the desired training outcomes from the Mock Drills, it is recommended that there must be a timely follow up action on all deficiencies observed.

4.2.8 VIDEO RECORDING OF RESCUE OPERATIONS

The requirement for video recording of rescue operations is laid down in ASC 04 of 2013. It is recommended that, all CFTs and Command Post should be fitted with cameras for real time video recording of the entire rescue operation. Also, the requirement of video recording of rescue operation should be incorporated in the Aerodrome Emergency Plan of all Airports.

4.2.9 PRESERVATION OF CCTV FOOTAGE FOR ACCIDENT INVESTIGATION

CCTV footage can provide important leads into various aspects for the purpose of Accident Investigation. It is recommended that guidelines contained in the ASC 05 of 2014 should be promulgated as CAR for better compliance and same should be incorporated in the organisation manuals of aerodromes.

4.3 INDIAN METEOROLOGICAL DEPARTMENT

4.3.1 TOWER MET OFFICER

The role and responsibilities of TMO during adverse weather are clearly delineated in CAMD Aviation Circular dated 01 Nov 2018. It is recommended that the presence of TMO be ensured in the tower along with DATCO especially during dynamic weather situations.

4.3.2 SURFACE WIND OBSERVATION FOR RUNWAY 10

Since the accuracy of reported surface winds for runway 10 was affected by non standard installation and poor maintenance, it is recommended that the sensors for measuring surface winds for runway 10 to be installed as per the specifications mentioned in DGCA CAR and regular maintenance should be ensured.

4.3.3 VISIBILITY LANDMARK CHARTS

At Kozhikode airfield, most of the daytime/night time visibility markers as per the available Chart were not distinctly noticeable therefore, it is recommended that the chart be updated in accordance with the current existing landmarks.

4.3.4 RUNWAY VISUAL RANGE SYSTEM

Vide DGCA letter No. 20025/13/06 – AL dated 08 August 2018, AAI was permitted to recommence wide body operations in Kozhikode post installation of transmissometer for RVR reporting. However, at the time of the accident RVR instrument had not been installed at Kozhikode. RVR can significantly enhance accuracy of visibility reporting leading to a better situational awareness of the pilots during low visibility. It is recommended that AWOS and RVR system be installed.

4.4 DIRECTORATE GENERAL OF CIVIL AVIATION

4.4.1 REVISION OF CARs

The Investigation Team observed that the recommendations made in respect of FOQA anomalies (post AIXL 2010 Mangalore Accident), have not been addressed for the last 10 years. It is recommended that DGCA should revise CAR Section 5, Series F, Part II Issue I, dated 30 Sep 99, Rev 1 dated 26th July 2017 on 'Monitoring of DFDR/QAR/PMR Data for Accident/Incident Prevention' in order to remove ambiguities in exceedance parameters, introduce monitoring of landing beyond touchdown zone and to standardize the FOQA limits for all type of aircraft operating in India.

While draft CARs are placed in open domain and public comments are solicited, however, to ensure better inclusiveness it is recommended that Subject Matter Experts from the industry be also utilized while planning and formulating CARs.

4.4.2 FOQA MONITORING

It is recommended that DGCA should ensure that 100% DFDR monitoring as stipulated in CAR is carried out by all scheduled operators. In addition to the unstabilized approach, long landings should also be monitored.

Reference DGCA CAR Section 8 'All Weather Operations (Adverse Weather)', DGCA may ensure compliance with the recommendations regarding use of Flaps, Thrust Reverser etc. and the same may be monitored during FOQA/SOP monitoring especially during monsoon and pre-monsoon.

4.4.3 SOQA MONITORING

Similar to FOQA, DGCA may consider implementing Simulator Operations Quality Assurance (SOQA) when an operator chooses to bring in new FSTDs or may choose to upgrade their existing simulator for better monitoring of training/checks being performed in the FSTD.

4.4.4 FLIGHT SURVEILLANCE

It is recommended that DGCA may ensure :

(i) Periodic surveillance of flights to critical and table top runways including 'red eye' flights.

(ii) Increased surveillance should be carried out during monsoons (DGCA CAR Section 5 Series F Part I).

(iii) Further, the monsoon circular ASC 03 of 2017 and ASC 02 of 2019 should also be aligned with the requirement of this CAR and CAR section 8 All Weather Operations "Adverse Weather/Monsoon Operations".

DGCA may ensure compliance of implementation of LOSA programme during their regular audits and surveillance.

4.4.5 NATIONAL AVIATION SAFETY PROGRAMME

There is an urgent requirement to revise targets for Safety Performance Indicator for remaining period of NASP (2018-22). Therefore, it is recommended that the NASP may be reviewed and Safety Performance Indicator/Safety Action Plan be revised in line with International best practices to achieve the objective of reducing the number of *Runway Excursions and Overruns*. Clear directions/guidelines should be issued by DGCA for its implementation and safety data should be published in a timely manner by DGCA.

4.4.6 CHILD RESTRAINT SYSTEM

It is recommended that DGCA may study the feasibility and efficacy of 'Child Restraint System' for safety of infants and children on board the aircraft.

4.4.7 RUNWAY STRIP

It is recommended that the long pending permanent exemption for runway strip width for Kozhikode airfield as sought vide letter No. AAI/AL/30-23(Misc-SA)/2018/660 dated 28 Sep 2018 may be resolved by DGCA on priority.

4.4.8 RUNWAY CENTRE LINE LIGHTS

The topography and weather phenomenon at Kozhikode and Mangalore put serious constraints on Flight operations at these airports. For maintaining directional control by the flight crew during adverse weather and to enhance situational awareness, centre line lightings may be made available on such runways. The need of installing centreline lights was highlighted in the recommendations involving incidents of AIXL aircraft in the year 2012 at Managlore and Etihad aircraft in the year 2019 at Kozhikode. Based on Airlines requests and on recommendations of investigation reports, AAI has agreed to install Runway Centre Line Lights at Kozhikode and Mangalore during next re-carpeting of runway which is due in 2022 and 2024 respectively. It is recommended that DGCA may ensure that Runway Centre Line Lights are installed at these airports within the said time frame or earlier.

4.4.9 PROMULGATION OF SAFETY CIRCULARS

It is recommended that DGCA may ensure that guidelines contained in ASC 06 of 2010, ASC 04 of 2013 and ASC 05 of 2014 are promulgated through CARs for better compliance and same is incorporated in the organization manuals of Airlines and Aerodrome Operator.

4.4.10 AIRPORT SAFETY RISK ASSESSMENT

DGCA may mandate all operators to carry out safety risk assessment for their type of aircraft so as to define the operational limits including tailwind while landing at critical runways, table top runways and runways when the braking action is reported as good, good to medium, medium, medium to poor and poor.

4.4.11 SMS TRAINING DURATION

In order to ensure standardization in the duration of SMS training across all stakeholders, it is recommended that CAR Section 1 Series C Part-1 on ‘Establishment of Safety Management System’ may be revised to include minimum duration of training especially for the SMS Managers/Nodal officers.

4.4.12 INSTALLATION OF RUNWAY OVERRUN AWARENESS & ALERTING SYSTEM (ROAAS)

It is recommended that DGCA may consider installation of ROAAS for all scheduled operators especially those operating turbojet aircraft (reference EASA Ed Decision 2020/001/R).

4.4.13 LOW VISIBILITY TAKE-OFF (LVTO) MINIMA

The Investigation Team reviewed the low visibility take-off minima of AIXL at Kozhikode (Calicut) and the LVTO minima was found to be 300 m. As per the DGCA CAR Section 8 Series C Part I, whenever RVR is not reported, the lowest visibility value is required to be 800 m.

It is recommended that DGCA may ensure that no operator files LVTO minima below 800 m visibility when RVR is not reported for the specific runway.

4.4.14 COMPETENCY BASED TRAINING AND ASSESSMENT (CBTA)

DGCA may introduce Competency Based Training and Assessment as recommended by ICAO and ensure pilots are trained and assessed on the nine competencies listed below:

(i) Communication
(ii) Aircraft Flight Path Management – Manual Control
(iii) Aircraft Flight Path Management – Automation
(iv) Leadership and teamwork
(v) Problem Solving and Decision making
(vi) Application of procedures
(vii) Work load Management
(viii) Situational Awareness
(ix) Knowledge

4.4.15 USE OF ONBOARD TECHNOLOGY FOR ASSESSMENT OF WIND

DGCA may advise all operators/flight crew to better utilize the onboard wind indication to enhance their situational awareness in order to execute a stabilized approach.

4.4.16 CLUBBING OF CIRCULARS INTO CAR

The investigation team observed that there are far too many circulars and CARs on the same topic e.g. Monsoon Operations, Adverse Weather, Stabilized Approach etc.

DGCA may compile all information in a single document addressing a particular topic in form of a CAR, Circular etc for ease of reference to the user.

4.4.17 SELF MEDICATION FOR DIABETES MELLITUS

DGCA should issue directions to all scheduled and non-scheduled operators to educate their aircrew regarding the aeromedical consequences of self medication. DGCA may undertake a study to establish prevalence of use of non-prescribed medications amongst aircrew especially for Diabetes.

4.4.18 COOPERATION BY DGCA DURING INVESTIGATION

The information sharing mechanism between the Investigation Team and concerned DGCA officials during aircraft accident/serious incident investigation should be in accordance with the Aircraft (Investigation of Accidents and Incidents) Rules, 2017 Rule 10(1) (a) and (b). DGCA may advise its officials to participate in discussions whenever required by the Investigation Team.

4.5 AIRCRAFT ACCIDENT INVESTIGATION BUREAU (AAIB)

4.5.1 ADEQUATE MANPOWER AT AAIB

It is recommended that AAIB may take necessary actions to ensure that existing posts of investigators are filled with permanent full time investigators and additional posts are created to cater for growth of aviation in India. Also, it is recommended that the AAIB may have a permanent Aerospace/Aviation Medicine Specialist as one of the investigators to participate in aircraft accident investigations as well as assist the 'Go Team' as a Human Factors expert.

4.5.2 FLIGHT RECORDERS LABORATORY

It is recommended that AAIB should set up a state-of-the-art Flight Recorders (DFDR and CVR) Lab with necessary hardware and software to carry out readout and analysis (including spectrum analysis). Aircraft Manufacturers be mandated to provide necessary Technical Literature, Hardware and Software for all type of aircraft that operate in India.

17/08/2021

Ved Prakash
Ex-DDG, DGCA

17 Aug 21

Gp Capt (Dr) Y S Dahiya
DMS(CA)

17/08/21

Mukul Bhardwaj
Lead Engineer

17 Aug 2021

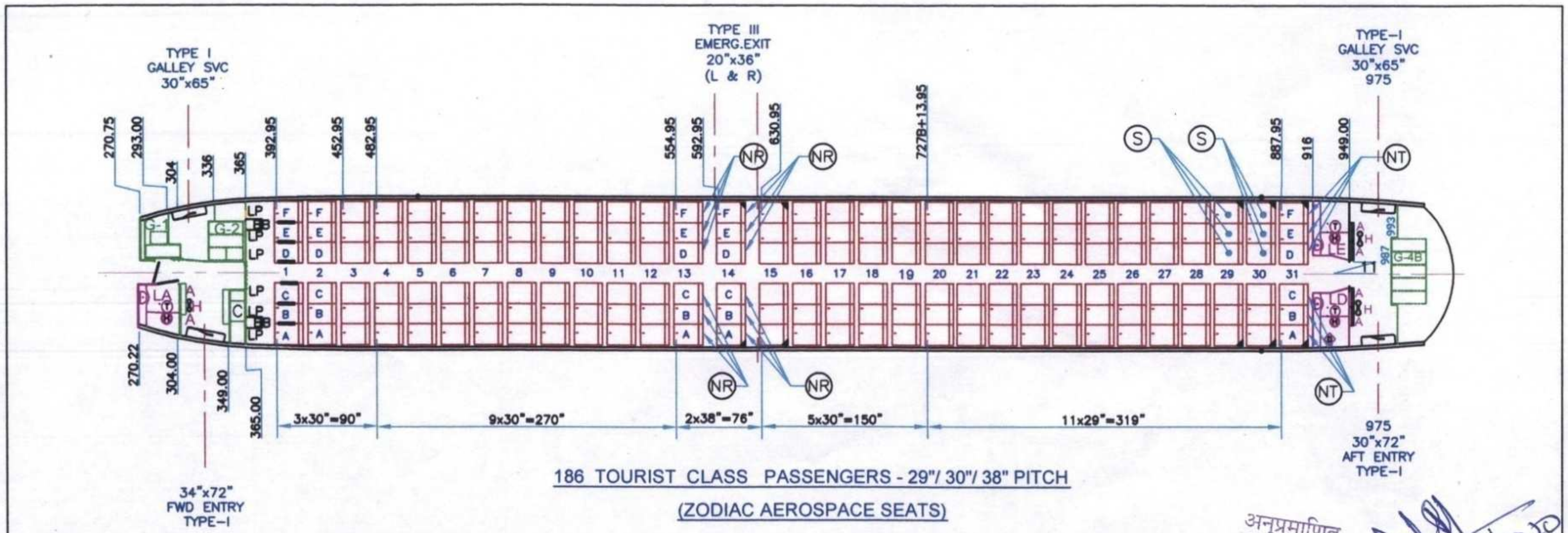
Jasbir Singh Larhga
Deputy Director, AAIB

Capt. Surender Singh Chahar
Former Designated Examiner Boeing 737
Investigator-in-Charge

Place: New Delhi

Date: 17th August 2021

Appendix A



186 TOURIST CLASS PASSENGERS - 29"/ 30"/ 38" PITCH

(ZODIAC AEROSPACE SEATS)

अनुप्रमाणित
Attested

[redacted]

उप निदेशक उड़नयोग्यता का कार्यालय/ O/o Deputy Director of Airworthiness
भारत सरकार, डीजीसीए / Govt. of India, DGCA
कोच्चिन हवाई अड्डा, कोच्चि-683111/ Cochin Airport, Kochi-683111

REG.NO.	VAR.NO.	MSN
VT–AXH	YL461	36323
VT–AXI	YL462	36324
VT–AXJ	YL463	36325
VT–AXM	YL464	36326
VT–AXN	YL465	36327
VT–AXP	YL466	36328
VT–AXQ	YL467	36329
VT–AXR	YL468	36330
VT–AXT	YL469	36331
VT–AXU	YL470	36332
VT–AXW	YL472	36334
VT–AXX	YL473	36335
VT–AXZ	YL474	36336
VT–AYA	YL475	36337
VT–AYB	YL476	36338
VT–AYC	YL477	36339
VT–AYD	YL478	36340

SEAT CHARACTERISTICS AND LEGEND	
(hatched)	IN ARMREST TABLE
(triangle)	NARROW SEAT
A	ATTENDANT SEATS.
C	CLOSET/STOWAGE UNIT
G	GALLEY
H	ATTENDANT HAND SET
T	TOILET
(NR)	NO RECLINE
LP	LITRATURE POCKET
BB	BABY BASSINET
(S)	STRETCHER SYSTEM
(NT)	NO BACKREST TABLE
ALL SEATS ARE EQUIPPED WITH INBOARD HANDICAPPED ARMREST EXCEPT SEATS WITH AT TABLE.	

DRAWING REFERENCE:– AEROCONSEIL 40090–01–A–CAB–F01

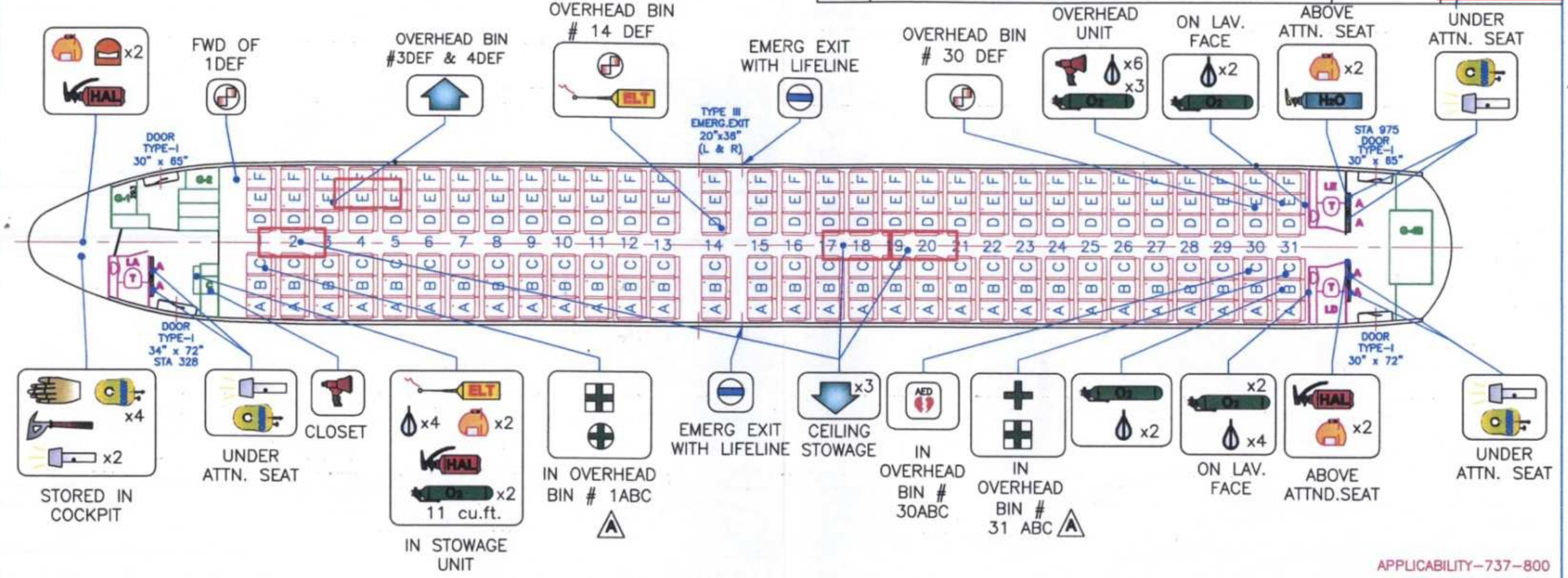
APPLICABILITY B737–800 VT–AXH THRU VT–AYD	AIR-INDIA EXPRESS LTD SANTA CRUZ MUMBAI–400 029	
DR	[redacted]	TITLE: LAYOUT OF PASSENGER ARRANGEMENT FOR AIR-INDIA express Ltd. BOEING 737- 800 AIRCRAFT.
CH		
APP		
DATE	17/01/2020	
SCALE: NTS	DRG. No.737- CON - 147 Sht. Of	Rev. –
TECHNICAL SERVICES		

Appendix B

अनुप्रमाणित
Attested

[redacted]

REV.	DESCRIPTION	DATE	SIGN
A	(1)–MEDICAL KIT AT BIN 2DEF SHIFTED TO BIN 1ABC. (2)–FIRST AID KIT AT BIN 30DEF SHIFTED TO BIN 31ABC.	16/02/2015	
B	COMPANY NAME CHANGE, AIR–INDIA CHARTERS LTD. TO AIR–INDIA EXPRESS LTD.	28/11/2019	[redacted]



APPLICABILITY–737–800

SYMBOL	DESCRIPTION	VENDOR	QTY.
	AUTOMATIC EXTERNAL DEFIBRILLATOR		1
	EXT. SEAT BELT	AMSOFE 2010-2-011-2862	3
	EMERGENCY ESCAPE ROPE		2
	FLASHLIGHT	P2–07–0003–001	8
	PROTECTIVE BREATHING EQUIPMENT(PBE), BOX	ESSEX PB & R CORP. (MR–10034N)	7
	CREW LIFE VEST	AIR CRUISER (ORANGE) 63600–593	10
	HEAT RESISTANT (FIRE PROTECTION) GLOVES	N STAR 2993	1 PAIR
	CRASH AXE	42D8331	1
	BCF FIRE EXTINGUISHER	KIDDE AEROSPACE 898052	3
	WATER FIRE EXTINGUISHER	KIDDE AEROSPACE 892480	1

SYMBOL	DESCRIPTION	VENDOR	QTY.
	UNIVERSAL PRECAUTION KIT		1
	LIFE LINE		2
	EMERGENCY TRANSMITTER & ELT BRACKET	M419	2
	VOICE GUN	MODEL A128A FEDERAL SIGNAL CORP	2
*	PASSENGER'S LIFE VEST (ONE LOCATED UNDER EACH SEAT.)	AIR CRUISER P/N. 63600–193	186
	FIRST AID KIT		2
	MEDICAL KIT		1
	OXYGEN BOTTLE (11Cu.ft.)	SCOTT AVIATION 5500–C1A–BF23A, 9700C1ABF23A, 3553AAAYAACXBD	9
	OXYGEN MASK	BE AEROSPECE P/N. 174095–35	18
	LIFE RAFT	AIR CRUISERS 64356–101	4

* EXTRA LIFE VEST P/N. 63600–193 AIR CRUISER IN BIN ABOVE SEAT NO 30 DEF, 14 DEF & FWD. OF 1 DEF. (4 EACH)

INFANT LIFE VEST P/N. P0640–103 EASTERN AERO MARINE. IN BIN ABOVE SEAT NO 30 DEF, 14 DEF & FWD. OF 1 DEF.(6 EACH)

REG.NO.	MSN
VT–AXH	36323
VT–AXI	36324
VT–AXJ	36325
VT–AXM	36326
VT–AXN	36327
VT–AXP	36328

APPICABILITY
737–800 A/C

AIR-INDIA EXPRESS LTD (B)
SANTA CRUZ MUMBAI 400 029

DR. [redacted]
CH
APPD
LETTER NO:–
DATED:–
DATE 31/05/2011
TECHNICAL SERVICES

TITLE
SAFETY & EMERGENCY EQUIPMENT LAYOUT FOR 737- 800 AIRCRAFT (FOR AIR-INDIA EXPRESS)

DRG. No. 737-A-094
SCAL
Sht. of
REV. B

Digitally signed by S R N GANGADHARA
Location: O/o DDG, Bangalore
Date: 2020-02-13 15:43:41

Appendix C

RELEVANT EXTRACT OF CVR TRANSCRIPT

HOT1 : Voice identified as of PF

HOT2 : Voice identified as of PM

RDO1 : Over the air Radio communication from PF

RDO2 : Over the air Radio communication from PM

TWR : Over the air Radio communication from DATCO

* : Unintelligible words

Conversation in local language transliterated into English and underlined.

UTC TIME	SOURCE	COMMUNICATION
13:18:52.0	SUMMARY	CONTROLLER REPORTS CALICUT RUNWAY IN USE IS 28. WINDS 270 DEG AT 14 KNOTS. VISIBILITY 1,500 MODERATE THUNDERSTORMS AND RAIN.
13:22:20.8	HOT2	270/14 KNOTS
13:24:39.7	SUMMARY	CAPTAIN INSTRUCTS FIRST OFFICER TO PUT HIS HEADSET ON
13:24:41.6	HOT1	* IS FULLY SERVICEABLE. AND UH, RUNWAY CHANGE AT CALICUT. UH REPORTED AS 28 WET, VISIBILITY 1500 METERS, WE NEED 1300 TO LAND SO IT'S GOING TO BE INTERESTING. 2-7-0 1-4 KNOTS. THUNDER SHOWER. LIKELY TO BE TURBULENT GUSTY AND ALL THAT AND WE'LL KEEP A SHARP LOOKOUT FOR CB ACTIVITY IN THE OUTBOUND. PROCEDURE TURN ** I-L-S 2-8 NOW. I TOLD YOU TO DO THIS, ALL THIS HAS TO CHANGE * ONE SECOND.
13:25:21.3	SUMMARY	FIRST OFFICER REQUESTS DESCENT FROM CONTROLLER
13:25:29.9	SUMMARY	CONTROLLER INSTRUCTS DESCENT TO FL 260

13:27:48.3	SUMMARY	CREW REQUESTS FURTHER DESCENT FROM FL 260
13:28:11.9	SUMMARY	[UNINTELLIGIBLE] CONTROL INSTRUCTS DESCENT TO FL 170
13:28:49.4	HOT1	WHAT IS THE LATEST Q-N-H REPORTED?
13:28:52.2	HOT2	SO LATEST QNH REPORTED IS 1007
13:28:55.5	HOT1	OH, THAT'S A SIGN OF WEATHER, NO? THE LOWER THE QNH THIS MEANS THERE IS MORE OF...CONVECTIVE ACTIVITY.
13:29:19.2	SUMMARY	CREW DISCUSSES APPROACH AS INPUT IN FMC
13:29:33.4	HOT1	THE GO AROUND, THERE MAY BE WEATHER, SO WE'LL KEEP TRACK OF THAT ALSO, OKAY?
13:29:36.6	HOT2	SURE CAPTAIN
13:29:38.6	HOT1	SO FINAL APPROACH FIX IS AT-
13:29:49.1	SUMMARY	CREW DISCUSSES INPUTTING APPROACH FIXES
13:30:56.7	HOT1	OKAY, SLOPE IS 3 POINT 2, IT'S STEEPER. -- FOR FLAPS 30 ---- YOU'LL GET AN APPROACH SPEED OF ABOUT 145, YOU'LL GET ABOUT 800 FEET PER MINUTE RATE OF DESCENT APPROXIMATELY.
13:31:10.1	SUMMARY	CREW REQUESTS DEVIATION TO THE RIGHT DUE TO WEATHER
13:31:26.1	SUMMARY	CONTROLLER APPROVES DEVIATION AND INSTRUCTS 1-3-4-4 DIRECT TO CHARLIE-LIMA-CHARLIE, WHEN ABLE
13:31:41.9	HOT1	AND UH, MINIMUM IS 576, WE NEED 1300. THE VISIBILITY REPORTED AS LATEST IS 1500, NO?
13:31:48.5	HOT2	CHECK
13:31:49.4	HOT1	I THINK IT'LL IMPROVE BY THE TIME WE *
13:32:00.3	HOT1	HOW MUCH OF...HOLD DO WE HAVE?

13:32:06.1	HOT1	UH WHAT IS OUR FUEL AT OUR DESTINATION? IT'S 3 POINT 8.
13:32:10.8	HOT1	I THINK...WE HAVE ABOUT UH...CO- COCHIN WEATHER IS OKAY?
13:32:16.5	HOT2	COCHIN WEATHER IS TWO THOUSAND FIVE HUNDRED AND RAIN
13:32:19.4	HOT1	OKAY. *. MINIMUM IS HOW MUCH THERE? THAT'S MUCH LESS, NO?
13:32:39.9	SUMMARY	CONTROLLER INSTRUCTS 1-3-4-4 TO CONTACT CALICUT APPROACH AT 123.35 [CALICUT TOWER FREQUENCY]
13:33:09.7	SUMMARY	CREW CONTACTS CALICUT TOWER, REPORTS PASSING FL 181, DESCENDING TO FL 170
13:33:16.6	SUMMARY	CALICUT TOWER ACKNOWLEDGES, ASKS FOR D-M-E DISTANCE FROM CHARLIE-LIMA-CHARLIE
13:33:25.7	SUMMARY	CREW REPORTS 52 NAUTICAL MILES FROM CHARLIE-LIMA-CHARLIE
13:33:43.5	SUMMARY	CALICUT TOWER INSTRUCTS DIRECT CHARLIE-LIMA-CHARLIE, DESCENT TO 7,000 FEET, TRANSITION LEVEL FL 115, QNH 1007
13:34:02.3	SUMMARY	CALICUT TOWER AFFIRMS, TELLS 1-3-4-4 TO EXPECT I-L-Z ZULU APPROACH FOR RUNWAY 28
13:34:09.1	SUMMARY	CREW ASKS CALICUT TOWER FOR THE LATEST WINDS AND VISIBILITY
13:34:17.1	SUMMARY	CALICUT TOWER REPORTS VISIBILITY OF 1,500M RAIN WITH THUNDERSTORMS
13:34:26.3	HOT1	IT'S JUST ABOVE MINIMUM SO WE CAN MAKE AN ATTEMPT, OKAY?
13:34:29.6	HOT2	CHECK
13:34:30.1	HOT1	RUNWAY IS WET, EXPECT TURBULENCE, EXPECT WEATHER, ALL PRECAUTIONS
13:34:49.1	HOT1	WE NEED UH, 2,500 TO GO TO COCHIN. OKAY?
13:34:54.0	HOT1	WE HAVE ABOUT THIRTEEN TO FOURTEEN HUNDRED HOLD FUEL, THAT'S ABOUT HALF AN HOUR HOLD. SO IF THE VISIBILITY IS POOR, WE HAVE ENOUGH FUEL TO EVEN HOLD FOR SOME TIME.

13:35:06.5	HOT1	WEATHER AT COCHIN IS ALSO ABOVE MINIMUM AT TWO THOUSAND
13:35:09.2	HOT2	TWO THOUSAND FIVE HUNDRED
13:35:10.2	HOT1	YEAH YEAH, I EXPECT THE WEATHER TO IMPROVE BY THE TIME WE GO OVER IT BECAUSE THIS RAIN WILL. KAM HO JAYEGA LET'S BE OPTIMISTIC.
13:35:17.3	HOT1	AND UH, --AFTER LANDING ON RUNWAY…UH 2-8, OKAY, WE SELECTED AUTOBRAKES 3, FLAPS 30
13:35:29.4	HOT1	VACATE VIA ALPHA, BRAVO, OR CHARLIE AS CONVENIENT, OTHERWISE GO TO THE END AND BACKTRACK.
13:35:34.2	HOT2	CHECK *
13:35:36.2	HOT1	BRIEFING. FOR A GO AROUND, WINDSHEAR ON APPROACH, UH…APPROACH TO STALL AND RECOVERY AND GO-AROUND IS AS BRIEFED IN THE FIRST SECTOR.
13:35:43.8	HOT2	CHECK *
13:35:44.4	HOT1	ANY DOUBTS?
13:35:45.5	HOT2	NO
13:35:45.8	HOT1	ANY QUESTIONS?
13:35:46.7	HOT2	NO QUESTIONS
13:35:47.4	HOT1	COMPLETE THE DESCENT CHECKLIST PLEASE, WHATEVER IS LEFT
13:35:49.8	HOT2	RECALL IS CHECKED, AND DESCENT CHECKLIST PRESSURIZATION LAND ALTITUDE THREE HUNDRED AND FIFTY
13:35:55.6	HOT2	CHECK. AUTOBRAKES 3.
13:35:57.6	HOT1	YEAH.
13:35:59.0	HOT2	LANDING DATA

13:36:02.1	HOT1	UH, LANDING DATA. FLAPS 30. V-REF IS 1-4-5 FOR FLAPS 30. MINIMUM IS 5-7-6 FOR I-L-S RUNWAY 2-8
13:36:16.1	HOT2	LANDING DATA. FLAPS 30. V-REF 1-4-5, MINIMUMS 5-7-6.
13:36:20.5	HOT2	APPROACH BRIEFING?
13:36:21.4	HOT1	COMPLETE
13:36:34.2	SUMMARY	CREW DISCUSSES MANIPULATING TERRAIN/RADAR RANGE OPTIONS
13:37:02.0	SUMMARY	CREW DISCUSSES FINALIZING FMC SETUP, FINISHES APPROACH CHECKLIST
13:39:58.7	HOT2	TEN THOUSAND FEET PROCEDURES
13:40:00.5	HOT1	- CHECK - CABIN … ALREADY SECURRED….
13:41:19.8	RDO2	CALICUT TOWER, EXPRESSINDIA 1-3-4-4 PASSING NINER THOUSAND, ONE ONE MILES CHARLIE-LIMA-CHARLIE, ON A STEADY RADIAL 2-8-5
13:41:29.1	TWR	EXPRESSINDIA 1-3-4-4 ROGER, CONTINUE VIA 2-8-5 RADIAL CHARLIE-LIMA-CHARLIE, DESCEND TO THREE THOUSAND SIX HUNDRED FEET. CLEARED I-L-S ZULU APPROACH RUNWAY 2-8. REPORT PASSING CHARLIE-LIMA-CHARLIE FOR APPROACH
13:41:53.8	HOT1	OKAY, SPEEDBRAKES
13:41:55.2	HOT2	CHECK * AND THREE THOUSAND SIX HUNDRED.
13:41:57.7	HOT1	YEAH, YEAH
13:41:59.4	HOT1	I HEARD THAT
13:42:00.2	HOT2	CHECK *
13:42:00.8	HOT1	OUR TARGET IS SLIGHTLY, OKAY, FINE. TELL HIM THAT IN CASE OF A MISSED APPROACH, UH, WE'D LIKE TO CONTINUE STRAIGHT AHEAD AND THEN TURN RIGHT STAYING CLEAR OF WEATHER. CAN YOU MAKE THIS CALL?

13:42:12.6	HOT2	YEAH
13:42:21.6	RDO2	CALICUT TOWER EXPRESS INDIA 1-3-4-4, IN CASE OF MISSED APPROACH DUE WEATHER, WE'LL UH- LIKE TO MAINTAIN RUNWAY HEADING AND THEN TURN RIGHT TO AVOID WEATHER
13:42:31.7	TWR	ROGER, APPROVED
13:42:39.6	HOT1	ASK HIM, ANY CHANGE IN THE VISIBILITY?
13:42:42.1	RDO2	ANY CHANGE IN THE VISIBILITY? EXPRESS INDIA 1-3-4-4
13:42:46.5	TWR	UH, STANDBY
13:43:09.3	HOT1	THERE IS TOO MUCH OF TURBULENCE SO I'LL JUST DELAY THE FLAPS, BECAUSE PREFERABLY WE'LL TRY AND...OH LOOK AT THE WEATHER HERE, YEAH, THERE'S A LOT OF WEATHER HERE. *
13:43:12.0	HOT2	CHECK
13:43:38.1	TWR	AIR EXPRESS INDIA 1-3-4-4 LATEST VISIBILITY TWO THOUSAND METERS AND UH...LIGHT RAIN.
13:43:43.0	RDO2	COPIED, EXPRESS INDIA 1-3-4-4
13:43:56.6	HOT1	FLAPS ONE
13:43:57.6	HOT2	OKAY
13:43:58.3	HOT2	FLAPS ONE SELECTED MOVING. YEAH.
13:44:00.8	RDO2	CALICUT TOWER, EXPRESS INDIA 1-3-4-4 OUT...LEAVING CHARLIE-LIMA-CHARLIE FOR (ROUTE/OUT) 1-0-9-1
13:44:06.6	TWR	EXPRESS INDIA 1-3-4-4 ROGER, DESCEND AS THE PROCEDURE, REPORT ESTABLISHED ON I-L-S RUNWAY 2-8
13:44:12.9	RDO2	DESCEND AS PER THE PROCEDURE, CALL YOU ESTABLISH ON I-L-S RUNWAY 2-8, EXPRESS INDIA 1-3-4-4

13:44:49.4	HOT1	FLAPS 2
13:44:57.5	HOT2	FLAPS 2, GREEN LIGHT
13:45:21.5	HOT1	OKAY. ALRIGHT, ILS PREPARATION. * * *. OKAY.
13:45:41.1	HOT1	OKAY, FLAPS 5
13:45:43.5	HOT2	FLAPS 5 SELECTED
13:46:22.6	HOT2	OKAY, I-L-S FREQUENCY...1-0-9 TUNED. AND I IDENTIFIED INDIA-CHARLIE-ALPHA-CHARLIE 2-8-3 AND D-A FIVE SEVENTY SIX
13:46:33.3	HOT1	INDIA-CHARLIE-ALPHA-CHARLIE IDENTIFIED
13:47:37.8	HOT1	OKAY, IDENTIFIED LOCALIZER
13:47:40.6	HOT2	CHECK
13:47:52.1	HOT2	L-NAV, VORLOC, GLIDESLOPE ARMED
13:47:53.6	HOT1	CHECK
13:48:07.3	HOT2	VORLOC CAPTURED, SINGLE CHANNEL
13:48:09.4	HOT1	CHECK
13:48:23.7	HOT1	* YOU JUST SEE THAT THIS WORKS
13:48:27.6	HOT1	YEAH JUST CHECK IT UH?
13:48:28.7	HOT2	YEAH
13:48:29.7	HOT1	REMEMBER PUT IT TO HIGH?
13:48:31.1	HOT2	HIGH

13:48:32.2	HOT1	HIGH YEAH
13:48:33.4	HOT1	HIGH SPEED
13:48:44.8	HOT2	CHECK
13:49:02.3	HOT1	* TAILWIND HERE
13:49:11.3	HOT2	LANDING GEAR DOWN?
13:49:11.9	HOT1	YEAH
13:49:17.6	HOT1	FLAPS 15
13:49:19.7	HOT2	FLAPS 15 SELECTED
13:49:21.3	HOT1	CHECK
13:49:21.8	HOT2	AND GLIDESLOPE CAPTURED
13:49:23.0	HOT1	CHECK
13:49:25.1	RDO2	CALICUT TOWER, EXPRESS INDIA 1-3-4-4 ON I-L-S RUNWAY 2-8
13:49:29.6	TWR	EXPRESS INDIA 1-3-4-4, RUNWAY SURFACE WET, LIGHT RAIN OVER THE FIELD, WIND 2-8-0 DEGREES 0-5 KNOTS.RUNWAY 2-8, CLEARED TO LAND.
13:49:38.4	RDO2	RUNWAY 2-8 CLEARED TO LAND, EXPRESS INDIA 1-3-4-4
13:49:41.4	HOT1	WHAT'S THE VISIBILITY?
13:49:43.3	RDO2	AND WHAT WAS THE VISIBILITY? EXPRESSINDIA 1-3-4-4.
13:49:45.5	TWR	VISIBILITY TWO THOUSAND METERS..UH...IT MAY LIKELY * * *... DECREASE TO ONE THOUSAND FIVE HUNDRED METERS
13:49:52.4	RDO2	COPIED.

13:49:53.7	HOT1	OKAY, CAN..UH START THE LANDING CHECKLIST PLEASE?
13:49:56.9	HOT2	YEAH
13:50:07.4	HOT2	FLAPS?
13:50:08.0	HOT1	FIFTEEN HOLD FLAPS.
13:50:09.0	HOT2	CHECK
13:50:09.2	HOT1	HOLD FLAPS… THIS IS A TROUBLESOME AREA
13:50:10.1	HOT2	CHECK
13:50:10.9	EGPWS	TWENTY FIVE HUNDRED [ELECTRONIC VOICE]
13:50:12.5	HOT2	LANDING CLEARANCE IS OBTAINED.
13:50:14.1	HOT1	WAIT, WE'LL HOLD IT AT FLAPS, THEN WE'LL DO THE REST
13:50:14.7	HOT2	CHECK, CHECK
13:50:17.8	HOT1	THIS IS THAT TROUBLESOME AREA WE'RE EXPECTING
13:50:20.1	HOT2	CHECK
13:50:41.0	HOT1	ISKO ON KAR DETE HAIN *(LET US PUT IT ON)*
13:50:49.9	HOT1	EXPECT TO SEE THE LEAD IN LIGHTS ALSO
13:50:52.0	HOT2	YEAH
13:50:58.7	HOT1	FLAPS 30
13:51:01.5	HOT2	FLAPS 30 SELECTED
13:51:04.5	HOT2	LEAD IN LIGHTS IN SIGHT

13:51:05.5	HOT1	YEAH
13:51:08.9	HOT1	ISKO KYA HO GYA *(WHAT HAS HAPPENED TO IT)*
13:51:11.1	HOT1	OH #SHIT
13:51:13.6	HOT1	WIPER IS (GONE/DONE)
13:51:16.5	HOT2	#SHIT
13:51:18.1	HOT1	GREAT YAAR
13:51:22.8	HOT1	[SOUND OF LAUGHTER] WHAT A DAY FOR THE WIPER TO GO [SOUND OF MORE LAUGHTER]
13:51:25.7	HOT1	OKAY, COMPLETE THE LANDING CHECKLIST
13:51:33.5	HOT2	LANDING CLEARANCE?
13:51:34.4	HOT1	IS...CONFIRM OBTAINED?
13:51:36.4	HOT2	AFFIRM
13:51:38.7	HOT1	OKAY, LANDING CHECKLIST IS COMPLETE
13:51:52.8	EGPWS	ONE THOUSAND [ELECTRONIC VOICE]
13:51:53.9	HOT1	CHECK
13:51:54.2	HOT2	CHECKED
13:51:58.5	HOT1	OKAY, PUT ON THE LIGHTS. ALL LIGHTS ON.
13:52:04.4	HOT2	SPEED
13:52:05.0	HOT1	YEAH, YEAH. CHECKED.
13:52:30.2	HOT2	SPEED

13:52:32.0	EGPWS	APPROACHING MINIMUMS [ELECTRONIC VOICE]
13:52:34.1	HOT1	LOOKING OUT **
13:52:34.3	EGPWS	FIVE HUNDRED [ELECTRONIC VOICE]
13:52:35.3	HOT2	CHECK
13:52:38.3	EGPWS	MINIMUMS [ELECTRONIC VOICE]
13:52:39.0	HOT1	LET'S GO AROUND
13:52:39.1	CAM	[SOUND OF AUTOPILOT DISCONNECT ALERT]
13:52:41.1	HOT2	OKAY
13:52:43.4	HOT2	OKAY, FLAPS
13:52:43.9	HOT1	LANDING GEAR UP
13:52:44.6	HOT2	YEAH
13:52:47.1	HOT2	POSITIVE RATE
13:52:48.1	HOT1	GEAR UP
13:52:48.9	HOT2	UM, GEAR UP. FLAPS 15 SETTING.
13:52:50.7	HOT1	CHECK
13:52:56.5	HOT2	SPEED
13:53:03.7	RDO2	TOWER, EXPRESS INDIA 1-3-4-4 GOING AROUND
13:53:07.2	TWR	ROGER
13:53:42.2	CAM	[SOUND OF ALTITUDE ALERT TONE]

13:53:44.0	HOT2	ONE THOUSAND TO LEVEL OFF
13:53:45.3	HOT1	CHECK
13:53:48.2	HOT2	AND WE'LL REQUEST FURTHER CLIMB?
13:53:50.3	HOT1	***NO WE WILL LEVEL OUT AT 36???
13:53:51.9	HOT2	CHECK
13:53:53.3	HOT2	CHECK
13:53:54.7	HOT2	TURNING
13:53:59.2	HOT2	COMMAND
13:54:16.1	HOT2	YEAH, YOU WANT RIGHT TURN, RIGHT?
13:54:19.6	HOT2	HEADING SELECT?
13:54:21.8	HOT1	AFTER TAKEOFF PROCEDURE
13:54:23.0	HOT2	HEADING SELECT, ALT HOLD
13:54:24.5	HOT1	AFTER TAKEOFF CHECKLIST
13:54:27.1	HOT2	CHECK *
13:54:37.2	HOT1	WHY ARE WE TURNING RIGHT...OKAY
13:54:43.2	HOT2	* WEATHER
13:54:54.4	TWR	EXPRESS INDIA 1-3-4-4 REQUEST REASON OF GO AROUND
13:55:00.0	HOT2	UH REQUEST REASON * ?
13:55:02.1	HOT1	SORRY?

13:55:02.7	HOT2	REQUEST REASON FOR THE GO AROUND HE'S ASKING
13:55:05.5	HOT1	TELL HIM WEATHER. JUST TELL HIM DUE WEATHER.
13:55:08.0	RDO2	DUE WEATHER. EXPRESS INDIA 1-3-4-4. HEAVY RAIN.
13:55:11.2	TWR	UH ROGER
13:55:13.6	HOT1	I THINK WE SHOULD CLIMB UP A LITTLE BIT?
13:55:15.5	HOT2	YEAH. SHOULD I ASK?
13:55:17.1	HOT1	YEAH
13:55:17.8	RDO2	UH, REQUEST FURTHER CLIMB EXPRESS INDIA 1-3-4-4
13:55:21.8	TWR	ROGER, CLIMB TO 1-0 THOUSAND FEET
13:55:24.5	HOT1	UHH
13:55:25.6	HOT2	UH...1-0 THOUSAND?
13:55:27.8	HOT1	OKAY. LET'S SAVE SOME FUEL YEAH, OTHERWISE WE'LL KEEP BURNING OUR FUEL OUT
13:55:30.0	RDO2	CLIMB UH...1-0 THOUSAND. EXPRESS INDIA 1-3-4-4.
13:55:43.6	HOT1	OKAY AFTER TAKEOFF PROCEDURE...AFTER TAKEOFF CHECKLIST IS COMPLETE?
13:55:46.3	HOT2	AFFIRM
13:55:46.7	HOT1	OKAY
13:55:47.9	HOT2	I'LL SET UP?
13:55:49.3	HOT1	*. AGAIN? YEAH.
13:55:51.9	HOT2	YEAH

13:55:52.4	SUMMARY	AIR INDIA 425 REQUEST RWY 10 FOR DEP. TWR APPROVES
13:55:59.8	HOT1	HOW'S HE…
13:56:02.2	HOT1	ASK HER…* NOT HELP US * *
13:56:08.6	RDO1	CALICUT EXPRESS INDIA 1-3-4-4
13:56:11.8	TWR	[FIRST PORTION OF WIND DATA NOT TRANSMITTED] 250° DEGREES, 0-8 KNOTS. CONFIRM LIKE TO MAKE APPROACH FOR 1-0?
13:56:15.2	HOT2	EXECUTE
13:56:16.7	HOT1	HE…HE WILL NOT LISTEN
13:56:28.5	RDO1	CALICUT EXPRESS INDIA 1-3-4-4
13:56:30.7	HOT1	DON'T DO ANYTHING. PAY ATTENTION.
13:56:31.5	TWR	GO AHEAD
13:56:32.2	HOT2	YEAH
13:56:32.8	RDO1	HOW'S THE VISIBILITY FOR RUNWAY 1-0?
13:56:35.5	TWR	BOTH RUNWAYS TWO THOUSAND METERS * WITH UH…LIGHT RAIN
13:56:41.6	RDO1	OKAY…I THINK…AND WHAT IS THE SURFACE WINDS?
13:56:45.9	TWR	SURFACE WIND NOW 2-6-0 DEGREES 0-5 KNOTS
13:56:49.7	RDO1	COPIED
13:56:52.3	RDO1	UH CAN WE LEVEL OUT AT LEVEL 7-0 PLEASE
13:56:54.8	TWR	ROGER, LEVEL OUT AT 7-0. INTERCEPT 2-8-5 RADIAL 1-5 D-M-E FIX

13:56:59.4	RDO1	ROGER
13:57:02.7	CAM	[SOUND OF ALTITUDE ALERT TONE]
13:57:04.5	HOT2	OKAY, ONE THOUSAND FEET TO GO
13:57:05.5	HOT1	OKAY, SET UP FOR 1-0
13:57:12.5	HOT1	YEAH, WE'LL STAY AROUND THIS 13 D-M-E POINT, OKAY?
13:57:15.9	HOT2	CHECK
13:57:16.3	HOT1	WE'LL DO A HOLD OUT HERE
13:57:19.6	TWR	EXPRESS INDIA 1-3-4-4 CONFIRM LIKE TO MAKE APPROACH FOR 1-0?
13:57:24.1	RDO1	YEAH...UH, WE'LL LIKE TO TRY IF YOU GIVE US UH- AN UPDATE ON THE...VISIBILITY FOR RUNWAY 1-0
13:57:30.9	TWR	VISIBILITY IS THE SAME SIR AT TWO THOUSAND METER, AND WE'LL INFORM UH ANY FURTHER IMPROVEMENT. AND UH- NOW WE'LL- WIND IS AT 2-6-0 DEGREES 0-5 KNOTS.
13:57:39.9	RDO1	UH...ANY UH C-BS JUST DUE WEST OF THE AIRPORT ON THE APPROACH PATH FOR RUNWAY 1-0
13:57:46.2	TWR	SAY AGAIN?
13:57:47.6	RDO1	IS THERE ANY REPORTED CHARLIE-BRAVO ON THE APPROACH PATH FOR RUNWAY 1-0?
13:57:53.4	TWR	REPORTED CHARLIE-BRAVO TWO THOUSAND FIVE HUNDRED FEET TOWARDS NORTH, NORTHWEST, WEST, EAST, SOUTHEAST
13:58:00.0	HOT1	OKAY
13:58:00.5	RDO1	COPIED, THANK YOU
13:58:02.1	HOT1	OKAY, SET UP FOR 1-0. LETS TRY.
13:58:04.3	HOT2	OKAY, SO VIA 2-8-5 *

13:58:07.3	HOT1	YEAH
13:58:16.8	HOT1	OKAY, SET IT UP FOR 1-0. OKAY?
13:58:32.0	HOT1	OKAY, NOW THIS POINT 2-8-4 WHAT *** LEVEL OUT HERE THREE THOUSAND SIX HUNDRED
13:58:37.4	HOT2	YEAH
13:58:38.2	HOT1	OKAY SO... (I'LL/ALRIGHT) TELL HIM THAT YOU WANT TO DESCEND (TO/TOO). OKAY, YOU FINISH THE THING UP.
13:58:46.0	HOT2	YEAH.
13:58:46.1	HOT1	***, YOU BETTER PUT THE CORRECT SPEEDS HERE
13:58:49.8	HOT2	YEAH. SO I'LL PUT 1-8-0, 3-6-0-0
13:58:53.5	HOT1	NOT 1-8-0. 1-...FLAPS 5 YEAH? FLAPS 5 SPEED I'LL TELL YOU. I ALREADY (SAID/SET) THAT ONE SEVENTY, THREE (SIX/SIXTY). OKAY?
13:59:03.2	HOT2	CHECK. EXECUTING.
13:59:04.7	HOT1	YEAH. YEAH *** YEAH. *** YEAH. YOU * PRETTY *, YEAH.
13:59:10.5	HOT2	YEAH.
13:59:11.9	HOT1	OKAY
13:59:13.2	HOT2	DONE
13:59:24.9	HOT1	HOW FAR IS IT?
13:59:26.9	HOT1	EXECUTE
13:59:27.8	HOT2	FIVE NAUTICAL MILES
13:59:28.5	HOT1	UH DON'T EXECUTE IT, JUST ONE SECOND. ASK HIM PERMISSION TO DESCEND TO THREE

		THOUSAND SIX HUNDRED
13:59:32.2	TWR	EXPRESS INDIA 1-3-4-4 REPORT POSITION
13:59:35.0	RDO1	UH WE ARE POSITIONING AT UH RADIAL 2-8-4, WE'D LIKE TO DESCEND TO THREE THOUSAND SIX HUNDRED
13:59:41.9	TWR	AIR EXPRESS INDIA 1-3-4-4 ROGER. DESCEND TO THREE THOUSAND SIX HUNDRED FEET. INTERCEPT 2-8-5 RADIAL 2- CORRECTION 2-8-4 RADIAL 1-5 D-M-E FIX FOR I-L-S APPROACH RUNWAY 1-0
13:59:52.2	RDO2	DESCEND TO THREE THOUSAND SIX HUNDRED FEET TO INTERCEPT UH...RADIAL 2-8-4 1-5 D-M-E FIX FOR I-L-S APPROACH RUNWAY 1-0, EXPRESS INDIA 1-3-4-4
14:00:18.7	SUMMARY	[TOWER REPORTS WIND AS 2-6-0 DEGREES AT 1-0 KNOTS TO OTHER DEPARTING AIRCRAFT]
14:00:26.7	HOT1	PEHLE MAANA NAHI APNE KO... PEHLE
14:01:19.6	HOT2	AND LANDING WEIGHT NOW...DECIMAL TWO
14:01:24.7	HOT2	SIXTY THREE ONE
14:01:25.7	HOT1	YEAH
14:01:28.9	HOT2	FLAPS 30?
14:01:30.9	HOT1	YUP
14:01:31.8	TWR	AIR EXPRESS INDIA 1-3-4-4 APPEARS YOU ARE GOING OUT BOUND INTERCEPT INBOUND 2-8-4 RADIAL
14:01:36.9	HOT1	TELL HIM WE ARE TURNING LEFT TO INTERCEPT
14:01:38.7	RDO2	WE ARE TURNING LEFT TO INTERCEPT. EXPRESS INDIA 1-3-4-4.
14:01:41.8	TWR	(ROGER/ALRIGHT)
14:01:46.7	HOT2	VERTICAL SPEED. M-C-P SPEED

14:02:06.0	HOT1	TIL TWELVE MILES WE HAVE TO DESCEND ONLY A THOUSAND FEET * * *
14:02:15.0	HOT1	UH, SHOULD WE GO FOR FLAPS 40 NOW?
14:02:17.9	HOT1	I HOPE THIS THING WORKS (NO/NOW)
14:02:20.5	HOT1	YEAH, HUH. ISKO 40 KARDO ABHI
14:02:23.8	HOT2	FLAPS 40?
14:02:24.5	HOT1	UH HUH HAA TAIL WINDS HAIN
14:02:25.7	HOT2	CHECK
14:02:27.5	HOT1	WE WILL RECONSIDER AGAIN
14:02:41.9	HOT2	FLAPS 40
14:02:42.5	HOT1	YEAH
14:03:14.9	HOT1	UHH...HERE WE WANT TO BE AT ONE (180/EIGHTY) EH?
14:03:17.5	HOT2	YEAH
14:03:18.5	HOT1	THERE WILL BE TAIL WINDS FLAPS 1
14:03:20.6	HOT2	SPEED CHECK. FLAPS 1, SELECTED MOVING
14:03:48.2	HOT1	WE HAVE MISSED APPROACH * TELL HIM WE'LL TURN LEFT THERE'S TOO MUCH WEATHER ON THE RIGHT
14:03:53.8	HOT1	YOU CAN TELL HIM THAT
14:03:54.8	HOT2	YEAH I'LL TELL NOW
14:03:55.7	HOT1	WAIT WAIT, AH NO NO. UH...ISKA- MISSED APPROACH KYA HAI

14:04:00.7	HOT2	ISKA MISSED APPROACH HOGA
14:04:06.0	HOT2	CLIMB STRAIGHT AHEAD TWO THOUSAND FOUR HUNDRED THEN...TURN RIGHT
14:04:09.8	HOT1	AH
14:04:10.1	HOT2	TO V-O-R TO JOIN AT THREE THOUSAND SIX HUNDRED
14:04:11.6	HOT1	TRACK
14:04:12.9	TWR	EXPRESS INDIA 1-3-4-4 CONFIRM MAKING APPROACH FOR 1-0
14:04:16.2	HOT1	AFFIRM
14:04:16.4	RDO2	AFFIRM. EXPRESS INDIA 1-3-4-4
14:04:18.8	TWR	ROGER CLEARED I-L-S ZULU APPROACH RUNWAY 1-0 VIA 2-8-4 RADIAL 1-5 D-M-E FIX REPORT ESTABLISHED ON LOCALIZER RUNWAY 1-0.
14:04:26.7	RDO1	CLEARED UH...I-L-S FOR...I-L-S UH...ZULU APPROACH RUNWAY 1-0 VIA 2-8-4 D-M-E FIX. CALL YOU ESTABLISHED ON LOCALIZER EXPRESS INDIA 1-3-4-4.
14:04:36.4	HOT2	OKAY I'LL GIVE YOU (ILS FREQUENCY)
14:04:39.4	HOT1	SELECT I-L-S 1-1-0 DECIMAL...
14:04:41.1	HOT2	OKAY
14:04:45.5	HOT2	1-1-0 DECIMAL 7
14:04:47.1	HOT1	YEAH YEAH
14:04:48.4	HOT1	1-1-0 DECIMAL 7? OKAY. OKAY.
14:04:53.1	HOT2	OKAY COURSE...FREQUENCY...AND *
14:04:54.6	HOT1	NEXT IS TWENTY TWO HUNDRED?

14:04:56.2	HOT2	YEAH
14:04:56.6	HOT2	NOW AFTER UH...
14:04:58.0	HOT1	13 D-M-E
14:04:58.9	HOT2	YEAH
14:04:59.4	HOT1	OKAY. FLAPS 5.
14:05:03.1	HOT2	FLAPS 5 SELECTED. MOVING.
14:05:16.7	HOT2	INDIA-CHARLIE-LIMA-BRAVO 1-0-3 TUNED AND IDENTIFIED
14:05:24.3	HOT2	UH LOCALIZER ALIVE
14:05:25.8	HOT1	CHECK
14:05:30.3	HOT1	THERE'S TOO MUCH WEATHER THAT SIDE (YEAH/HERE). LET'S HOPE HERE IT'S OKAY?
14:05:43.4	HOT2	I'LL JUST ADVISE THE CREW
14:05:44.8	HOT1	YEAH
14:05:46.4	COM	CABIN CREW, LANDING STATIONS
14:05:51.4	HOT2	AUTOBRAKES (3 SELECTED /THREE/RESELECTED)
14:05:53.0	HOT1	CHECK. CROSSING THIS POINT, NOW?
14:05:55.5	HOT2	YEAH
14:05:58.4	HOT2	RETARD M-C-P SPEED
14:05:59.7	HOT1	GETTING DOWN TO TWENTY TWO
14:06:01.6	HOT2	CHECK

14:06:10.4	HOT2	AND CLEARED FOR THE APPROACH
14:06:12.3	HOT1	YEAH
14:06:13.8	HOT1	SO, YOU ARM THE APPROACH?
14:06:15.6	HOT2	YEAH
14:06:18.7	HOT2	L-NAV VORLOC GLIDESLOPE ARMED
14:06:19.8	HOT1	CHECK
14:06:22.2	HOT2	VORLOC CAPTURED, SINGLE CHANNEL
14:06:24.9	HOT1	OKAY
14:06:26.5	RDO2	CALICUT TOWER, EXPRESS INDIA 1-3-4-4 ON I- LOCALIZER RUNWAY 1-0
14:06:27.1	CAM	[SOUND OF ALTITUDE ALERT TONE]
14:06:32.3	TWR	EXPRESS INDIA 1-3-4-4 ROGER. DESCEND TO TWO THOUSAND TWO HUNDRED FEET AS PER PROCEDURE. UH REPORT FULLY ESTABLISHED I-L-S RUNWAY 1-0
14:06:40.1	RDO2	DESCEND TO TWO THOUSAND TWO HUNDRED FEET UH, WE'LL CALL YOU FULLY ESTABLISHED I-L-S RUNWAY...1-0. EXPRESS INDIA 1-3-4-4
14:06:46.5	HOT2	CHECK
14:06:47.2	HOT1	CHECK
14:06:56.4	HOT2	OKAY, CHECK
14:06:57.9	HOT1	YEAH
14:07:00.0	HOT1	YOU PUT IT ON PROPERLY IN THERE. I'LL TELL YOU WHEN TO PUT IT ON. I HOPE IT WORKS.
14:07:03.6	HOT2	CHECK

14:07:05.1	HOT1	[SOUND OF LAUGHTER]
14:07:11.6	HOT1	CHECKED
14:07:14.7	EGPWS	TWENTY FIVE HUNDRED [ELECTRONIC VOICE]
14:07:16.1	HOT1	CHECK
14:07:16.3	HOT2	RADIO ALTIMETER ALIVE
14:07:17.4	HOT1	CHECK
14:07:17.8	HOT2	ALT ACQUIRED
14:07:18.9	HOT1	CHECK
14:07:28.8	HOT1	VORLOC CAPTURED. LOC- OKAY. CHECK.
14:07:31.6	HOT2	HEADING TO COURSE..
14:07:42.2	HOT1	ISKO KAREN
14:07:43.9	HOT2	THODI DER MEIN KARTE HAIN
14:07:47.3	HOT1	WHAT IS THIS?
14:07:50.6	HOT1	SPEED TO ITNI HE RAHAYGE *(SPEED WILL BE THIS MUCH ONLY)*
14:07:55.0	HOT2	OKAY
14:07:55.7	HOT1	OKAY
14:07:58.7	HOT1	FLAP-
14:07:59.1	HOT2	GLIDESLOPE CAPTURED
14:08:00.0	HOT1	FLAPS 25

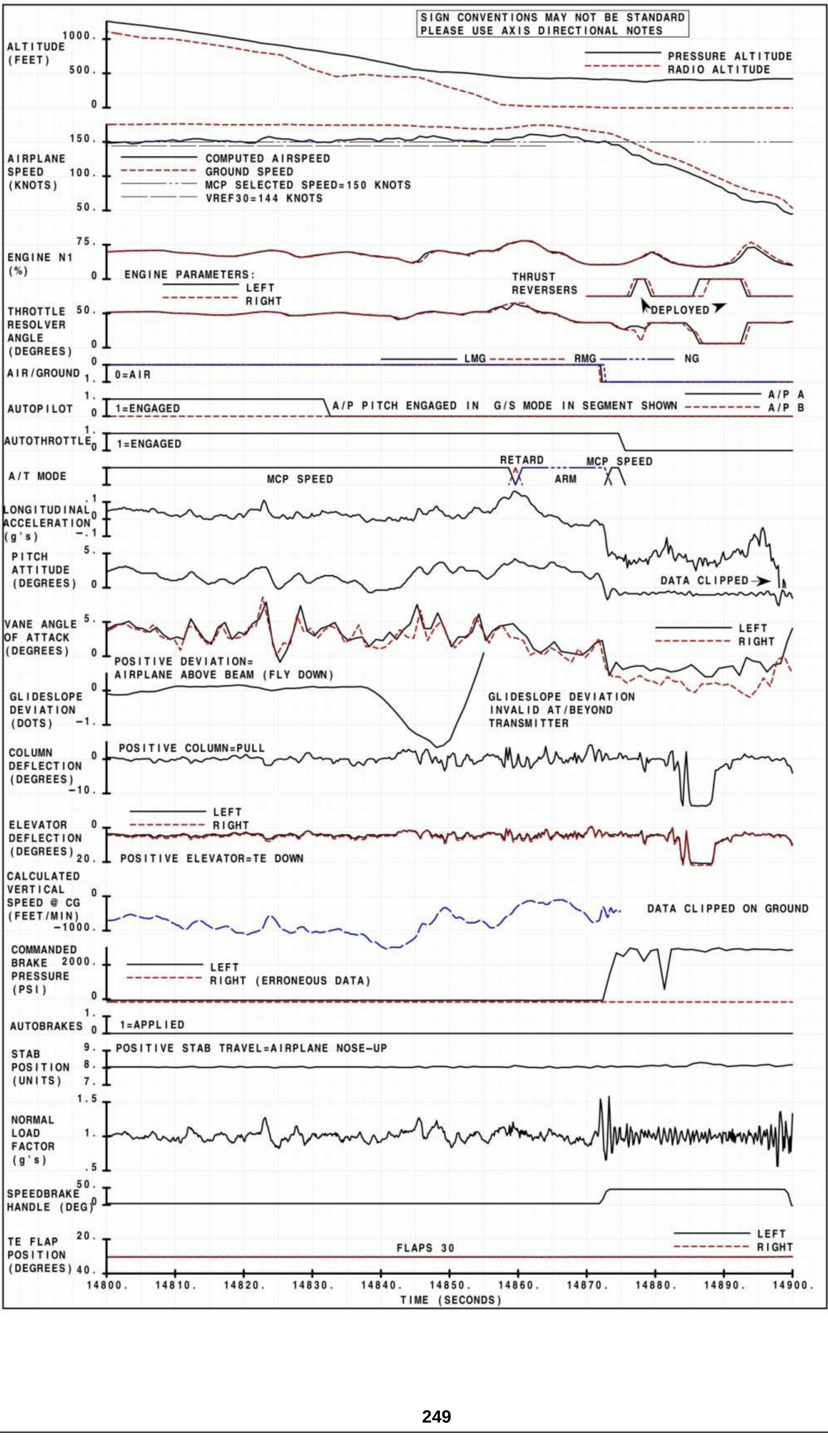
14:08:01.8	HOT2	FLAPS 25 SELECTED. MOVING.
14:08:03.8	RDO2	CALICUT TOWER EXPRESS INDIA 1-3-4-4 ON I-L-S RUNWAY 1-0
14:08:07.6	TWR	EXPRESSINDIA 1-3-4-4 ROGER. LIGHT RAIN OVER THE FIELD, RUNWAY SURFACE WET. WIND2-5-0 DEGREES 0-8 KNOTS.RUNWAY 1-0 CLEARED TO LAND.
14:08:16.1	RDO2	RUNWAY 1-0 CLEARED TO LAND AND WHAT'S THE VISIBILITY? EXPRESS INDIA 1-3-4-4
14:08:20.3	TWR	VISIBILITY TWO THOUSAND METER UH…WITH UH AND LIGHT RAIN
14:08:24.2	RDO2	COPIED SIR EXPRESS INDIA 1-3-4-4
14:08:29.1	HOT1	I THINK WE'LL KEEP IT 30 AGAIN YEAH, CHANGE IT TO 30
14:08:32.7	HOT1	THERE'S GONNA BE TURBULENCE
14:08:33.7	HOT2	CHECK
14:08:34.1	HOT1	VERY TURBULENT, YAAR, FOR SAFETY, THEEK HAI NA?
14:08:37.7	HOT2	YEAH
14:08:38.8	HOT1	THEEK HAI
14:08:42.3	HOT2	AND I'LL…GIVE YOU 30?
14:08:43.8	HOT1	YEAH YEAH. NO NO. UH.
14:08:45.8	HOT2	NO?
14:08:46.1	HOT1	YEAH, FLAPS 30
14:08:46.9	HOT1	COMPLETE LANDING CHECKLIST
14:08:47.8	HOT2	FLAPS 30 SELECTED. MOVING.

14:08:49.0	HOT1	COMPLETE LANDING CHECKLIST PLEASE.
14:08:50.5	SUMMARY	LANDING CHECK LIST CARRIED OUT
14:08:57.6	HOT2	LANDING CLEARANCE?
14:08:58.5	HOT1	OBTAINED.
14:08:59.1	HOT2	OBTAINED. LANDING CHECKLIST COMPLETED.
14:09:00.1	HOT1	OKAY, NOW PUT THIS TO ***
14:09:10.7	HOT2	APPROACHING ONE THOUSAND, STABILIZED, NO FLAGS
14:09:12.3	HOT1	CHECK, CHECK
14:09:13.8	HOT2	ALL LIGHTS ON
14:09:21.1	CAM	ONE THOUSAND [ELECTRONIC VOICE]
14:09:22.2	HOT1	CHECK
14:09:41.1	HOT1	OKAY, RUNWAY IN SIGHT
14:09:41.7	HOT2	RUNWAY IN SIGHT, CHECK
14:09:43.5	EGPWS	APPROACHING MINIMUMS [ELECTRONIC VOICE]
14:09:44.2	CAM	[SOUND OF AUTOPILOT DISCONNECT TONE]
14:09:45.7	EGPWS	FIVE HUNDRED [ELECTRONIC VOICE]
14:09:46.1	HOT1	VISUAL
14:09:47.2	HOT2	F-D
14:09:48.0	HOT1	CHECK

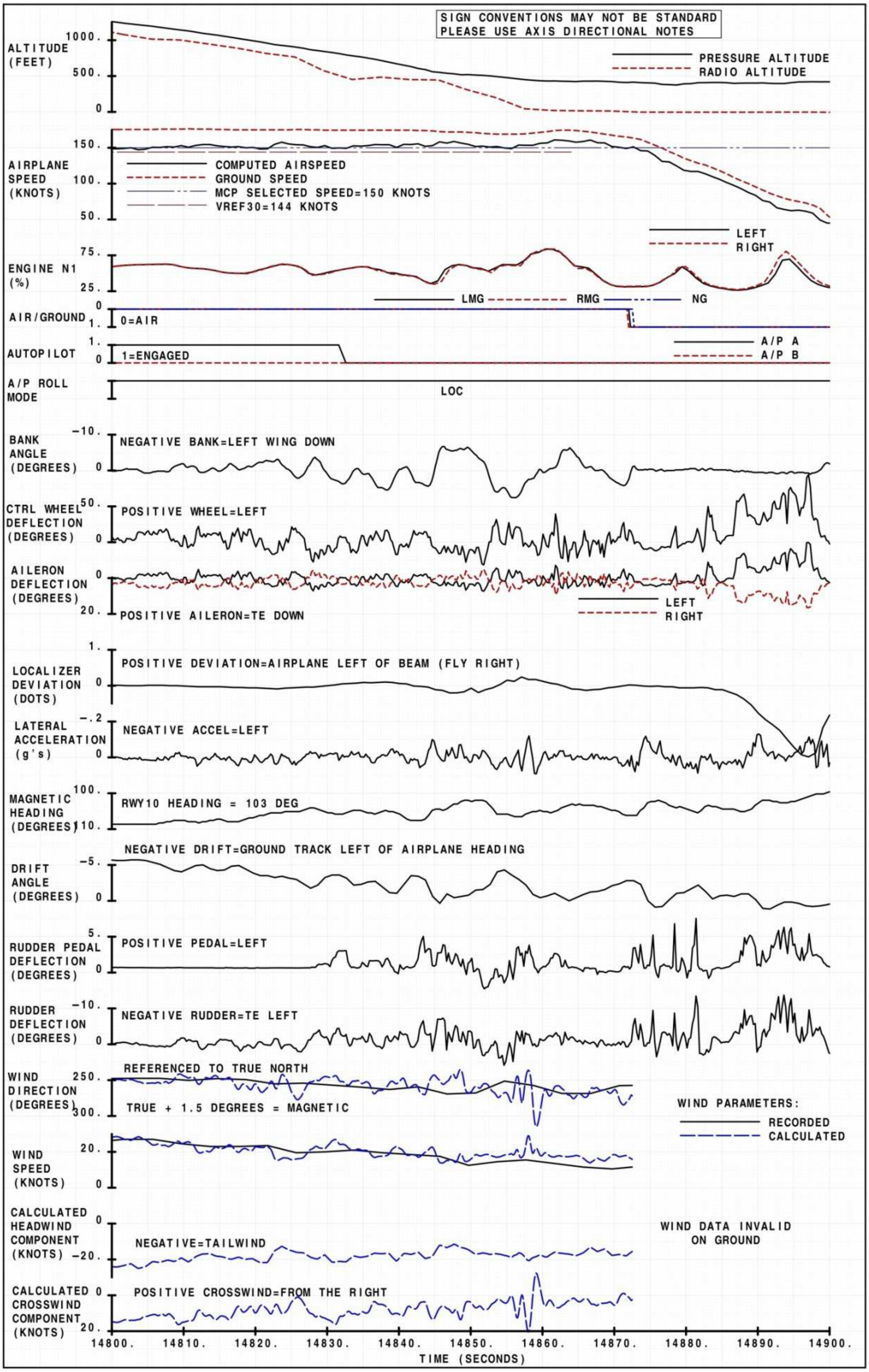
14:09:48.6	EGPWS	MINIMUMS [ELECTRONIC VOICE]
14:09:49.8	HOT1	* LANDING
14:09:51.3	HOT2	CHECK
14:09:53.1	HOT2	RATE OF DESCENT
14:09:53.8	HOT1	CHECK
14:09:56.7	HOT2	RATE OF DESCENT CAPTAIN
14:09:57.8	HOT1	YEAH YEAH. CORRECTING, CORRECTING, CORRECTING.
14:09:58.3	EGPWS	GLIDESLOPE, GLIDESLOPE [ELECTRONIC VOICE]
14:09:59.9	HOT2	CHECK
14:10:01.1	HOT2	(UP/UM) OK?
14:10:07.6	EGPWS	ONE HUNDRED [ELECTRONIC VOICE]
14:10:10.1	EGPWS	FIFTY [ELECTRONIC VOICE]
14:10:11.0	EGPWS	FORTY [ELECTRONIC VOICE]
14:10:12.2	EGPWS	THIRTY [ELECTRONIC VOICE]
14:10:14.6	EGPWS	TWENTY [ELECTRONIC VOICE]
14:10:18.2	HOT2	JUST CHECK IT
14:10:22.3	HOT2	CAPTAIN?
14:10:23.2	EGPWS	TEN [ELECTRONIC VOICE]
14:10:24.6	HOT2	GO AROUND

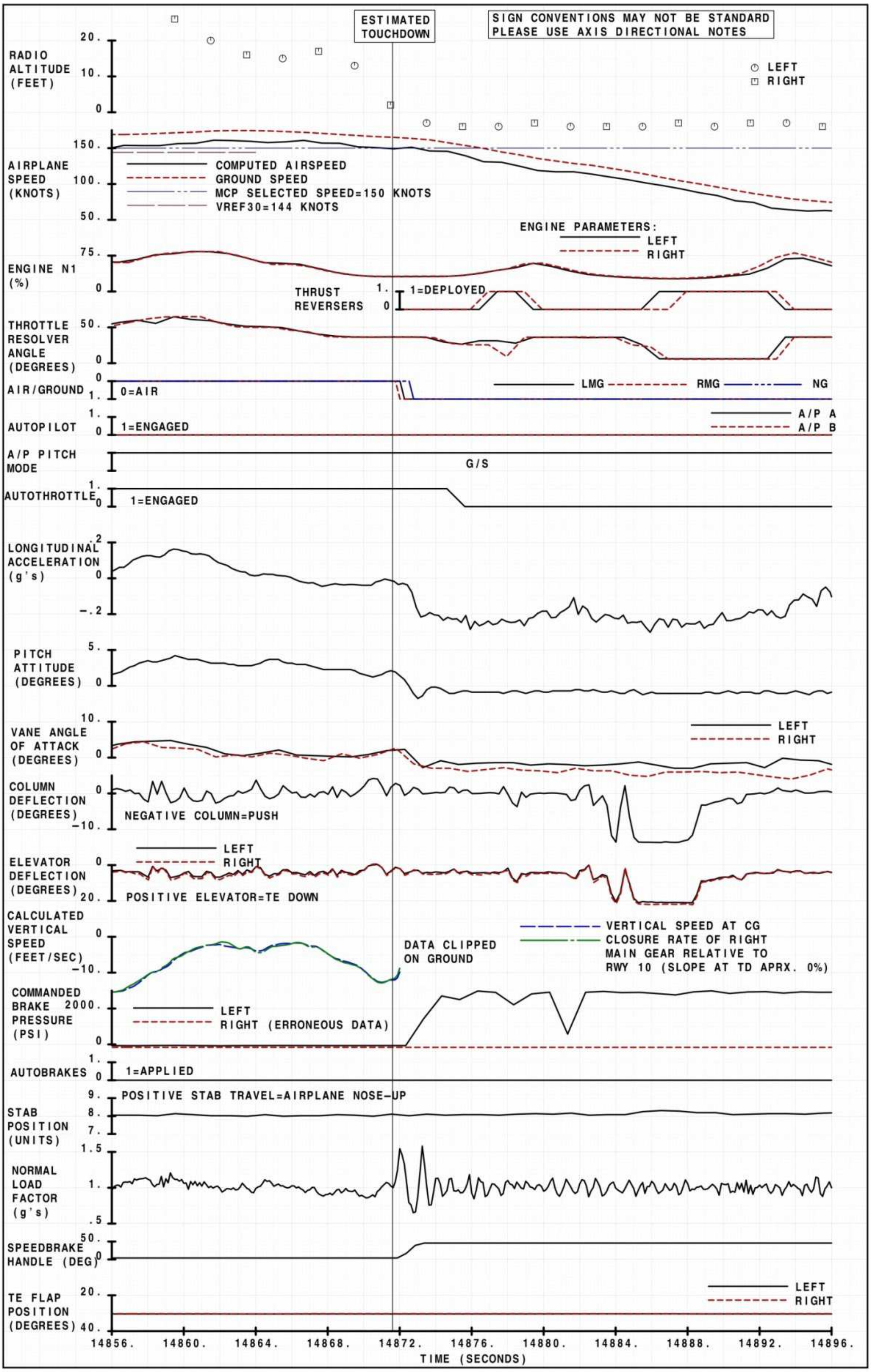
14:10:25.4	CAM	[SOUND SIMILAR TO GEAR TOUCHDOWN]
14:10:27.5	HOT2	SPEED BRAKES…UP
14:10:30.7	HOT2	AUTO BRAKE DISARM
14:10:34.2	UNK HOT1	OH #SHIT
14:10:47.3	UNKHOT1	#SHIT
14:10:48.0	HOT2	#SHIT
14:10:56.5	**END OF TRANSCRIPTEND OF RECORDING**	

Appendix-D

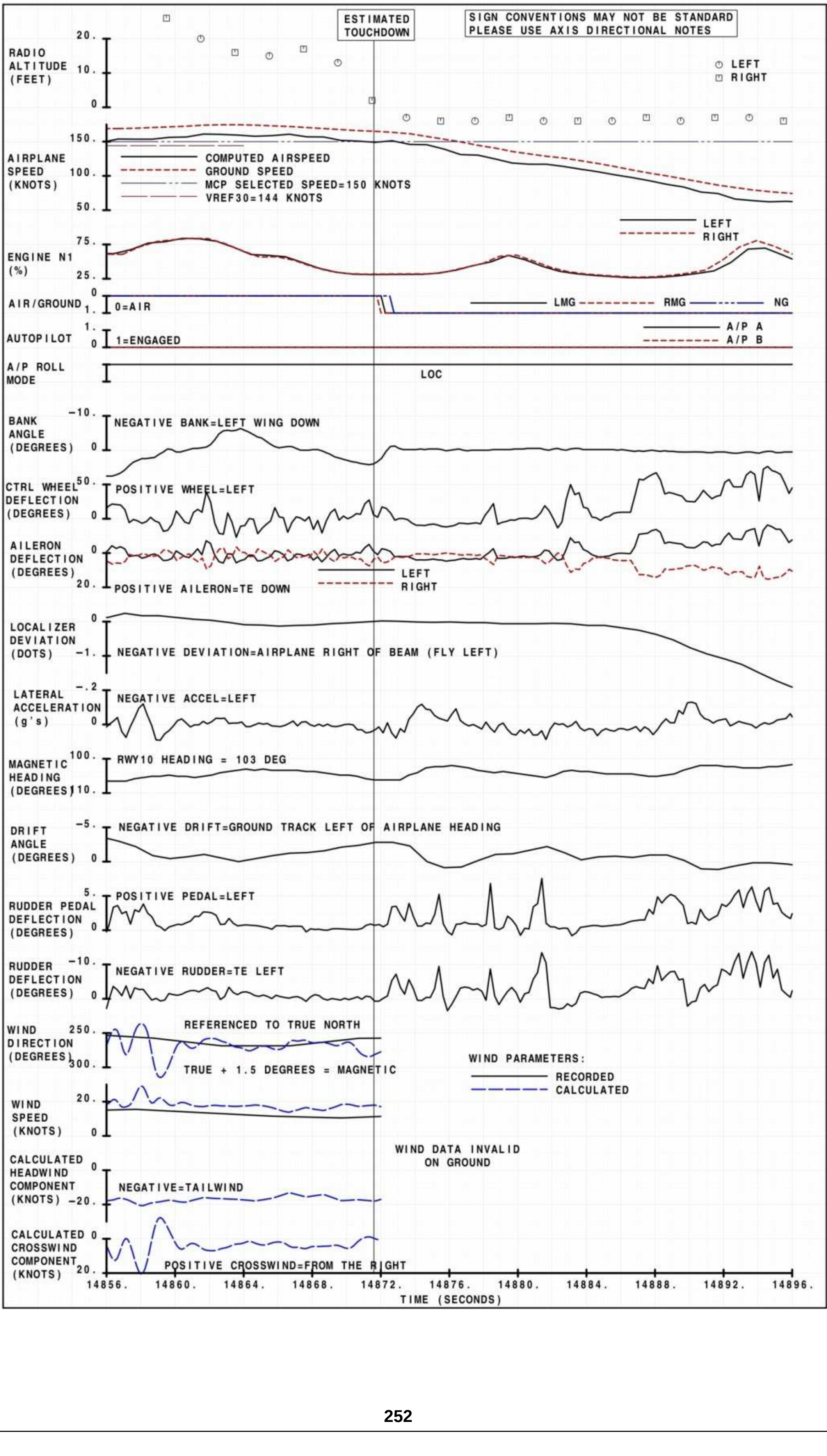


SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ALTITUDE (FEET)
PRESSURE ALTITUDE
RADIO ALTITUDE
AIRPLANE SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150 KNOTS
VREF30=144 KNOTS
ENGINE N1 (%)
ENGINE PARAMETERS:
LEFT
RIGHT
THRUST REVERSERS
DEPLOYED
THROTTLE RESOLVER ANGLE (DEGREES)
AIR/GROUND
0=AIR
LMG
RMG
NG
AUTOPILOT
1=ENGAGED
A/P PITCH ENGAGED IN G/S MODE IN SEGMENT SHOWN
A/P A
A/P B
AUTOTHROTTLE
1=ENGAGED
A/T MODE
MCP SPEED
RETARD
ARM
MCP SPEED
LONGITUDINAL ACCELERATION (g's)
PITCH ATTITUDE (DEGREES)
DATA CLIPPED
VANE ANGLE OF ATTACK (DEGREES)
LEFT
RIGHT
POSITIVE DEVIATION= AIRPLANE ABOVE BEAM (FLY DOWN)
GLIDESLOPE DEVIATION (DOTS)
GLIDESLOPE DEVIATION INVALID AT/BEYOND TRANSMITTER
COLUMN DEFLECTION (DEGREES)
POSITIVE COLUMN=PULL
ELEVATOR DEFLECTION (DEGREES)
LEFT
RIGHT
POSITIVE ELEVATOR=TE DOWN
CALCULATED VERTICAL SPEED @ CG (FEET/MIN)
DATA CLIPPED ON GROUND
COMMANDED BRAKE PRESSURE (PSI)
LEFT
RIGHT (ERRONEOUS DATA)
AUTOBRAKES
1=APPLIED
STAB POSITION (UNITS)
POSITIVE STAB TRAVEL=AIRPLANE NOSE-UP
NORMAL LOAD FACTOR (g's)
SPEEDBRAKE HANDLE (DEG)
TE FLAP POSITION (DEGREES)
LEFT
RIGHT
FLAPS 30
14800. 14810. 14820. 14830. 14840. 14850. 14860. 14870. 14880. 14890. 14900.
TIME (SECONDS)

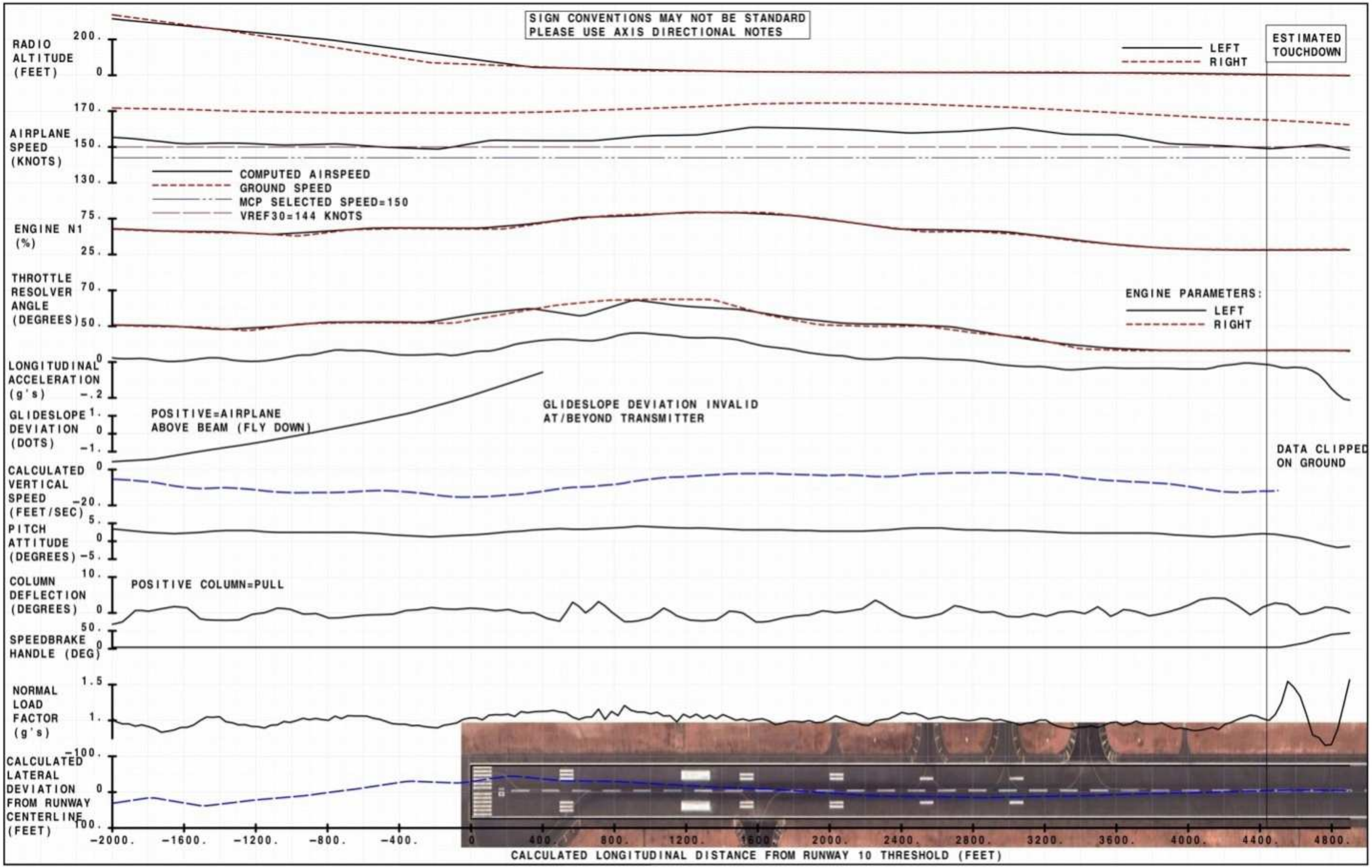

SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ALTITUDE (FEET)
PRESSURE ALTITUDE
RADIO ALTITUDE
AIRPLANE SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150 KNOTS
VREF30=144 KNOTS
ENGINE N1 (%)
LEFT
RIGHT
AIR/GROUND
0=AIR
LMG
RMG
NG
AUTOPILOT
1=ENGAGED
A/P A
A/P B
A/P ROLL MODE
LOC
BANK ANGLE (DEGREES)
NEGATIVE BANK=LEFT WING DOWN
CTRL WHEEL DEFLECTION (DEGREES)
POSITIVE WHEEL=LEFT
AILERON DEFLECTION (DEGREES)
POSITIVE AILERON=TE DOWN
LOCALIZER DEVIATION (DOTS)
POSITIVE DEVIATION=AIRPLANE LEFT OF BEAM (FLY RIGHT)
LATERAL ACCELERATION (g's)
NEGATIVE ACCEL=LEFT
MAGNETIC HEADING (DEGREES)
RWY10 HEADING = 103 DEG
DRIFT ANGLE (DEGREES)
NEGATIVE DRIFT=GROUND TRACK LEFT OF AIRPLANE HEADING
RUDDER PEDAL DEFLECTION (DEGREES)
POSITIVE PEDAL=LEFT
RUDDER DEFLECTION (DEGREES)
NEGATIVE RUDDER=TE LEFT
WIND DIRECTION (DEGREES)
REFERENCED TO TRUE NORTH
TRUE + 1.5 DEGREES = MAGNETIC
WIND PARAMETERS:
RECORDED
CALCULATED
WIND SPEED (KNOTS)
CALCULATED HEADWIND COMPONENT (KNOTS)
NEGATIVE=TAILWIND
WIND DATA INVALID ON GROUND
CALCULATED CROSSWIND COMPONENT (KNOTS)
POSITIVE CROSSWIND=FROM THE RIGHT
14800. 14810. 14820. 14830. 14840. 14850. 14860. 14870. 14880. 14890. 14900.
TIME (SECONDS)

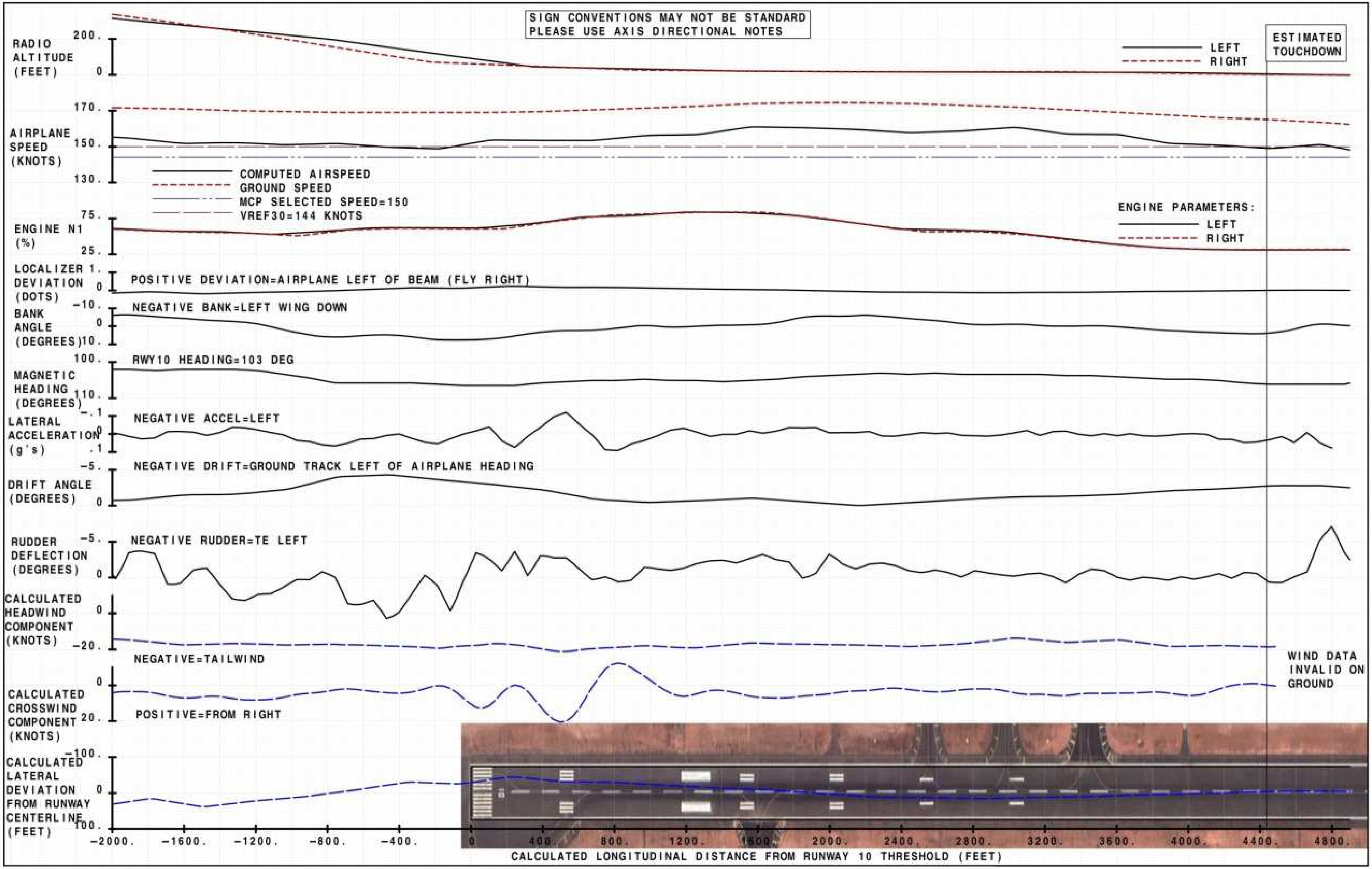


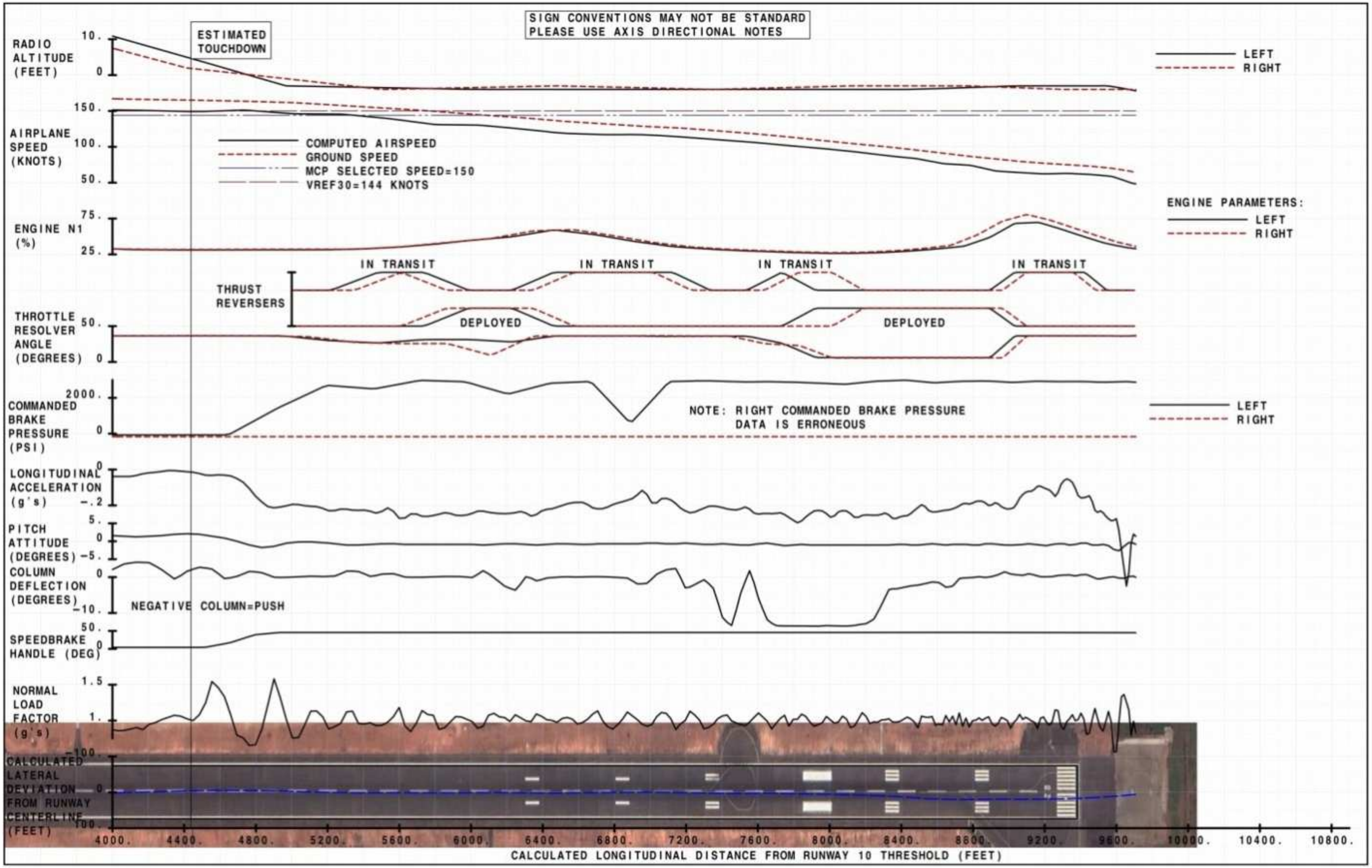
ESTIMATED TOUCHDOWN
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
RADIO ALTITUDE (FEET)
LEFT
RIGHT
AIRPLANE SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150 KNOTS
VREF30=144 KNOTS
ENGINE PARAMETERS:
LEFT
RIGHT
ENGINE N1 (%)
THRUST REVERSERS
1=DEPLOYED
THROTTLE RESOLVER ANGLE (DEGREES)
AIR/GROUND
0=AIR
LMG
RMG
NG
AUTOPILOT
1=ENGAGED
A/P A
A/P B
A/P PITCH MODE
G/S
AUTOTHROTTLE
1=ENGAGED
LONGITUDINAL ACCELERATION (g's)
PITCH ATTITUDE (DEGREES)
VANE ANGLE OF ATTACK (DEGREES)
LEFT
RIGHT
COLUMN DEFLECTION (DEGREES)
NEGATIVE COLUMN=PUSH
ELEVATOR DEFLECTION (DEGREES)
LEFT
RIGHT
POSITIVE ELEVATOR=TE DOWN
CALCULATED VERTICAL SPEED (FEET/SEC)
VERTICAL SPEED AT CG
CLOSURE RATE OF RIGHT MAIN GEAR RELATIVE TO RWY 10 (SLOPE AT TD APRX. 0%)
DATA CLIPPED ON GROUND
COMMANDED BRAKE PRESSURE (PSI)
LEFT
RIGHT (ERRONEOUS DATA)
AUTOBRAKES
1=APPLIED
POSITIVE STAB TRAVEL=AIRPLANE NOSE-UP
STAB POSITION (UNITS)
NORMAL LOAD FACTOR (g's)
SPEEDBRAKE HANDLE (DEG)
TE FLAP POSITION (DEGREES)
LEFT
RIGHT
14856. 14860. 14864. 14868. 14872. 14876. 14880. 14884. 14888. 14892. 14896.
TIME (SECONDS)



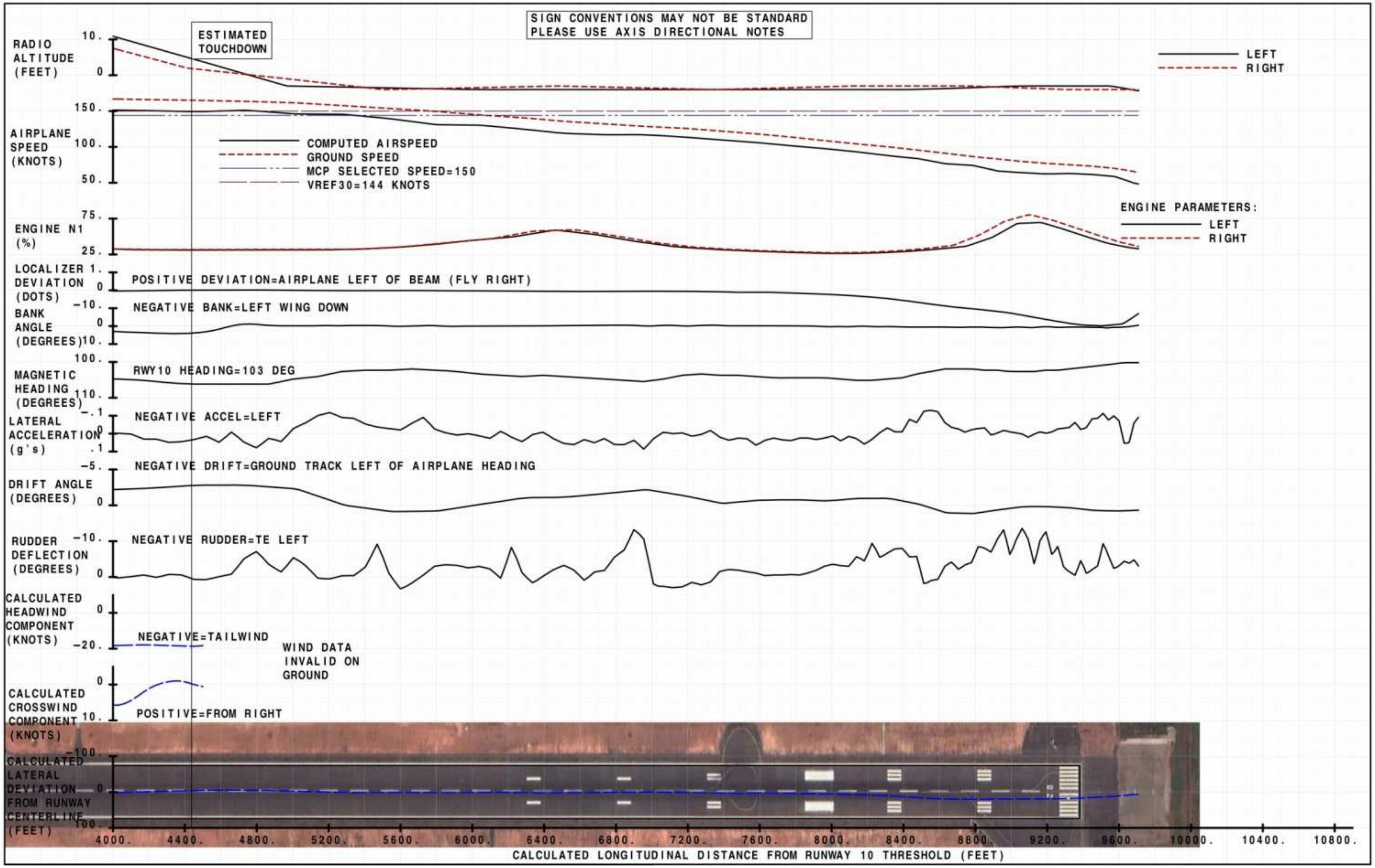
ESTIMATED TOUCHDOWN
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
RADIO ALTITUDE (FEET)
LEFT
RIGHT
AIRPLANE SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150 KNOTS
VREF30=144 KNOTS
ENGINE N1 (%)
LEFT
RIGHT
AIR/GROUND
0=AIR
LMG
RMG
NG
AUTOPILOT
1=ENGAGED
A/P A
A/P B
A/P ROLL MODE
LOC
BANK ANGLE (DEGREES)
NEGATIVE BANK=LEFT WING DOWN
CTRL WHEEL DEFLECTION (DEGREES)
POSITIVE WHEEL=LEFT
AILERON DEFLECTION (DEGREES)
LEFT
RIGHT
POSITIVE AILERON=TE DOWN
LOCALIZER DEVIATION (DOTS)
NEGATIVE DEVIATION=AIRPLANE RIGHT OF BEAM (FLY LEFT)
LATERAL ACCELERATION (g's)
NEGATIVE ACCEL=LEFT
MAGNETIC HEADING (DEGREES)
RWY10 HEADING = 103 DEG
DRIFT ANGLE (DEGREES)
NEGATIVE DRIFT=GROUND TRACK LEFT OF AIRPLANE HEADING
RUDDER PEDAL DEFLECTION (DEGREES)
POSITIVE PEDAL=LEFT
RUDDER DEFLECTION (DEGREES)
NEGATIVE RUDDER=TE LEFT
WIND DIRECTION (DEGREES)
REFERENCED TO TRUE NORTH
TRUE + 1.5 DEGREES = MAGNETIC
WIND PARAMETERS:
RECORDED
CALCULATED
WIND SPEED (KNOTS)
WIND DATA INVALID ON GROUND
CALCULATED HEADWIND COMPONENT (KNOTS)
NEGATIVE=TAILWIND
CALCULATED CROSSWIND COMPONENT (KNOTS)
POSITIVE CROSSWIND=FROM THE RIGHT
14856. 14860. 14864. 14868. 14872. 14876. 14880. 14884. 14888. 14892. 14896.
TIME (SECONDS)

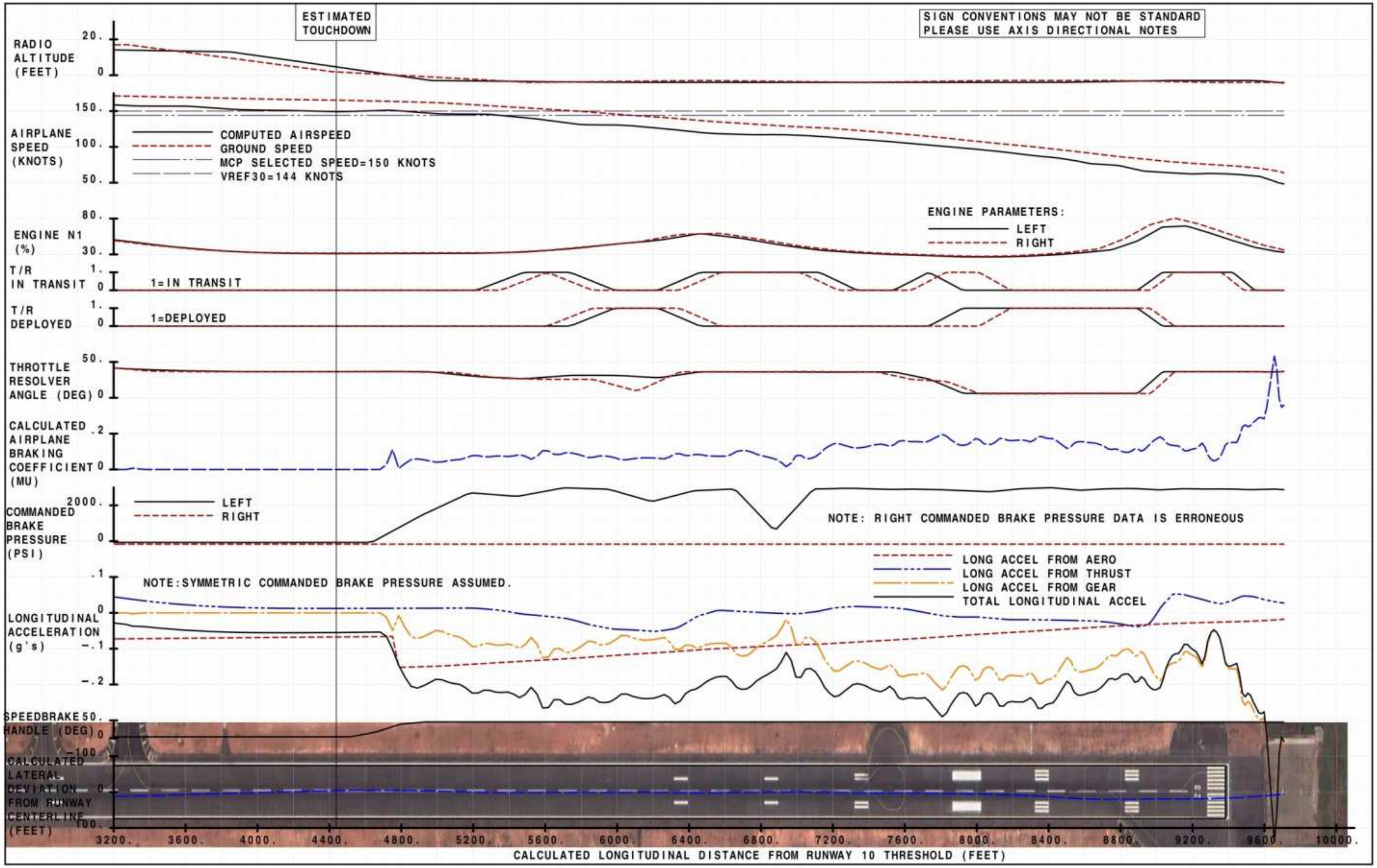

SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ESTIMATED TOUCHDOWN
LEFT
RIGHT
RADIO ALTITUDE (FEET)
200.
0
AIRPLANE SPEED (KNOTS)
170.
150.
130.
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150
VREF30=144 KNOTS
ENGINE N1 (%)
75.
25.
THROTTLE RESOLVER ANGLE (DEGREES)
70.
50.
ENGINE PARAMETERS:
LEFT
RIGHT
LONGITUDINAL ACCELERATION (g's)
0
-.2
GLIDESLOPE DEVIATION (DOTS)
1.
0
-1.
POSITIVE=AIRPLANE ABOVE BEAM (FLY DOWN)
GLIDESLOPE DEVIATION INVALID AT/BEYOND TRANSMITTER
DATA CLIPPED ON GROUND
CALCULATED VERTICAL SPEED (FEET/SEC)
0
-20.
PITCH ATTITUDE (DEGREES)
5.
0
-5.
COLUMN DEFLECTION (DEGREES)
10.
0
POSITIVE COLUMN=PULL
SPEEDBRAKE HANDLE (DEG)
50.
0
NORMAL LOAD FACTOR (g's)
1.5
1.
CALCULATED LATERAL DEVIATION FROM RUNWAY CENTERLINE (FEET)
-100.
0
100.
-2000. -1600. -1200. -800. -400. 0 400. 800. 1200. 1600. 2000. 2400. 2800. 3200. 3600. 4000. 4400. 4800.
CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 10 THRESHOLD (FEET)


SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ESTIMATED TOUCHDOWN
RADIO ALTITUDE (FEET)
200.
0
LEFT
RIGHT
AIRPLANE SPEED (KNOTS)
170.
150.
130.
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150
VREF30=144 KNOTS
ENGINE N1 (%)
75.
25.
ENGINE PARAMETERS:
LEFT
RIGHT
LOCALIZER DEVIATION (DOTS)
1.
0
POSITIVE DEVIATION=AIRPLANE LEFT OF BEAM (FLY RIGHT)
BANK ANGLE (DEGREES)
-10.
0
10.
NEGATIVE BANK=LEFT WING DOWN
MAGNETIC HEADING (DEGREES)
100.
110.
RWY10 HEADING=103 DEG
LATERAL ACCELERATION (g's)
-.1
0
.1
NEGATIVE ACCEL=LEFT
DRIFT ANGLE (DEGREES)
-5.
0
NEGATIVE DRIFT=GROUND TRACK LEFT OF AIRPLANE HEADING
RUDDER DEFLECTION (DEGREES)
-5.
0
NEGATIVE RUDDER=TE LEFT
CALCULATED HEADWIND COMPONENT (KNOTS)
0
-20.
NEGATIVE=TAILWIND
WIND DATA INVALID ON GROUND
CALCULATED CROSSWIND COMPONENT (KNOTS)
0
20.
POSITIVE=FROM RIGHT
CALCULATED LATERAL DEVIATION FROM RUNWAY CENTERLINE (FEET)
-100.
0
100.
-2000. -1600. -1200. -800. -400. 0 400. 800. 1200. 1600. 2000. 2400. 2800. 3200. 3600. 4000. 4400. 4800.
CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 10 THRESHOLD (FEET)



SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ESTIMATED TOUCHDOWN
RADIO ALTITUDE (FEET)
LEFT
RIGHT
AIRPLANE SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150
VREF30=144 KNOTS
ENGINE N1 (%)
ENGINE PARAMETERS:
LEFT
RIGHT
IN TRANSIT
THRUST REVERSERS
DEPLOYED
THROTTLE RESOLVER ANGLE (DEGREES)
COMMANDED BRAKE PRESSURE (PSI)
NOTE: RIGHT COMMANDED BRAKE PRESSURE DATA IS ERRONEOUS
LEFT
RIGHT
LONGITUDINAL ACCELERATION (g's)
PITCH ATTITUDE (DEGREES)
COLUMN DEFLECTION (DEGREES)
NEGATIVE COLUMN=PUSH
SPEEDBRAKE HANDLE (DEG)
NORMAL LOAD FACTOR (g's)
CALCULATED LATERAL DEVIATION FROM RUNWAY CENTERLINE (FEET)
4000. 4400. 4800. 5200. 5600. 6000. 6400. 6800. 7200. 7600. 8000. 8400. 8800. 9200. 9600. 10000. 10400. 10800.
CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 10 THRESHOLD (FEET)


SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
ESTIMATED TOUCHDOWN
RADIO ALTITUDE (FEET)
LEFT
RIGHT
AIRPLANE SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150
VREF30=144 KNOTS
ENGINE N1 (%)
ENGINE PARAMETERS:
LOCALIZER DEVIATION (DOTS)
POSITIVE DEVIATION=AIRPLANE LEFT OF BEAM (FLY RIGHT)
BANK ANGLE (DEGREES)
NEGATIVE BANK=LEFT WING DOWN
MAGNETIC HEADING (DEGREES)
RWY10 HEADING=103 DEG
LATERAL ACCELERATION (g's)
NEGATIVE ACCEL=LEFT
DRIFT ANGLE (DEGREES)
NEGATIVE DRIFT=GROUND TRACK LEFT OF AIRPLANE HEADING
RUDDER DEFLECTION (DEGREES)
NEGATIVE RUDDER=TE LEFT
CALCULATED HEADWIND COMPONENT (KNOTS)
NEGATIVE=TAILWIND
WIND DATA INVALID ON GROUND
CALCULATED CROSSWIND COMPONENT (KNOTS)
POSITIVE=FROM RIGHT
CALCULATED LATERAL DEVIATION FROM RUNWAY CENTERLINE (FEET)
CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 10 THRESHOLD (FEET)


ESTIMATED TOUCHDOWN
SIGN CONVENTIONS MAY NOT BE STANDARD PLEASE USE AXIS DIRECTIONAL NOTES
RADIO ALTITUDE (FEET)
20.
0
AIRPLANE SPEED (KNOTS)
150.
100.
50.
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED SPEED=150 KNOTS
VREF30=144 KNOTS
ENGINE N1 (%)
80.
30.
ENGINE PARAMETERS:
LEFT
RIGHT
T/R IN TRANSIT
1=IN TRANSIT
T/R DEPLOYED
1=DEPLOYED
THROTTLE RESOLVER ANGLE (DEG)
50.
CALCULATED AIRPLANE BRAKING COEFFICIENT (MU)
.2
COMMANDED BRAKE PRESSURE (PSI)
2000.
LEFT
RIGHT
NOTE: RIGHT COMMANDED BRAKE PRESSURE DATA IS ERRONEOUS
LONGITUDINAL ACCELERATION (g's)
.1
-.1
-.2
NOTE:SYMMETRIC COMMANDED BRAKE PRESSURE ASSUMED.
LONG ACCEL FROM AERO
LONG ACCEL FROM THRUST
LONG ACCEL FROM GEAR
TOTAL LONGITUDINAL ACCEL
SPEEDBRAKE HANDLE (DEG)
50.
CALCULATED LATERAL DEVIATION FROM RUNWAY CENTERLINE (FEET)
100.
-100.
3200. 3600. 4000. 4400. 4800. 5200. 5600. 6000. 6400. 6800. 7200. 7600. 8000. 8400. 8800. 9200. 9600. 10000.
CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 10 THRESHOLD (FEET)