REPORT
ON

ACCIDENT TO AIR INDIA EXPRESS BOEING 737-800 AIRCRAFT VT-AXV ON 22nd MAY 2010 AT MANGALORE

BY

THE COURT
AIR MARSHAL BN GOKHALE, PVSM, AVSM, VM (Retd)
FORMER VICE CHIEF OF AIR STAFF, INDIAN AIR FORCE

GOVERNMENT OF INDIA
MINISTRY OF CIVIL AVIATION

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FORMER VICE CHIEF OF AIR STAFF, INDIAN AIR FORCE

ASSESSORS:

1. **Capt. Ron Nagar,**
   Senior Vice President (Ops & Trg),
   Kingfisher Airlines, Mumbai

2. **Shri Babu Peter,**
   Executive Vice President (Engg),
   Go Airlines (India) Pvt Ltd, Mumbai

3. **Shri SS Nat,**
   Deputy DGCA (Retd),
   Club One Air, New Delhi

4. **Shri Gurcharan Bhatura,**
   Executive Director (Ops) (Retd),
   Airports Authority of India, New Delhi

5. **Group Captain Deepak Gaur,**
   Director Medical Services (Aviation Medicine),
   Air Headquarters, New Delhi

SECRETARY

Shri S N Dwivedi,
Director of Airworthiness,
O/o DGCA, New Delhi

NEW DELHI
31st OCTOBER, 2010

Contents

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Executive Summary

Air India Express operates a scheduled Quick Turn Around (QTA) flight IX-811/812 daily, on sector Mangalore-Dubai-Mangalore. On 21st / 22nd May 2010, a similar flight was operated by Capt Z Glusica and First Officer H S Ahluwalia, along with 4 Cabin crew. As per the schedule, the crew had been given adequate time to rest. The outbound flight IX-811 was uneventful. The aircraft was refuelled and released from Dubai after transit checks. The aircraft was serviceable except for two defects of minor nature carried forward under Minimum Equipment List (MEL), one for passenger seat 25C and another for Right Hand Tail Logo Light.

Subsequently, the same crew had operated flight IX-812 on 22nd May 2010 from Dubai to Mangalore. On this flight, there were 160 passengers including 4 infants. The flight chocked off from Dubai at 02:36 hours IST. As indicated in the DFDR, the take-off, climb and cruise were uneventful.

The aircraft first came in contact with the Mangalore Area Control at 05:32:52 hours IST, when it was approaching the reporting point IGAMA, at FL-370. The Mangalore Area Control Radar (MSSR) was unserviceable since 20th May 2010 and a NOTAM to this effect had been issued.

The Cockpit Voice Recorder (CVR), which had recorded conversation for the last 2 hours and 05 minutes for this flight, indicated that there was ‘no conversation’ between the two pilots for the first 1 hour and 40 minutes and that the Captain was asleep with intermittent sounds of snoring and deep breathing.

Mangalore airport has a Table Top runway. Owing to the surrounding terrain, Air India Express has made a special qualification requirement that only the Pilot in Command (PIC) shall carry out takeoff and landing.

The aircraft was cleared to descend at 77 DME from Mangalore at 05:47:34 hours IST. The visibility was 6 km and the aircraft was advised to carry out an ILS DME Arc approach for R/W 24.

It is evident from the investigation that the flight crew had failed to plan the descent profile properly, due to which the aircraft was high and did not intercept the ILS Glide Slope from below, which is the standard procedure. This led to the aircraft being at almost twice the altitude on finals, as compared to a standard ILS approach. In the ensuing ‘Unstabilised Approach’, the First Officer gave three calls to the Captain to ‘Go Around’. Also, there were a number of EGPWS warnings of SINK RATE and PULL UP.

Despite the EGPWS warnings and calls from the First Officer to ‘Go Around’, the Captain had persisted with the approach in unstabilised conditions. The final touch down of the aircraft was at about 5200 ft from the beginning of R/W 24, leaving only about 2800 ft to the end of paved surface, to stop the aircraft.

Note: 1. For the purpose of this report the timings have been converted to IST i.e. UTC + 5:30 hours e.g. 21:06 UTC is equal to 02:36 IST (next day).

2. Dubai Local Time is UTC plus 4 hours or IST minus 1 hour 30 minutes.

Soon after the touchdown, the Captain had selected Thrust Reverser. But, within a very short time of applying brakes, the Captain had initiated a rather delayed 'go around' or an attempted take-off, in contravention to Standard Operating Procedure (SOP) laid down by the manufacturer i.e. Boeing Commercial Airplane Company, USA.

The aircraft overshot the runway and its right wing impacted ILS localiser antenna mounting structure. Thereafter, aircraft hit the airport boundary fence and fell into a gorge. Due to impact and fire, the aircraft was destroyed. In this tragic accident, 152 passengers and all 6 crew members lost their lives. There were only 8 survivors**.** The investigation determines that there were no airworthiness issues with the aircraft and there was no sign of bird strike or any evidence of sabotage.

Direct cause of the Accident:

The Court of Inquiry determines that cause of this accident was the Captain's failure to discontinue the 'unstabilised approach' and his persistence in continuing with the landing, despite three calls from the First Officer to 'go around' and a number of warnings from EGPWS.

The contributory factors were:

(a) In spite of availability of adequate rest period prior to the flight, the Captain was in prolonged sleep during flight, which could have led to sleep inertia. As a result of relatively short period of time between his awakening and the approach, it possibly led to impaired judgment. This aspect might have got accentuated while flying in the Window of Circadian Low (WOCL).

(b) In the absence of Mangalore Area Control Radar (MSSR), due to un-serviceability, the aircraft was given descent at a shorter distance on DME as compared to the normal. However, the flight crew did not plan the descent profile properly, resulting in remaining high on approach.

(c) Probably in view of ambiguity in various instructions empowering the 'co-pilot' to initiate a 'go around', the First Officer gave repeated calls to this effect, but did not take over the controls to actually discontinue the ill-fated approach.

The recommendations and safety issues in this report focus on Fatigue Risk Management System (FRMS) especially for flights carried out during Window of Circadian Low (WOCL), Crew Resource Management (CRM), Flight Safety counselling, runway excursions and regulations for employment of foreign pilots, to name a few. The recommendations have been made to the operator, Air India Express, Airports Authority of India (AAI) and to the Regulator, Directorate General of Civil Aviation (DGCA).

The Court of Inquiry has also recommended setting up of an independent Indian Civil Aviation Safety Board (ICASB) urgently in view of rapid growth of aviation in the country. Such independent safety organisations have been set up in USA, UK, Canada, France and Indonesia to name a few. The proposed ICASB will focus on all flight safety related issues to suggest proactive measures, to minimise accidents and incidents.

Abbreviations Used

ACMS	Aircraft Conditioning Monitoring System
ADIRU	Air Data Inertial Reference Unit
AFCME	Air Force Central Medical Establishment
AICL	Air India Charters Limited (Air India Express)
ALAR	Approach and Landing Accident Reduction
AMO	Airport Meteorological Office
AMS	Aeronautical Meteorological Station
AOP	Air Operator Permit
APU	Auxiliary Power Unit
ARA	Annual Review of Airworthiness
ARFF	Airport Rescue and Fire Fighting
ARINC	Aircraft Radio Incorporated
ASDA	Acceleration Stop Distance Available
ASFT	Airport Surface Friction Tester
ATC	Air Traffic Control
ATPL	Airline Transport Pilot Licence
ATS	Air Traffic Service
BAH	Bahrain
BCAS	Bureau of Civil Aviation Security
BDDS	Bomb Detection & Disposal Squad
BITE	Built In Test Equipment
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CAP’S PNL LTG	Captain’s Panel Lighting
CAR	Civil Aviation Requirement
CB	Circuit Breaker
CDU	Control Display Unit
CFT	Crash Fire Tender
CRM	Crew Resource Management
CSMU	Crash Survivable Memory Unit
CTR PNL LTG	Centre Panel Lighting
CVR	Cockpit Voice Recorder
DARA	Directorate of Aerodrome and Air Routes
DEU	Display Electronic Unit
DFDR	Digital Flight Data Recorder
DGCA	Director General of Civil Aviation
DME	Distance Measuring Equipment
DVOR	Doppler Very High Frequency Omni Range
DVTR	Digital Voice Tape Recorder
EEC	Electronic Engine Control
EGPWS	Enhanced Ground Proximity Warning System
EGT	Exhaust Gas Temperature
EMAS	Engineering Material Arresting System
F/O	First Officer
F/OBS	Flight Observer
FATA	Foreign Aircrew Temporary Authorisation
FCOM	Flight Crew Operations Manual

FCTM	Flight Crew Training Manual
FDAU	Flight Data Acquisition Unit
FDR	Flight Data Recorder
FDRS	Flight Data Recorder System
FDTL	Flight Duty Time Limitations
FOQA	Flight Operation’s Quality Assurance
FRMS	Fatigue Risk Management System
FRTO	Flight Radio Telephony Operators License
FSD	Flight Standards Directorate
GCAA	General Civil Aviation Authority
GPS	Global Positioning System
GPWC	Ground Proximity Warning Computer
IAF	Indian Air Force
ICAO	International Civil Aviation Organization
ICASB	Indian Civil Aviation Safety Board
ILS	Instrument Landing System
IMD	India Meteorological Department
IST	Indian Standard Time
IVS	Inertial Vertical Speed
LDA	Landing Distance Available
Loc	Localiser
LOFT	Line Oriented Flying Training
LOPA	Layout of Passenger Accommodation
LOT	Line Oriented Training
LRU	Line Replaceable Unit
LVDT	Linear Variable Differential Transducer
MEL	Minimum Equipment List
METAR	Meteorological Report (Aviation Routine Weather Report)
MMEL	Master Minimum Equipment List
MML	Mangalore
MMR	Multi Mode Receiver
MSSR	Multi Mode Secondary Surveillance Radar
N1	Fan Speed
N2	Core Speed
NACIL	National Aviation Company of India (Ltd)
NAV	Navigation
NDB	Non Directional Beacon
NOTAM	Notices to Airmen
NTSB, USA	National Transportation Safety Board, USA
OGV	Outer Guide Vane
OIR	Operational Incident Report
PAPI	Precision Approach Path Indicator
PDP	Pre Determined Point
PED	Portable Electronic Device
PFD	Primary Flight Display
PIC	Pilot in Command
PSEU	Proximity Switch Electronics Unit
QRH	Quick Reference Handbook
QTA	Quick Turn Around
R/W	Runway

RESA	Runway End Safety Area
REU	Remote Electronics Unit
RFF	Rescue and Fire Fighting
RFSL	Regional Forensic Science Laboratory
RTOW	Regulated Take Off Weight
Rx/Tx	Receiver/Transmitter
R/T	Radio Telephony
ROD	Rate of Descent
RTO	Rejected Takeoff
SFI	Synthetic Flight Instructor
SGA	Soft Ground Arrester
SOP	Standard Operating Procedure
STA	Station
STD	Scheduled Time of Departure
SUT	Supernumerary Under Training
T/R	Thrust Reversers
TAF	Terminal Aerodrome Forecast
TCF	Terrain Clearance Floor
TE	Trailing Edge
TODA	Take off Distance Available
TORA	Take off Run Available
TRE	Type Rated Examiner
TRI	Type Rated Instructor
UCM	Un-commanded Motion
ULB	Underwater Locator Beacon
ULD	Underwater Locating Device
UTC	Universal Time Constant
VBV	Variable Bleed Valve
VHF	Very High Frequency
VOR	Very High Frequency Omni Range
VSD	Vertical Situation Display
VSV	Variable Stator Vane
WBL	Wing Buttock Line
WOCL	Window of Circadian Low
WSO	Watch Supervisory Officer

Photographs, Diagrams and Tables

Photographs

Diagrams

Tables

1. Factual Information

1.1 History of Flight

Air India Charters Limited operates a low-cost airline, under the brand name of Air India Express. It operates a scheduled Quick Turn Around (QTA) flight IX-811/812 daily, on sector Mangalore-Dubai-Mangalore. The Scheduled Time of Departure (STD) of flight IX-811 from Mangalore is 21:35 hours IST and STD for flight IX-812 from Dubai is 01:15 hours Local Time (02:45 hours IST). The Scheduled Time of Arrival of flight IX-812 at Mangalore is 06:30 hours IST, thereby, a substantial portion of return flight falls in period of Window of Circadian Low (WOCL).

On 21st / 22nd May 2010, Air India Express operated Boeing 737-800 aircraft VT-AXV for a similar flight from Mangalore to Dubai and back. Capt Z Glusica and First Officer H S Ahluwalia, along with 4 Cabin Crew operated the flight. As per the schedule, the crew had been given adequate time to rest.

Due to non-availability of a Medical Officer, the crew was not subjected to any pre-flight medical check prior to departure from Mangalore. However, the engineering personnel, who interacted with the Captain and the First Officer while seeing off the flight IX-811 from Mangalore, stated that both the pilots appeared to be healthy and normal. They also stated that both these pilots had carried out all pre-departure checks and start up procedure as per the standard practice. In addition, as indicated on the DFDR, the outbound flight IX-811 was uneventful and landed at Dubai at 23:44 hours Local Time (01:14 hours IST).

During a halt of 1 hour and 22 minutes at Dubai, the Air India Commercial Staff as well as maintenance personnel from Oman Air and the ground staff of DNATA, to whom these functions are outsourced; reported to have seen both the Captain and First Officer having gone to the terminal building and duty free shop. These personnel had indicated that both of them appeared normal and there was nothing unusual in their behaviour. Being a QTA flight, as per regulations, no pre-flight medical was required at Dubai.

The ground staff had carried out the turnaround servicing and refuelling with total fuel for the Sector of 13,900 kg including 1,600 kg of fuel for 'tankering'. Two minor snags, which included un-serviceability of Passenger Seat No 25 C and Right Hand Tail Logo Light, were carried forward under MEL from the previous flight. Subsequently, the same crew operated flight IX-812 on 22nd May 2010 from Dubai to Mangalore. On this flight, there were 160 passengers including 4 infants. The flight chocked off from Dubai at 01:06 hours Local Time (02:36 hours IST), 09 minutes before the Scheduled Departure Time. As indicated in the DFDR, the take-off, climb and cruise were uneventful.

Note: 1. For the purpose of this report, all times are in Indian Standard Time (IST). IST is UTC plus 5 hours and 30 minutes, e.g. 16:05 hours UTC is 21:35 hours IST.

2. Dubai Local Time is UTC plus 4 hours or IST minus 1 hour and 30 minutes.

The aircraft first came in contact with the Mangalore Area Control on frequency 127.55 MHz at 05:32:48 hours IST, when it was approaching the Reporting Point IGAMA, at FL-370. The Mangalore Area Radar (MSSR) was unserviceable since 20th May 2010 and a NOTAM to this effect had been issued. The First Officer, who was making all the R/T calls, requested for Radar Identification to which, he was informed regarding un-serviceability of the Radar.

The Cockpit Voice Recorder (CVR), which normally records conversation for a minimum period of last two hours of the flight (2 hours, 05 minutes for this flight), indicated that there was 'no conversation' between the two Pilots for the first 1 hour and 40 minutes of recording and the Captain was asleep with intermittent sounds of snoring, deep breathing and towards the end of this period, sound of clearing throat and coughing. The First Officer was making all the Radio Calls.

The aircraft reported position at IGAMA at 05:33:20 hours IST. Approximately 5 minutes later, the First Officer asked for the type of approach to which the ATC replied ILS DME Arc approach. At about 130 miles from Mangalore, the aircraft requested for descent clearance. This was, however, denied by the ATC Controller, who was using standard procedural control, to ensure safe separation with other air traffic. At 05:46:54 hours IST, aircraft reported its position when it was at 80 DME on radial 287 MML, as instructed by Mangalore Area Control. The aircraft was cleared to 7000 ft and commenced descent at 77 DME from Mangalore at 05:47:34 hours IST. The visibility reported was 6 km.

Mangalore airport has a Table Top Runway. The airport is at Latitude 12º 57' 43.40" N, Longitude 074º 53' 23.20" E with elevation of 101.629 meters above mean sea level. Owing to the surrounding terrain, Air India Express had made a special qualification requirement that only the PIC shall carry out the take off and landing. Captain Glusica had made a total of 16 landings in the past at this airport and First Officer Ahluwalia, who was stationed at Mangalore, had operated as a Co-pilot on 66 flights at this airport.

While the aircraft had commenced descent, there was no recorded conversation regarding the mandatory preparation for descent and landing briefing as stipulated in the SOP. Prior to the descent, there were some in-audible and intermittent sounds from the Captain's Channel on the CVR. This was first time that the CVR had indicated that there was any intra-cockpit conversation between the two pilots. After the aircraft was at about 50 miles and descending out of FL 295, the conversation between the two pilots indicated that an incomplete approach briefing had been carried out.

At about 25 nm from DME and descending through FL 184, the Mangalore Area Controller cleared the aircraft to continue descent to 2900 ft. At this stage, the First Officer requested, if they could proceed directly to Radial 338° and join the 10 DME Arc. Through out the descent profile and DME Arc Approach for ILS 24, the aircraft was much higher than normally expected altitudes.

The aircraft was handed over by the Mangalore Area Controller to ATC Tower at 05:52:43 hours IST. The ATC, thereafter, asked the aircraft to report having established on 10 DME Arc for ILS R/W 24.

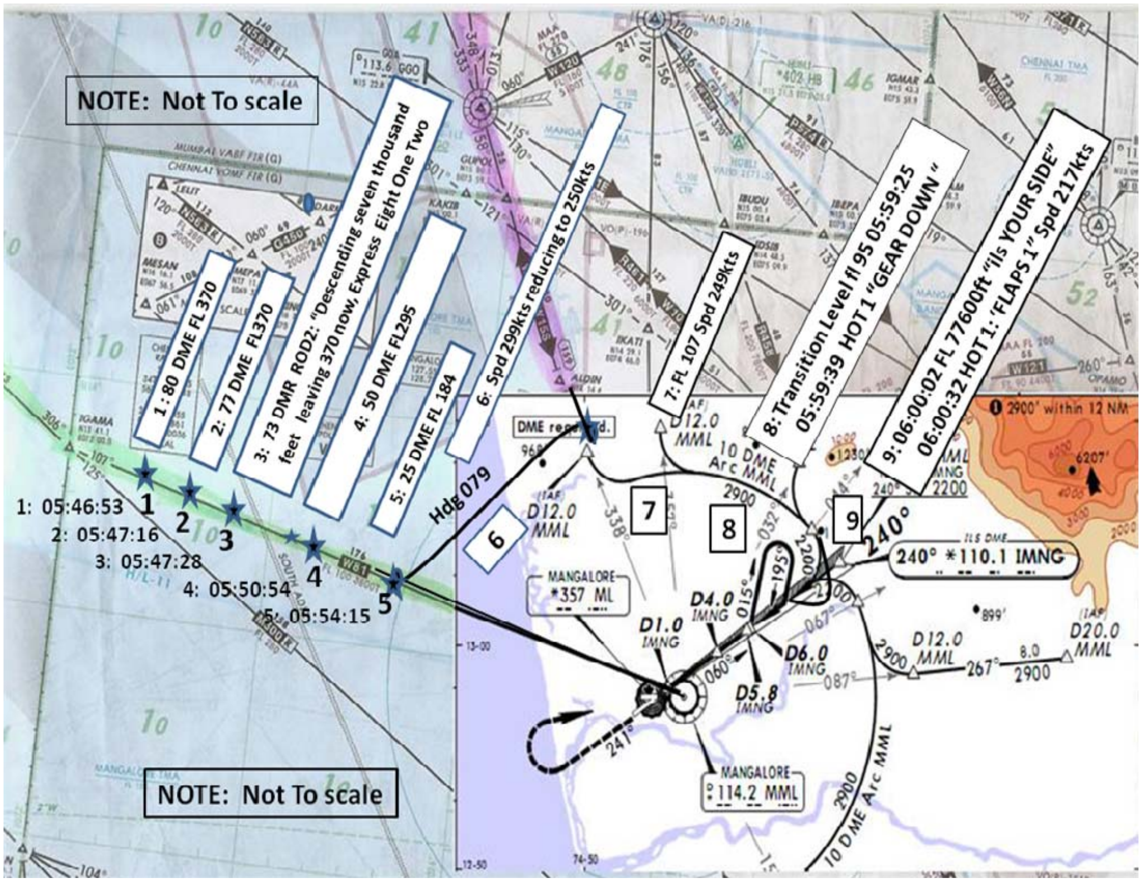


Diagram 1: Plan View of Initial Radial and Descent Profile of Accident Aircraft

Considering that this flight was operating in WOCL, by this time the First Officer had also shown signs of tiredness. This was indicated by the sounds of yawning heard on the CVR.

On having reported 10 DME Arc, the ATC Tower had asked aircraft to report when established on ILS. It appears that the Captain had realised that the aircraft altitude was higher than normal and had selected Landing Gear 'DOWN' at an altitude of approximately 8,500 ft with speedbrakes still deployed in Flight Detent position, so as to increase the rate of descent. As indicated by the DFDR, the aircraft continued to be high and did not follow the standard procedure of intercepting the ILS Glide Path at the correct intercept altitude. This in-correct procedure led to the aircraft being at almost twice the altitude as compared to a Standard ILS Approach.

During approach, the CVR indicated that the Captain had selected Flaps 40° and completed the Landing Check List. At 06:03:35 hours IST at about 2.5 DME, the Radio Altimeter had alerted an altitude of 2500 ft. This was immediately followed by, the First Officer giving a call of "IT IS TOO HIGH" and "RUNWAY STRAIGHT DOWN". In reply, the Captain had exclaimed "OH MY GOD". At this moment, the Captain had disconnected the Auto Pilot and simultaneously increased the rate of descent considerably to establish on the desired approach path. At this stage, the First Officer had queried "GO AROUND?"

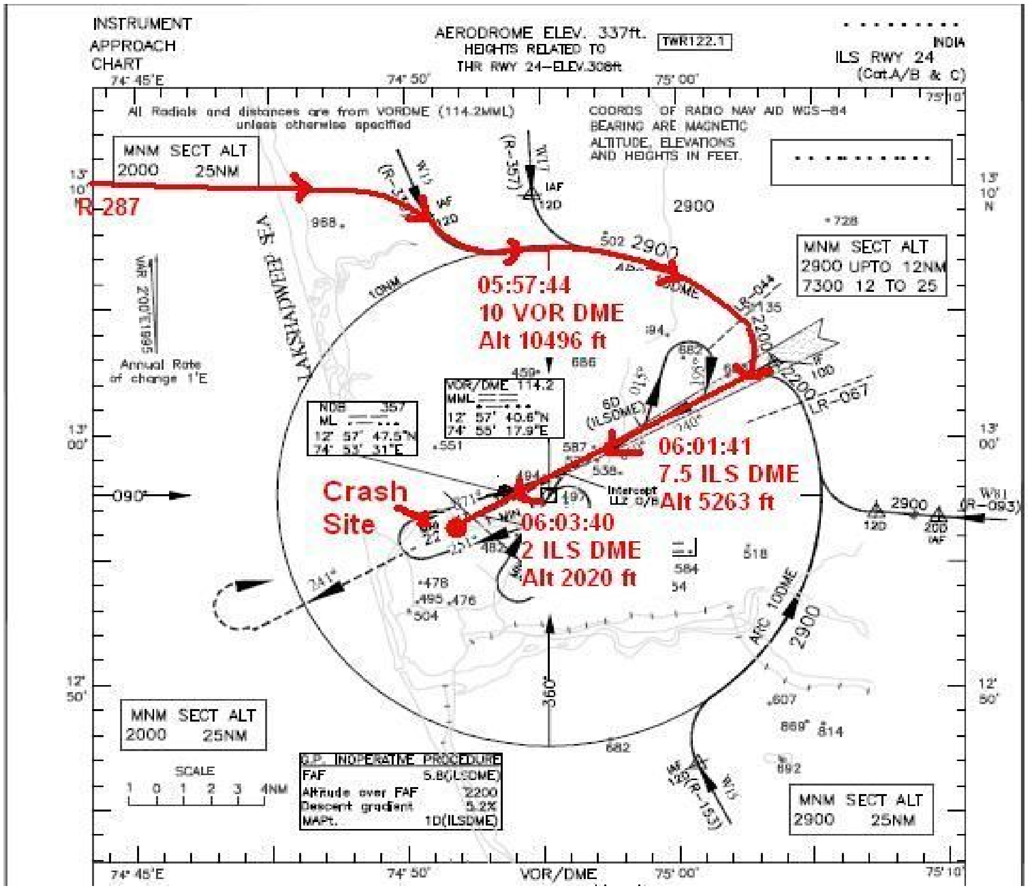


Diagram 2: Plan View of DME Arc Approach Leading to ILS

To this query from the First Officer, the Captain had called out "WRONG LOC….. LOCALISER ….. GLIDE PATH". It appears from the above that the Captain had realised the error and his subsequent correction indicated that he was not incapacitated.

The First Officer had given a second call to the Captain for "GO AROUND" followed by "UNSTABILISED". However, the First Officer did not appear to take any action, to initiate a Go Around. Having acquired the R/W visually and to execute a landing, it appears that the Captain had increased the rate of descent to almost 4000 ft per minute. Due to this, there were numerous warnings from EGPWS for 'SINK RATE' and 'PULL UP'.

On their own, the pilots did not report having established on ILS Approach. Instead, the ATC Tower had queried the same. To this call, the Captain had forcefully prompted the First Officer to give a call of "AFFIRMATIVE". The ATC Tower gave landing clearance thereafter and also indicated "WINDS CALM".

As per the ATC Controller, the aircraft was high on approach and touched down on the runway, much farther than normal. This was also substantiated by other witnesses such as RFF Crew and AME of Air India Express awaiting arrival of this aircraft, at the apron. As per the DFDR, aircraft had crossed the threshold at about 200 ft altitude with indicated speed in excess of 160 kt, as compared to 50 ft with target speed of 144 kt for the landing weight.

Despite the EGPWS warnings and calls from the First Officer to go around, the Captain had persisted with the approach in unstabilised conditions. Short of Touchdown, there was yet another (Third) call from the First Officer, this time on VHF Channel “GO AROUND CAPTAIN” followed by “WE DON’T HAVE RUNWAY LEFT” on the intercom. However, the Captain had continued with the landing and the final Touchdown was about 5200 ft from the threshold of R/W 24, leaving approximately 2800 ft of remaining paved surface.

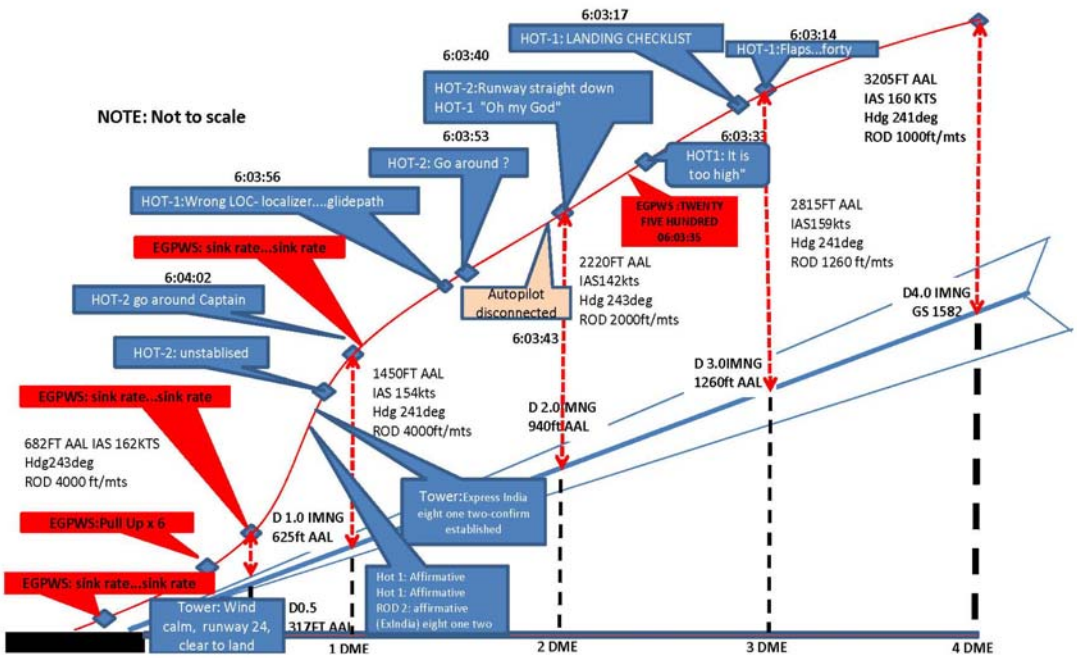


Diagram 3: Approach Profile Including Salient Recordings from CVR

The Captain had selected Thrust Reversers soon after touchdown. It was evident from the DFDR and wreckage examination that the Auto Brake selection was at position 2. As per the DFDR, within 6 seconds of applying brakes, the Captain had initiated a ‘Go Around’, in contravention of Boeing SOP.

The aircraft overshot the runway including the strip of 60 metres. There is a downward slope from end of R/W 24 towards the boundary fence. After overshooting the R/W and strip, the aircraft continued into the Runway End Safety Area (RESA) of 90 metres. Soon after which, the right wing impacted the localiser antenna structure located further at 85 metres from the end of RESA (60+90+85=235 Metres). Thereafter, the aircraft hit the boundary fence and fell into a gorge. During the entire period of CVR and ATC Tape recording, there was no emergency call from the aircraft indicating any type of failure. This was also substantiated by the analysis of DFDR Data.

The ATC Controller was not able to see the aircraft at the end of R/W 24. However at 06:05:04 hours IST, ATC Controller had radioed the aircraft to back track as per the standard practice. The last recording on CVR was an aural warning of ‘BANK ANGLE’ at 06:05:03 hours IST.

The aircraft crashed into a gorge, about 500 meters from the boundary fencing and the coordinates of the accident site were Latitude N 12º 56’ 47.64” and Longitude E 074º 52’ 25.2. Due to impact and fire, the aircraft was destroyed. In this tragic accident, 152 passengers and all 6 crewmembers lost their lives. There were 8 survivors, out of which 7 passengers sustained serious injuries and one person escaped with minor bruises.

Photo 1: Google Earth View of Mangalore Airport

Although the crash site was outside the airport area, the crash and fire crew responded timely. Since the roads are narrow, the RFF Vehicles reached the crash site with difficulty. The response by the Civil Administration including Fire, Medical and Police Departments to this disaster was also fairly fast. The local population rendered a lot of help for the rescue operations. Subsequently, Air India volunteers known as ‘Air India Angels’ provided yeomen service to the bereaved families and survivors in association with Civil Administration.

The post-mortem and toxicology reports of both the Captain and the First Officer did not indicate consumption of any drugs, alcohol or medicines.

At the behest of the Court, a team of experts from Bomb Detection and Disposal Squad (BDDS) O/o Bureau of Civil Aviation Security (BCAS), Chennai was deputed on 13th June 2010 to examine the wreckage. As per their report dated 22nd June 2010, there was no evidence of any sabotage.

The entire wreckage from the crash site was later shifted to a secure area within the airport premises. For the ease of investigation, it was arranged in the shape of an actual aircraft as shown below: -

Photo 2: Photograph of the Re-arranged Wreckage

Under the supervision of Court of Inquiry, 63 components including both the engines were sent to the overhaul facilities of M/s Air India, Mumbai for detailed examination.

1.2 Injuries to Persons

The following table indicates the fatalities and injuries to the Crew and Passengers:

Injuries	Crew	Passengers	Total
Fatal	2+4	152	158
Serious	--	7	7
Minor/None	--	1	1
Total	6	160	166

The fatalities and injuries to the crew and passengers have also been indicated as per their nationality, in the following table:

Nationality	Fatalities		Survivors	Total
	Passenger	Crew		
Banglades	0	0	1	1
India	152	5	7	164
Serbia	0	1	0	1
Total	152	6	8	166

1.3 Damage to Aircraft

Right wing of the aircraft had impacted the ILS Localiser Antenna structure at the end of R/W 24 and sheared into pieces. Right Engine also broke off from the wing. The remaining portion of the aircraft fell in the gorge, broke into three parts and caught fire.

The aircraft along with the contents was totally destroyed due to impact and post crash fire.

1.4 Other Damages

As a result of the aircraft overshooting the runway, damage occurred to two Runway End Lights and five Elevated Approach Lights at the end of R/W 24. In addition, the mounting structure as well as some elements of ILS Localiser Antenna at the end of runway 24 and a part of the airport boundary fence, belonging to Airports Authority of India was also damaged. While falling into the gorge and before coming to a rest at the crash site, damage also occurred to some trees and vegetation.

1.5 Personnel Information

1.5.1 Pilot in Command - Captain Zlatko Glusica

The Captain was a 55-year-old pilot who lived near Belgrade, Serbia. He was employed as Pilot in Command (PIC) on Boeing 737-800 in Air India Express since 15th December 2008, after having been issued the Foreign Aircrew Temporary Authorisation (FATA) by the DGCA. His last licensing medical examination, wherein he was declared medically fit Class 1 & 2, was held at Belgrade and was valid till 16th Aug 2010.

The PIC began his aviation career in JAT academy, in erstwhile Yugoslavia. After completion of his training, he joined the JAT airline and flew DC-9. Later, he had also flown Boeing 737-300 aircraft. After the breakup of Yugoslavia, Capt Glusica flew as PIC in different countries including Malta, Canada and Australia to name a few.

Captain Glusica was remarried after divorcing his first wife. He had children from both wives and was reportedly very fond of all his children. His son from the first wife was undergoing commercial flying training. As per some of his colleagues employed by Air India Express, Capt Glusica had shown no signs of stress with regard to the family or finances. They had stated that he was a well-built and physically fit person, a non-smoker and a teetotaller. During his entire period of employment with Air India Express, Capt Glusica had never been grounded on account of alcohol consumption.

During interaction with other pilots, who had flown with Capt Glusica, he was reported to be a friendly person, ready to help the First Officers with professional information. Some of the First Officers had mentioned that Captain Glusica was assertive in his actions and tended to indicate that he was ‘ALWAYS RIGHT’.

On 17th March 2010, Capt Glusica had been called to the Flight Safety Department of Air India Express regarding a 'Hard Landing Incident' on a flight operated by him from Muscat to Thiruvananthapuram on 12th December 2009. While the Chief of Flight Safety had stated that the counselling was carried out in an amicable and friendly manner, it was given to understand from his colleagues that Capt Glusica was upset about the counselling. As per the statements of some of the Serbian pilots, he felt that the counselling was not called for, since this was the very first such incident and not a trend. Also, it was the first officer who had carried out the landing and that the 'Vg' limit recorded was only 1.9 Vg as against the manufacturer's limit of 2.1Vg.

Air India Express employs a number of foreign PIC to cater to the shortfall of captains on its strength. These foreign pilots are employed through several agencies under individual contracts. Capt Glusica, after having obtained a valid endorsement on Boeing 737-800 aircraft, was employed by Air India Express. The terms of contract of the Captain included 2 months (8 weeks) of flying duty in India and two weeks off to his hometown, near Belgrade, Serbia. Captain Glusica had availed his two weeks off till 18th May 2010. This was his first flight after returning from vacation.

Brief particulars of Captain Glusica are as follows: -

Nationality	**Serbian**
Date of Birth	16th May 1955
ATPL No, validity and the country of issue	SRB 0230/0276, 22nd May 2013, SERBIA
FATA No, validity and issuing authority	184/09, 31st July 2010 by DGCA, India
Place, date and country of the last Medical Examination and its validity and assessment	Belgrade, on 5th August 2009 Class 1 & 2 Valid till 16th August 2010.
Date of last Instrument Rating Check	14th May 2009
Validity of Instrument Rating Check	7th June 2011
Date of last Route check	15th March 2010
Date of last Ground Refresher Training	29th December 2009
English Language Proficiency Check and validity	Level - 4, Valid till 5th March 2011
Date of endorsement as P1 and P2 on B-737-800 in the licence	8th February 2006
Total flying experience as PIC	10215:50 Hours
Total flying experience on B-737-800	2844:50 Hours
Hours flown in the last 365 days	728:30 Hours
Hours flown in the last 90 days	147:00 Hours
Hours flown in the last 30 days	31:40 Hours
Hours flown in the last 7 days	7:25 Hours
Hours flown in the last 24 hours	7:25 Hours
Rest availed prior to operating IX 811/ 812 of 21st / 22nd May, 2010	Arrived Mangalore by IC-179 (Mumbai-Mangalore) on 19th May 2010 as a passenger and thereafter availed a total of about 54 hours of rest.

1.5.2 First Officer - H.S. Ahluwalia

First Officer Harbinder Singh Ahluwalia was 40 years of age and belonged to Mumbai, India. Air India Express employed him as a co-pilot on Boeing 737-800 w.e.f. 27th April 2009. His last licensing Class-I Medical Examination, wherein he was declared medically fit, was held at AFCME, New Delhi on 11th February 2010. This was valid for six months upto 10th August 2010.

The First Officer began his aviation career from Gujarat Flying Club, Vadodara. He, thereafter, joined Jet Airways, where he flew as a co-pilot on Boeing 737-800 for almost five years.

First Officer Ahluwalia belonged to a business family residing in Mumbai. He was unmarried and used to visit his widowed mother and other family members frequently. His colleagues and other captains who flew with him had informed the Court that First Officer Ahluwalia was professionally well informed. He had obtained his ATPL and was due for Command Training on Boeing 737-800 aircraft. Having completed a total of about 3500 hours of flying and 3200 hours on type, First Officer Ahluwalia had queried the management on 27th October 2009 regarding his 'Command Up-gradation as per company requirement'.

To this, the Chief of Operation had replied that the company policy for command conversion was based on: -

- Years of service on Company Aircraft.
- Hours on type on Company Aircraft (2000 hrs relaxed to 1500 hrs taking into account prior experience)
- Seniority in the Air India Express list and related stipulations.

First Officer Ahluwalia was known to be meticulous in his adherence to procedures. He was also known to be a man of few words. He had complained in writing, his reservations about one of the foreign captains for not following the company SOP as well as correct CRM technique. The management had planned to counsel both, the concerned captain and First Officer Ahluwalia. However, the counselling had not taken place prior to the date of accident. In the interim, the scheduling staff had been verbally instructed, not to pair these two pilots together.

The First Officer was stationed at Mangalore, where he was sharing an apartment with another co-pilot of Air India Express.

Brief particulars of First Officer HS Ahluwalia are as follows: -

Nationality	**Indian**
Date of Birth	5th November 1969
ATPL No, validity and the country of issue	3575, valid till 21st July 2010, India
FRTOL No, validity and the country of issue	5027, valid till 1st April 2013, India
Date, place and validity of last Medical Examination	11th February 2010, AFCME, New Delhi, Class-I, valid till 10th August, 2010
Instrument rating, Licence Renewal Check	14th February 2010
Date of Last Route Check.	17th February 2010
Date of Last Refresher	28th April 2010
Total flying experience	3620:00 Hours
Total flying experience on B-737-800	3319:40 Hours
Hours flown in the last 365 days	411:30 Hours
Hours flown in the last 90 days	184:45 Hours
Hours flown in the last 30 days	55:05 Hours
Hours flown in the last 7 days	14:20 Hours
Hours flown in the last 24 hours	7:25 Hours
Rest availed prior to operating IX 811/ 812 of 21st / 22nd May 2010	Flew as First Officer on 18th May 2010 by Flt No IX-812 from Dubai to Mangalore and thereafter availed a total of about 82 hours of rest.

1.5.3 Cabin Crew

The details of Cabin Crew were as follows:

(a) Ms Sujata Survase, Staff No 15334

- Date of Joining Training - 27th September 2007
- Carried out B-737-800 aircraft ab-initio training in Batch No 12 on 3rd January 2008 and passed the examination with 90%
- Safety and Emergency Procedure (SEP) training done from 2nd to 5th Nov 2009 - Current and Valid
- Dangerous Goods (DG) training done from 5th to 6th November 2009 - Current and Valid
- Practical training done on 12th November 2009 - Current and Valid

(b) Mr. Mohammed Ali, Staff No 15425

- Date of Joining Training - 5th Aug 2008
- Carried out B 737- 800 aircraft ab-initio training in Batch No 15 on 22nd December 2008 and passed the examination with 94%
- SEP training done from 26th to 30th October 2009 - Current and Valid
- DG training done on 28th October 2009 - Current and Valid
- Practical training done on 29th October 2009 - Current and Valid

(c) Mr. Yugantar Rana, Staff No 15424

- Date of Joining Training - 5th August 2007
- Carried out B 737-800 aircraft ab-initio training in Batch No 15 on 22nd December, 2008 and passed the examination with 96%
- SEP training done from 9th to 18th September 2009 - Current and Valid
- DG training done on 19th November 2008 - Current and Valid
- Practical training done on 6th November 2008 - Current and Valid

(d) Ms Tejal Komulkar, Staff No 15476

- Date of Joining Training - 7th July 2009
- Carried out B-737- 800 aircraft ab-initio training in Batch No 17 on 1st January 2010 and passed the examination with 96%
- SEP Training done from 18th to 22nd Sep 2009 - Current and Valid
- DG Training done from 8th to 9th December 2009 - Current and Valid
- Practical training done on 26th November 2009 - Current and Valid

The information in respect of Cabin Crew in tabulated format is given below:-

Name		Ms. Sujata Survase	Ms.Tejal AnilKumar Komulkar	Mr. Yugantar Rana	Mr. Mohd Ali
Date of Birth		31^{st} Aug 81	5^{th} May 85	23^{rd} Feb 82	3^{rd} Nov 84
Total experience as Crew Member Approved by DGCA		1616 Hours	333:05 Hours	1352 Hours	702:15 Hours
Total experience on the B-737-800 aircraft as DGCA approved crew member		1616 Hours	333:05 Hours	1352 Hours	702:15 Hours
Date of Last refresher training	**FS**	02.11.2009	18.09.2009	09.09.2009	26.10.2009
	DG	06.11.2009	09.12.2009	19.11.2009	28.10.2009
	WD	12.11.2009	26.11.2009	05.11.2008	29.10.2009
Rest availed prior to operating IX- 811/ 812 of 21^{st}/ 22^{nd} May 2010		24 Hours	24 Hours	24 Hours	24 Hours

Note: Fire and Smoke (FS) Training, Dangerous Goods (DG) Training, Wet Drill (WD)

1.6 Aircraft Information

Boeing 737-800 is a twin-engine jet transport aircraft manufactured by Boeing Commercial Airplane Company, USA. It is designed to operate short to medium range flights with a capacity of up to 189 passengers. The airplane has a design range of 2900 nautical miles. It has a wingspan of 117 feet 5 inches and length of 129 feet 6 inches. Air India Express aircraft are powered by two CFM 56-7B27/3 high bypass ratio, dual rotor, turbo fan engines, each developing 23700 pounds of thrust at sea level.

1.6.1 Aircraft Particulars

Boeing 737-800 aircraft VT-AXV bearing Manufacturer's Serial No 36333 was manufactured by Boeing Commercial Airplane Company, Seattle, USA in the year 2008. FAA had issued the Export Certificate of Airworthiness No E429821 dated 15th January 2008 to this aircraft. The aircraft was entered in DGCA Civil Aircraft Register on 15^{th} January 2008.

The short term Certificate of Registration (C of R) and short term Certificate of Airworthiness (C of A) No 3081 was issued by DGCA on 15^{th} January 2008 and this C of A was valid till 14^{th} February 2008.

Regular C of R was issued by DGCA on 21st January 2008. As per the C of R, the aircraft was owned by M/s Four Lions Aircraft LLC, C/o Wilmington Trust Co, Rodney Square North, 1100 North Market Street, Wilmington, Delaware, 198900001, USA and was leased to M/s Ulster Aviation Leasing Limited, 5th floor, 75, St. Stephen's Green Dublin, Ireland. The operator and lessee of the aircraft was Air India Charters Limited (AICL), Mumbai. Regular C of A was revalidated on 15th February 2008 based on the export C of A and was valid till 14th January 2013. The Aircraft Station License No A-013/05/WRLO-08 for the aircraft VT-AXV was issued by Ministry of Communication and it was valid till 31st December 2010. The aircraft insurance was valid till 30th September 2010.

As per the Airplane Flight Manual, the minimum Flight Crew necessary to operate the aircraft was two. The Maximum All Up Weight of the aircraft was 77,110 kg. The aircraft had seating capacity of 186 passengers in the cabin for all economy configurations. It had two cargo compartments for carrying passenger baggage and cargo.

The permit to operate scheduled air transport services (No S-14) was issued to AICL on 22nd April 2005. Aircraft VT-AXV was entered in this permit in year 2008. The permit was last revalidated on 22nd April 2008 and was valid up to 21st April 2013. The first Annual Review of Airworthiness (ARA) was carried out on 23rd December 2008 at 3007.44 Airframe hours and 1192 landings. The second (last) Annual Review of Airworthiness was completed on 29th December 2009 at 6481 Airframe hours and 2542 landings. The next ARA was due on 14th January 2011.

All the applicable Airworthiness Directives and DGCA Mandatory Modifications were found complied with, as on the date of accident.

1.6.2 Airframe Particulars

Airframe Hours/landings as on 21st May 2010:-

Hours Since new	:	7199:41 Hrs.
Number of landings since new	:	2833
Hours since last Annual Review of Airworthiness (29th December, 2009)	:	719:00 Hrs
Landings since last Annual Review of Airworthiness (29th December, 2009)	:	291

1.6.3 Engine Particulars

The aircraft was fitted with two CFM 56-7B27/3 turbo fan engines.

Engines Hours/cycles as on 21st May 2010:-

	LEFT	**RIGHT**
Engine Serial Number	896199	897200
Hours since new	7199:41	7199:41
Cycles since new	2833	2833
Hours since last ARA	719:00	719:00
Cycles since last ARA	291	291

1.6.4 Auxiliary Power Unit (APU) Particulars

Make	:	Honeywell
Model	:	131-9B
Serial Number	:	P-7138

1.6.5 Maintenance Arrangements

Air India Charters Ltd (AICL) was approved by DGCA to carry out line and base maintenance of Boeing 737-800 aircraft under the provision of CAR 145 up to Phase 48 i.e. 24000 Hrs / 9600 Landings / 2880 Days Inspection Schedule. AICL engineers carry out line maintenance within India. The maintenance outside India is out-sourced to other approved maintenance organisations available at the respective locations. The line maintenance at Dubai is outsourced to M/s Oman Air.

At the time of accident, Air India Express had 8 Extended Transit Stations namely, Kochi, Kozhikode, Thiruvananthapuram, Chennai, Trichi, Mangalore, Mumbai and Delhi, where aircraft were positioned for about a week for operational convenience. Mangalore was one such station where AICL held DGCA approval to carry out Extended Transit Checks, which was carried out every 75 hours / 15 days. Out of the above 8 Extended Transit Stations, two stations namely, Mumbai and Thiruvananthapuram were Base Stations, where Phase Checks of Boeing 737-800 aircraft was presently carried out. Mumbai base was approved for all phase checks up to P-48 including Major Check i.e. P-15 and its multiples, whereas Thiruvananthapuram was approved for carrying out Phase checks up to P-48 except for Major Check.

The aircraft VT-AXV was maintained as per the DGCA approved Maintenance Programme Revision 4 dated 29th June 2009.

1.6.6 Maintenance Records

AICL maintains aircraft records in Hard Copy. As per maintenance records, the last major check Phase 15 i.e. 7500 Hours / 3000 Landings / 900 Days, was carried out on aircraft VT-AXV on 10th March 2010 at 6482 Airframe Hours and 2542 Landings since new at the approved maintenance facilities of Air India, Mumbai. The next multiple of Phase 15 i.e. Phase 30 was due on 26th August 2012 at 13982 Hours / 5542 Landings. Phase-16 i.e. 8000 Hours / 3200 Landings check was also carried out along with Phase-15 inspection. Phase 17 i.e. 8500 Hours / 3400 Landings, was carried out on the aircraft on 21st April 2010 at 6899 Airframe Hours and 2720 Landings since new. The next higher check Phase 18 i.e. 9000 Hours / 3600 Landings, was due on 19th June 2010 at 7399 Hours and 2920 Landings since new. The last Extended Transit check was carried out on 20th May 2010 at Mangalore. The next Extended Transit Check was due on 3rd June 2010. The last Transit Check was carried out at Dubai Airport on 22nd May 2010 by the maintenance engineers of M/s Oman Air before releasing the aircraft for ill fated flight on Dubai-Mangalore sector.

1.6.7 Incidents

The aircraft VT-AXV was involved in six incidents in the preceding 12 months from the date of accident. Out of these incidents, one was Hard Landing and five were Bird Strikes. In brief, they were as follows: -

- Hard landing incident was reported on 5th July 2009 at Pune. AICL used to categorise 1.81Vg as Hard Landing. The Manufacturer has prescribed 2.1Vg as Hard Landing

- On 12th July 2009 on arrival at Kochi, blood stains were found on the nose cowl of Right Engine

- On 21st October 2009, a dent and blood stain was observed on LH horizontal Stabiliser between stations 234.43 and 244.72 at Kochi

- On 30th October 2009, bloodstains were found above R1 windshield and on RH flap at Trichi. No other abnormality was observed

- On 30th April 2010, bird feathers were found in Left Engine compressor inlet. No damage was observed.

- On 8th May 2010, Bird Strike was noticed on Right Engine Inlet cowl at Chennai. No damage was observed

All incidents were investigated and necessary rectification action had been taken.

1.6.8 Snags Reported

A total of 12 snags were reported on VT-AXV aircraft within last six months. These snags were related to Lights / Communication / Navigation systems. Appropriate maintenance action had been taken to rectify these snags.

On 20th May 2010, during Abu Dhabi - Mangalore sector, pilot had reported that during cruise at Flight Level 350, 'DISPLAY SOURCE FAILURE' flag had appeared. Non Normal Checklist was carried out. However, there was no other abnormal indication. During rectification on ground, both Display Electronic Unit (DEU) and Circuit Breakers (CB) were recycled. All the indications were normal. Subsequently, the aircraft had operated 6 sectors and no snag of this nature was reported.

On 21st May 2010, the pilot had not reported any snag at Dubai, on the Mangalore - Dubai sector. The aircraft was released for flight from Dubai to Mangalore after carrying out Transit Inspection at Dubai.

1.6.9 Minimum Equipment List

The aircraft had a DGCA approved Minimum Equipment List (MEL) which was prepared on the basis of Master MEL (MMEL) approved by the US Federal Aviation Administration (FAA). The MEL for the aircraft VT-AXV was invoked 3 times in March 2010 and 6 times in the month of April 2010. On 25th April 2010, HF No 2 was found not tuning. Snag was isolated to Defective HF Coupler.

The aircraft was released under MEL 23-11 in Cat C (Validity 10 days). It was revoked on 30th April 2010 after taking corrective action. This snag had not repeated till the date of the accident. The aircraft was released under MEL 25-26 under Cat D (Valid for 120 days) on 19th April 2010 with Passenger Seat 25 C unserviceable. It was revoked on 20th April 2010. However, again on 23rd April 2010, aircraft was released under MEL with Passenger Seat 25 C unserviceable, which was not revoked till the time of accident. Right Hand Logo Light was unserviceable and released under MEL 33-11 under Cat D, which was in effect at the time of accident.

From the records, it was evident that Air India Express had been following correct procedure for MEL release and rectifying the defects within the stipulated period. However, it was noticed from the seat allocation chart that a passenger was allotted seat 25 C, which was released under MEL. It was also confirmed by the departure engineer that a message to this effect had been sent to Dubai. However, there was no confirmation from Dubai about receiving and taking suitable action in this regard. As IX-812 was not flying with full load, it is presumed that Cabin Crew, having knowledge regarding the un-serviceability of the seat from aircraft documents, might have re-seated the passenger to a serviceable seat. None of survivors was occupying seat 25C.

1.6.10 Weight and Balance Information

The aircraft, after manufacture, was weighed at the facility of M/s Boeing Company, Seattle USA, on 7th January 2008. The DGCA approved weight schedule was prepared as per the data provided by M/s Boeing Company.

The details of weight schedule were as follows:-

a)	Aircraft Empty Weight	:	42539.03 kg
b)	Max fuel capacity (At density of .785 kg/litre)	:	20427.35 kg
c)	Maximum Takeoff weight	:	77110 kg
d)	Empty weight CG (cm)	:	1679.6516 cm (forward of front spar)
e)	Datum	:	1371.6 cm (forward of front spar)
f)	Max. Permissible number of Passengers	:	186
g)	Number of Crew	:	2 + 4

As per the Load and Trim sheet for flight IX-812 of 22nd May 2010 from Dubai to Mangalore, following were the actual weights v/s Maximum permissible weights:-

Weight	Actual Weights for IX-812	Maximum Permissible
Take Off Weight	73770 kg	77110 kg
Landing weight	64970 kg	66360 kg
Zero fuel weight	60070 kg	62731 kg

The Regulated Take Off Weight (RTOW) for the flight was calculated as 74900 kg. The aircraft was refuelled at Dubai prior to departure and the total fuel on board the aircraft was 13,900 kg including 1,600 kg for 'tankering'.

1.6.11 Record of Previous Flight on VT-AXV Prior to The Accident

On 21st May 2010, Air India Express had operated a QTA Flight IX-819 and IX-820, Mangalore - Doha - Bahrain and back. The same aircraft i.e. Boeing 737-800, VT-AXV had been flown. The return Flight IX-820 had arrived Mangalore from Bahrain (BAH) at 19:20 hours IST on 21st May 2010. No snag had been reported on the Aircraft. Two snags under MEL had been carried forward, one relating to passenger seat 25C and other relating to Right Hand Tail Logo Light. After the crash of VT-AXV on 22nd May 2010, the DFDR had also indicated that the aircraft was fully serviceable at the end of this flight from Bahrain.

1.6.12 Landing Distances Specified by M/s Boeing Company

1.6.12.1 Landing Distances

The manufacturer of Boeing 737-800 aircraft has given Landing Distances (Normal Configuration) in the Flight Crew Operations Manual (FCOM), Performance in Flight - Quick Reference Handbook (QRH). A copy of the Advisory Information from the QRH of M/s Boeing Company for Normal Configuration Landing Distances with Flap 40, which was the landing configuration selected by the accident aircraft, is given on the next page.

737-800WSFP1/CFM56-7B27
FAA
Category C/N Brakes

BOEING

Performance Inflight - QRH
General

737 Flight Crew Operations Manual

ADVISORY INFORMATION

Normal Configuration Landing Distances

Flaps 40

	LANDING DISTANCE AND ADJUSTMENT (FT)											
	REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS		SLOPE ADJ PER 1%		TEMP ADJ PER 10°C		APP SPD ADJ	REVERSE THRUST ADJ	
BRAKING CONFIGURATION	60000 KG LANDING WEIGHT	PER 5000 KG ABOVE/ BELOW 60000 KG	PER 1000 FT STD/ HIGH*	HEAD WIND	TAIL WIND	DOWN HILL	UP HILL	ABV ISA	BLW ISA	PER 10 KTS ABOVE VREF40	ONE REV	NO REV
Dry Runway												
MAX MANUAL	2740	170/-150	50/70	-100	350	30	-30	50	-50	200	40	80
MAX AUTO	3470	180/-200	70/100	-130	440	0	0	70	-80	340	0	0
AUTOBRAKE 3	4800	290/-320	120/160	-210	730	10	-20	120	-120	510	10	10
AUTOBRAKE 2	6130	410/-430	170/230	-290	1000	90	-120	160	-160	490	180	180
AUTOBRAKE 1	6740	480/-500	200/270	-340	1170	180	-200	180	-180	480	490	770
Good Reported Braking Action												
MAX MANUAL	3770	220/-230	90/130	-170	610	90	-80	90	-90	290	170	370
MAX AUTO	4140	230/-250	100/130	-180	630	70	-60	90	-90	340	190	420
AUTOBRAKE 3	4810	290/-320	120/160	-220	740	20	-30	120	-120	510	20	50
AUTOBRAKE 2	6130	410/-430	170/230	-290	1000	90	-120	160	-160	490	180	180
Medium Reported Braking Action												
MAX MANUAL	5080	340/-350	150/200	-270	1000	220	-180	130	-140	370	460	1100
MAX AUTO	5320	350/-360	150/200	-270	1000	190	-150	130	-140	440	470	1110
AUTOBRAKE 3	5410	360/-370	150/210	-280	1030	160	-130	140	-150	510	370	1020
AUTOBRAKE 2	6290	420/-450	180/240	-320	1140	180	-170	170	-170	490	290	590
Poor Reported Braking Action												
MAX MANUAL	6570	490/-490	210/290	-410	1580	540	-350	180	-190	440	1000	2600
MAX AUTO	6830	490/-480	210/290	-410	1570	540	-340	170	-190	470	1000	2620
AUTOBRAKE 3	6830	500/-500	210/300	-410	1580	520	-340	180	-190	480	1020	2650
AUTOBRAKE 2	7050	500/-500	220/310	-420	1620	510	-340	190	-210	490	870	2330

Reference distance is for sea level, standard day, no wind or slope, VREF40 approach speed and two engine detent reverse thrust.
Max manual braking data valid for auto speedbrakes. Autobrake data valid for both auto and manual speedbrakes.
For max manual braking and manual speedbrakes, increase reference landing distance by 200 ft.
Actual (unfactored) distances are shown.
Includes distance from 50 ft above threshold (1000 ft of air distance).

***For landing distance at or below 8000 ft pressure altitude, apply the STD adjustment. For altitudes higher than 8000 ft, first apply the STD adjustment to derive a new reference landing distance for 8000 ft then apply the HIGH adjustment to this new reference distance.**

Table 1: Normal Configuration Landing Distances for Flap 40

1.6.12.2 Factors Affecting Landing Distance

The manufacturer has also given a table which indicates the factors affecting Landing Distance vide Boeing 737 NG Flight Crew Training Manual (FCTM). The Boeing Company has also indicated the Proper and Improper Approach Procedure in this manual. A copy of the Boeing 737 NG FCTM Page is given below:-

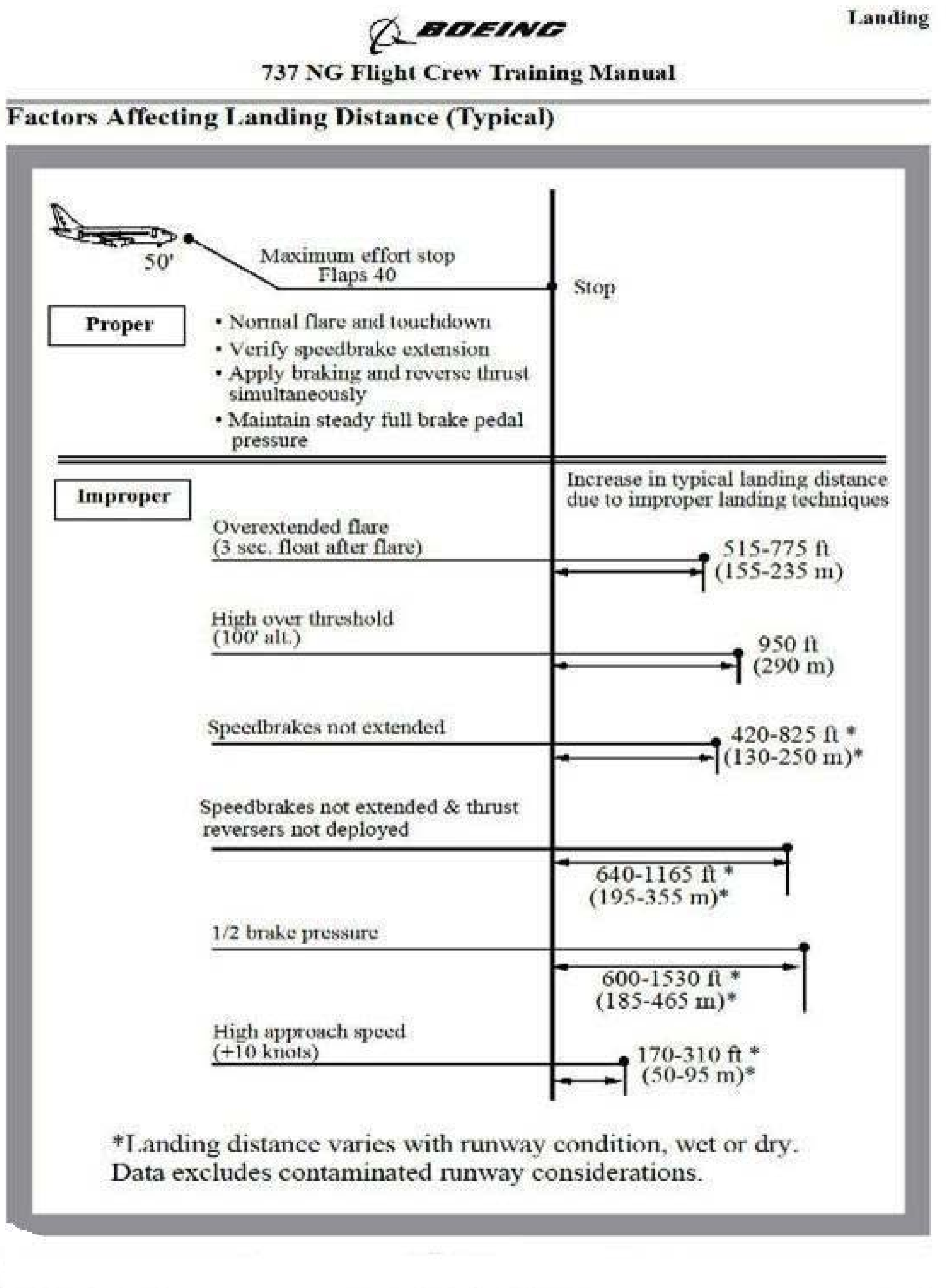


Table 2: Extract of FCTM Regarding Factors Affecting Landing Distance

1.6.13 Aircraft Systems

A brief description of the following aircraft systems is given below for a better understanding of this report.

1.6.13.1 Flight Control System

The Primary Flight Control System, consisting of 2 Ailerons, 2 Elevators and a Rudder, moves the airplane about its three axes, Longitudinal, Lateral and Vertical.

The Secondary Flight Controls consisting of 12 Leading Edge Devices, 4 Trailing Edge Flaps, 12 Spoilers/Speedbrakes and Horizontal Stabiliser, make the lift and handling properties of the airplane better.

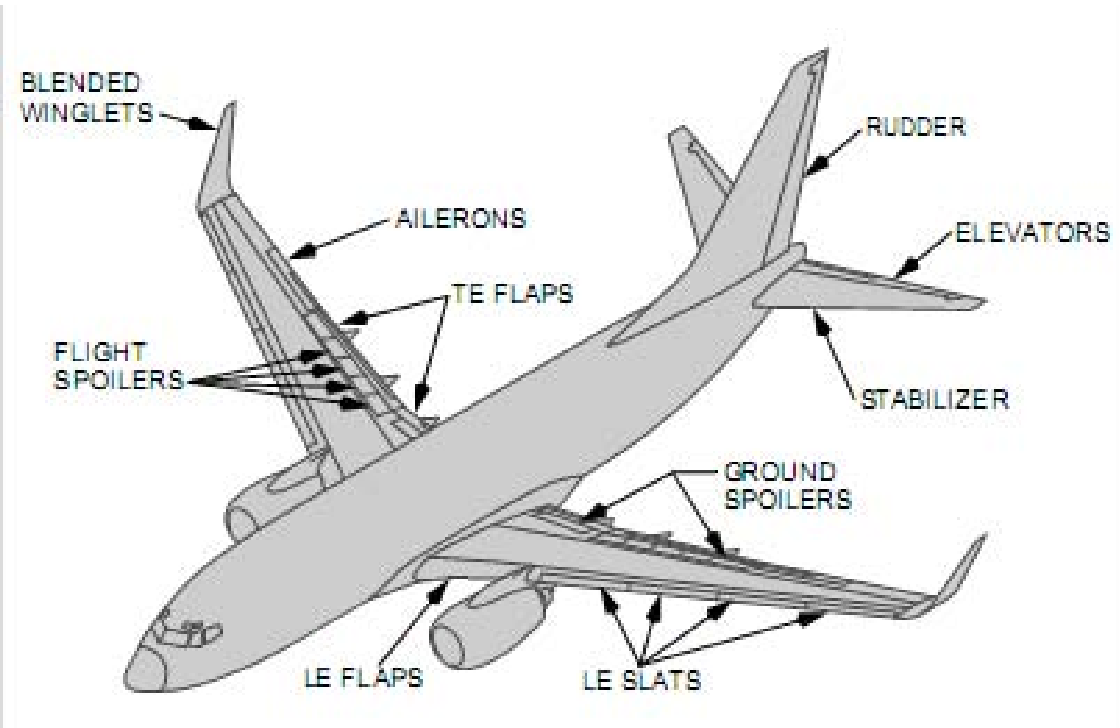


Diagram 4: Flight Control Systems

1.6.13.2 Horizontal Stabiliser

The Horizontal Stabiliser controls the pitch trim of the airplane about the lateral axis. The pilot manually controls position of the Horizontal Stabiliser with Stabiliser trim switches. Also, the pilot can use the Stabiliser trim wheels on each side of the control stand. When the autopilot engages, it controls the position of the Horizontal Stabiliser. During autopilot or manual electric operation, the actuator back drives the Stabiliser trim wheels.

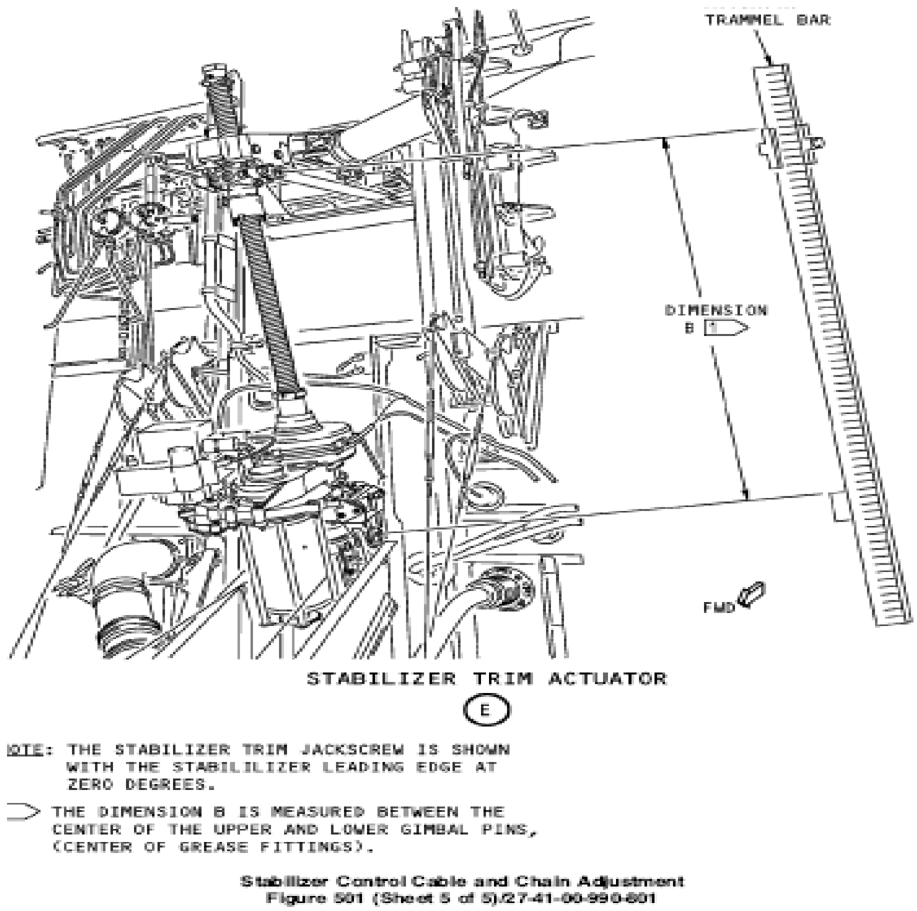


Diagram 5: Horizontal Stabiliser

The Stabiliser trim wheels on the control pedestal move cables that give an input to the gearbox, which in turn moves a jack screw and moves the Stabiliser.

The electric Stabiliser trim switches control an electric motor near the gearbox. The motor moves the gears to move the Stabiliser. The autopilot also controls the Stabiliser trim motor. When the Stabiliser moves, it also moves the elevators to streamline the elevators with the Stabiliser.

1.6.13.3 Trailing Edge Flaps

The Trailing Edge (TE) flaps increase the wing area and the wing camber. This increases lift to help improve the takeoff and landing performance of the airplane. During cruise, the TE flaps fully retract. During landing, the TE flaps extend to increase lift and increase drag to permit slower speeds at touchdown. During the normal operation of the TE flaps, the TE flaps are mechanically controlled and hydraulically operated. During the alternate operation, the TE flaps are electrically controlled and electrically operated. The flap load relief function retracts the TE flaps at high airspeeds to prevent structural damage to the TE flaps and wing structures. The TE flap skew and asymmetry detection functions stop the TE flap hydraulic operation, if the TE flaps are not aligned. The TE flap Un-Commanded Motion (UCM) detection function stops the TE flap hydraulic operation, if the TE flaps move away from their commanded position.

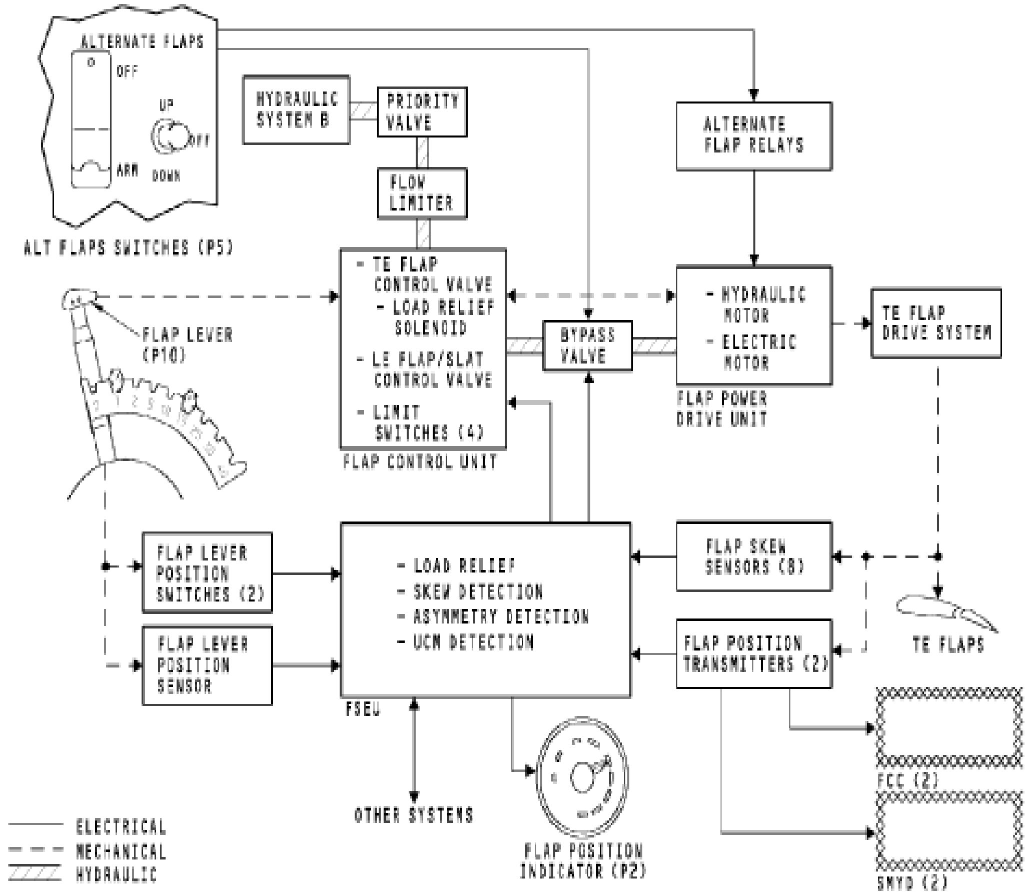


Diagram 6: Trailing Edge Flap System

1.6.13.4 Leading Edge Flaps and Slats

The Leading Edge (LE) flaps and slats increase the wing area and the wing camber. This increases lift to help improve the takeoff and landing performance of the airplane. The LE devices include two Krueger flaps and four slats on the leading edge of each wing. During cruise, these surfaces fully retract. These surfaces extend during takeoff to increase lift, which permits slower speeds for airplane rotation. During landing, the LE slats fully extend to increase lift and help prevent a stall.

During normal operation, the LE flaps and slats are mechanically controlled. During alternate operation, these are electrically controlled. The LE cruise depressurisation function depressurises the LE flap and slat actuators. This occurs when all the LE devices and the flap lever are at the up position and the airplane is in the air. The LE Un-Commanded Motion (UCM) detection function stops the LE normal operation if two or more LE flaps or slats move away from their commanded position. There is a position indication in the flight deck, for all the LE devices during normal operation and alternate operation. During the normal operation, if the airplane comes close to a stall condition, the auto slat function fully extends the LE slats. This helps to prevent a stall.

1.6.13.5 Spoilers and Speedbrakes

The spoilers help the ailerons control airplane roll about the longitudinal axis. They also supply speedbrake control to reduce lift and increase drag during landing and while aborting takeoff. There are six spoilers on each wing. The most outboard and the most inboard spoiler on each wing are ground spoilers and remaining are flight spoilers. During roll control, the flight spoilers on one wing move up and all the other spoilers stay down. The pilots manually control roll with the control wheels. When the autopilot is in 'auto land' mode, the autopilot commands the flight spoilers.

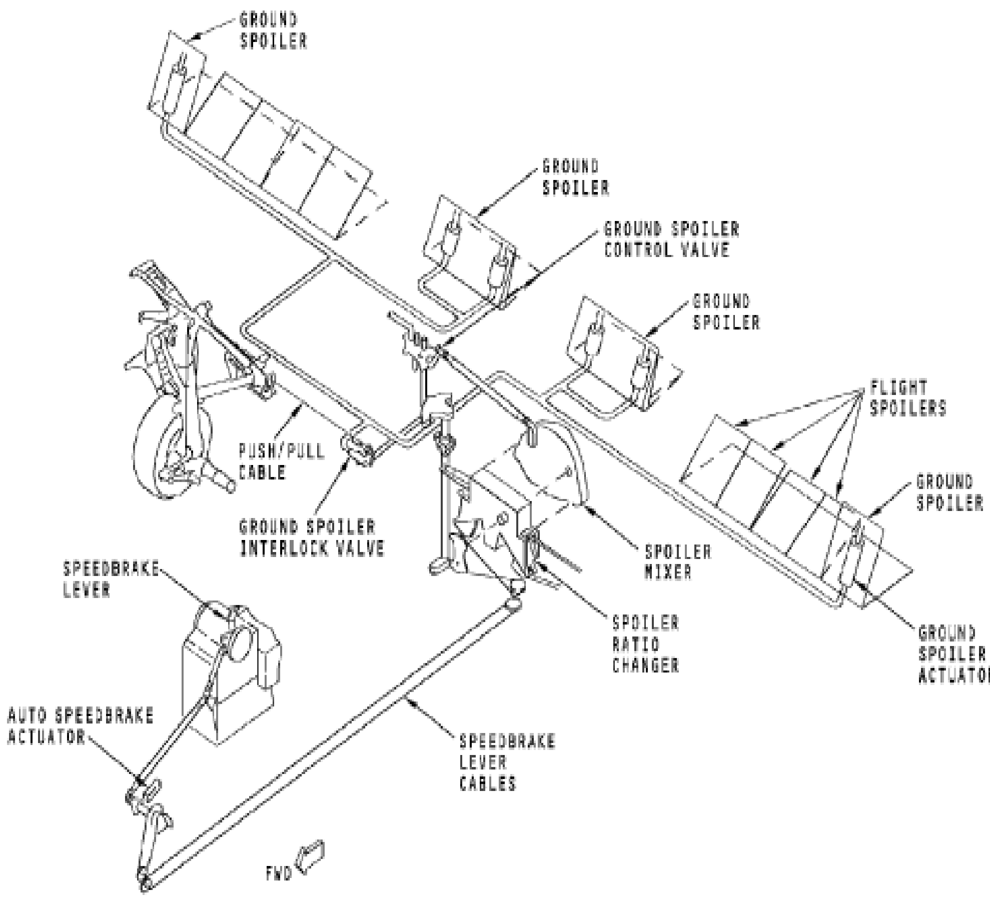


Diagram 7: Speedbrake Control System

During speedbrake control, the spoilers on both wings move symmetrically. The pilots manually command speedbrake control with a speedbrake lever on the aisle stand. The autopilot does not control the speedbrake function.

The auto speedbrake function supplies automatic extension or retraction of all the spoilers during landing and rejected take-off.

1.6.13.6 Brakes and wheels

The hydraulic brake system controls hydraulic pressure to the main landing gear brakes. Brake hydraulic source selection uses the alternate brake selector valve and the accumulator isolation valve to control different pressure sources to supply pressure to these brake functions:-

- Normal brakes
- Alternate brakes
- Accumulator brakes.
- Gear Retract Brakes

The brake pedals control the normal and the alternate brake systems.

Normal Brakes

If hydraulic system 'B' supplies pressure, the normal brake system uses hydraulic system 'B' pressure to operate the brakes.

Alternate Brakes

The alternate brake system uses hydraulic system 'A' pressure to operate the brakes when hydraulic system 'B' does not supply pressure.

Accumulator Brakes

When the hydraulic systems 'A' and 'B' do not supply the required pressure, the brake accumulator supplies the same, to the normal brake system.

Gear Retract Brakes

During landing gear retraction, the alternate brake system gets pressure to operate the brakes. This stops wheel rotation before the landing gear retracts.

Brake Pedal Mechanism

The brake pedal mechanism sends brake pedal inputs to the brake metering valves to manually control brake metered pressure.

Two sets of brake pedals operate the brake pedal bus mechanism. Pedal movement goes through vertical control rods to the lower bell cranks. These bell cranks connect to brake pedal bus crank assemblies and cable quadrants with fore-aft control rods. Input to the left cable quadrant, controls the left brakes with brake cables on the left side of the airplane. The right cable quadrant and cables are on the right side of the airplane and operate the same as the left.

Transverse control rods connect the left and right brake pedal bus crank assemblies. This permits control of the left and right brakes with the Captain or the First Officer pedals.

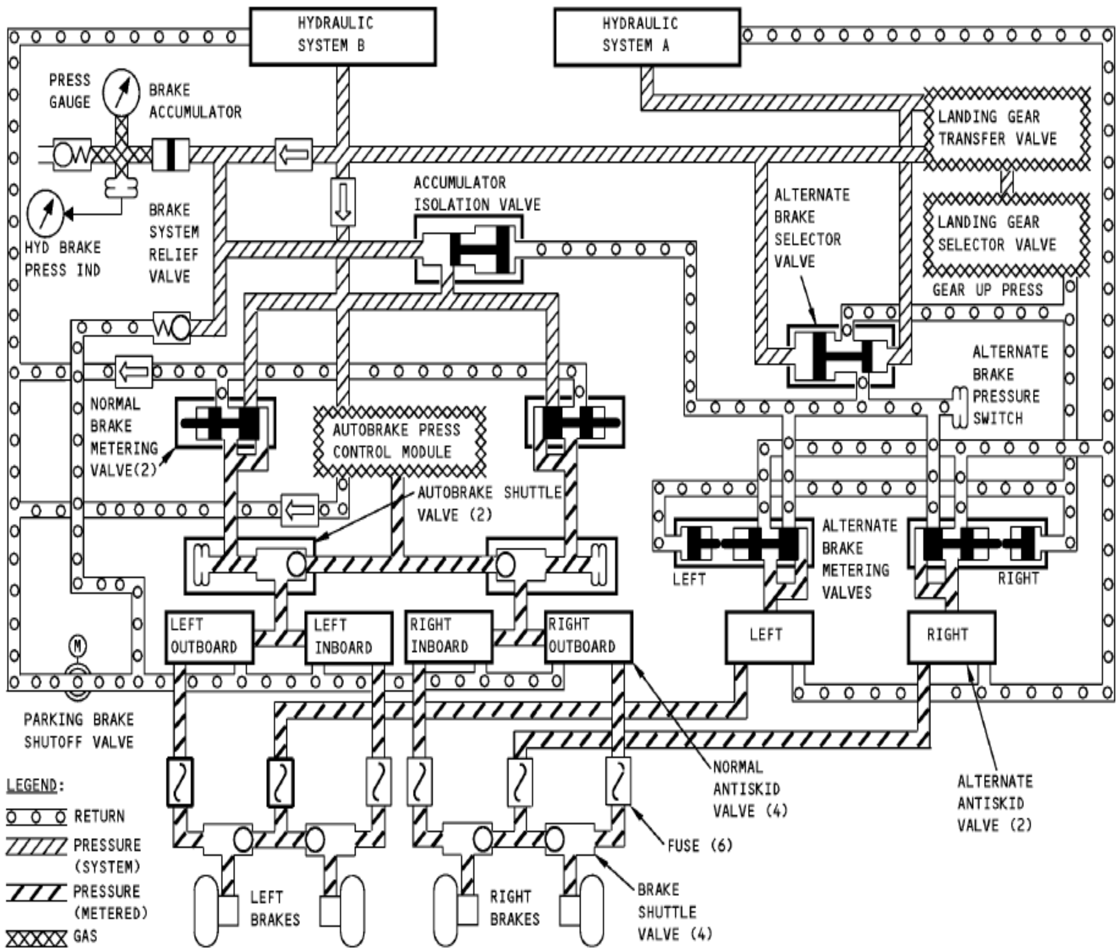


Diagram 8: Gear Retract Brake System

Auto brake System

The auto brake system monitors wheel deceleration and controls metered pressure on touchdown to maintain the value selected by the pilot on the AUTO BRAKE select switch, until the airplane comes to a full stop. Following are the auto-brake functions:-

- 1, 2, 3, and MAX deceleration positions command the auto-brake system during landing brake control to modulate brake pressure until the airplane is at a full stop

- Rejected Take Off (RTO) position commands the auto-brake system to apply full pressure to the wheel brakes and stop the airplane. The auto-brake system operates in RTO when the pilot starts a rejected takeoff at groundspeed more than 88 knots.

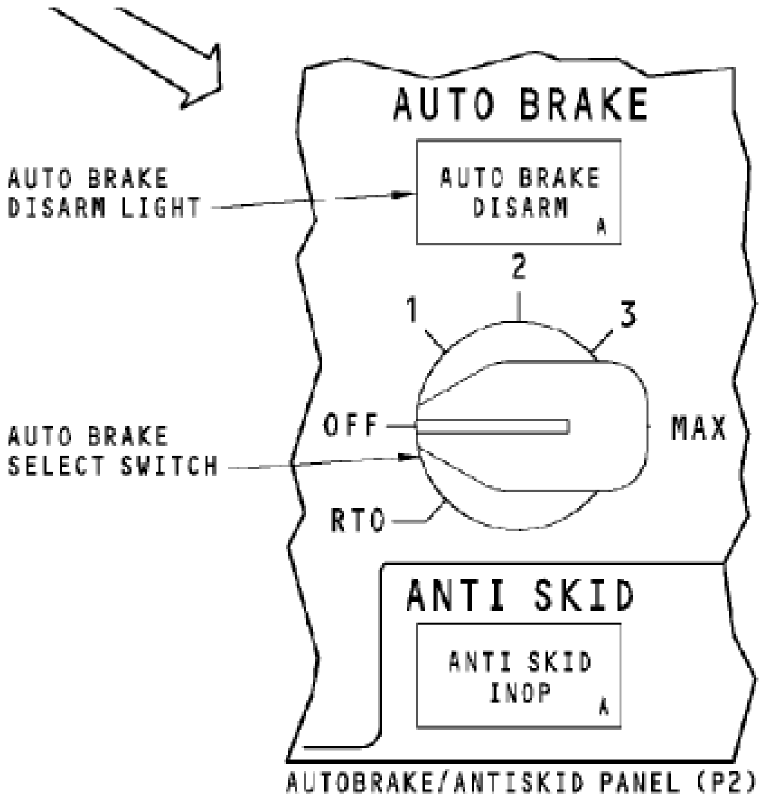


Diagram 9: Auto Brake System

1.6.13.7 Engine Thrust Reverser System

The Thrust Reverser (T/R) system changes the direction of the fan air exhaust to help decrease the speed of the airplane after landing or during RTO.

The T/R system has two thrust reversers. T/R 1 is for Left Engine and T/R 2 is for the Right Engine.

Each T/R has a left and right half. Each half has a translating sleeve, which moves aft for reverse thrust. The sleeves work at the same time, but are independent from each other. Three hydraulic actuators move each sleeve. Rotary flex shafts make sure that the hydraulic actuators extend and retract at the same rate. Each T/R has Linear Variable Driven Transducer (LVDT), which supplies translating sleeve position data to the Electronic Engine Control (EEC).

The T/R control system uses hydraulic actuators to move the translating sleeves. The sleeves move aft during deploy operation.

1.6.13.8 Instrument Landing System

The Multi-Mode Receiver (MMR) contains the Instrument Landing System (ILS) and the Global Positioning System (GPS). The ILS provides lateral and vertical position data necessary to align the airplane on the runway for approach. The system uses signals from Glide Slope ground station and Localiser ground station. The Glide Slope ground station transmits signals to give the airplane a descent path to the touchdown point on the runway. The Localiser ground station transmits signals to give the airplane lateral guidance to the runway centre line. The receivers get manual tune inputs from the navigation (NAV) control panels.

The VOR/LOC antenna and the localiser antenna send localiser signals through the localiser antenna switches to the MMR. The localiser antenna switches select the VOR/LOC antenna or the localiser antenna as the source of Radio Frequency (RF) input to the MMR. The glide slope antenna sends glide slope signals to MMR.

1.6.13.9 Radio Altimeter System

The Radio Altimeter system has two Receiver/Transmitters (Rx/Tx). Each Rx/Tx has a receiver and a transmitter antenna. The radio altimeter Rx/Tx makes a frequency modulated continuous wave RF signal which is sent to the ground and reflected back to the airplane. The time that it takes for the signal to travel from the transmit circuit of the Rx/Tx to the receive circuit of the Rx/Tx is changed into absolute altitude. The number one system altitude shows on the Captain’s Display and the number two system shows on the First Officer’s display. The altitude data and signal validity is sent on two ARINC 429 data buses.

The Rx/Tx get discrete inputs from the Proximity Switch Electronics Unit (PSEU) used to count flight legs for fault recording.

1.6.13.10 Enhanced Ground Proximity Warning System

The Enhanced Ground Proximity Warning System (EGPWS) alerts the flight crew of an unsafe condition when the airplane is near the terrain. It also supplies a warning for wind shear conditions.

The EGPWS uses GPS and disk loadable software databases to give the flight crew improved terrain awareness. This is done by the display of detailed terrain information for the area around the aircraft. The EGPWS also warns the flight crew of an early descent.

The EGPWS gives the pilots aural and visual warnings of unsafe conditions. The warnings continue until the pilots correct the condition. The system operates when the airplane is less than 2450 feet above the ground.

The EGPWS function contains a worldwide terrain database. The Ground Proximity Warning Computer (GPWC) compares airplane position and track with this database to find if there is a warning condition. This is the terrain awareness function. The EGPWS also contains an airport database. This database contains terrain information for all hard surface runways that are more than 3500 feet or longer. The GPWC compares airplane position and runway location to find if there is a warning condition. This is the Terrain Clearance Floor (TCF) function.

EGPWS Modes

Following are the modes of EGPWS:-

- Mode 1 - Large descent rates
- Mode 2 - Too much of a closure rate when approaching terrain that is rising
- Mode 3 - Too much altitude loss during climb-out (at takeoff or in go around) when the airplane is not in the landing configuration
- Mode 4 - Not enough terrain clearance
- Mode 5 - Too much deviation below the glide slope
- Mode 6 - Aural callouts when the airplane descends through selected radio altitudes
- Mode 7 - Warning for wind shear conditions.
- In addition to the EGPWS modes 1 through 7, following two additional functions are used:-

  i) Terrain Clearance Floor - early descent on approach
  ii) Terrain Awareness - display of terrain around the airplane.

Mode 1 alert and warning conditions can occur between 2450 feet and 10 feet of radio altitude. The type of annunciation depends on the rate of descent and the radio altitude. The first annunciation is a caution. If the rate of descent does not decrease, the annunciation changes to a warning. The LRU that supply inputs for mode 1 operation are the radio altimeter trans-ceivers and the left and right Air Data Inertial Reference Unit (ADIRU).

The mode detector in the GPWC calculates the descent rate from the Inertial Vertical Speed (IVS) input. If it is not available, the mode detector uses an internally calculated altitude rate. If the IVS and the internally calculated rates are invalid, the barometric altitude rate from the ADIRU is used. When the GPWC uses barometric altitude rate, the lower altitude cut off changes from 10 feet to 30 feet. When there is a caution or warning condition, the mode detector sends a discrete signal to the speech prom to make the aural messages come on. The aural messages go to the Remote Electronics Unit (REU), which sends them to the flight compartment speakers.

Mode 2 supplies alerts and warnings when the closure rate to the terrain is too large. Mode 2 has two sub modes, mode 2A and mode 2B. Mode 2A occurs for a large closure rate if the flaps are not in the landing configuration and glide slope deviation is more than 2 dots. Flaps 30 or more is a landing configuration. Mode 2A can have two alert levels, a caution condition or a warning condition. If the terrain closure is too large, the EGPWS gives the TERRAIN aural caution message twice and PULL UP shows on the Primary Flight Display (PFD).

If the condition is not corrected, the caution aural message changes to the warning PULL UP message and PULL UP continues to show on the PFD. When the mode 2A envelope is no longer active due to either a terrain drop off or a pull up manoeuvre by the flight crew, the altitude gain function operates. PULL UP continues to show on the PFD until the altitude increases 300 feet or 45 seconds have elapsed. If there is still a terrain closure rate during this period, however, the EGPWS also gives the TERRAIN aural caution message. After a 300 feet increase in inertial altitude or when the landing gear comes down, the PULL UP indications on the PFD stop and the aural warnings also goes off.

Mode 2B gives alerts for a large closure rate if the flaps are in the landing configuration (30 units or more). Mode 2B can have a caution condition or a warning condition. If the terrain closure is excessive, the GPWC gives the TERRAIN aural caution message repeatedly. If this condition lasts for more than 1.6 seconds, the GPWC gives the PULL UP aural warning message and a PULL UP annunciation on the PFD.

1.6.13.11 Cockpit Voice Recorder (CVR)

The voice recorder unit makes a continuous record of flight crew communication and flight compartment sounds. It erases the communication data automatically so that the memory stores only recent audio.

The voice recorder unit keeps the last 120 minutes of communication data in memory. The voice recorder unit receives audio from the Remote Electronic Unit (REU) and the area microphone. The area microphone is in the cockpit voice recorder panel. The voice recorder unit receives time from the clock system for reference.

The voice recorder unit collects the audio at the same time from the following:-

- Captain microphone and headphone
- First officer (F/O) microphone and headphone
- Observer (OBS) microphone and headphone
- Area microphone on the cockpit voice recorder panel

The inputs from the captain, first officer, and observer microphones go to the REU. The REU mixes each station microphone audio with that station headphone audio. The REU then increases the audio signal and sends it to the voice recorder. The area microphone collects flight compartment sounds, such as voices and aural warnings.

1.6.13.12 Flight Data Recorder System (DFDRS)

Flight Data Recorder (DFDR) stores airplane parameters and system data for a minimum of last 25 hours of operation. DFDR protects the parameters and the system data. If there is an airplane incident, these parameters supply data on flight conditions and airplane systems operation. Airline personnel can also use the data to make an analysis of system performance during airplane maintenance.

The DFDRS gets and stores airplane parameters from airplane systems and sensors. The DFDR keeps this data for use during a flight mishap investigation. The DFDR protects the data from heat and water. The DFDR records parameters that are necessary for regulatory agencies.

ACMS data from the Flight Data Acquisition Unit (FDAU) goes through the data loader control panel to a data loader. The data loader can store data from the FDAU on a disk. The data loader control panel switch lets one select the transfer of ACMS data. One can transfer software from a disk in the data loader to the FDAU through the data loader control panel.

The Control Display Unit (CDU) controls the ACMS functions in the FDAU. The DFDRS operates automatically when one of the engines is in operation or the airplane is in the air. It also operates on the ground when the TEST/NORMAL switch on the flight recorder test module is in the TEST position. The flight recorder test module shows the condition of the flight recorder system. If there is a system fault, amber OFF light comes on. The OFF light also comes on when the system switched OFF.

1.7 Meteorological Information

The Mangalore Airport is situated on the western coast of India. It is thus subjected to active South West monsoon conditions, normally between June-September every year. In the month of May, generally pre-monsoon weather prevails with clouds and occasional thunder showers. The airport is situated on a tabletop plateau with surrounding undulating terrain and valleys. Therefore Mangalore also witnesses phenomena like mist and low clouds at the edge of the airfield. However, in periods other than the SW monsoon, the weather is generally fair to fine with good visibility.

1.7.1 Area Weather Information

Airport Meteorological Office (AMO), Bangalore provides the Area Weather Forecast and Terminal Aerodrome Forecast (TAF). This is valid for a period of 6 hours interval.

On 21st May 2010 at 23:30 hours IST, AMO, Bangalore had issued Area Forecast for Mangalore Airport and 100 nm around, valid from 05:30 hours IST to 11:30 hours IST on 22nd May 2010. The forecast was as follows: -

- Surface wind 290 /10 kt.

- Upper winds in knots and temperature in degree Celsius as follows:-

16000M	110/50	-80
13500M	110/50	-65
12000M	140/30	-50
10500M	160/20	-37
09000M	160/10	-27
07500M	090/05	-13
06000M	000/00	-03
4500M	050/05	+04
3000M	360/05	+13
2100M	340/20	+17
1500M	290/10	+20
0900M	320/10	+23
0600M	300/10	+25
0300M	290/10	+27

The area forecast was as follows:

- Weather : TEMPO Hz; MOD TURB AND ICING IN CB
- Visibility : 6 KM; TEMPO
- Clouds : FEW SC 450/600 M SCT CU 600/750M
- Freezing level : 5200 M
- Additional Notes : MOD TURB AND ICING IN CB
- Warning : Visibility likely to reduce to 5000M in Haze
- QNH : 1006 hPa
- Temp : 27 degree
- Dew point : 26 degree

1.7.2 Mangalore Airport Weather Information

India Meteorological Department (IMD) has set up an Aeronautical Meteorological Station (AMS) at Mangalore Airport to provide the following meteorological services:-

- Current weather observation on 24 hour basis
- Spot weather observations during monsoon period
- Area forecast issued by AMO, Bangalore
- Route Forecast (ROFORS) issued by AMO, Bangalore, on demand

The Meteorological office at Mangalore works on 24 hours basis. Due to space constraints in the ATC Control Tower, the Met Office continues to function from the old ATC building.

The Met Office provides forecast for any significant weather arising locally and METAR every 30 minutes. The Mangalore Met office had issued METAR at 05:30 hours IST on 22nd May 2010.

When the aircraft came in contact with Mangalore Area at 05:36 hours IST, the First Officer was given the following weather information from METAR of 05:30 hours:-

"Winds - Calm, Visibility - 6km, Cloud - Few 2000 ft, Temperature - 27^{o}, Dew Point - 26, QNH - 1006 hPa"

At 06:04:19 hours IST when the aircraft was given landing clearance for R/W 24 by ATC, Mangalore, the winds were reported to be calm.

The Sunrise on 22nd May 2010 was at 06:03 hours IST.

1.8 Aids to Navigation and Landing

1.8.1 Multi Mode Secondary Surveillance Radar (MSSR)

The MSSR is manufactured by BEL Bangalore in collaboration with Northrop Grumman. The significant details are as follows: -

- Model No. : NGOSCO
- Date of Commission : 30th January 2004

The serviceability of MSSR during the period from Jan to May 2010 was 97.28%. However, the Radar had become unserviceable on 20th May 2010 and continued to be unavailable during the period of accident.

1.8.2 Non Directional Beacon (NDB)

The NDB is manufactured by SAC. The significant details are as follows: -

- Model No. : SAC500/30075xx040019
- Date of Commission : 18th August 2004

The serviceability of NDB during the period from Jan to May 2010 was 100%.

1.8.3 Doppler Very High Frequency Omni Range (DVOR)

The DVOR is manufactured by ASII. The significant details are as follows:-

- Model No. : 1150 / 41627(Rev) U
- Date of Commission : 12th December 2003
- Date of last Air Calibration : 8th September 2009

The serviceability of DVOR during the period from Jan to May 2010 was 100%

1.8.4 Distance Measuring Equipment (DME)

The DME is manufactured by GCEL. The significant details are as follows: -

- Model No. : 752 / 908466
- Date of Commission : 12th September 1991
- Date of last Air Calibration : 8th September 2009

The serviceability of DME during the period from Jan to May 2010 was 100%

1.8.5 Instrument Landing System (ILS)

The Localiser and the Glide Path of ILS system are manufactured by NORMARC. The significant details are as follows: -

Localiser

- Model No. : NM 3513B (Two Frequency)/ 278
- Date of Commission : 8th September 2006 for R/W 24
- Date of last Air Calibration : 14th May 2010

Glide Path

- Model No. : NM 3533B (Two Frequency)/
- Date of Commission : 8th September 2006 for R/W 24
- Date of last Air Calibration : 14th May 2010

ILS DME

The ILS DME co-located with Glide Path is manufactured by ASII and the significant details are follows: -

- Model No. : 1118
- Date of Commission : 8th September 2006 for R/W 24
- Date of last Air Calibration : 14th May 2010

The serviceability of ILS during the period from Jan to May 2010 was 100%.

1.8.6 State of Navigation and Landing Aids on 22nd May 2010

The MSSR Radar was unserviceable from 20th May 2010 for which a NOTAM had been issued by AAI. The un-serviceability was due to shearing-off of the Antenna Rotary Joint. While the radar has built-in redundancy of an alternate rack to keep it serviceable, only first line spares are held at Mangalore to cater to minor technical breakdowns. Spare Antenna Rotary Joint had to be transported from Delhi resulting into delay of making the radar serviceable till 24th May 2010.

Both ILS and VOR/DME were serviceable. The air calibration of ILS was last carried out on 14th May 2010 wherein Precision Approach Path Indicator (PAPI) was found compatible with the Glide path. Regular ground maintenance calibration check of PAPI was last carried out on 18th May 2010 and no abnormality was found.

There was no abnormality reported by crew of other flights regarding the Navigational aids.

After the accident, the ILS was recalibrated on 16th Jun 2010 since the localiser antenna was damaged during the air crash.

1.9 Communication

The aircraft remained in communication with Mangalore ATC till the crash, from the time it first came in contact with the Mangalore Area control on frequency 127.55 MHz at 05:32:45 hours IST. The aircraft was then cruising at FL-370 approaching Reporting Point IGAMA. Later on, it contacted the ATC Tower on VHF frequency 122.1 MHz.

No communication problems were reported between the Flight Crew and the Air Traffic Control throughout, from its initial contact till the time of accident. From the ATC tape and CVR, it was apparent that the crew faced no difficulty during the flight, to contact ATC, Mangalore.

1.10 Mangalore Airport Information

Till 2006, Mangalore Airport had a tabletop runway 27/09 with a length of only 1625 metres. This short runway restricted the type of aircraft operations. In view of incidents of overshooting the runway at Jaipur and Port Blair by Boeing 737-200 aircraft, it was decided to extend the runways at both these airports and at Mangalore. A new runway with orientation of 24/06 was constructed in the available land adjacent to the existing runway. The length of new runway is 2450 metres, which facilitates operations by aircraft such as Boeing 737-800 and Airbus 320. The new runway 24/06 provides night landing facilities and an ILS Cat-I from the earlier offset ILS. The Rescue and Fire Fighting Services were upgraded to category 7.

Mangalore Airport has Latitude 12º 57’ 43.40” N and Longitude 074º53’ 23.20” E with elevation of 101.629 metres above mean sea level. Runway 24/06 has a concrete surface with dimensions 2450 x 46 metres, elevation 103.07 metres and PCN 54/R/B/X/T. It is provided with runway strip of 75 metres of width on either side of runway centreline. At the time of accident, RESA of 90 metres x 90 metres was provided at the end of runway strip 24.

1.10.1 Licensing of Mangalore Airport

Licensing of all Airports in India is governed by Civil Aviation Requirement (CAR), Section-4, Series-F, Part-I, dated 16th Oct 2006 issued by DGCA. On submission of required documents by AAI on 01st Nov 2006, the Mangalore airport was inspected by DGCA from 31st Jul to 03rd Aug 2007. As per procedure, License No AL/Public/023 was issued by DGCA under Rule 78 of the Aircraft Rules, 1937 on 16th December 2009 to AAI for a period of six months initially on provisional basis from 16th December 2009 to 15th June 2010. At the time of accident, Mangalore airport had a valid licence. Surveillance Inspection was also carried out by DGCA two days before the accident.

While Action Taken Report enumerating the follow-up on a number of observations by the DGCA was completed, AAI had filed for extension of license on 6th May 2010 seeking exemption on four points including the width of the Strip. In response, DGCA had directed AAI to submit Risk Assessment Analysis done by expert group so as to consider a permanent waiver.

1.10.2 Runway 24/06 Safety Areas

The salient features of the Mangalore airport safety areas are as follows:-

- Runway Strip Length : 2570 metre
- Runway Strip Width : 75 metre as against 150 metre on either side of runway centreline. A permanent exemption has been sought due to deep valleys on either side of the runway strip.
- Length of Runway 24/06 : 2450 metre
- Width of Runway 24/06 : 46 metre
- Location of Threshold for R/W 24/06 : Immediately at the beginning of R/W
- Runway End Safety Area (RESA) : 180mx90m at the time of accident Later decreased to 90mx90m

Runway 24 declared distances are as under:-

- Take off Run Available (TORA) : 2450m
- Take off Distance Available (TODA) : 2450m
- Acceleration Stop Distance Available (ASDA) : 2450m
- Landing Distance Available (LDA) : 2450m

Runway Longitudinal Slope for R/W 24 is as under:-

- From 0 m to 565m : + 0.46%
- From 564m to 1105m : - 0.56%
- From 1104 to 2450m : 0%

At the time of accident, at the end of R/W 24 after the length of 2450 metres, there was 60 metres of Basic Strip followed by RESA of 180m (now reduced to 175m). After end of runway at 237m within RESA, a concrete structure had been constructed on which the ILS Localiser Antenna is mounted. This entire area is on a downward slope from the end of R/W 24.

The non-frangible ILS mounting was not considered to be an obstacle since it was on a downward slope and not above the permissible height within the take-off or approach funnel.

1.10.3 Runway 24/06 Lighting Information

The Mangalore airport is equipped with night landing facilities. Runway 24/06 has been provided with truncated Simple Approach Lighting System on both sides.

The Airport also has a standard PAPI fitment for both runways 24/06, set at 3 degree and was calibrated on 14th May 2010 along with air calibration of ILS.

1.10.4 Runway 24 ILS System

Runway 24 has been provided with ILS Cat-I. Its Glide Path is set at 3 degree. It was air calibrated just prior to the accident on 14th May 2010.

The ILS and DME equipment have built-in automatic monitoring system, which continuously monitors the performance of the equipment using redundant integral and near field monitors. In case of any deviations of operational parameters from the specified limits by ICAO, the monitors shut down the operating mode and transfer to the stand-by mode.

1.10.5 Location of Air Traffic Control Tower

Prior to the construction of new Runway 24/06, a centrally located ATC Tower for Runway 27/09 existed. However, this location was found to be unsuitable for controlling flying and surface operations for the new Runway 24/06. Since, the earlier parking bays and old terminal building continued to be used, a semi permanent ATC Tower was built close to dumbbell 24. This temporary tower, however, has limited view of the end of Runway 24/06 and also of the new terminal building and parking bays, which has been made operational in the first week of August 2010, after the accident.

1.10.6 Facilities in the ATC Tower

The ATC Tower is fitted with standard communication facilities with remote controls for runway lightings, including PAPI. The Tower does not have an Approach Radar and is also not fitted with a Repeater of the Area Radar (MSSR).

This temporarily constructed ATC Tower has constraints of space. As such, the Meteorological officer finds it difficult to get a 360 degree view for reporting visibility, as well as any local weather phenomena.

As per AAI, considering the low density of air traffic at Mangalore, provision of Approach Radar is not considered cost effective. The controllers at Mangalore however, did express such a need especially in view of the surrounding terrain, which adds to the criticality of this airfield. Provision of at least a repeater of the Area Radar (MSSR) in the ATC Tower would add to the situational awareness of the controllers.

1.10.7 ATC Watch Hours

The Mangalore Area Control works on 24 hours basis with controllers working on shift duties. While this Area Control is provided with a Radar (MSSR), in case of un-serviceability, it continues to provide procedural control on 24 hour basis. The night shift consists of 8 controllers with one of them designated as Watch Supervisory Officer (WSO).

The watch hours for Mangalore ATC Tower were from 06:00 hours to 22:00 hours at the time of accident. The Rescue and Fire Fighting (RFF) Crew reported at 05:30 hours to be ready for operations from the designated watch hours at 06:00 hours.

Two controllers, who are part of the night shift, are detailed to man the ATC Tower. As per the procedure, one of these controllers goes for runway inspection leaving the Area Control at about 05:40 hours. Meanwhile, an ATC Traffic Hand opens the ATC Tower. On completion of runway inspection, the ATC controller reaches the Tower about 5-7 minutes before the official watch hours i.e. 06:00 hours.

Mangalore airport starts the morning watch hours from 06:00 hours mainly to cater to the scheduled arrival of Air India Express flight IX-812. The flight is scheduled to arrive at 06:30 hours daily. However, invariably the flight arrives just past 06:00 hours due to either early departure from Dubai or due to tail winds during flight. Since the Area Control is aware of this movement, sending two controllers from the night shift to give 'landing clearance' becomes very convenient. However, such procedure does not cater to an unscheduled movement such as diversion to Mangalore in emergency.

1.10.8 Manning of ATC Controllers and Training

At the time of accident, Mangalore airport had a total of 29 ATC controllers who worked in three shifts every day. Depending on their training and categorisation, the controllers were assigned duties on the Area Control and the ATC Tower. One senior controller amongst the shift was assigned the duties of Watch Supervisor Officer (WSO). Normally, there were eight controllers in each shift; two of them manned the ATC Tower. As per laid down procedure, periodic training was being carried out for all the controllers locally.

1.10.9 ATC Tape Recorder

The ATC Tape Recorder system being used at Mangalore airport is a Digital Voice Tape Recorder (DVTR). It has facilities to programme and record various R/T Channels as well as Telephone and intercom conversation along with time of recording. The basic details of DVTR are given below:-

S N	Description	Details
1.	Make	Ricochet AS, Norway
2.	Model	64 channel, Dual
3.	Date of installation	18.10.2007
4.	Date of commissioning	25.01.2008
5.	Major breakdowns since commissioning	NIL
6.	Maintenance	In house
7.	Type of check being carried out	Daily DVTR Recording Check
8.	Number of channels available on equipment	64
9.	Number of channels being used currently	38

1.10.10 Runway Markings and Friction

At the time of accident, the runway marking for R/W 24/06 at Mangalore conformed to CAR, Section-4, Series-B, Part-I dated 31.07.2006 issued by DGCA and ICAO Annexure - 14.

The condition of runway surface at the time of accident was dry and not contaminated. There were no significant rubber deposits in the touchdown zone. However, the accident aircraft had finally touched down at about 5200 ft from the beginning of R/W 24, which corresponds to touchdown zone of R/W 06. This area, where the accident aircraft had touched down, was also devoid of reverted rubber deposits.

Considering the number of flight movements, the policy requires testing of friction values once a year. The previous friction test using Airport Surface Friction Tester (ASFT) vehicle was carried out on 27th December 2008. As per these test results, the friction values were 0.64 mµ to 0.66 mµ. However, similar test was not carried out prior to the accident, for the preceding one and half years.

The runway friction values had been evaluated soon after the accident; on 5th June 2010 in accordance with DARA Circular No. 6 of 2006 of AAI and ASFT Mark IV SAAB 9000 equipment was deployed using both the smooth and ribbed tyres. The values obtained were in the range of 0.78 mµ to 0.91 mµ, which were much higher than the minimum required 0.40 mµ.

1.10.11 Rescue and Fire Fighting (RFF) Capability at Mangalore Airport

At the time of accident, Mangalore airport maintained Rescue and Fire Fighting Capability at level - 7 as laid down in CAR, Section-4, Series-B, and Part-I, dated 31st July 2006. There were a total of 6 RFF vehicles, 4 of which were Rosenbauer, re- christened as Panther 1 to 4 and 2 TATRA vehicles known as Agni Shatru and Agni Vijay. There were 3 ambulances as part of the team.

The 4 Rosenbauer were procured centrally by AAI. These new RFF vehicles are heavy, but have a good capability of Rescue and Fire Fighting within the airfield. Considering the surrounding terrain of the Table Top runway at Mangalore, no terrain specific tests were conducted prior to their allotment to Mangalore Airport. As such, when these RFF vehicles were taken outside the airport, difficulty was experienced while negotiating the narrow and curving roads. These vehicles had not been registered with Regional Transport Authority at the time of accident. The RFF manpower was 31 and was well trained.

It was given to understand that the responsibility of Rescue and Fire Fighting operations outside the Mangalore Airport area lies with the civil administration. However, within 5 km of the airport especially in view of an accident on overshoot or undershoot area, the RFF for the airport needed to be deployed at the earliest to carry out RFF operations.

As per the Airport Director, Mangalore, yearly exercises involving civil administration had been carried out for an aircraft emergency within the airfield. However, a full-scale simulation for outside the perimeter had not been carried out. Only a Table Top exercise had been carried out to assign responsibilities and for preparing an emergency telephone list of various authorities.

Full emergency exercise was carried out in December 2007 inside the airport. Partial mock up exercise was carried out on 19th April 2010. The last fire drill was carried out on 7th May 2010 and the last Airport Environmental Management Committee meeting was held on 17th February 2010.

1.10.12 Rescue and Fire Fighting Carried Out On 22nd May 2010

After the accident, ‘Panther 1’ reached the localiser area in about 30 seconds. Thereafter, it extinguished the aircraft parts, which were on fire, and lying close to the airport fence. However, the aircraft had gone down the slope and came to a halt in the gorge about 500 metres from the fence.

As per the discussion at Mangalore airport as well as with AAI, the jurisdiction of Mangalore RFF was to attend to contingencies within the airport. However, on the day of accident, Mangalore Airport RFF was the first to reach the crash site. Since the Rosenbaur RFF vehicle was unable to negotiate the narrow roads, TATRA RFF reached the sites within 4-5 minutes.

Photo 3: Rescue and Fire Fighting at the Crash Site

Although they reached as quickly as possible, the aircraft had already suffered major impact and a dense fire and smoke had engulfed the aircraft. Most of the other RFF crew, who were off duty and at residences near by, also rushed to the crash site with all available RFF vehicles and ambulances. With great motivation and involvement, the fire was partly brought under control by the AAI staff in the next 30-40 minutes by which time the Civil Fire Tenders had also joined fire fighting at the crash site. The entire fire could only be brought under control in about 2 hours.

Cutting trees to approach the crash site took some time, which hindered the rescue operations. Other than 8 survivors who had jumped out of the aircraft, the crew and passengers had already died due to impact injuries, suffocation and fire, by the time the RFF personnel could reach the occupants.

1.11 Flight Recorders

The aircraft was fitted with solid state CVR and DFDR. The CVR in damaged condition was retrieved from the accident site on 23rd May 2010. The Memory Unit of DFDR was found in damaged condition and was retrieved on 25th May 2010.

While Air India has facilities for decoding the Flight Recorders, it was not possible to do so, since the recorders were damaged during the accident. The Flight Recorders had suffered severe damage and the outer casings had been burnt due to excessive heat during the aircraft crash and the post impact fire. The Court therefore took the recorders to the NTSB, USA where they were successfully repaired and decoded so that these could be once again read at the laboratory of DGCA, New Delhi.

1.11.1 Downloading of DFDR Data of the Accident Aircraft

The salient features of DFDR fitted in the accident aircraft are as follows:-

- Manufactured by : L-3 Communications Fairchild USA
- Manufacturer Part No : 2100-4043-00
- Serial No. : 00297819

The DFDR of accident aircraft was recovered from the crash site after 3 days i.e. on 25th May 2010. The DFDR had sustained substantial damage due to impact and post impact fire. The DFDR had broken into two pieces, one piece contained the Crash Survivable Memory Unit (CSMU) and other containing the connector as shown in the photograph below:-

Photo 4: Digital Flight Data Recorder (In Damaged Condition)

1.11.2 Downloading of CVR Data of the Accident Aircraft

The salient features of CVR fitted in the accident aircraft are as follows:-

- Manufactured by : Honeywell
- Manufacturer Part No : 980-6022-001
- Serial No : 120-12117

The solid-state CVR fitted on the accident aircraft was recovered from the crash site next day i.e. on 23rd May 2010.

The CVR had sustained significant heat and fire damage to the exterior as shown below:-

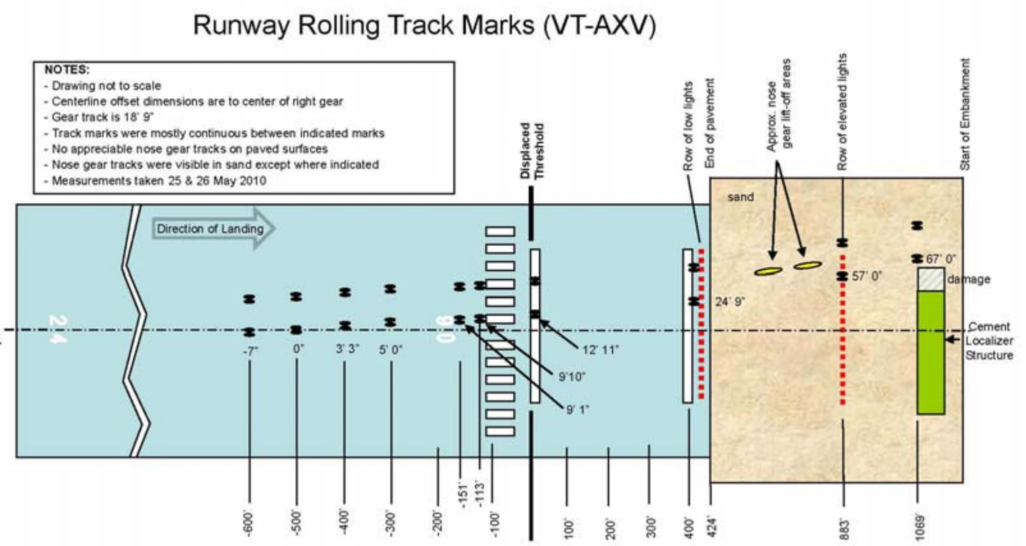
Photo 5: Connector of the CVR Damaged Due to Fire

Photo 6: Damaged CVR Recovered From the Crash Site

1.12 Wreckage and Impact Information

1.12.1 General Wreckage Distribution

Aircraft was cleared for the ILS approach Runway 24. As per the Fire personnel positioned at the Pre Determined Point (PDP) (Coordinates: 12˚ 57.376' N; 74˚ 53.366' E; 777 metres. from the beginning of R/W 24; height of the vehicle including surface elevation: 12 metres), the height of the approaching aircraft was above the height of the fire vehicle. Tyre marks for about 22 metres were observed in the area where aircraft had finally touched down, approximately 5200 ft from beginning of R/W 24, way ahead of the normal touchdown zone. The aircraft had veered off towards left of the centreline as shown below:-



(Source: NTSB, USA)

Diagram 10: Approximate Path Followed By the Accident Aircraft

Thereafter, aircraft broke two runway edge lights towards the left of landing run (1st and third on left of centre line viewing from R/W 24). Then the aircraft overran the R/W 24 end and entered the Runway End Safety Area (RESA). It further broke five approach lights for R/W 06, in the RESA. In the RESA, wheel marks of all the three landing gears indicated that the aircraft was gradually turning towards the left. This is indicated in a rough Diagram 10, placed above.

Photo 7: End of Runway 24 (Far View)

Photo 8: End of Runway 24 (Another View)

At a distance of 235 metres from R/W 24 end, the ILS localiser antenna had been mounted on a concrete structure. The out board portion of the right wing impacted this localiser mounting structure and got separated. The Right wing contacted two left pillars and the extreme left pillar collapsed. The second pillar from left, showed impact damage about 10 feet above ground. Outer portion of the right wing (WBL 616.75 to WBL 680.40) consisting of winglets was recovered at the localiser structure.

Photo 9: Broken ILS Mounting Structure Due to Impact of Wing

Photo 10: Broken Wing of Aircraft after Impacting the ILS Mounting Structure

The aircraft then impacted the boundary fence and a portion of the Right wing (from WBL 71.24 to WBL 616.75) containing T/E Flap number 8, L/E Flaps and Slats, was found lying at the edge of the boundary. There were indications of fire visible in this area on the vegetation where the portion of the wing was found. Mangalore being a tabletop runway, the aircraft moved down along the slope of the hill after impacting the boundary fence. A portion of the Right wing, Right engine, Right main landing gear and few other structural parts separated from the aircraft in this area. Due to impact, component/parts of the Right engine also separated. Right engine fan frame, thrust reverser frame, core engine and associated components were recovered on the slope.

Photo 11: Right Engine lying on the Slope near End of the Airport Fencing

At the end of the initial down-slope, there was a road followed by a gorge. The aircraft entered the gorge and separated into three main portions. The aircraft caught fire and a large portion of the aircraft was consumed in the fire. Due to impact and fire, the aircraft was destroyed.

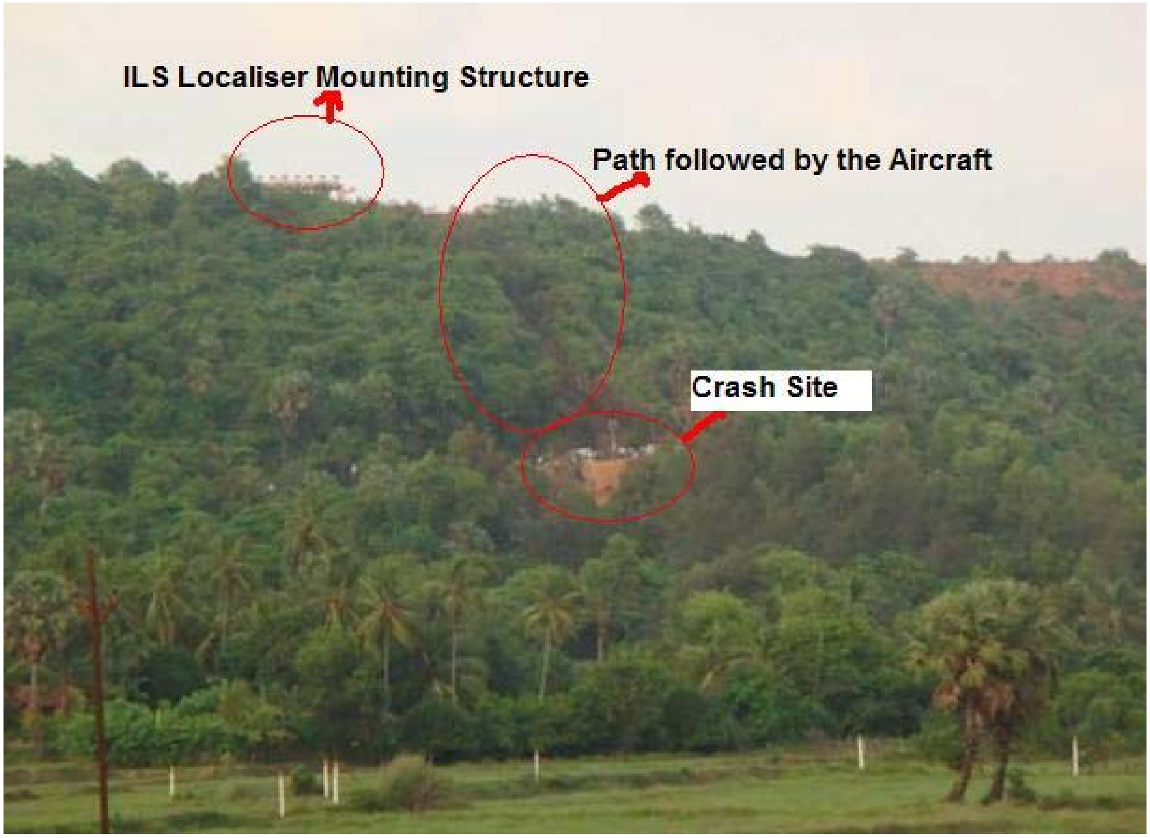


Photo 12: View of Path Followed by the Aircraft from Localiser Structure

Photo 13: Gorge - The Final Resting Place of Wreckage

There were no aircraft parts recovered before the end of R/W 24. There were no fire/soot marks and there were no signs of Bird Strike.

1.12.2 Cockpit Switches and Gauges

The cockpit portion (STA 130 to STA 259.5; part of Section 41) had separated from the fuselage. The Nose gear was attached to the cockpit portion. The EE compartment/Lower Lobe of the fuselage below WL 208.1; STA 259.5 to STA 360 was damaged. Due to impact, the nose compartment had shattered. The avionics and electrical components, radar and FDIU were found in their usual location. Few of the units were damaged/stripped open, while a majority of the units were recovered in undamaged condition. The instruments and the display units were also found in their usual location, but in damaged condition.

After the initial rescue and recovery actions, position of switches and CB's in the cockpit were as follows: -

- 'CAP'S PNL LTG' and 'CTR PNL LTG' CB's were observed to be popped out. All Other CB's were either damaged or in 'IN' position.
- Auto brake Switch Selected to '2'
- Auto Throttle S/W in 'Off' position.

Similarly some of the positions of the Cockpit Controls were as follows: -

- Landing Gear Lever : Near Down Detent and Jammed
- Thrust Lever : Fully Forward
- Flaps : At Flap 40 detent
- Speedbrakes : Down Detent

Photo 14: Control Stand

1.13 Medical and Pathological Information

A total of 128 bodies including the co-pilot were brought to Wenlock hospital for post mortem examination and the remaining bodies were sent to other hospitals. All 8 survivors were passengers and were treated in different hospitals.

1.13.1 Post-mortem report of PIC Captain Glusica

The Captain's autopsy was conducted in Father Muller Medical College, Mangalore, on 22 May 2010 between 3.00 pm to 4.30 pm. The body was identified by his passport size photographs and printed pieces of paper found on his person. It is evident that the Captain had died of deceleration injuries sustained on impact. The coronaries were found to be normal and patent. No abnormal odour was noted in the stomach contents. The cause of death was written as 'due to multiple injuries sustained in the aircraft accident consistent with the history provided.' The viscera and blood samples were preserved to assess blood alcohol levels and carbon monoxide and sent to Regional Forensic Science Laboratory (RFSL), Mangalore.

1.13.2 Post-Mortem Report of First Officer HS Ahluwalia

The First Officer's autopsy was conducted at the Dept of Forensic Medicine, Kasturba Medical College, Mangalore on 23rd May 2010. The body was identified by the presence of a yellow coloured chain and locket as well as by evidence of a surgery, which was confirmed by his relatives. Major deceleration injuries were noted. Samples of the stomach and its contents as well as parts of other relevant organs were forwarded to RFSL, Mangalore.

1.14 Fire

1.14.1 Fire in the Air

There was no evidence of in-flight fire. The eyewitness also confirmed that no fire was seen before the impact.

1.14.2 Post Impact Fire

A large portion of aircraft was found burnt / melted / fused due to the fire. The examination of the wreckage revealed that the fire was post impact. The first sign of fire damage was seen on the vegetation, at the edge of the airport boundary, where the portion of the right wing was recovered. Apparently, the fire had started after the aircraft wing impacted the localiser structure.

1.14.3 Emergency Response

Emergency Rescue and Fire Fighting response by the RFF Crew of Mangalore Airport was swift. One of the RFF Panther-1 was at the PDP close to the runway and had witnessed the aircraft touching down late. As soon as the aircraft had entered RESA causing the dust to rise, this RFF had rushed behind the aircraft. However, after initial impact with the ILS localiser mounting structure, the aircraft had continued to plough down into the gorge outside the airfield perimeter.

This RFF reached to the edge of the slope close to airfield perimeter and tried to throw water and foam towards the aircraft. But, the crash site was out of its range. It, therefore, extinguished fire of all parts of the right wing, which had broken off after the impact with ILS structure.

Source: www.coastaldigest.com

Photo 15: RFF Crew Laying Hoses to Fight the Fire

Meanwhile, second RFF TATRA reached the accident site from the crash gate, after following the narrow winding roads downhill. Although, it reached within about 4 minutes of the accident, the ensuing fire and smoke precluded rescue operations. The crew also had to cut trees and vegetation and take help from RFF hoses to go down to the aircraft for access to the passengers and crew. However, the intense fire and smoke had already taken the toll with only 8 passengers jumping out of broken portions of the aircraft.

The Mangalore airport RFF crew residing nearby also rushed to the crash site with all possible RFF vehicles and ambulances. In about 30 minutes, the civil fire tenders had also joined the combined operation of trying to recover charred remains of the crew and passengers. The dedication and involvement of all personnel of Mangalore airport, civil administration and the civil population was praiseworthy.

1.15 Survival Aspects

The injuries to the occupants were mainly due to aircraft impacting the gorge and subsequent fire. Most of the passengers had received fatal injuries. A large number of fatalities were due to burns. Several passengers had died due to decelerated injuries and burns. Of the eight survivors, seven passengers had received serious injuries and one passenger had received minor injury.

The Captain's body was found on the LH seat and co-pilot's body was lying near the cockpit. The body of one of the cabin crew was found in burnt condition near the cockpit door. The pilot and co-pilot's seats were found in burnt condition.

1.15.1 General Description

All survivors were fully awake and alert during landing and prior to the crash. They had noticed smoke and fire inside the passenger compartment, which seemed to be coming more from the front section. All survivors had un-harnessed themselves and moved out of their seats to make good their escape from a break in the fuselage from where they could see daylight. This break had provided them with natural light to facilitate their escape. From the description of the survivors it also appeared that the fuselage had broken at a point just behind the wings and they had either jumped out or were pushed by others through this opening created by the broken fuselage. Soon after their escape, while some of them were still in the vicinity of the wreckage, the plane had caught fire. Some of the survivors had sustained burn injuries on their hands and face, while escaping from the aircraft.

1.15.2 Evacuation of Passengers and the Crew Members

As mentioned in earlier paragraph, the impact and resultant fire had already taken the toll of all crew members and passengers other than 8 who had escaped on their own. Although the fire personnel made quick and gallant effort, the rapid spread of fire and impact forces had resulted in fatalities to 6 crew members and 152 passengers. Due to tilting of the aircraft during the crash, it would have difficult for the passengers to operate emergency exit. As such, the survivors had escaped through a break in the fuselage and not by opening any emergency exit.

1.15.3 Survivors

There were a total of 8 survivors who had occupied seats as shown in the Layout of Passenger Accommodation (LOPA). These survivors had occupied the seat No 7A, 17C, 19A, 19C, 20C, 21C, 23D & 23F. It could be seen that there was no specific pattern of seating, which helped in survival. All the eight survivors were occupying seats in different rows and not necessarily along the window or aisle. Of these, most were grouped from seat rows 17 to 23 and only one was ahead at 7A. However, it was to their good fortune that the aircraft broke into 3 main portions which allowed them to jump out of the openings mainly to the left since the aircraft had tilted to the right when it finally came to rest.

The survivors were also interviewed by the Court regarding other passengers and crew members. The survivors had stated that some of the other passengers had also tried to unfasten their seat belts in an attempt to escape, but seemed unable to move due to rapid spread of fire. One of the survivors even remembered pushing a lady passenger while jumping out of the aircraft. This was later corroborated by the lone lady survivor from the accident aircraft.

Diagram 11: LOPA of the Accident Aircraft

1.15.4 Assistance to Injured and Family Members

Apart from the personnel of Mangalore airport who had responded very swiftly to the accident, the disaster management by civil administration was also timely. The civil fire tenders had reached within 30 minutes as also the police and medical personnel. There was also spontaneous outpouring of assistance from the civil population.

Air India had also reacted swiftly with their Emergency Response procedure. An onsite office for assistance to the survivors and bereaved family members was set up at Mangalore airport and in town. An organisation within Air India made up of volunteers known as ‘Air India Angels’ did praiseworthy job of providing help to the injured and to the family members of those who had lost their lives in the accident. Later ‘single window’ assistance was provided by Air India and the District Administration together, to provide initial grants as well as death certificates. All the survivors and bereaved families had praised the assistance provided by Air India Angels.

1.16 Examination and Testing of Components

A total of 63 components were removed from the wreckage site to the Overhaul Division of Air India Mumbai for detailed examination. On some of the components essential testing was carried out at various laboratories under the supervision of team members associated with the Inspector of Accident and the Court of Inquiry.

1.16.1 Flight Compartment Controls and Indicators

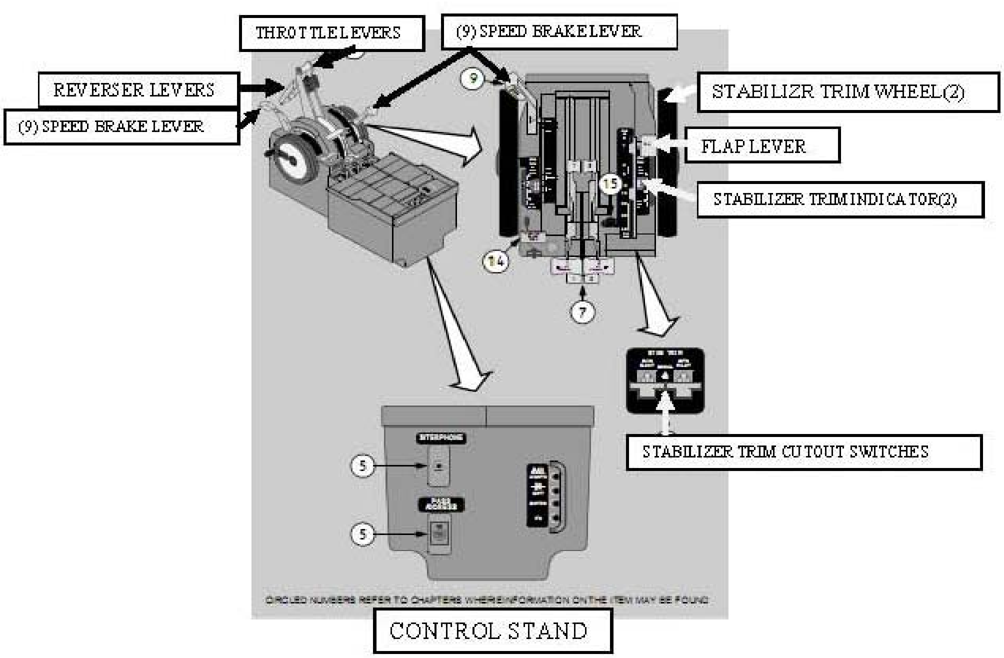


Diagram 12: Flight Controls - Control Stand

At the Overhaul Divisions of Air India at Mumbai, examination of the Control Pedestal and Cockpit revealed the following:-

- Both Throttle levers were away by about 1.5 inches from full forward position. These were not free to move
- T/R levers were in fully stowed position
- Flap levers were in 40 detent position
- NBR1 engine start lever was moving freely
- NBR 2 engine start lever was close to cut off, but not in cut off position
- Stab Trim position indicator on RH side was in Full nose down position
- Stab Trim position indicator on LH side had impact damage and it was stuck in Full nose up position
- Speedbrake lever was in Full down detent position
- Stab trim cut out switch was in normal position
- Both Fire switches were in Normal position
- T/E Flap jack screw was at full extend position with 29 thread counts from full up stop position.

1.16.2 Testing of Components

A total of 63 components were subjected to detailed examination and testing. These included:-

- Panels
- Flap and slat jack screws
- Spoiler actuators
- Both Engines
- All brake assemblies
- All wheel assemblies

These components were transported to various Overhaul shops of M/s Air India at Mumbai for inspection. Sample test/ inspection results are as follows: -

1.16.2.1 Brake Selector Panel and Flap Position Indicator External Inspection Report

Photo 16: Brake Selector Panel and Flap Position Indicator

Part No.	233A2224-5 / 2061-15-1
Sr. No.	D02583 / 2806
CMM	73-31-01
General Condition	Connector plate bent at J1 connector. L2 Anti Skid Indicator & L4 indicator damaged. Flap position front glasses broken.
S/W Position	N1 Set – Auto SPD Ref – Auto Auto brake indicator – 2 S2 Fuel flow S/W – Rate R Flap position indicator – Flaps

As per DFDR read out, Auto Brake activation indicated at 06:04:43 hours IST and increase in brake pressure by about 65 PSI on both Left and Right brakes, which was indicative of normal functioning of Auto Brake.

Flap lever was seen on the Flap 40 detent, which corresponded to RH Flap position indicator needle. This also corresponded to the fully extended Jackscrews.

1.16.2.2 Leading Edge Flap Actuator

Photo 17: Leading Edge Flap Actuator

Part Number	382000-1001
Serial Number	10161
Position	# 2.
CMM	27-80-05
Total length	"L" :- 26.2 Inches (Between bearings centre)
Findings	(a) Actuator position - extended corresponding to flap extended. (b) Physical condition is ok. (c) No parts missing.

1.16.2.3 LE Slat Actuator Assembly

Photo 18: Leading Edge Actuator Assembly

Part No.	381800-1005
Serial No.	23103.
Position	# 07, LE SLAT.
CMM	27-80-06
Total length	"L":- 22.0 in. (From Piston eye end to Body eye fitting centre.)
Findings	(a) Actuator position-extended corresponding to flap extended (b) Full body found burn marks. (c) Piston rod is intact.

All the Leading Edge Flap / Slat actuators were found in the extended position, which correspond to the flap lever position of 40^o. Therefore, it could be concluded that all Leading Edge devices had operated as per the cockpit input.

1.16.2.4 Ground Spoiler Actuator

Photo 19: Ground Spoiler Actuator

Part No.	65C2684-3/251A1510-3
Serial No.	EFS08654
Position	#12
CMM	27-62-71
Findings	(a) Actuator position- Retracted corresponding to Spoiler retracted. (b) No parts are missing. (c) Actuator found burn marks.

Examination of the Central Pedestal had revealed that Speedbrake lever was in the forward detent position. This corresponds to fully retracted position of the speedbrakes. Retrieved actuator position also indicated speedbrakes in fully retracted position.

From the DFDR read out, it is clear that speedbrakes were deployed in flight from 06:04:02 to 06:04:22 hours IST and again on landing from 06:04:42 to 06:04:54 hours IST. Thereafter, it remained retracted till the end. From the above, it can be seen that speedbrakes had responded correctly to the commands.

1.16.2.5 Trailing Edge Flap Ball Screw Assembly # 1

Photo 20: Trailing Edge Flap Ball Screw

Part No.	07323P000-01
Serial No.	5030
IPC Ref.	27-51-42-03
Total length	"L" :- 20.00 Inches (stop end to Centre of yoke end bushed hole)
Findings	(a) Ball nut & Gimbals assy. found in flap fully extended position

Flap handle was found in the 40 detent. Trailing Edge Flap Jack Screws were found in the fully extended position, which corresponded to the fully extended position of the flap. From DFDR data, it was seen that flap lever and the flap surface were in 40 degree position in flight from 06:03:23 to 06:04:16 hours IST. Thereafter, while the flap lever continued to remain in the 40 detent, the surface had retracted to 30 degree between 06:04:17 and 06:04:37 hours IST due to increase in speed of the airplane. Flap surface was again extended to 40 degrees from 06:04:38 hours IST till the time of the accident. From the above, it could be implied that Flap system had responded correctly to the commands.

1.16.2.6 Stabiliser Position

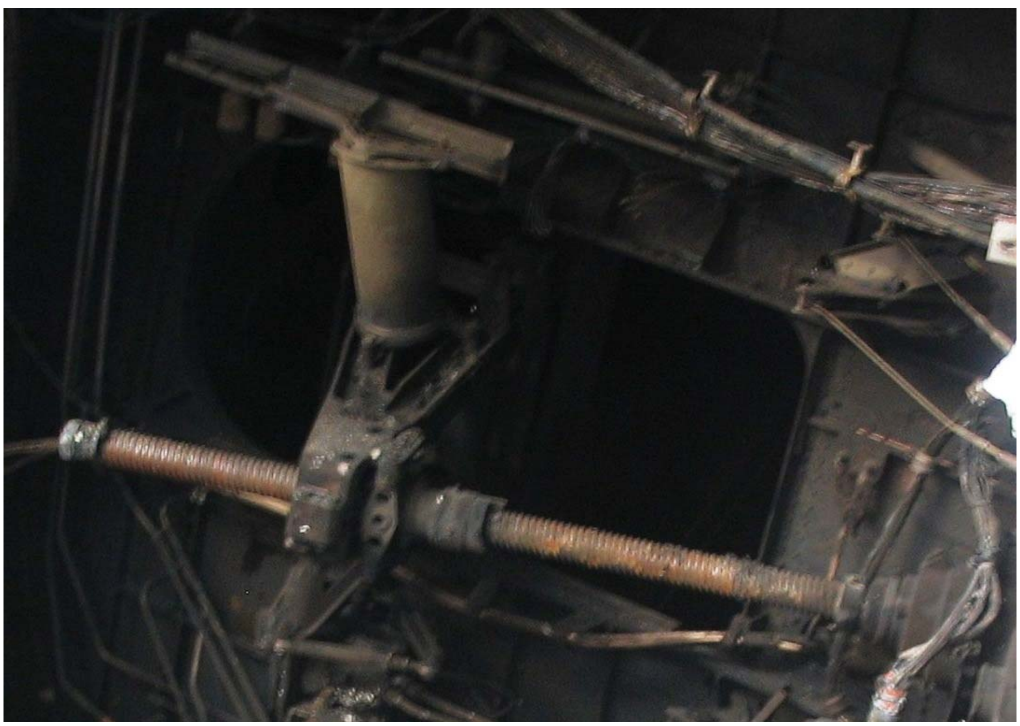


Photo 21: Photograph of Stabiliser Jack Screw

The dimension 'B' as given in the Diagram No 5 was measured from the debris. It was found to be 37 inches. This corresponds to 6 units of Stabiliser Trim. For airplane full nose 'UP' position, the dimension 'B' should be 21.32 inches and for full nose 'DOWN' condition, the dimension should be 45.84 inches. From this observation, it could be inferred that the horizontal Stabiliser was in nose 'DOWN' position, which is the landing configuration.

1.16.2.7 Examination of Engines

The Engines were inspected at the Engine Overhaul Division of M/s Air India, Mumbai. The detailed inspection reports are as follows:-

Left Hand Engine:-

INSPECTION REPORT

ENGINE MODEL : CFM56-7B27/3 **DATE : 28 July 2010**
ENGINE S/No. : 896199
ENGINE TSN/CSN : 7189/2829 **CUSTOMER : AI EXPRESS**

A. REASON FOR REMOVAL:

Engine was removed from accident aircraft VT-AXV #1 and inducted into shop for detailed visual inspection and to explore possibility of finding the power setting at the time of impact by physical evidences on the engine.

B. INSPECTION FINDINGS:

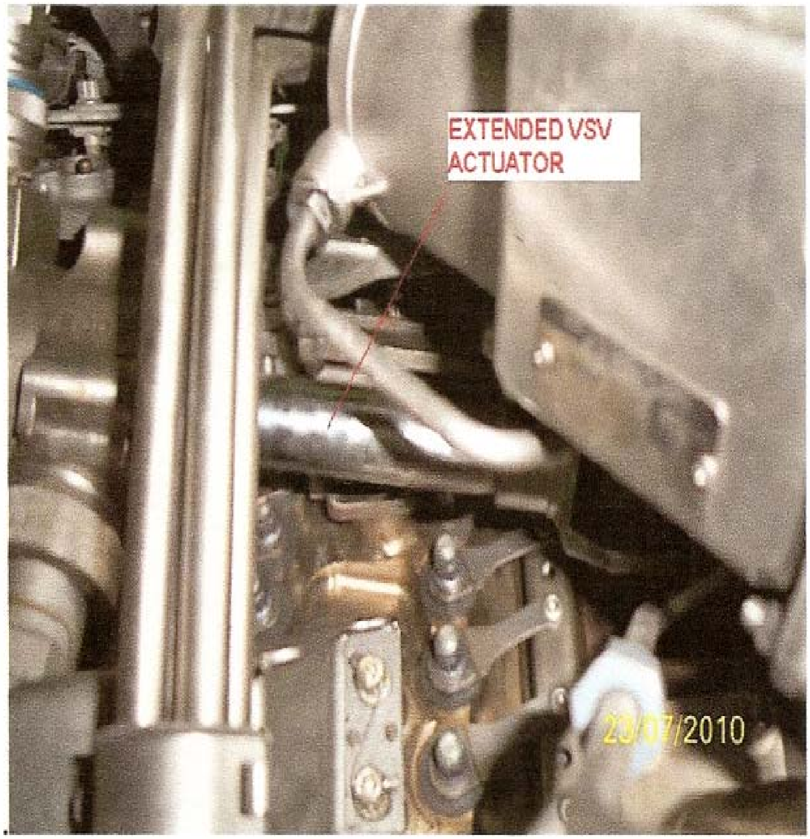
1. Inlet cowl removed from the engine as instructed and engine installed on pedestals.
2. Inlet cowl found with impact damages at the forward end causing metal and composite material to liberate and enter into the gas path.
3. Fan frame and spinner cone found with deep dents.
4. All fan blades are found damaged. Some fan blades are observed torn with pieces missing.
5. The N1 and N2 spools of the engine could be rotated.
6. Exhaust nozzle and plug found with impact damages.
7. Variable bleed valves found fully open. Refer photograph below.

Variable Bleed Valve

Page 1 of 2

Photo 22: Extract of the Inspection Report of Left Hand Engine (Page -1)

8. Variable stator vane actuators found extended exposing approximately 3.500 inch of actuator piston rod. Refer photograph below.



VSV Actuator.

9. Transient bleed valve found fully open.

C. INFERENCE:

The variable bleed valve found fully open, the variable stator vane actuators found extended and the transient bleed valve found fully open.

From the physical evidences of the position of the variable bleed valves, the variable stator vane actuators and the transient bleed valve observed during inspection, it appears that the engine in as received condition in shop is towards low power configuration.

Photo 23: Extract of the Inspection Report of Left Hand Engine (Page -2)

Right Hand Engine

INSPECTION REPORT

ENGINE MODEL : CFM56-7B27/3
ENGINE S/No. : 897200
ENGINE TSN/CSN: 7189/2829

DATE : 28 July 2010

CUSTOMER: AI EXPRESS

A. REASON FOR REMOVAL:

Engine was removed from accident aircraft VT-AXV #2 and inducted into shop for detailed visual inspection and to explore possibility of finding the power setting at the time of impact by physical evidences on the engine.

B. INSPECTION FINDINGS:

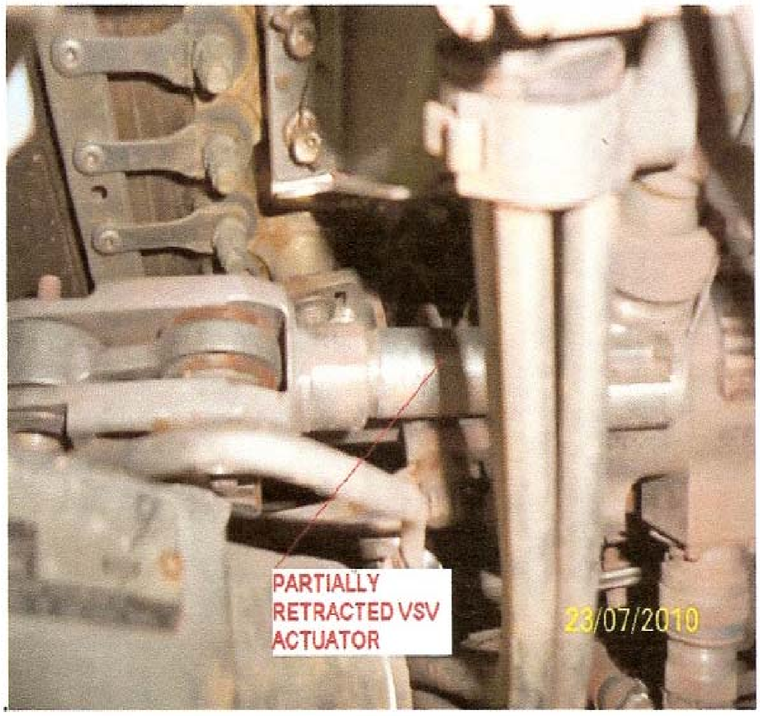
1. Fan frame and turbine rear frame found distorted.
2. The forward and aft engine mounts found missing and thrust links found broken.
3. Fan frame observed twisted approx. 90 degree anti-clockwise looking from rear of the engine.
4. Low pressure turbine shaft found broken and the low pressure compressor with fan received as a separate disintegrated unit. All fan blades found sheared off near the root of the blade.
5. The N1 and N2 spool of the engine could not be rotated.
6. Accessory gear box and most of the accessories observed broken.
7. Variable bleed valve doors found closed, bleed ring area found totally distorted. Refer photograph below.

Variable Bleed Valve

Page 1 of 2

Photo 24: Extract of the Inspection Report of Right Hand Engine (Page -1)

8. Variable stator vane actuators found extended partially. Approximately 1.3 inch of actuator piston rod found extended. Refer photograph below.



VSV Actuator.

9. Transient bleed valve found fully closed.
10. All fan OGVs, fan frame and the bleed valve actuating ring found distorted.
11. Most of the engine electrical harness found broken and missing.
12. All pneumatic ducts, fuel tubes and oil tubes are found damaged.
13. Accessory Gearbox found broken near the lower end exposing the gear train inside the gearbox.
14. EEC found liberated from engine and the broken pieces of EEC received separately.
15. The Exhaust nozzle, the exhaust plug and the center vent tube found twisted and distorted.

C. INFERENCE:

The variable bleed valve found fully closed. The variable stator vane actuators found extended partially. Approximately 1.3 inch of VSV actuator piston rod found extended. The transient bleed valve found fully closed.

From the physical evidences of the position of the variable bleed valves, the variable stator vane actuators and the transient bleed valve observed during inspection, it appears that the engine in as received condition in shop is towards high power configuration.

Photo 25: Extract of the Inspection Report of Right Hand Engine (Page -2)

Summary of Engine Inspection

From the examination of the engines, it was evident that Left Engine was found in the low power position and Right Engine was found in the high power position. As per the observations made on the debris, both Thrust levers were at the forward position which indicated demand for high power. At the time of impact with the ILS Localiser Structure, Right Engine along with the Right wing had separated from the aircraft and engine had disintegrated at high power.

In the case of Left Engine, it was reported by the survivors that engine was still rotating when they escaped from the aircraft. It appears that engine had continued to run and possibly wound down due to fuel starvation. This could explain engine being found in the low power position on examination.

As per recordings on the DFDR at 06:04:42 hours IST just before touchdown, Thrust levers were at 26 degrees and corresponding N2 on Left Engine was 76.8% and N2 on Right Engine was 78.1%. EGT of Left Engine was 499 degrees and that of Right Engine was 517 degrees. Fuel flow recorded was 523 kg/hour on Left Engine and 603 kg/hour on Right Engine.

Thrust Reversers were in transit at 06:04:43 hours IST and were fully deployed by 06:04:44 hours IST. Thrust Reversers remained deployed for 10 seconds from 06:04:44 to 06:04:54 hours IST. Maximum power developed during this period was N1 76.8% on both engines, N2 was 93% on Left Engine and 91.9 on Right Engine respectively. Corresponding EGT and Fuel flow increase was also recorded. Thrust Reversers were in transit again from 06:04:54 to 06:04:57 hours IST and were fully stowed by 06:04:58 hours IST.

At 06:04:55 hours IST, both Thrust Levers were pushed forward to 84 degrees, which corresponded to full forward power position. Both engines had responded immediately and by 06:04:58 hours IST, N2 had increased to 83.4% and 87.5% on Left Engine and Right Engine respectively. Maximum N1 recorded was 77.55% and 87.5% on Left Engine and Right Engines respectively.

From the above, it could be concluded that both engines responded to the Forward and Reverse Thrust commands, and developed power as intended. Captain, after landing used full reverser for 10 seconds and then opened power on both engines to full power till the time of the accident.

During deposition by GM, CFM Engine Shop, Air India, Mumbai at the Public Hearing, these reports were submitted. On query by the Court, he had mentioned that there was no evidence of any bird ingestion in either of these engines.

1.16.2.8 Brake Assembly Inspection Report

Wear indicator pins had indicated that brake stack wear was in normal pattern and the wear was within Component Maintenance Manual (CMM) limits. All four brakes were functionally tested as per CMM and found to be satisfactory. No evidence of any leakage was observed.

Part No.	2612312-1	2612312-1	2612312-1	2612312-1
Brake Sr No.	B4226	B7423	B6221	B5382
Position	#1	#2	#3	#4
Installed on	12th Sep 09	2nd Sep 09	21st Apr 10	2nd Oct 09
Number of Landings	723	751	113	666
General Condition	No damage. (Rotors found free.)	No damage. (Rotors found free.)	No damage. (Rotors found free.)	Damage Observed on piston housing
Missing Parts	Nil	Nil	Nil	Qty. one indicator pin found missing
Hydraulic Leakage	No trace of hydraulic leakage	No trace of hydraulic leakage	No trace of hydraulic leakage	No trace of hydraulic leakage
Condition of Piston Housing	No damage observed	No damage observed	No damage observed	Damage observed at one location
Condition of Heat Stack	No damage observed	No damage observed	No damage observed	Found stuck in the wheel assembly S/N B10899
Indicator Pin	Both the pin in position	Both the pin in position. Out of which one found bent	Both the pin in position. Out of which one found bent	One pin in position and other found missing

Photo 26: Brake Assembly Serial No B4226

As per the DFDR, in flight residual brake pressure of 227 PSI on the left and 180 PSI on the right brakes was recorded. At 06:04:42 hours IST on touchdown, Auto Brake activation was indicated with rise in brake pressure to 301 PSI on the left and 244 PSI on the right brakes. At 06:04:49 hours IST, Auto Brake was disengaged and increase in brake pressure to 1196 PSI on the left and 887 PSI on the right was recorded, which indicated manual brake application. Maximum brake pressure of 3075 PSI and 2425 PSI was recorded on the left and right brakes, respectively, at 06:04:52 hours IST. At 06:04:54 hours IST, brakes were released indicating drop in brake pressure to 339 PSI on the left and 342 PSI on the right. This also corresponds to the Thrust Reversers moving from Deployed Position to the Stowed Position.

From the above, it could be seen that all the four brakes were functional and the brake system had provided Auto and manual braking as per the inputs. However, at 06:04:55 hours IST, when both Thrust Levers were pushed to the full power position, there was an indication of progressive increase in brake pressure to full brake application on both left and right brakes. This could be explained by inadvertent or intentional application of the brakes by the fight crew, who had possibly noticed the ILS localiser mounting structure, appearing in front.

1.16.2.9 Nose Wheel and Tyre Assembly

Photo 27: Nose Wheel and Tyre Assembly

Part No.	277A6000-453	277A6000-453
Serial No.	B19837	B 18600
Position	Left Hand	Right Hand
Date installed	25th April 2010	19th April 2010
Landings done	113	117
Tyre Findings	Tyre cuts noticed on sidewall towards O/B side at 2 locations.	Tyre cuts noticed on sidewall towards O/B side at 2 locations (2"x2" side wall tyre piece missing)
Hub Assembly Findings	All tie bolts found intact Pressure relief valve found intact Wheel bearing and seal found intact. No damage noticed on I/B and O/B HUB externally.	All tie bolts found intact. Pressure relief valve found intact Wheel bearing and seal found intact No damage noticed on I/B and O/B HUB externally.

From the above, there was no indication of any defect on both the nose wheel assemblies prior to the accident.

1.16.2.10 Main Wheel and Tyre Assembly

Photo 28: Main Wheel and Tyre Assembly

Part No.	277A6000-204	277A6000-204	277A6000-204	277A6000-204
Serial No.	B9061	B14941	B8266	B10899
Position	# 1	# 2	# 3	# 4
Date of Installation	07.05.2010	18.04.2010	01.05.2010	18.05.2010
Landings done	63	135	79	14
Tyre Findings	a) Deep cut noticed at 2 locations on sidewall. b) Burn marks noticed on tread area approx 2 feet by 10 inch on crown area. c) Wheel assy. Holding 30 PSI pressure	Tyre found burst and burn at about ¾ of tyre crown area	a) Tyre burst b) Tyre found damaged at four locations c) Tyre cut noticed about 4 feet due to burst towards I/B side	a) Brake and wheel found jammed b) Tyre burst c) Burn marks noticed on tread area approx 2 feet by 10 inch on crown area
Hub Assembly Findings	a) All tie bolts found intact b) All fusible plugs found intact c) No damage noticed on heat shields and keys d) Pressure relief valve found intact e) Wheel bearing and seal found intact f) No damage noticed on I/B and O/B HUB externally	a) All tie bolts found intact b) All fusible plugs found intact c) No damage noticed on heat shields and keys d) Pressure relief valve found intact e) Wheel bearing and seal found intact f) Minor Damage noticed on I/B and O/B HUB externally	a) All tie bolts found intact b) All fusible plugs found intact c) Minor damage noticed on heat shields and keys d) Pressure relief valve found intact e) Wheel bearing and seal found intact f) No damage noticed on I/B and O/B HUB externally.	a) All tie bolts found intact b) All fusible plugs found intact. c) No damage noticed on heat shields and keys d) Pressure relief valve found intact e) Wheel bearing and seal found intact f) Minor damage noticed on I/B and O/B HUB externally.

The analysis of the Main Wheel showed no pre-existing defects. Three tyres were burst due to post impact damage. Number 1 Wheel Assembly, which was intact, was holding 30psi pressure at the time of examination.

1.17 Organisational and Management Information

1.17.1 Brief History of Air India Express

Air India Charters Limited (AICL), Mumbai operates a low cost airline under name 'Air India Express' and is a wholly owned subsidiary of Air India. The DGCA had issued the Air Transport Operating Permit (AOP) No S-14, in Passenger/Cargo Category, on 22nd April 2005. The permit was re-validated on 22.4.2008 up to 21.4.2013. The airline commenced its operations on 29th April 2005 with 26 flights per week, using 3 leased Boeing 737-800 aircraft. At the time of accident, the airline had a total of 25 (22+3) Boeing 737-800 aircraft in their fleet, indicating a rapid growth within 5 years. The AI Express aims to provide low competitive fares to connect Indian cities directly to destinations in the Gulf, South and South East (SE) Asia.

At the time of accident AICL operated about 204 flights every week and connected 27 cities across South and SE Asia as well as the Middle East. It operated from multiple bases, and was using 8 bases namely Kozhikode, Kochi, Chennai, Thiruvananthapuram, Mumbai, Delhi, Mangalore and Dubai. The average aircraft utilisation for May 2010 was 09:15 hours per day.

1.17.2 Organisational Structure

Since Air India Express is a wholly owned subsidiary of Air India, it was convenient to depute Post Holders from the parent company for initial setting up of operations. However, even with 25 aircraft on its strength and widespread operations, this arrangement of deputing the management from parent company had been continued. The Post Holders of Chief of Operations, Training and Flight Safety continued to be Senior Pilots of Air India, who flew Boeing 777 or Boeing 747 to maintain their currency. None of these Post Holders were qualified on Boeing 737-800 aircraft, operated by Air India Express.

The Chief of Flight Safety of Air India Express reported to the Chief of Flight Safety, Air India, who in turn reported to the Chairman. Similarly, the Chief of Training was also from Air India and it was only after the accident that one of the senior captains from Air India Express qualified on Boeing 737-800 had been appointed as Chief of Training.

For a legacy carrier like Air India, low cost operations are a totally different philosophy. Unlike Air India, which operates on long haul international sectors, Air India Express operates on short haul international sectors from multiple bases and many of these are Quick Turn Around (QTA) flights.

It was evident from above that although Air India Express had a separate AOP, it did not function as a separate entity. During interaction with Post Holders, the demarcation of responsibility between Air India and Air India Express was not clearly evident. The organisation chart of Air India Express at the time of accident is shown on the next page:-

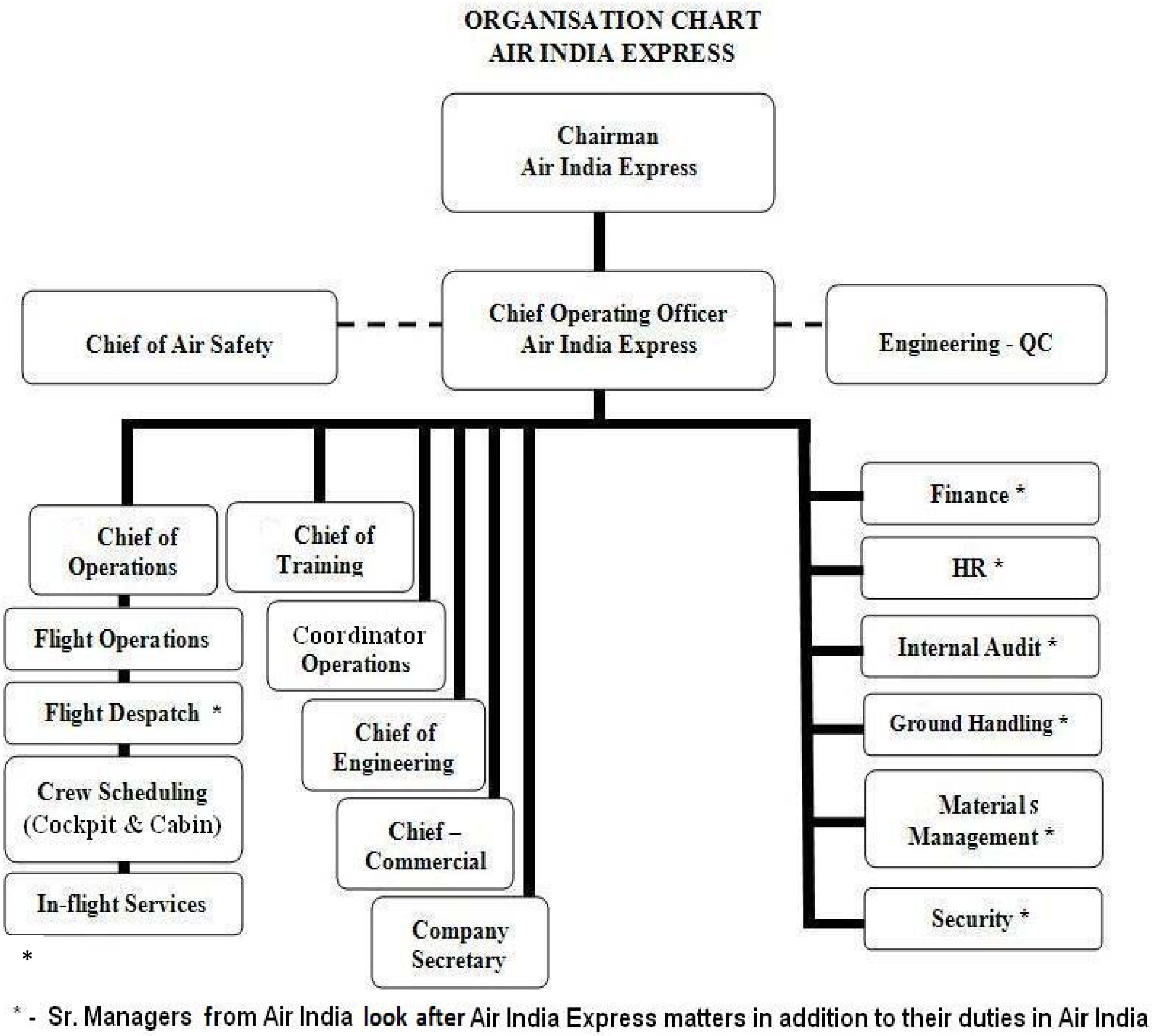


Diagram 13: Organisation Chart of Air India Express

1.17.3 Flight Operations

1.17.3.1 Command Conversion

Air India used to initially train their pilots on Airbus A-310 aircraft after which the pilots used to graduate to wide body aircraft such as Boeing 747 and Boeing 777. With a dwindling fleet of A-310 aircraft, Air India had started sending Pilots to Air India Express for Command Conversion Training on Boeing 737-800 aircraft. Once qualified, the newly trained Captains would revert to Air India on wide body aircraft. Such an arrangement continuously added training load on Air India Express. This was also a bone of contention for the contractual Air India Express Pilots who were awaiting their turn to qualify as Captains. The senior management would use ad-hoc formula for relative seniority in progressing the two sets of Pilots for Captaincy. With lack of communication and transparency, such decisions became an irritant for the contractual Pilots. This was also evident from the query raised by late First Officer Ahluwalia, who wanted to know as to how long he would need to wait for Command conversion even after obtaining ATPL.

1.17.3.2 Tenure of Deputation

The Post Holders of Air India Express who were deputed from Air India had occupied the office for different periods of tenure. This arrangement was not conducive to efficient management since it takes some time to understand the functions of a low cost carrier operating from multiple bases. After the accident, however, the Chairman had given instructions for the deputation to be for a minimum period of 5 years. Similarly, the flight crew, which were sent to Air India Express for command conversion on Boeing 737- 800, used to revert to Air India shortly before their Command Conversation on Air India aircraft. This again was not a conducive or good practice since the contractual personnel of Air India Express felt that it was functioning more as a training airline and that too, feeding Captains into a more lucrative job profile of the parent company, Air India. Also such practice gave an impression of a mindset that it was only a stop-gap arrangement for Air India Pilots to be on deputation to Air India Express.

1.17.3.3 SOP and Flight Manuals

Air India Express had flight crew comprising of those on contract and also on deputation from Air India. In addition, a number of foreign pilots had been contracted due to shortage of Captains. In a hybrid composition such as this, it was important to adhere to a common SOP.

Till the time of the accident, the SOP though prevalent, had not received approvals of the DGCA. Since flight crew were from different backgrounds, they might have carried habits from the previous operator. It was, therefore, important that all crew followed standard and approved SOP of Air India Express. This would have enhanced the Situational Awareness and Communication Skills of the pilots to maintain a safer envelop of operations and better safety standards.

1.17.3.4 Multi Base Operations

Air India Express operates flights mainly to the Middle East as well as South and South East Asia. Since Air India Express is designed to be a low cost airline, it is operating from 8 different bases to cater to the passenger traffic from those areas. As such, some of the aircraft are based at these airfields. Similarly, as much as possible, the flight crew are also stationed at these places.

While such multi-base operation is a good commercial model, it also adds to some constraints on the functioning of Air India Express. In view of such operations, the aircraft need to be rotated for major maintenance, which is carried out at Mumbai. Since the company has not yet ensured computerisation and networking, the flow of information is not smooth. The analysis of CVR as part of FOQA is also being carried out partially by downloading the CVR only at Mumbai and not from other bases.

Due to multi-base operations, important information like Flight Operations Bulletin (FOB) and other documents are circulated to the Flight Crew Members without ensuring that these have been received and read by them.

1.17.3.5 Coordination Meetings

It is important that the operations department holds periodic coordination meetings, which is a pivot for effective and efficient operations. Such meetings are not only mandated by DGCA, but also help in better understanding as well as synergy of operations with training, flight safety, maintenance, to name a few. This is particularly important in multi base operations with flight crews of diverse backgrounds. However, it was noticed during investigation that hardly any minuted co-ordination meetings including those of Flight Safety Committee were held by the Post Holders.

1.17.3.6 ILS Approach Procedure

The flight crew who deposed in the Court narrated the standard ILS Approach procedure of intercepting the ILS Localiser initially and thereafter, intercepting the Glide Path at the correct altitude. While this procedure is the most desired, the flight crew of accident aircraft did not follow the same. There was no documented procedure with Air India Express for intercepting the Glide Path from above before the accident. However, after the accident, Boeing had incorporated a procedure of intercepting the Glide Path from above so as to meet the criteria for a Stabilised Approach.

1.17.3.7 Stabilised Approach

As per standard procedure, all aircraft must be stabilised on approach by 1000 feet altitude in IFR and 500 feet altitude during VFR. If the desired approach conditions are not met before these heights, the aircraft must go around and make another approach for landing. All the flight crew who interacted with the Court also confirmed that similar procedure was being followed by Air India Express. In addition, in case of unstabilised conditions, if the First Officer gave a call to this effect, the Captain invariably performed a ‘go around’. However, contrary to the SOP, during this accident, the Captain had persisted with landing from an unstabilised approach.

1.17.3.8 Go Around Procedure

The Air India Express SOP on ‘Go Around’ on final approach conforms to the procedure to be followed when an aircraft is on an unstabilised approach. It is expected that after two calls on intercom to this effect, the First Officer performs a ‘Go Around’.

Some of the pilots, who deposed in the Court had stated that a ‘Go Around’ had to be followed up by an Operational Incident Report (OIR). Many pilots felt that such reporting also added pressure on them while flying. Undoubtedly being a commercial venture, an operator would want to know the reasons for ‘Go Around’. However, the same can be discerned while carrying out FOQA analysis and if there is a trend of consistent unstabilised approaches by a particular pilot, he could be duly counselled. In response, it was mentioned by the Post Holders of AI Express that the OIR were being raised since the DGCA wanted to collect data on ‘Go Around’.

It was also given to understand by one of the foreign pilots that when he had to 'Go Around' at one of the airports, the ATC controller had asked for the Captain's particulars and also the reason for going around. Such R/T call on an open channel was not only embarrassing for this pilot, but after landing, he was asked questions by the media. This can also lead to additional stress and pressure on a pilot who at that moment would have taken the correct action of 'Going Around' instead of continuing with the approach and landing, which could well have resulted in an accident/ incident.

1.17.4 Employment of Foreign Pilots: Captain Z Glusica

Air India Express employs foreign pilots from different agencies around the world. Due to shortage of qualified Captains, the main thrust is on employing the PIC. These foreign pilots are governed by individual contracts such as 8 weeks duty followed by 2 weeks leave in their own country. Such frequent movement in and out of country creates difficulty for crew scheduling. It was informed to the Court that the foreign pilots fly about 75% of the total hours in a year as compared to their Indian counter parts.

Captain Glusica was employed by Air India Express through a Serbian Agency since 15th December 2008. His contract included 14 days off every 2 months of flight duty in India. He had availed his off days and had returned from home town on 18th May 2010. While he had operated from Mangalore in November 2009, the QTA flight on 21st / 22nd May 2010 was his very first flight after return from leave.

The Court wanted to obtain detailed background of Captain Glusica to dwell into the aspects such as Flight Safety track record, weaknesses in Training, if any, Medical History etc. However, it was noticed that such details were not available with the operator and the same was also not mandated by the Regulator i.e. DGCA for issuance of FATA. It may be pertinent to mention that after about 3 months the Court could access some of these details. It was also intimated to the Court that possibly due to uncertainty regarding the renewal of FATA, Captain Glusica was in search of employment with other international carriers such as Turkish Airlines. After the crash, the RFF Crew had found Turkish currency in his shirt pocket.

1.17.5 Flight Crew Training

With a rapid growth in last 5 years, the requirement of training within Air India Express had also increased considerably. It was reported that the strength of pilots had increased from 30 to 242 in 5 years. In addition, 105 Captains and 115 First Officers are under training. Apart from training and retraining its own flight crew on contract and those deputed from Air India for Command Conversion had also added to the training task.

The foreign pilots also needed to be given adequate training to make them fully conversant with Indian conditions of weather, Radar coverage, RT phraseology especially in view of different accents and aerodrome procedures etc. With multi base operations, the training requirement had to be programmed as per crew scheduling. A number of senior staff from both Management and Flight Crew had mentioned the aspect of programming as a major constraint. Undoubtedly, training had remained disjointed and somewhat a weak area. This was evident from the performance of both flight crews of the accident aircraft in terms of non-adherence to SOP as well as faulty planning of descent profile.

1.17.5.1 Simulator Training

Air India Express has a simulator for Boeing 737-800 aircraft at its premises in Mumbai, which was installed on 28th February 2007. Depending on the training requirement, the flight crew are scheduled for simulator training. However, this simulator suffers from maintenance problems and frequent breakdowns. The average serviceability of the simulator was about 17 hours per day and average utilisation rate was about 14 hours per day during the last one year. As such, on many occasions, simulator of other agencies was used for training. Since there is a vast requirement of training, the simulator should have much better logistics support and serviceability.

1.17.5.2 Availability of SFI and TRE/TRI

At the time of accident, there were a total of 5 SFI, 4 TRE and 7 TRI for training of 242 pilots including both, Captains and First Officers. With such vast requirement of training and retraining, there was a proportional need for additional SFI and TRI. To ensure that the flight crew of varied backgrounds function cohesively, there was a need for more effective training and testing. To be able to do this, Air India Express needs to have more TRE. A number of Post Holders as well as other senior pilots had brought out this requirement during their deposition.

1.17.5.3 Training on CRM

The senior management personnel of Air India Express, who deposed in the Court, had indicated that Crew Resource Management (CRM) training was covered during initial training and in various simulated LOFT exercises. GM-Training had also mentioned that although more recurrent training on CRM was desirable, the scheduling constraints had precluded such a requirement.

Considering the diverse backgrounds of flight crew, it is important that the quantum of training on CRM be increased. Such CRM training needs to be validated during training flights and simulator to address the issue of crews with different backgrounds and cultures performing as a cohesive team.

1.17.5.4 Trans-Cockpit Authority Gradient

In this accident, the First Officer had been able to identify the unstabilised approach conditions, but a steep gradient had apparently precluded him from taking over the controls or to enforce any corrective actions.

1.17.5.5 Training Infrastructure

Air India Express does not have its own infrastructure for conducting training and has to share the facilities of Air India. In view of large requirement of training such an arrangement does add to the constraints.

1.17.6 Flight Safety Organisation and Supervision

1.17.6.1 FOQA and CVR Analysis in Multi-Base Operations

During the investigation, it was observed by the Court that Air India Express was carrying out CVR analysis as mandated by the CAR, Section-5, Series F, Part-I, Revision 2, dated 17th March, 2009 only for flights operating to Mumbai. This did not give correct analysis since the airline operates from many other bases. It was also noticed that the equipment being used for monitoring the CVR did not give the desired quality of voice recognition.

In view of multiple base operations, it took about 3 weeks for Air India Express to monitor 100% FOQA analysis of DFDR. This duration should be cut down for faster monitoring of various parameters by networking and computerisation.

1.17.6.2 Policy regarding Hard Landing

The Flight Safety Department of Air India Express had set a limit of 1.65 Vg as a Company filter to counsel flight crew for what is considered to be a 'Hard Landing' during touchdown. While the manufacturer has the AMM figure of 2.1 Vg to be correlated with other parameters, it was mentioned to the Court that one of the DGCA officials had given verbal instructions to report 'Hard Landing' in case the Vg was 1.8 or more.

Setting such lower limit of Vg as compared to the CMM had resulted into Flight Safety counselling of pilots, as was the case with late Captain Glusica. The flight crew, who deposed in the Court, expressed their apprehension at being called to the Flight Safety Department for counselling, as it could well mean a blot on their career. A number of pilots had expressed such anxiety and possibility of stress while executing a landing to conform to these limits.

1.17.6.3 Flight Safety Counselling

It is a common industry practice to call the flight crew for counselling in case of a serious violation of safety standards. However, each operator adopts different techniques to counsel the flight crew, with a purpose of correcting any wrong practice especially, if it is noticed to be a trend with such a pilot. Further, personal interaction allows an erring pilot to explain the circumstances, so that the incident can be analysed more comprehensively. It also allows the supervisors to address shortcomings, if any, in the training being imparted.

The pilots of Air India Express, on the other hand, are averse to being called by the Flight Safety Department since it is considered that any adverse remarks would jeopardise their career progression. The pilots consider it somewhat demeaning and further stressful, if such counselling is indicated on Crew Schedules and is open information to other pilots.

The underlying purpose of counselling is to guide the erring pilot so that he does not commit such mistake again. The intention is not to be intimidating or threatening, as it would then defeat the very purpose of such personal interaction. Although, none of the pilots specifically mentioned of having been subjected to a harsh counselling by any of the supervisors of the Flight Safety Department of Air India Express, the Court had received a number of informal inputs to this effect.

It is pertinent to note that unless an isolated incident so warrants a personal counselling, it is desirable to do so in case of a persistent trend. The counselling can also be done by personal e-mail. If it needs to be done in person, discretion should be maintained so that a pilot does not feel embarrassed. To reiterate, the personal interaction should be for corrective action and not to intimidate a pilot. In the case of late Captain Glusica, he was counselled for a one-off incidence and that too for exceeding the landing 'Vg' limit, which was below the limit set by the manufacturer. As per the supervisors, the counselling was carried out as per the verbal instructions of landing 'Vg' limits set by the Regional representative of the DGCA.

1.17.6.4 Counselling to Late Captain Glusica

On 17th March 2010, Capt Glusica had been called to the Flight Safety Department of Air India Express regarding a 'Hard Landing Incident' on a flight operated by him from Muscat to Thiruvananthapuram on 12th December 2009. While the Chief of Flight Safety had stated that the counselling was carried out in an amicable and friendly manner, it was given to understand from his colleagues that Capt Glusica was upset about the counselling. As per the statements of some of the Serbian pilots, he had felt that the counselling was not called for since this was the very first such incident and not a trend. Also, it was the First Officer who had carried out the landing and that the 'Vg' limit recorded was only 1.9 Vg as against the manufacturer's limit of 2.1 Vg.

None of the Pilots who deposed in the Court could give specific instances of any harsh or intimidating counselling. However, the Court had gleaned that most of the Pilots had not taken counselling in a positive manner possibly leading to apprehension and stress. Since counselling is an important function and an art which not everyone can be good at, Air India Express Flight Safety Department needs to carry out such counselling in a discreet or a friendly manner or else, it could be counterproductive.

1.17.6.5 Training in Flight Safety Functions for Supervisors

It was noticed by the Court that none of the senior supervisors responsible for flight safety had undergone any formal training in this specialised area. There was a need for not only the supervisors of the flight safety department but also those from operations, training and engineering to go through training capsules on flight safety so that all activities are focused towards safe operations.

1.17.6.6 Implementation of Fatigue Risk Management System (FRMS)

Since a number of flights flown by AI Express are QTA flights with extended hours of flights at night and in the period of WOCL, the flight crew should be trained to manage fatigue arising out of flying at odd hours. They would need to adjust themselves to take rest according to the flight schedules. As such, Air India Express needs to train the flight crew on Fatigue Risk Management System.

1.17.6.7 Air India Flight Safety Journal 'Safe Wings'

Air India used to publish a flight safety Journal 'Safe Wings' to spread Flight Safety awareness among the pilots and engineers of the organisation. During deposition in Public Hearing, it was mentioned by ED-Flight Safety that this journal had been discontinued since July 2008. Such journals are useful in bringing out various recommendations of earlier incidents/accidents and also make the flight crew aware of new initiatives in enhancing flight safety.

1.17.7 Computerisation for Efficient Functioning

1.17.7.1 Scheduling of Pilots

Air India Express does not use computerised programming for Crew Scheduling. Instead, it is carried out using pencil, paper and eraser. This is in contravention to the CAR, Section - 3, Series - C, Part - I, revised in 2009 issued by DGCA, which prescribes use of computers. This aspect had also been brought out by the DGCA audit. Although the entries are inked the next day, such practice leaves a room for frequent changes leading to lack of transparency.

A number of flight crew had also mentioned that they were not aware of a long-term schedule (one week is the normal industry practice) to plan their own personal activities. As per them, this aspect not only added stress, but also had implications on the requisite rest periods when the flight schedule was changed at last minute. Since crew scheduling has implications on flight safety, it is desirable to implement computerisation of crew scheduling at the earliest.

1.17.7.2 Scheduling of Cabin Crew

During interaction with the Cabin Crew of Air India Express, it was also brought out that there were frequent changes to their schedules. In addition, during the course of investigation, it was learnt that a number of cabin crew had completed their annual flight duty hours and hence, they could not be utilised for the remaining period. This had even led to cancellation of few flights. Such shortcoming in scheduling of Cabin Crew can be overcome by the use of computerisation and networking.

1.17.7.3 Multi Base Operations

Since AI Express operates from multiple bases, all aspects of Operations, Engineering and Commercial can be well co-ordinated with use of Computers. This was evident from allotment by the Commercial staff of an unserviceable Seat No 25C, which was carried forward under MEL to a passenger travelling from Dubai on IX-812 on 22nd May 2010.

1.17.7.4 Ease of Communication with Flight Crew

Use of Computers will also allow an efficient and faster means of communications with the flight crew operating from multiple bases. Changes to operating instructions or any flight safety alerts can also be made known to them at the earliest.

1.17.8 Working Environment

During interaction with Post Holders and other senior Pilots of AI Express, it was evident that the senior management lacked cohesion. The Court was made privy to a number of e-mails indicating a strained relationship not conducive for efficient and safe operations. Since the Post Holders were from the parent company Air India, friction was visible between the contractual senior pilots of Air India Express with these Post Holders.

There were hardly any coordination meetings between all the Post Holders to synergise the working environment. This needs to be addressed on priority as it has implications on flight safety.

1.18 Additional Information

1.18.1 Use of Mobile Phones and Personnel Electronic Devices

For the purpose of aircraft industry, Portable Electronic Devices (PED) can be divided into two categories. One category of PED are those which intentionally transmits radio signals like mobile/cellular phones, amateur radio transceivers and transmitters that control devices such as toys, etc. Others are those, which are not intentional transmitters of radio signals like laptop computers, video cameras, calculators, electric shavers etc. However, some of the later category of PED can also have additional features and may fall into intentional transmitters of radio signals category.

The frequency bands of the electronic equipment of aircraft are different than that of the PED. There are chances, though very remote, that the electromagnetic emissions from PED may interfere with the airborne equipments. Therefore, the use of PED, which intentionally transmit radio signals like mobile/cellular phones, amateur radio transceivers on board the aircraft, is prohibited.

In the year 2008, a research was carried in USA on the use of PED on aircraft. Federal Aviation Administration (FAA) requested Radio Technical Commission/ Committee for Aeronautics (RTCA) to present an up-to-date evaluation of the use of PED on board civil aircraft with emphasis on intentional transmitters such as devices enabled with cellular technologies, wireless RF network devices. RTCA submitted the report in December 2008, and in its report, it has stated 'At this point, there is not sufficient information to support a universal change in existing policies regarding the use of transmitting PED on board aircraft.' The existing policies of use of PED aboard US registered aircraft are defined in FAA Advisory Circular 91-21.1B.

DGCA vide its Rule 29 B of Aircraft Rules, 1937 also prohibits the operation of PED aboard Indian registered civil aircraft. This rule permits the use of specified PED and other devices that in the opinion of the operator do not cause interference with the navigation of or communication systems of that aircraft. The conditions for use of PED are specified in CAR Section 5, series X, Part I. Electronic devices, intentionally transmitting radio signals like mobile/cellular phones, amateur radio transceivers etc if carried on board, shall be kept switched off in all phases of flight. Electronic devices which are not intentional transmitter of radio signals such as laptop computers, electronic entertainment devices shall not be used by any person inside the aircraft during take-off, climb, descent, final approach and landing phases of flight. All operators shall by suitable means address passengers on board their aircraft, to this effect.

The Indian operators including Air India Express have a procedure for announcements by cabin crew about switching off the mobile phones and other electronic devices before takeoff and landing phase of a flight. As per statements made by the survivors, cabin crew had made such announcements prior to landing of the ill-fated flight.

1.18.2 Table Top Airport at Mangalore

The Mangalore Airport is at Latitude 12º 57' 43.40" N and Longitude 074 º53' 23.20" E with elevation of 101.629m above mean sea level. The Airport presently has two runways 24/06 in operation since 2006 and the old runway 27/09. Runway 24/06 is predominately being used for airline operation and is also fitted with ILS Cat-1. While the length of the runway 24/06 is adequate for operations by aircraft such as Airbus A320 and Boeing 737-800, the downward slope at end of R/W 24 leading into hill slope is not recommended if one is to consider the hazards of overshooting the paved surface during takeoff or landing. There is a concrete structure at the end of R/W 24, which cannot be classified as obstruction as per ICAO Annexure-14, since it is below the approach and take off funnel.

There are three tabletop airports in India from where scheduled flights operate. These are Mangalore, Kozhikode and Lengpui. Because of the undulating terrain and constraints of space, these airfields require extra skill and caution while carrying out flight operations. The hazard of undershooting and overshooting, in particular, can lead to grave situations, as was the case in this accident.

These table top runways also have a problem of access roads around the airfield, which may need to be used in case of aircraft accidents. The narrow and winding roads can delay and hinder the rescue operations.

1.18.3 Critical Airfields

DGCA has classified certain airfields as critical which need special qualification for the flight crew to undertake operations. The criteria for classifying airfields as critical are based on various factors such as terrain, length of runway, predominance of inclement weather etc. There are 11 such airfields, which include the Table Top runways of Mangalore, Kozhikode and Lengpui. In addition airfields such as Patna, Jammu, Leh, Port Blair etc also qualify as 'critical airfields'.

The operators can add some more airfields as critical, in case additional caution needs to be exercised during operations. As per SOP of Air India Express, three airfields at Mangalore, Kozhikode and Pune qualify as 'critical airfields'. These airfields are, therefore, cleared for operations by experienced flight crew and take off and landings have to be carried out by PIC only.

1.18.4 Distance to Go Markers (DTGM)

As a visual reference to ascertain the remaining distance, it is recommended to install DTGM on runway shoulders. A number of pilots mentioned to the Court that such visual aids were helpful during take-offs and landings. The pilots also mentioned that Mangalore being a Table Top Runway installation of DTGM would be an additional help.

Since a number of civil air operators also use IAF airfields, use of DTGM could help the pilots to ascertain critical distances such as TODA, ASDA etc. if such runways do not have standard ICAO markings. DTGM are made out of frangible material and are installed at not only all Indian Air Force airfields, but also at a number of civil airfields abroad.

In this connection, DGCA had also issued a circular No AV. 20021/1/82-AR II (P) dated 9th October 1985. It was an advisory for providing Fixed Distance Markers along the runways.

1.18.5 Pilot Fatigue: FDTL Regulation 28 of 1992

The Flight and Duty Time Limitations (FDTL) for Air India Express was being governed by Para 4 of AIC 28 of 1992 issued by DGCA, which is applicable to International operations.

On the other hand, Para 3 of above regulation deals with operations within the country and neighbouring countries, without specifying the names of neighbouring countries or in terms of change in Time Zones. In 1992, when this regulation came into force, there were only 2 commercial operators. Air India would fly long haul sectors and Indian Airlines would undertake flights domestically and to the neighbouring countries. In view of rapid growth in civil aviation sector and introduction of typical operators like Air India Express, as well as other related issues regarding fatigue, WOCL, rest periods etc., a revision of AIC 28 of 1992 has already been mandated by the Bombay High Court. A committee under the chairmanship of DGCA had submitted the revised FDTL Regulation to the Ministry of Civil Aviation during September 2010.

1.18.6 Controlled Rest in Seat

The Court was informed by a number of senior pilots who operate two-man cockpits such as Boeing 737-800 that they do feel like taking a short nap (micro sleep or power nap) during the cruise phase of flying. Most of them have admitted of having either availed such a nap themselves or seen other crewmembers dozing off for a while. There are dangers of such a nap prolonging into a deep sleep causing effects of sleep inertia. There is also a possibility of induced sleep, which affects the other crew members, who may also doze off.

There have been many incidents of such nature worldwide. The DGCA had also investigated a case of 2 flight crews allegedly sleeping at the same time and over flying the destination during 2009. The DGCA had issued Air Safety Circular No 2 of 2009 dated 12th January 2009 by which the 'cabin crew is required to interact with pilots on intercom every 30 minutes'. Although such a procedure is useful, it is possible that only one of the pilots who is awake all the time, would reply and the other crew could go into deep sleep. This was evident from the CVR, wherein Captain Glusica had slept for a considerable period with First Officer Ahluwalia responding not only to the R/T, but also to queries by the Cabin Crew.

A number of pilots of Air India Express had mentioned to the Court that after operating QTA flights at night, the pilots generally feel fatigued and wish to complete the flight as soon as possible.

Many airlines such as Air Canada have, therefore, brought out SOP accepting the fact that flight crew do take a nap which may actually refresh them prior to descent and landing. DGCA, therefore, needs to take a comprehensive view into the aspect of Controlled Rest in Seat, especially in a two-man cockpit. After due analysis, a regulation needs to be brought out for its effective implementation.

1.18.7 Submission by the Participants to the Court

The Court had invited a number of participants to suggest improvements in Flight Safety. Other than Air India Express, DGCA and AAI, various associations of pilots, engineers and ATC Guild had also actively participated in these deliberations. Their suggestions regarding flight safety counselling, FDTL, Duty Hours etc. were noted.

In view of rapid growth in civil aviation sector, apart from focus on additional infrastructure, there is also a need to pay attention on human resource issues such as training, scheduling and fatigue factors etc. The ATC and Engineering personnel brought out the need for DGCA Regulation on Duty Time Limitations to cater to fatigue.

1.18.8 Brief on Airports Authority of India

Airports Authority of India (AAI) was constituted by an Act of Parliament and came into being on 1st April 1995 by merging erstwhile National Airports Authority and International Airports Authority of India. The merger brought into existence a single organization entrusted with the responsibility of developing, upgrading, maintaining and managing civil aviation infrastructure as well as management of air space. Details regarding AAI can be browsed on http://www.aai.aero.

Apart from airport management, AAI ensures training of Air Traffic Controllers and Rescue and Fire Fighting Crew. AAI also carries out central procurement of various CNS and ATM equipment as well as RFF vehicles.

1.18.9 Brief on DGCA

1.18.9.1 Organization and personnel

Directorate General of Civil Aviation (DGCA) is an attached office under the administrative control of Ministry of Civil Aviation, Government of India. DGCA promulgates the regulations under the Aircraft Act, 1934 and the Aircraft Rules, 1937. Civil Aviation Requirements (CAR) are issued under Section 5A of the Aircraft Act, 1934 and these are also kept updated from time to time in line with Standard and Recommended Practices; and associated procedures contained in the ICAO Annexes.

The Director General heads DGCA. There are 14 Regional / Sub-regional offices spread throughout the country. The duties, functions and responsibilities of DGCA are defined and these can be browsed at DGCA website www.dgca.nic.in. DGCA formulates rules and regulations, issues registration to aircraft, licences to pilots, AME, ATC controllers and aerodromes. It also grants approvals to operators and maintenance organisations, issues certificate of airworthiness and their renewal.

1.18.9.2 Safety oversight capability

DGCA conducts audits, surveillances and carries out Spot / Surprise Checks to ensure effective implementation of safety related rules, regulations and requirements. Regional and Sub-Regional Offices of DGCA carry out surveillance checks as per the Standard Check List formulated area wise. These Check Lists are available on DGCA website for information. DGCA brings out a Quarterly News Letter ‘Nai Udan’ in which Flight Safety issues are briefly mentioned.

DGCA is also mandated to ensure that all the foreign airlines operating in India adhere to safe operating environment as outlined by ICAO. During investigation, it was brought out that DGCA was in the process of bringing out necessary regulation in this regard.

During the investigation, it was also brought out that DGCA had directed all the operators to incorporate Safety Management System (SMS) to enhance the level of safety. Such comprehensive measures in all spheres of aviation activity can be implemented with requisite vigour, only when the senior management is also exposed to training in Flight Safety.

1.18.9.3 Audit of Air India Express

DGCA had carried out an audit of Air India Express during November 2007. A number of observations were made during this audit. After the accident, DGCA carried out another audit during June 2010. A number of observations were repeated in this audit e.g. Post Holders not being qualified on type, non-computerisation of Crew Scheduling etc. DGCA had also directed Air India Express to operate as an Independent Entity in view of their separate AOP.

1.18.10 Setting up of Indian Aviation Safety Board

In the last decade, there has been a rapid growth in the Indian Civil Aviation sector. With further growth projected in this vital means of transportation, there is a need for an independent body, which will function as a watchdog in the matters of flight safety. The role of this independent body would be not only to investigate accidents and incidents of serious nature in Indian Aviation, but also to draw upon the recommendations emerging from accidents and incidents, worldwide. Since this organisation will be focusing mainly on flight safety related issues, it will help in formulating proactive strategies to reduce accidents and incidents.

Such independent safety organisations have been set up in various countries such as National Transportation Safety Board (NTSB) of USA, Air Accidents Investigation Branch (AAIB) of UK, Transportation Safety Board (TSB) of Canada, Bureau d'Enquetes et d'Analyses (BEA) of France and National Transportation Safety Committee (NTSC) of Indonesia, to name a few. It is pertinent to mention that a similar organisation known as National Transportation Safety Board, India had been set up in 1987 on the lines of NTSB, USA. However, it did not have the independence as a statutory body and therefore, it did not fructify into a permanent set up.

In view of increase in volume of air traffic, a proposal to this effect has already been taken up by the DGCA and the Ministry of Civil Aviation.

2. Analysis

2.1 General

The analysis has been carried out to arrive at 'what', 'how' and 'why' the accident took place. While the aspects of piloting have been analysed, some of the other factors have also been dwelt upon to either rule out their relevance or to establish their bearing on the accident. Some of the factors considered include Air India Express organisational issues including flight safety counselling, safety areas at Mangalore Airport, fatigue and aero medical issues as well as interference by PED, to name a few.

2.2 Sequence of Events

2.2.1 Pre-departure Check by AME

As per the Oman Air personnel at Dubai, to whom the maintenance had been outsourced, the aircraft had arrived in a serviceable state from Mangalore for the QTA flight. The Flight Crew had also not reported any unserviceability. The Oman Air maintenance staff had carried out refuelling as per the instructions of Flight Crew. The aircraft had then been released after the turn around servicing, along with 2 defects carried forward under MEL from the previous flight. These 2 defects were of minor nature, one on passenger seat 25C and the other on Right Hand Tail Logo Light.

2.2.2 Pre-Flight Check by Pilot

Statements of the Ground Handlers, Commercial Staff and Maintenance personnel at Dubai had confirmed that the pilots had performed all their Pre-Flight Checks in a normal manner.

2.2.3 Take Off

From the analysis of the DFDR, it is evident that the take-off was un-eventful.

2.2.4 Climb

From the analysis of the DFDR, it is evident that climb was un-eventful.

2.2.5 Cruise

Analysis of DFDR and CVR revealed that the aircraft did not fly through any noticeable turbulence and followed the prescribed route from Dubai to Mangalore. Recording available on the CVR was for the last 2 hours and 5 minutes. During cruise, there was no intra-cockpit communication between the Captain and First Officer for the initial 1 hour 40 minutes. However, there was occasional communication between cabin crew and the First Officer.

On the CVR, there was a definite evidence of Capt Glusica having slept in his seat during the cruise. Captain's heavy breathing and snoring was recorded intermittently on the Captain's microphone channel of the CVR, while the First Officer had made all the required R/T calls. The Captain's breathing pattern indicated that he was sleeping and it was recorded from the 11th minute of available 2 hours and 5 minutes of the CVR recording. This was recorded intermittently until 21 minutes before the accident.

It was also evident from the CVR recording that there was no interaction between the Captain and the First Officer regarding position reporting or weather monitoring. Mangalore Area Control gave them instructions to carry out VOR DME Arc approach for runway 24. This vital information was received only by the First Officer and communicated by him to the Captain much later. This was in contravention of Air India Express SOP. This also indicated total breakdown of proper crew coordination and CRM.

The First Officer was continuously monitoring and communicating on R/T. At 05:37:16 hours IST, the First Officer requested if they were identified on radar. First Officer was advised by the ATC that the radar was not available. The information of radar not being available was also published in the NOTAM issued since 20th May 2010.

At 05:41:50 hours IST, the First Officer briefed the Captain regarding the weather and gave a short briefing on the expected approach at Mangalore. This was the first time that the CVR recording had revealed limited communication between the flight crew. However, the Captain did not communicate effectively in response to this briefing. The approach briefing was incomplete and not in conformity with stipulated procedures mentioned in the SOP.

2.2.6 Descent

At about 130 miles from Mangalore, the aircraft requested for descent clearance. This was, however, denied by the Mangalore Area Controller, who was using standard procedural control, to ensure safe separation with other air traffic. As instructed by Mangalore Area Control, the aircraft had reported its position at 05:46:53 hours IST, when it was 80 DME on radial 287 MML. The aircraft was cleared to 7000 ft and commenced descent at 77 DME from Mangalore at 05:47:28 hours IST. The visibility was reported to be 6 km.

At 05:50:46 hours IST, the First Officer had reported passing through FL 295. Soon after, at 05:50:54 hours IST and 50 DME MML the Captain had deployed speedbrakes to increase the Rate of Descent (ROD). At 05:51:57 hours IST, the Captain and the First Officer performed the Descent Preparation as per FCOM during the descent, but this was much later than the stipulated procedures.

As per the Air India Express B737-800 SOP, Descent Preparation should start at approximately 150 nm and should be completed before the aircraft descends below the cruising altitude for landing. It includes weather review, approach briefing and delegation of duties to be performed by the Captain and First Officer. This was especially incorporated to enhance situational awareness throughout the descent, approach and landing.

The delegation of duties helps in proper communication, understanding and reduces the workload on the flight crew. The purpose of the pre-descent briefing is to ensure that both crew members have a clear understanding of the proposed plan of action and are in complete agreement as to how this plan will be executed.

As per Air India Express SOP, use of headsets is mandated from start of pre-flight check list up to top of climb and from top of descent up to completion of secure check list after landing. However, the CVR transcript indicates that the first communication by the Captain using Hot mike started, only at 05:52:08 IST, which was about 13 minutes before the crash.

The salient features of the Approach Briefing contained in the Air India Express B737-800 SOP are well defined. It should be completed before the instrument approach wherein the Pilot Flying (Captain in the instant case) should brief the Pilot Monitoring (First Officer in this case) of his intentions in conducting the approach. Both pilots should review the approach procedure, approach information, minima and missed approach procedure, alternatives including landing and stopping distance planning.

2.2.7 Interception of DME Arc

At 05:54:19 hours IST, the First Officer had reported 25 DME MML and the Area Control had cleared the aircraft to 2900 feet and to change over to ATC Tower. At 05:54:30 hours IST, the First Officer had requested to proceed directly to 338 radial MML and gave his flight level as 184. There is no established procedure to join the DME Arc approach of ILS 24 while approaching MML from IGAMA on radial 287. Area Control agreed to his request to proceed and establish radial 338 inbound for the 12 DME fix. This is the Initial Approach Fix to commence the 10 DME Arc on radial 338 inbound MML.

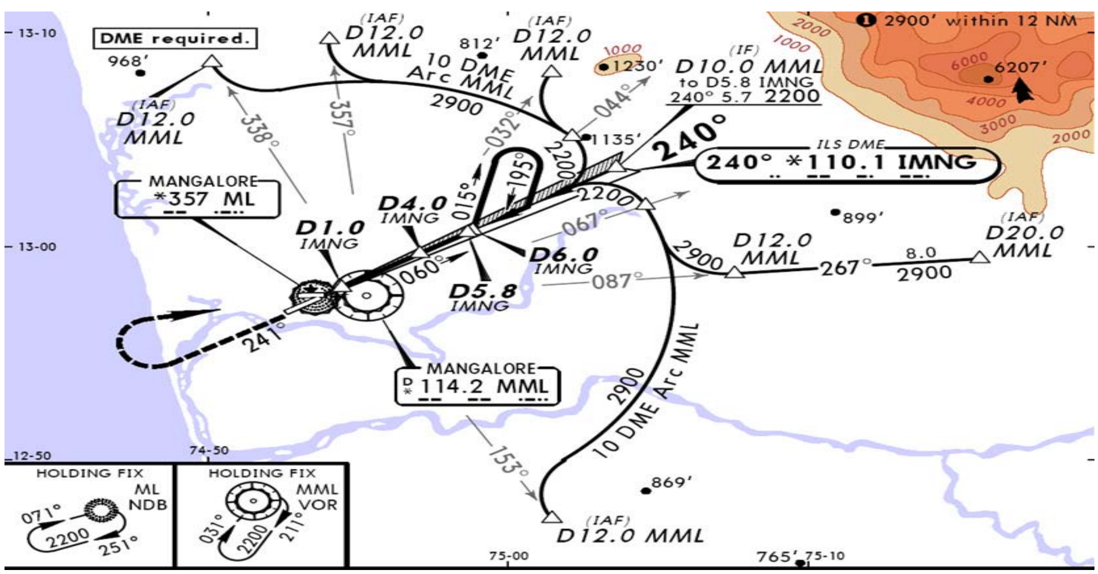


Diagram 14: DME Arc Approach for Mangalore Airport

At 05:55:03 hours IST, after establishing contact with ATC Tower, the aircraft was advised to join the VOR 10 DME Arc. At 05:57:42 hours IST, the First Officer confirmed having established 10 DME Arc for ILS runway 24, to which ATC Tower had advised the aircraft to call when established on ILS. From 05:55:13 to 05:58:56 hours IST, the only sounds made by the Captain were of exhaling, yawning and throat clearing. During the same time, the First Officer also made a sound of extended yawning and whistling on three occasions. Passing through transition at FL 095, the First Officer initiated the actions for setting the QNH which was 1006 hPa.

Subsequently, at 05:59:39 hours IST, the Captain ordered the landing gear to be lowered. The speedbrakes was already deployed in flight detent position, because of the high descent profile. The Captain had realised that he was high. So, he lowered the landing gear at this stage to obtain a higher rate of descent.

2.2.8 Capture of Localiser

Prior to the intercept of ILS, the SOP states that the flap selection should be in accordance with flap extension schedule and monitored by the First Officer. The SOP states that the Captain should initiate the completion of ILS preparation prior to the intercept of the localiser with ‘Flaps 5’. As the aircraft was cleared by the ATC Tower for the ILS approach, there are mandatory verifications, which need to be completed by both Captain and First Officer.

On the first positive inward motion of the localiser pointer, the First Officer should have called “LOCALISER ALIVE”, which he did not call. The First Officer gave a call of VOR LOC arming and VOR LOC capture. This call of “VOR LOC CAPTURED” at 06:00:24 hours IST appears to be the first time that the localiser was captured and the FMA ‘VOR LOC ARM’ (white) turned to ‘VOR LOC CAPTURED’ (green). As per SOP, the localiser capture should have been in ‘Flaps 5’ configuration and at appropriate speed. During the capture mode, aircraft had crossed the localiser and after an ‘S’ turn, had recaptured the extended centre line on localiser. This was due to selection of ‘Flaps 1’ instead of ‘Flaps 5’ and speed higher than stipulated. First Officer had realised this and gave a call “VOR LOC CAPTUR...ED” in a singsong manner.

From the above, it is evident that the Flap selection and Speed Control had been delayed with respect to the laid down SOP. It is pertinent to mention that the aircraft was descending with the speedbrakes deployed in flight mode.

2.2.9 Initial Approach

Having captured the localiser and during an attempt to capture the glide slope, at 06:01:01 hours IST and about 9.7 DME, the Captain requested for “FLAP 10”, while descending through 5930 feet. The speed at this time was 202 kt, which was higher than the maximum ‘Flap 10’ extension speed. This was checked by a questioning tone calling “TEN?” by the First Officer. The Captain reacted to this query and promptly reduced the speed as appropriate. This is not a normal sequence of selection of flaps. However, to cater for a descent and speed reduction, ‘Flap 10’ could be selected as per SOP.

At 7.6 DME, the aircraft was fully established on the localiser and was descending passing through 5150 feet altitude with a rate of descent of 1641 ft per minute. Soon after this, a prolonged coughing sound was heard on the Captain’s channel. This was followed by a sound of relief (AAAH!). At 06:01:57 hours IST, the Captain ordered “FLAP 15” while passing through 4630 feet altitude and 6.7 ILS DME.

It was observed that the FMA when read from Left to Right has, in the first column ARM (white), second column VOR LOC (green) and third column MCP speed (green). The MCP indicated Auto-throttle was ‘Armed’ and level change mode was selected with the VOR LOC in ‘Armed Mode’. The altitude window had indicated 2900 feet. It is pertinent to mention that the speedbrakes were still deployed in the flight detent in spite of selection of 'Flap 15'.

2.2.10 Selection of Speedbrakes During Approach

There are panel light indications in front of the flight crew. In front of the Captain, the indications are for arming the Speedbrakes, whereas, in front of First Officer is a panel light, which reads "SPEEDBRAKES EXTENDED". The Speedbrake control and panel lights are shown below: -

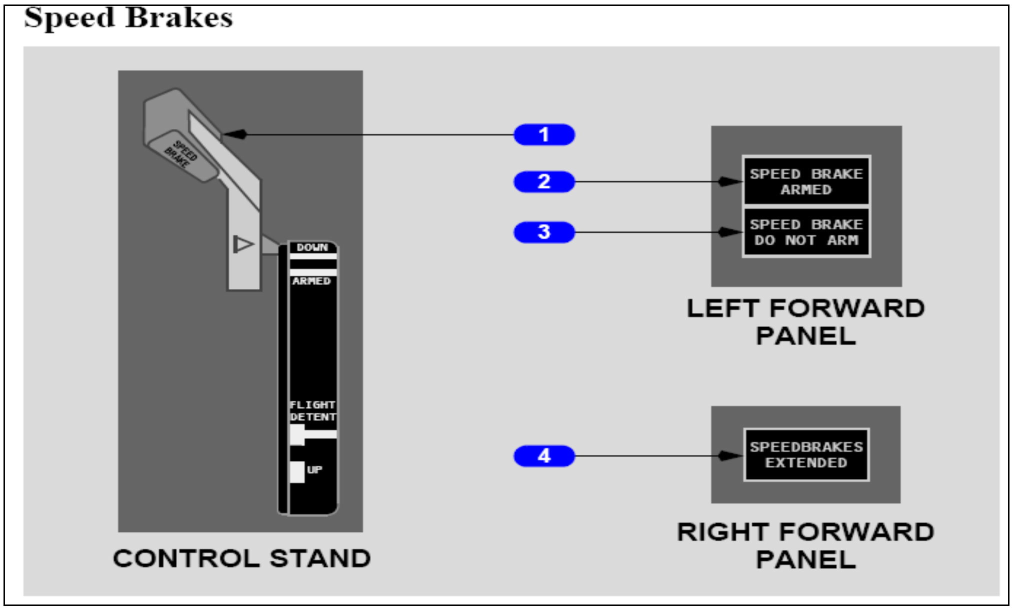


Diagram 15: Speedbrakes

The Speedbrakes extended light illuminates 'Amber' under the following conditions: -

1 SPEED BRAKE Lever

DOWN (detent) – all flight and ground spoiler panels in faired position.

ARMED –

- automatic speed brake system armed
- upon touchdown, the SPEED BRAKE lever moves to the UP position, and all flight and ground spoilers extend.

FLIGHT DETENT – all flight spoilers are extended to their maximum position for inflight use.

UP – all flight and ground spoilers are extended to their maximum position for ground use.

Photo 29: Description of Speedbrake Lever

At 06:02:43 hours IST, at altitude of 3465 ft, 4.3 ILS DME and a speed of 167 kt, 'Flaps 25' had been selected and the speedbrakes were retracted. This was in contravention of the SOP. The Speedbrakes Extended Light remained 'Amber' from when the flaps were selected beyond 10 to the time the speedbrakes were retracted to the 'Armed' position after selection of 'Flaps 25'.

During the critical phases of the approach and after selection of 'flaps 40', the Captain had redeployed the speedbrakes to Flight Detent at 06:03:26 hours IST. At a speed of 155 kt, 1420 ft 1.0 ILS DME, ROD of 3208 ft per minute, pitch attitude was 9° below the horizon. At 06:04:17 hours IST, 550 ft, 0.2 ILS DME, at a speed of 165 kt and a ROD of 2535 ft per minute, the speedbrakes were retracted to the flight detent position.

Air India Express SOP states that the use of Speedbrakes with the flaps extended should be avoided as far as possible. With Flaps 15 or greater, the Speedbrakes should be retracted. **Speedbrakes should be retracted before reaching 1,000 feet AFE.**

2.2.11 High on Approach

At 06:03:14 hours IST, 3.0 DME, ROD 1043 ft per minute, Speed 159 kt and at a height of 2815 ft, the Captain had requested for 'flaps forty' followed by the landing checklist. The landing checklist was done in a challenge and response tone, which was very clear and without any hesitation. It was at this time that the flight crew had shown correct CRM and alertness. Soon after completing the landing checklist, at 06:03:33 hours IST, the First Officer had commented "IT IS TOO HIGH". At this time, the airplane was 2.2 DME, 2570 ft, speed 143 kt and a ROD of 1588 ft per minute. Two seconds later, the aural call from the Radio Altimeter "TWENTY FIVE HUNDRED**"** was heard. It appears that the First Officer had looked at the visual profile and tried to draw the Captain's attention that the aircraft approach was very high.

At 06:03:40 hours IST, 2.0 ILS DME, 142 kt, 2365 ft and a ROD 1671 ft per minute, the First Officer had said "RUNWAY STRAIGHT DOWN". First Officer was trying to draw attention of the Captain of higher approach for the second time. At this stage, it is evident that the Captain had also seen the runway and said "OH MY GOD". The glide slope mode was engaged at this stage, but due to steep approach, a false glide slope was captured.

2.2.12 Disengagement of Auto-Pilot

At 06:03:43 hours IST, 1.9 ILS DME, 142 kt, 2300 ft and ROD 1508 ft per minute, the Captain disengaged the auto pilot and took over the controls manually. At 06:03:53 hours IST, 1.5 ILS DME, 1925 ft and ROD 2929 ft per minute, the First Officer suggested a 'GO-AROUND?' in a mild querying tone. Three seconds later, the Captain made a comment of "WRONG LOC - LOCALISER .... GLIDE PATH".

2.2.13 Unstabilised Approach

The AI Express SOP emphasises that the procedures and parameters listed for approach, are not mere targets, but are mandatory conditions and limits. Any deviation occurring at or beyond the beginning of the stabilised approach requires a mandatory 'go-around'.

After setting the localiser frequency and course, arming the APPROACH selects the APPROACH mode. The APPROACH switch illuminates and VOR/LOC and Glide Slope annunciate 'Armed'. The APPROACH mode permits selecting the second autopilot to engage in CMD. This arms the second Auto Pilot for automatic engagement after LOC and G/S capture; and when descent occurs below 1500 Radio Altitude. If the First Officer had made the airspeed and sink-rate deviation callouts, both the Captain and the First Officer might have been further alerted to the fact that the airplane's airspeed and sink-rate were excessive. When the Captain had ordered for Flap 10, the First Officer had enquired "10?" to which the Captain had replied, "WAIT A MINUTE". This indicated that the First Officer had alerted the Captain of airspeed being above the flap-load speed.

During the approach and landing, speed had reached 165 kt, in Flap 40 configuration. As a design feature, at an air speed of 162 kt, the Flap 40 would retract to position 30. This is due to the Flap Load Relief System. When the air speed reduces to 158 kt, the flaps would extend to 40 position again as per the auto function.

The EGPWS warnings were being continuously broadcast in the cockpit, first as 'SINK RATE' and then 'PULL UP'. The approach was not conducted in compliance with the airline's guidelines for stabilised approach. It appears that after sighting runway, the Captain continued the approach in unstabilised conditions, which indicated that he was 'FIXATED ON THE RUNWAY'. The First Officer did not make any call outs regarding the altitude, speed and sink-rate.

2.2.14 Landing

From a highly unstabilised approach, the Captain had persisted with the landing. As deduced from the DFDR, the aircraft was almost 200 ft above the threshold and at a speed of 164 kt as compared to 50 feet and 144 kt normally applicable for this configuration.

Due to such a high speed, the Flap Load Relief had moved the flaps from 40^o to 30^o and subsequently, when the speed reduced below 158 kt, the flaps got re-deployed to 40^o. This extension during the flare, close to the ground resulted into a prolonged float and a late touchdown. The right wheel touched first at about 4500 feet from the beginning of runway 24. However, the aircraft bounced slightly and it finally touched down at about 5200 feet.

2.2.15 Braking

Although the runway length of 8033 feet at Mangalore is adequate for Boeing 737-800 operations, most of the pilots prefer to use Auto Brake setting of 3 or MAX to ensure timely stoppage of aircraft. However, in the accident aircraft, the Auto

Brake setting was set at 2. After touchdown, the Captain had selected Thrust Reversers and commenced braking. It was initially gradual due this setting. However, later when the brake pressure had been increased manually, as per the aircraft braking system, the aircraft started decelerating much faster. It was brought out by the Boeing Test Pilot during Public Hearing that if the Captain had deployed detent reverse thrust and had applied maximum manual braking at touchdown, the aircraft could have stopped by 7600 feet beyond the R/W 24 threshold i.e. on the paved portion of R/W 24.

While such stoppage figures are demonstrable during controlled test flying scenarios, these cannot be considered for landings during routine line operations. However, if the Captain had initiated maximum manual braking with Thrust Reversers, the aircraft could have stopped in the overshoot area and the accident might have been averted.

2.2.16 Accident

After having commenced braking, the Captain made a grave mistake of stowing Thrust Reversers and opening full throttle with the intention of going around. The Boeing SOP categorically states that during landing, having selected thrust reversers, these should not be cancelled to initiate another take off. Despite such clear instructions, the Captain had tried to go around. This further aggravated the situation and the aircraft impacted the non-frangible ILS mounting structure close to the airport fencing and fell into a gorge.

2.2.17 Pilot Incapacitation

The Cockpit Voice Recorder reveals coherent speech of both pilots during the last 17 minutes of the flight before the crash. This included Flap Selection, Landing Check Lists by both pilots and identification of wrong glide path by the Captain. Further, the DFDR data reveals positive control inputs including disengaging of Auto-pilot, flying manually by giving control column inputs and deploying Reverse Thrust after touch-down. Pilot incapacitation is, therefore, ruled out.

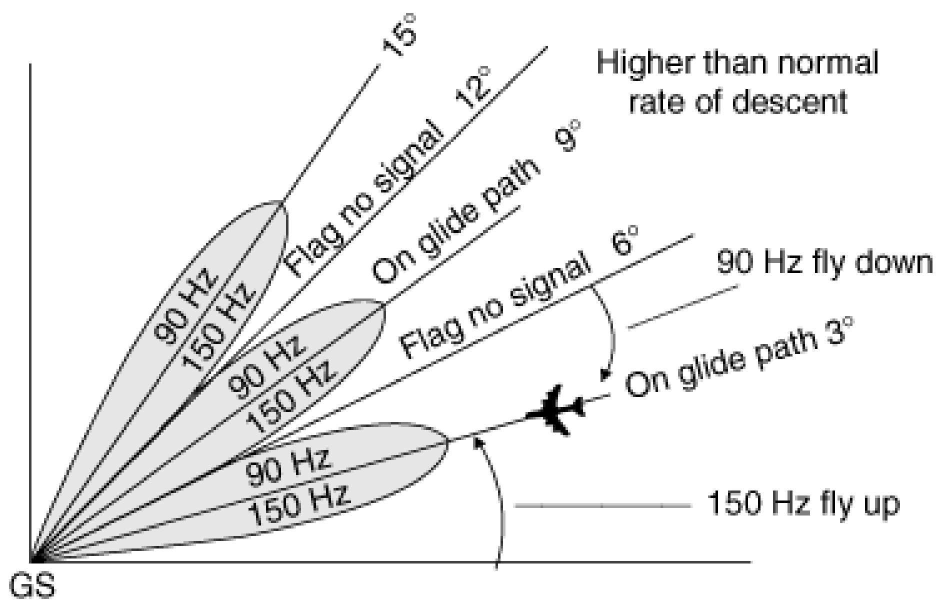
2.2.18 Aspects of Hard Landing and Going Around

Flight Safety counselling on one-off incident of Hard Landing by Captain for 1.9 Vg, which was much less than AMM limit of 2.1 Vg cannot be considered as a contributing factor towards the accident. Having been consistently unstabilised on the ILS Approach, even if the Captain had been able to stop the aircraft on the runway, the subsequent FOQA analysis of DFDR and possibly of CVR, would have indicated various violations of SOP by the Captain. This would have, in any case, warranted another reprimand by the authorities. In a high energy and fast approach, resulting in a very late touchdown, no prudent pilot would also aim to make a smooth touchdown to avoid flight safety counselling. The aircraft in this instant had not been able to remain firmly on the runway because of higher speed at touchdown and not possibly because of any attempted smooth landing.

Similarly, having been repeatedly asked by the First Officer to ‘Go Around’, from an unstabilised condition, it will not be correct to surmise that raising of an OIR for another, but safer approach and landing, would play on the mind of a highly experienced Captain. He should have been aware of having violated correct procedure on approach and landing. In this case also during the FOQA analysis, such violations would have been noticed.

2.2.19 Incorrect Procedure to Ascertain False ILS Glide Slope

Having analysed that the aircraft was very high on approach, the Captain should have co-related the parameters with various laid down cross-references of distance, height, speed and rate of descent. As a matter of fact, it is with such cross-references that a pilot would not only identify a false glide slope, but take corrective measures including a 'Go Around'. It can been seen from the chart below that in deviations from the standard 3° Glide Path, the aircraft descends on a steeper path.



(Source: http://www.answers.com Copyright McGraw Hill. 'An Illustrated Dictionary of Aviation, 2005')

Diagram 16: Graph for Descent during False ILS Glide Path

Note: A characteristic of the glide-slope portion of the ILS, in which one or more false glide slopes at different angles to the horizontal occur well above the true glide slope. This is because of a radiation pattern of the antenna and the ground reflection of some of the transmitted energy, resulting in more than one overlapping lobe. The false glide slopes occur at odd multiples of the true glide-slope angle (typically 3°) (i.e., at 9° and 15°). At even multiples (6°, 12°), a centred glide-slope needle occurs, but this is because of a null signal; reverse sensing is present above and below these glide slopes. **A pilot can easily recognize this false indication by the steeper-than-normal rate of descent.** Pilots will not experience false glide slopes below the true glide-slope angle. **Pilots can avoid encountering a false glide slope by following published approach procedures**.

2.3 Flight Crew Performance

2.3.1 Crew Resource Management (CRM)

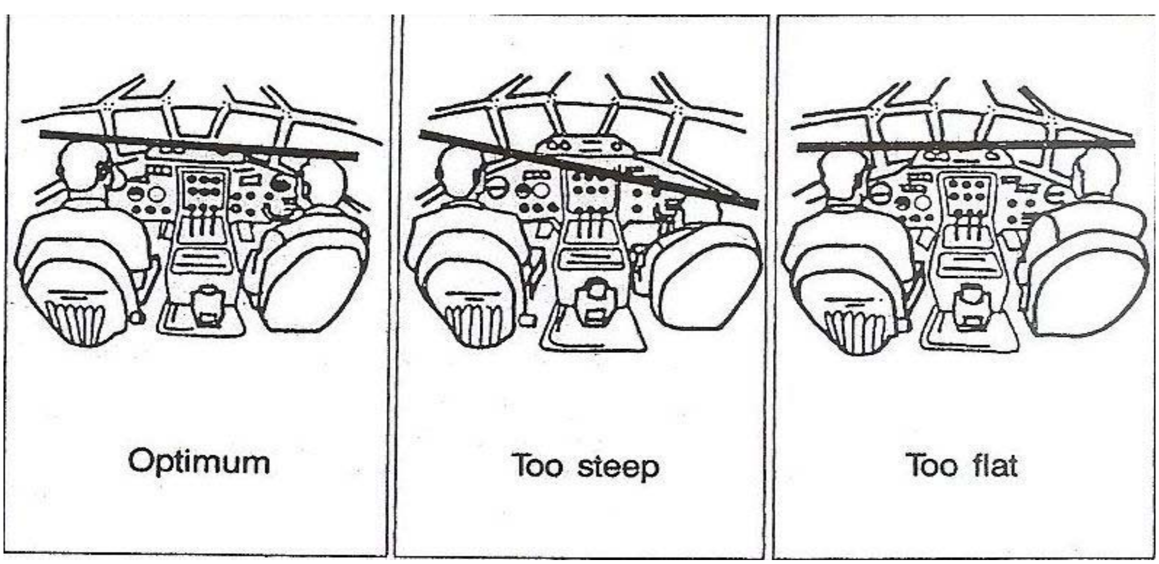
The First Officer failed to challenge any of the Captain's errors as his CRM training and experience, should have equipped him to do so. CRM is an effective method to use all available resources to achieve a safe and efficient flight. Specific issues such as leadership, assertiveness, decision-making, delegation and acceptance, as well as crew interaction and communication constitute the basic elements of CRM.

The prime objective of CRM training is to produce an atmosphere of sound leadship by the Captain. CRM fosters participation by subordinates by encouraging Captains to be receptive to their inputs or suggestions. There is a need to encourage requisite assertivness in subordinate crew when they express their concerns. Interpersonal communications, skills and healthy relationship improves the environment for an effective and conducive cockpit environment. Good CRM practices and procedures should be reinforced and evaluated as an integral part of training during both, Line Oriented Flying Training (LOFT) in simulator and Route Training.

2.3.2 Trans-Cockpit Authority Gradient (TAG)

There are recommendations to maintain stabilised approach criteria. Maintaining a stable speed, descent rate and vertical/lateral flight path in landing configuration is commonly referred to as the Stabilised Approach. However, the crew had compromised safety of the flight. Teamwork or crew coordination in this flight was also lacking.

The authority relationship between the Captain and the First Officer appears to have reduced the performance of the crew. The Captain had ignored the submissive concern of the First Officer about the unstabilised condition of aircraft during approach and landing.



(Source: Edwards 1975)

Diagram 17: Levels of Trans-Cockpit Authority Gradient

There is an optimum 'Trans-Cockpit Authority Gradient' to allow effective interface between pilots during the flight. In this case the 'Trans-Cockpit Authority Gradient' was very steep, because of the assertive Captain and a submissive First Officer. The reduced performance had resulted in a chain of errors going undetected and uncorrected. This steep 'Trans-Cockpit Authority Gradient', limited the communication skills of both the crewmembers, especially the First Officer who tried to draw the attention of the Captain to conduct a 'Go-Around' due to unstabilised conditions. The reasons appear to be the authoritative style of the Captain and desire of the First Officer to avoid conflict.

Socio-cultural factors also appeared to have played a role in this accident. The First Officer had failed to be more assertive when the Captain was continuing the approach in unstabilised conditions. Socio-psychological influences can interfere with the proper exchange of briefing and standard call-outs; and thus affect safe operations. In spite of First Officer clearly advising the Captain of discrepancies, the Captain failed to take corrective action. Air India Express therefore, needs to develop effective CRM Training that will foster Crew Co-ordination so that the crew develop bonding and motivate each other to accomplish team goals over and above their individual goals.

2.3.3 Analysis of Crew Conversation

From the CVR transcript, it was evident that the Captain did not communicate with the First Officer, especially during the descent phase and the expected instrument approach briefing. There were also indications that the task performance was affected because the First Officer did not query or effectively communicate with the Captain. Limited communication including omission of a number of crucial and mandatory calls affected the crew performance.

The CVR indicated low standard of CRM by both pilots. The First Officer did not use an appropriate and assertive style to communicate with the Captain. The technique employed by the crew in flying the approach profile involved a high cockpit workload. The crew failed to use the standard height and distance relationship to check their vertical profile throughtout the ILS approach. Many aspects of how these two pilots communicated to perform routine tasks, suggested that the pilots were not working in harmony.

2.3.4 Monitoring of Training and Evaluation

It was observed that the organisation had not paid adequate emphasis to monitor training and subsequent evaluation to raise the standards for Safe operation. There was no audit of training requirements.

It was noted that standard industry acronyms were not being used. Instead, terms like Supernumerary Under Training (SUT) and Line Oriented Training (LOT) appeared in the Training Manual, but not in Air India Express SOP. Training had been done with passengers on board and even observation flights had been recorded against hours gained towards reckonable experience.

2.4 Cabin Crew Performance

All the 4 cabin crew died in this crash. The cabin crew had also not been subjected to any pre-flight medical at Mangalore. However, none of the ground staff, who interacted with the cabin crew at Mangalore or Dubai had noticed any signs of medical problem.

As per the survivors of this ill-fated flight, the cabin crew had been alert and co-operative throughout the flight. They had also made the necessary announcements regarding switching off the mobile phones and PED; as well as safety instructions prior to landing.

From the CVR recording, it can be discerned that the cabin crew had been entering the cockpit to enquire whether the flight crew needed any food or beverages, which is a normal practice.

2.5 Airworthiness of Accident Aircraft

Boeing 737 - 800 aircraft VT - AXV, Serial No. 36333, manufactured in January 2008 was registered in India with DGCA on 15th January 2008. DGCA had granted the Certificate of Airworthiness No 3081. The Aircraft was operating with Air India Express since its manufacture.

As per the Air Frame Log Book Entry, Phase - 17 Inspection was carried out on this aircraft on 21st April 2010 and the last extended Transit Inspection was carried out on 20th May 2010. The aircraft had completed 7199.41 hours and 2833 landing as on 21st May 2010. The scrutiny of the Engine Log Books indicates that the engines were maintained as per the required procedure.

Scrutiny of the aircraft Log Books indicates that the aircraft had been maintained in continued airworthiness as per the approved Aircraft Maintenance Programme. All the required Mandatory Modifications and Airworthiness Directives had been complied with.

The analysis of the defects recorded reveals that the aircraft had not experienced any serious snags / defects which might have contributed to the cause of accident. The aircraft was released from Dubai to operate the ill-fated flight IX-812 to Mangalore on 22nd May 2010 with two carry forward snags under MEL. The carry forward snags were of minor nature, related to Right Hand Logo Light and Seat No 25C being un-serviceable.

Post accident inspection carried out on various components indicated that both the engines and aircraft systems were serviceable till the time accident. Neither pilots had reported any abnormality or emergencies during the flight nor was it indicated in the post crash CVR/DFDR analysis.

There was no fire in the flight. Also, during the landing roll, there was no indication of deflation or tyre burst prior to the crash. The aircraft was fully serviceable and was in a state of airworthiness till the accident.

2.6 Bird Strike

There was no bird strike reported by the flight crew or any birds sited during approach and landing phase of the accident aircraft. The post accident inspection of both engines has also confirmed that there was no evidence of any bird strike or bird ingestion.

2.7 Portable Electronic Devices

The Court went through a number of studies carried out regarding interference by Mobile phones that were completed by NASA, USA. The Court also examined effects of other Portable Electronic Devices (PED) on electronic equipment installed on aircraft as well as on ground installations at the airports. The Electro Magnetic Interference (EMI) trials carried out have not indicated any disturbance by mobile phones or PED. Despite such findings, the studies do not rule out an odd possibility of interference due to issues such as shielding of cables, power output of PED, distance of PED from electronic modules etc. As such, most of the operators worldwide do not permit use of mobile phones and PED during the critical phases of flight viz take-off and landing.

The survivors had mentioned to the Court that the Cabin Crew had made necessary announcements regarding switching off the mobiles and the computers. It can also be seen from the analysis of CVR and DFDR data, the aircraft had responded as per the inputs given by flight crew, at all phases of the flight, including approach and landing. No abnormalities were voiced by any of the flight crew. Hence, the interference by PED carried by occupants of the ill-fated flight is ruled out.

2.8 Analysis of Safety Factors at Mangalore Airport

Since Mangalore airfield has a Table Top Runway, Air India Express had classified it a critical airfield. As such, it requires special clearance for both the flight crew to operate from Mangalore. The Air India Express SOP warrants that only PIC should carryout take-off and landing from Critical Airfields. With this caution, it was expected that an experienced PIC would have ensured that all the necessary approach parameters would be met for a safe landing.

The runway length for R/W 24/06 is 8033 feet, which is more than adequate for operations for aircraft such as Boeing 737-800 and Airbus 320 family. The safety areas for R/W 24/06 were in accordance with CAR issued by DGCA and Annexure-14 of ICAO. Hence, it did not contribute to this accident.

2.8.1 Runway Surface and Friction

The runway surface was dry and not contaminated at the time of the accident. A light drizzle had started only after the aircraft had touched down on the runway. Although the runway friction values had not been evaluated for one and half year, the friction test carried out soon after the accident indicated values of 0.78 mμ to 0.91 mμ as against the minimum values of 0.40 mμ. Such large variation in friction value as compared to 0.64 – 0.66 mμ measured in December 2008, needs further examination by AAI in terms of calibration of Friction Tester, types of tyres used on the tester and maintenance of runway surface etc.

2.8.2 Downward Slope in Overshoot Areas

Mangalore being a table top runway with deep valleys and gorges on either ends of airport, there should be no downward slope in the overshoot area. This is particularly in view of a large number of accidents recently, which have occurred during takeoff and landing phases, resulting in runway excursion.

2.8.3 Maintenance of RESA

Inspection of RESA at Mangalore had revealed that at the time of accident, localiser antenna and some temporary concrete platforms for ILS calibration were located within RESA. It also lacked regular maintenance. The RESA did not have adequate sand refilled as the concrete mounting structure of approach lights were protruding above the surface. Also, there were shrubs and vegetation in RESA as evident from the photograph shown below. Regular ploughing of this area would have prevented such growth.

Photo 30: RESA for R/W 24 at Mangalore on the Day of Accident

2.8.4 Soft Ground Arrestor

In order to help in retarding an aircraft in the overshoot area, ideally, a system such as EMAS, be installed at the table top airports. However, in case it is not cost effective, then at least a Soft Ground Arrestor (SGA) should be available as part of RESA. Such SGA is maintained at all Indian Air Force bases with regular filling of sand and ploughing.

2.8.5 Non-frangible ILS Mounting Structure

The ILS structure at Mangalore has a concrete mounting which is non-frangible. Since the structure is below the surface level of runway, it is not an obstacle within the approach or takeoff funnel. However, the Captain on leaving the paved surface seemed surprised that such a big structure was present in the overshoot area. As per CVR recording, it was evident from his call, “A BIG ONE”. Once the downward slope is filled up and brought to the same level as of the runway, this non-frangible ILS structure will also get buried below the surface leaving only the frangible ILS Localiser Antenna, on the top.

2.8.6 Strip Width

Due to the constraints of terrain, the strip width is only 150 metres as against the mandated 300 metres. This limitation is one of the major permanent concessions sought by AAI for licensing of Mangalore airport. Two points emerge from this concession. Firstly, there should be no further erosion of strip width and necessary engineering precautions need to be taken to ensure this. Secondly, all operators would need to impose crosswind limitations during take-off and landings, so as to avoid aircraft excursion laterally.

2.8.7 Narrow Roads outside the Perimeter

Considering the risk analysis and the possibility of aircraft overshooting down the hill slope beyond the Mangalore airport perimeter, the RFF vehicles like Rosenbaur should be able to reach the crash site urgently. For this, the access roads should be broad enough, which was not the case around Mangalore airport at the time of accident.

2.9 Analysis of Area Radar Availability

The Area Radar MSSR had a fairly good state of serviceability since its installation in the year 2000. There is built in redundancy in terms of alternate rack for 24x7 operations. There were adequate first line spares and maintenance support available locally for any urgent repairs to ensure continued serviceability of the Radar. However, on 20th May the mounting arm had broken for which the spare had to be airlifted from Delhi and the radar was made serviceable only on 24th May, 2010.

From 20th May till 24th May the radar remained unserviceable and a NOTAM to this effect had been published. Without radar, the area control needed to resort to procedural control, which leads to intense R/T activity. On 22nd May 2010, if the radar was available the ill-fated flight IX-812 would normally have been given descent at 130 DME. However, to ensure safe separation from other traffic the descent was given at 77 DME. All flight crew are trained to plan descent from such closer distances and if not possible to intercept the ILS DME Arc, the aircraft should descend in the ‘HOLDING AREA’ so as to avoid being high on approach. However, the flight crew of accident aircraft failed to plan the descent properly.

2.10 Additional Area Radars in the Region

Notwithstanding the fact that the unserviceability of the radar did not contribute to the accident, efforts must be made to maintain even higher state of serviceability of this MSSR, since this radar has a pivotal role in controlling the transiting traffic in this region.

Most of the controllers had suggested to the Court that there should be additional Area Radars at Kozhikode and Kochi. This would help in assigning the responsibility of radar coverage during periods of unserviceability of Mangalore Radar and vice versa. Such redundancy would also help with the projected growth in air traffic in the years ahead.

2.11 Weather Conditions

No significant weather had been either forecasted or reported en-route from Dubai to Mangalore. The visibility at Mangalore was 6 km at the time of accident. As such the prevailing weather conditions did not contribute towards the accident.

2.12 Sabotage Aspects

The Bomb Disposal and Detection Squad (BDDS), Chennai, Bureau of Civil Aviation Security, had subjected the wreckage, the crash site and the surrounding area to explosive examination. In their report, these experts had concluded that there was no explosion on board the aircraft prior to the crash. Based on the report by BDDS, sabotage as a cause of the crash was ruled out.

2.13 Fire

2.13.1 Fire in Air

There was no report of the aircraft having caught fire in the air by the flight crew or by any of the witnesses who observed the accident aircraft on runway. The readings of CVR and DFDR have further substantiated this aspect.

2.13.2 Fire on Ground

On impact with the ILS structure, major portion of the right wing and engine had separated from the aircraft. As a result of this impact, the parts had caught fire, which were extinguished by the first RFF vehicle.

When the aircraft finally came to rest in the gorge, the aircraft had caught fire. This resulted in suffocation and burn injuries, leading to death of crew and passengers, other than 8 survivors. A number of parts of the aircraft had also been consumed in the fire. The RFF crew of Mangalore had responded well but owing to the distance and difficult terrain could not reach the site quicker than about 4-5 minutes by which time the aircraft had been engulfed in fire. With sustained and involved efforts by the airport staff and civil fire department the fire was brought under control so that the charred bodies could be removed from the aircraft wreckage.

The RFF crew would have contributed to better rescue operations, if the Hazard identification and risk management exercises would have taken into account possibility of crash outside the airport. Mock drills conducted catering to such circumstances would have highlighted the need for better access roads.

2.13.3 Crowd Control

The crash site was approachable by a narrow and winding road. The subsequent RFF vehicles could not reach the crash site as people had crowded the roads. The local residents were among the first to help in the rescue operations and their help deserves to be appreciated. But, the large crowd of onlookers had hindered efforts of the specialist agencies of fire and medical. In this connection, the DGCA had issued guidelines vide Air Safety Circular No 03 of 2001. But, these guidelines were not available with the executing authorities.

2.14 Aero medical Aspects

2.14.1 Medical History of Pilot-in-Command: Captain Z Glusica

2.14.1.1 General Health

The Captain was a 55 year old pilot who lived near Belgrade, Serbia. He was employed as PIC on Boeing 737-800 in Air India Express w. e. f. 15th December 2008, after having been issued the Foreign Aircrew Temporary Authorisation (FATA) by the DGCA. His last licensing medical examination, wherein he was declared medically fit Class 1 & 2, was held at Belgrade and was valid till 16th August 2010. As per the existing DGCA regulations in force, he was not subjected to any licensing medical examination for civil flight crew in India. Other senior flight crew from Serbia as well as Indian First Officers had confirmed that he was a non-smoker and teetotaller.

His wife and son residing near Belgrade, Serbia, had confirmed to Air India Express representative on 15th August 2010, that prior to accident, the Captain had been suffering from a "little stomach upset and sore throat". His wife had also stated that a pouch of medicines recovered from his hotel room at Mangalore, along with other personal effects delivered to her, contained Aspirin and some antibiotics. The details of these medications could not be established by the Court, since she had disposed them off. One of the First Officers with whom he had flown earlier deposed to the Court that the Captain had taken a Vitamin C tablet during a flight and on being queried by the First Officer, he had commented that it helped him to stay awake. Analysis of post mortem blood sample of the Captain did not reveal presence of any alcohol, sedative or anti-histamines that might have induced drowsiness.

2.14.1.2 Opportunity for Rest

Captain Glusica had returned to Mumbai after his break abroad on 18th May, 2010 at 2130 hrs by flight AI 126 from Frankfurt. Crew Scheduling Department of Air India Express had requested him if he could operate flight IX 811/ 812 on 21st /22nd May 2010, to which he had agreed. He had reached Mangalore on 19th May 2010 from Mumbai by IC-179 and was staying at the Gateway Hotel, Mangalore, where he had checked-in during the afternoon of 19th May 2010. On return to India, the Captain had spent one night at Mumbai and two local nights in hotel at Mangalore. This provided him with sufficient opportunity for rest prior to undertaking the IX-811 / 812 flight for Mangalore-Dubai-Mangalore sector on 21st May 2010. The time zone difference between Serbia and India is 3.5 hours (with daylight saving) and the rest opportunity was adequate to cater to circadian desynchronises, if any. The Court is of the opinion that Air India Express was well within the stipulations of the existing FDTL Regulations, in asking the Captain to operate the flight.

2.14.1.3 Personal Professionalism in Flight Crew

Personal professionalism in pilots includes, inter alia, judicious use of rest during the allotted hours to avoid fatigue during flying. It is also not possible to ascertain whether a pilot does actually get restful sleep during the time available to him. For this, the pilots need to be given training in Fatigue Risk Management.

Similarly, self-medication by flight crew is avoidable. Ideally, the Captain should have consulted an airline doctor regarding his “seemingly trivial” disability. A physician, who has received training in Aviation Medicine, would have clarified issues pertaining to the peculiar concerns of flying with “stomach upset and sore throat” as well as the implications of flying with medication, if required.

2.14.2 Medical History of First Officer: HS Ahluwalia

2.14.2.1 General Health

First Officer Harbinder Singh Ahluwalia, a 40-year-old pilot belonged to Mumbai. He was unmarried. He was employed as First Officer on Boeing 737-800 in Air India Express w. e. f. 27th April 2009, after having served as First Officer with Jet Airways for about five years. From the statements of eye witnesses, who had interacted with him at Mangalore and Dubai, it can be surmised that he was in apparent good health. Perusal of his Permanent Medical Records (PMR) revealed that he was declared temporarily unfit for flying and investigated for Systolic murmur and Sinus Tachycardia in March 2001. His tachycardia was attributed to anxiety regarding medical exam and he was declared fit in April 2002. Since then he had been found fit on all licensing medical examinations. His last licensing medical examination was held at AFCME, New Delhi on 11th February, 2010 wherein he was declared Fit Class 1 Medical Examination till 10th August, 2010. His colleagues and family had confirmed that he was a teetotaller and a non-smoker.

2.14.2.2 Opportunity for Rest

First Officer Ahluwalia was posted at Mangalore and was sharing an apartment in Mangalore with another First Officer of the same airline. His last flight prior to the fateful flight was IX-811/ 812 on 17/ 18th May 2010. He thus had adequate rest period prior to the fateful flight.

2.14.3 Pre-flight Medical Examination

Air India Express did not have a Medical Officer on its rolls or on contract at Mangalore. No pre-flight medical examination was therefore conducted on any flight crew for flights originating from Mangalore. The DGCA requirement for pre-flight medical examination is specified in CAR, Section 5, Air Safety, Series 'F' Part III, Issue 1 dated 13th November 2009. This CAR mandates a breathalyser check for all crew of at least 40 % flights originating from a station. However, the requirement for 100% medical check of all flight crew is not clearly spelt out. The Handbook on Medical Assessment of Civil Flight Crew on the DGCA website (which is stated to be a guideline and not to be quoted as authority) identifies the requirement for pre-flight medical of all flight crew as a responsibility of Airline Doctors. Nevertheless, it is understood that many other Indian scheduled operators are conducting pre-flight medical examination of 100% flight crew from the stations where flights originate.

The hotel staff and Air India Express ground personnel who had interacted with the flight crew did not notice anything abnormal about the flight crew on the night of 21st May 2010, before IX 811 took off for Dubai. Similarly, ground personnel at Dubai did not find anything abnormal about both flight crew. However, since there was definite evidence of coughing and throat clearing by the Captain on the CVR, as also since the Captain's wife had stated that he was suffering from stomach upset and sore throat prior to the accident, it is possible that the Captain was not fully fit on the day of the flight.

2.14.4 Evidence and Possible Consequences of Fatigue

2.14.4.1 Sleep in Cockpit

On the Cockpit Voice Recorder (CVR), there was definite evidence of Capt Glusica sleeping on his seat during cruise. Captain's heavy breathing, mild snoring and light rhythmic breathing was recorded intermittently on the Captain's microphone channel of the CVR while the First Officer had made all the R/T calls. That the breathing pattern was indicative of sleep, was confirmed by CVR experts from DGCA, New Delhi as well as those from NTSB, Washington DC, USA. The typical breathing pattern was recorded starting from 11th minute of available 2 hours and 5 minutes of the CVR recording. It was recorded intermittently till 21 minutes before the accident. At places, rhythmic breathing (regular cadence) was heard immediately after loud R/T calls recorded on the Area Mike. This suggested that the deep sleep was of such quality that it was difficult to be easily aroused or disturbed. The CVR had recorded a total duration of 1 hour and 28 minutes of breathing pattern /snoring suggestive of deep sleep. Factors that may have possibly contributed to his fatigue, manifesting into uncontrolled sleep are discussed as follows: -

- Operations in WOCL
- Medical Fitness to undertake the Flight

2.14.4.2 Operations in WOCL

The Captain was operating flight in the Window of Circadian Low (WOCL) after a long break from flying duties. Normal physiology of human sleep suggests that it is difficult to maintain arousal and alertness during 02:00 to 06:00 hours, the main WOCL period. In this case, it was further compounded by a break from duties demanding such requirements.

2.14.4.3 Medical Fitness to undertake the Flight

His family had stated that prior to the accident; Captain Glusica was suffering from "stomach upset and sore throat". Throat clearing and coughing sounds made by the Captain had been recorded on the CVR. The hotel staff at Mangalore had confirmed that Capt Glusica had eaten very little during his stay on 19th, 20th and 21st of May 2010. It was possible that he might have been suffering from mild Upper Respiratory Infection. Drowsiness may occur in an individual suffering from fever due to "sore throat" even without medication. Although, the laboratory report has confirmed that there was no evidence of commonly used sedatives in the Post Mortem blood and body samples of Captain Glusica, it is possible that he was not fully fit and hence found it difficult to stay awake.

2.14.4.4 Cumulative Fatigue and Jet Lag

There is no necessity for foreign flight crew proceeding on leave to their home town to declare their travel to other countries or carrying out flying during such break. Perusal of Captain Glusica's log book revealed that he had done a 4-hour (5 landings) flight at Budapest while on leave on 14th May 2010. Also, presently, there is no requirement for flight crew to be given more rest to acclimatise after return to India, depending on the number of time zones crossed. A flight crew who spends his vacation in Panama or Canada for instance, would not be acclimatised to Indian local time within two or three days of return to India due to jet lag. It may be prudent for the airlines to ascertain details of travel of their flight crew during their last week of leave abroad.

2.14.4.5 Sleep Inertia

Arousal from Stage III or Stage IV (slow wave) sleep can lead to sleep inertia, where alertness and psychomotor ability is impaired. Duration of such sleep inertia may vary amongst individuals and circumstances from a few minutes up to 4 hours, but usually less than 30 minutes. There is no direct evidence that sleep inertia exhibits a circadian rhythm. However, it appears that sleep inertia is more intense when awakening occurs near the trough of the core body temperature as compared to its circadian peak. (***Tassi P, Muzet A.*** *Sleep inertia in Sleep Med Rev. 2000 Aug; 4(4):341-353)*. In view of long duration of sleep, there was a distinct possibility of Captain Glusica being in deep sleep (Stage III or IV sleep) before his arousal. The sleep inertia was likely to be more intense since it had occurred in WOCL, when the core body temperature is normally at its nadir. Such sleep inertia might well have persisted till the aircraft had crashed.

2.14.4.6 Consequences of Fatigue

"When alertness is impaired, people may fix their focus on a minor problem, when there is a risk of a major one; may fail to anticipate danger; may display automatic behaviour syndrome; may fail to appreciate the gravity of a problem or situation; may display flawed logic; and may apply inappropriate corrective actions.." (*A guide for investigating fatigue: Transportation Safety Board of Canada. & Human Factors for Transport Investigators, Canberra, 2 - 6 July 2001).* The Captain had realised that the flight was high on approach. This was evidenced by the Captain's remark of **"**WRONG LOC.. LOCALISER... GLIDE PATH**"** in response to First Officer's announcement of "RUNWAY STRAIGHT DOWN!". At this stage, on realising being high on approach, instead of initiating a 'Go Around', the Captain had chosen to disengage auto-pilot and had manually increased the rate of descent. Further, he had persisted in maintaining this steep rate of descent to fulfil his intention of making good a landing, despite three unambiguous calls by the First Officer to 'GO AROUND' and one call of 'UNSTABILISED' as well as several aural warnings of "SINK RATE" and "PULL UP**"** by the EGPWS of the aircraft. Such violation of laid down SOP and failure to appreciate the dangerous situation might have been partly due to fatigue and sleep inertia.

2.14.5 The Survivors

Of the 166 occupants on board the ill-fated aircraft, there were 2 flight crew, 4 cabin crew and 160 passengers. Passengers included 156 seat occupying persons and 4 infants. All the 6 crew members and 152 passengers had lost their lives in the accident. Only 8 passengers survived the accident. These included 7 adult males and 1 adult female. The survivors were occupying seat Nos. 7A, 17C, 19A, 19C, 20C, 21C, 23D and 23F. Of these, most were grouped from seat rows 17 to 23 and only 1 was ahead at 7A.

All survivors in their statements to the Court had spoken of being awake and alert to the events as they had unfolded that morning. Among them was a lady passenger seated at 7A (a seat she had exchanged with a fellow passenger as she was allotted 7B). This young lady had informed the Court that after landing the aircraft appeared to be very fast, but was decelerating along with the sounds associated with braking. However, she had then noticed that the engine sound had again increased, which added to her concern. Her fears were confirmed when she felt the aircraft vibrating very severely and then crashing. She possibly was unconscious for a while and remembered waking up in darkness of the passenger compartment still harnessed to her seat. She could see foliage and hence little light from her window. She distinctly remembered undoing her seat belt buckle herself and walking rearwards in the dark aisle towards the opening, from where daylight was streaming in. She was probably pushed out of the aircraft by another survivor and once outside the aircraft had heard the sound of running engine.

It emerged that once the aircraft had finally come to rest in the gorge, the survivors found themselves in darkness inside the aircraft, with a lot of shouts and screams from other passengers. They had noticed smoke and fire inside the passenger compartment, which seemed to be coming more from the front section. All survivors had unbuckled themselves and moved out of their seats to make good their escape from a break in the fuselage from where they could see daylight and therefore which naturally guided them towards their escape. From the description of the survivors it also appeared that the fuselage had broken at a point just behind the wings and they had either jumped out or pushed by others through this opening created by the broken fuselage. Soon after their escape, while some of them were still in the vicinity of the wreckage, the fire had increased. Some of the survivors had sustained burn injuries to their hands and face while escaping from the aircraft.

It is evident that those who survived were fortunate not to receive debilitating deceleration injuries like fractures of lower limbs which could have made it virtually impossible to make good a quick exit. Further, their seat locations were close to the break in the fuselage from where daylight was coming in. Coupled with their situational awareness, this helped them in quickly leaving the aircraft wreckage. None of the cabin crew survived the crash and none of the survivors used the over-wing emergency exits (near Rows 14 & 15), or the exits in the fore or aft sections. The break in the fuselage thus appeared to have provided a fortuitous escape path for the survivors.

2.14.6 Requirement for Post-Mortem Examination

2.14.6.1 Non-availability of DGCA Air Safety Circular 3 of 1984

Post-mortem examinations of all crew and passengers were conducted at five different hospitals/ Medical Colleges in Mangalore, under the aegis of Government Wenlock Hospital, Mangalore. Relatives or friends had identified the bodies. Although qualified Forensic Medicine specialists had performed the autopsies, they were not aware of any specific requirements of post-mortem examinations of air crash victims.

The DGCA Air Safety Circular 3 of 1984, which deals with action required by Police authorities in case of aircraft accidents, also highlights the specific requirements during the conduct of autopsies on the victims including passengers and crew. This circular was not available with the District Administration or Police Authorities at Mangalore. They were in possession of an older circular of 1977 from DGCA, which was sketchy in its inputs on post-mortem requirements. Even this circular was made available to the specialists conducting the autopsy, only after they had already carried out the post-mortems.

2.14.6.2 Requirement of Sealing Personal Effects

Captain Glusica's personal belongings recovered from his hotel room included, among other things, a pouch of medicines. However, these had been sent back to his family prior to examination by the Court. This information, coupled with the fact that his wife and son have talked of his suffering from 'stomach upset and sore throat', gives reason to believe that the Captain was taking some medicines. Since the medicines had been disposed off by his family, it was not possible for the Court to assess whether they included some drugs which could have contributed to his drowsiness/ sleepiness. It is considered important to seal all the personal effects of the crew in case of an accident and these should be handed over only to the Court of Inquiry before releasing them to members of the family. The Court specifically requested RFSL to re-examine the Captain's blood sample to look for anti-histaminic drugs that are among those usually prescribed for 'sore throat'. These were found to be absent in the sample. However, knowledge about the exact medications available in the pouch could have helped the Forensic Laboratory to confirm their consumption, if any.

2.14.6.3 Special Requirements for Aircraft Accidents Investigation

As a result of paucity of information available to the forensic experts, they conducted the autopsies with the primary aim of establishing the identity of the victims and establishing cause of death. In an aircraft accident, in addition to these objectives, carefully performed autopsies on crew and passengers can shed light on several aspects that may help in establishing the cause of the accident and to understand aspects of survivability and injuries to occupants. Both these aspects can be useful in suggesting remedial measures.

2.14.6.4 Toxicological and Chemical Analysis

Similarly, the toxicological analysis of blood/ urine/ body samples of flight crew to specifically look for presence of alcohol, lactic acid and carbon monoxide are mandated by the DGCA circular. This can provide vital evidence to the Court. In the instant case, the samples were collected from bodies of both flight crews to the extent possible. However, the police authorities had not submitted these samples for forensic laboratory analysis immediately. In fact the samples were forwarded to RFSL, Mangalore only after the Court had directed Police to do so on 11th July 2010. Such delay in analysis of samples can lead to inaccuracy in reporting and is avoidable. In addition, the DGCA Air Safety Circular No 3 of 1984 does not require analysis of collected samples to be tested for presence of prescription and over-the-counter medications. However, such analysis would be important to rule out consumption of all types of medication.

2.14.6.5 Availability of Specialist in Aviation Medicine

After the accident, no Aviation Medicine Specialist had visited the crash site. It was at the behest of the Court that on 6th June 2010 an Aviation Medicine Specialist of DGCA visited Mangalore. Later on, Group Captain Gaur was inducted as an additional Assessor.

Although several autopsies had been conducted painstakingly by the experts, a large number of passengers' autopsy reports had been Diagramy. The cause of death in some of these was mentioned as 'Due to Mechanical and Thermal Injuries'. However, no details of fractures or burns had been recorded. Due to lack of such information it was difficult to fully understand the aspects of crash force dynamics leading to deceleration injuries and to address issues of survivability of passengers. Similarly, no post-mortem X-rays of the flight crew had been conducted. X-rays can often provide crucial evidence about the axis of deceleration forces, by means of assessing injuries to vertebrae and long bones. X-rays of the small bones of the hand can provide corroborative evidence as to which pilot was on controls at the time of impact. These aspects could have been addressed if a specialist in Aviation Medicine was attending the autopsies and guiding the Forensic Medicine experts in the same.

2.14.6.6 Tagging and Identification of Bodies

The bodies of all crew and deceased passengers were transported from the crash site to various hospitals with the help of local volunteers and fire fighters. The importance of tagging the bodies to establish their location in the wreckage (seat numbers or fore/ aft galley as applicable) was not known to the local authorities and was therefore not done. It was therefore difficult to establish the identities of occupants and to know for certainty their actual seating in the aircraft. This issue was highlighted in the deposition by one of the Forensic experts who conducted the autopsies. It is important that the officers supervising the rescue operations know these aspects, so that they can guide the fire fighters and rescuers accordingly.

In view of the above issues, a comprehensive revision of the DGCA Air Safety Circular 3 of 1984 as well as its dissemination to all authorities is considered essential.

2.14.7 Post-Mortem Findings

2.14.7.1 Post-Mortem Report of Capt Z Glusica

The Captain's autopsy was conducted in Father Muller Medical College, Mangalore, on 22nd May 2010. The body was identified by his passport size photographs and printed pieces of paper found on his person. It was evident that the Captain had died of deceleration injuries sustained on impact. The coronaries were normal and patent, which indicated that there was no evidence of Myocardial Infarction (Heart Attack). The cause of death was written as 'due to multiple injuries sustained in the aircraft accident consistent with the history provided.' The viscera and blood samples were preserved to assess blood alcohol levels and carbon monoxide. The report of the Regional Forensic Science Laboratory (RFSL), Mangalore, dated 25th August 2010 on the analysis of these specimens stated that the samples were negative for, inter alia, Alcohol, Nifedipine, Temazepam, Diazepam, carboxyhaemoglobin and common anti-epileptic drugs. In view of Captain's prolonged sleep, these samples were additionally tested for anti-histamines. The result was negative.

2.14.7.2 Post-Mortem Report of First Officer HS Ahluwalia

The First Officer's autopsy was conducted at the Dept of Forensic Medicine, Kasturba Medical College, Mangalore on 23rd May 2010. The body was identified by the presence of yellow coloured chain and locket as well as by evidence of a surgery, which was confirmed by the relatives. Major deceleration injuries were noted. Samples of the stomach and its contents as well as parts of other relevant organs were forwarded to RFSL, Mangalore. The results from the laboratory report dated 25th August 2010 were negative for Alcohol, Nifedipine, Temazepam, Diazepam and common anti-epileptic drugs. Carboxyhaemoglobin could not be estimated.

2.14.7.3 Post-Mortem Report of Passengers and Cabin Crew

Most of the autopsy reports for passengers and cabin crew revealed presence of charring. A large number of bodies were found in pugilistic attitude, suggestive of severe burns. A number of bodies also had evidence of decelerated injuries, in addition to burn injuries. Only a few bodies had evidence of decelerated injuries with minimal or nil burns and one body neither had burns nor decelerated injuries. Cause of death for this child had been given as Asphyxia due to smoke inhalation. The eight survivors were all from a common area in the middle of the fuselage, except for one lady who was seated at 7A. A LOPA with colour coding of 8 survivors and nature of injuries to the deceased passengers has been prepared after analysing autopsy reports. The LOPA is shown at Para 1.15.3 of Factual Information. It was evident that most of the passengers had died due to burns sustained in the post impact fire. Some passengers who had survived the deceleration forces of impact, but were injured or disoriented in the darkness, could not possibly escape from the burning aircraft. It is pertinent to mention that all survivors had stated that not only were they fully awake at the time of landing, but were observant of the noise and vibrations, which were not normal and made them anticipate the disaster in some manner.

2.15 Analysis of ATC and Flight Recorders:

2.15.1 ATC Recorder Analysis

The recording of ATC Tape was also available on the CVR recording. However, some of the significant observations of ATC Tape Recording were as follows:

- The aircraft came in contact with Area Control at 05:32:50 hours IST and was reported to be flying at FL-370.
- After reporting point IGAMA, the aircraft had asked for descent clearance at about 130 miles DME. The pilot was informed of unserviceability of the Area Radar. He was denied permission to descend at 130 DME.
- Aircraft was advised to carry out ILS DME Arc approach for R/W 24.
- ATC had informed the pilot about weather at Mangalore at 05:37:06 hours IST and visibility of 6 km.

- Aircraft was given clearance for descent at 80 DME.

- Area Control handed over the aircraft to ATC Tower at 05:54:51 hours IST when the aircraft was on DME Arc.

- Since there was no call from aircraft for seeking landing clearance, the ATC Controller had queried the pilot, if the aircraft was stabilised on ILS glide path.

- On confirmation from the pilot, aircraft was given landing clearance

- There was a call on VHF channel of ATC Tower by the First Officer asking Captain to 'GO AROUND'.

- After the late touchdown and unable to see the aircraft at the end of R/W 24, the ATC had given a routine call to the aircraft to backtrack (and taxi to aircraft parking bay).

After any accident, the ATC tape is required to be sealed. However, due to some unexplained reasons, the media had reported about the First Officer having given a call to the Captain to 'GO AROUND'.

2.15.2 Digital Flight Recorder (DFDR) Analysis

The Salient observations were as follows:

- The descent from 37000 ft had commenced at 05:47:37 hours IST at 77 DME.

- At 05:56:57 hours IST at an altitude of 28952 ft Speedbrakes were deployed. The deflection of the speedbrakes handle had increased from 3.66 ˚ to 30.67˚ and the corresponding deflection of the spoilers 3, 4, 9 and 10 was 7.6˚, 18.19˚, 16.88˚ and 6.91˚ respectively.

- Aircraft had entered 10 DME ARC at 05:58:40 hours IST, when the heading was 93.5˚, air speed was 251 kt and pressure altitude was 10496 ft. It had exited the DME Arc and aligned with R/W 24 heading at 06:01:41 hours IST, at 7.5 DME, IAS 178.8 kt, Pressure Altitude 5263 ft.

- Speedbrake handle and corresponding spoilers were retracted at 06:02:50 hours IST at altitude of 3767ft. Speedbrakes were again deployed from 06:04:03 to 06:04:21 hours IST, wherein corresponding pressure altitude had decreased from 1661 ft to 720 ft.

- At 06:04:41 hours IST, Weight on Wheel (WOW) was indicated on right wheel.

- Flap 1 was selected at 7000 ft, subsequently flap 5, 10, 15 and 40 were selected. Flap 40 was selected at an altitude of 3000 ft. At 06:04:22 hours IST while flap lever was at 40, the flap surface moved to 30 at IAS of 165 kt at altitude of 650 ft.

- EGPWS aural warnings of “SINK RATE” had come from 06:04:05 hours IST to 06:04:07 hours IST at 1500 ft Pressure altitude and again came from 06:04:13 hours IST to 06: 04:14 hours IST at 1100 ft. GPWS “PULL UP” warning came from 06:04:15 hours IST to 06:04:25 hours IST at Pressure Altitude of 1000 ft. EGPWS “SINK RATE “warning had again come from 06:04:26 hours IST to 06:04:28 hours IST at Pressure Altitude of 560 ft and finally at 100 ft.

- Weight on Wheel on both the main gears was recorded at 06:04:43 hours IST, the vertical acceleration recorded at this point was 1.5 Vg. At 06:04:45 hours IST, WOW was recorded on the Nose gear with vertical acceleration of 1.2 Vg.

- Auto brakes were deployed from 06:04:42 hours IST to 06:04:48 hours IST. Thereafter, manual brakes were utilised temporarily.

- At 06:04:45 hours IST, thrust reversers were deployed.

- From 06:04:55 hours IST to 06:04:57 hours IST, the thrust reversers were in transit. The throttle resolver angle of Left and Right engine was increased to 83.87 and during this period, the speed was 79 kt.

- At 06:04:59 hours IST, both fuel flow and EGT had started rising.

- At 06:05:03 hours IST, at the end of DFDR recording, the speed was 55 kt.

2.15.3 Cockpit Voice recorder (CVR) Analysis

The salient observations from the CVR recordings were as follows:

- The recording started at 03:59:50 hours IST, while the airplane was in cruise flight. First Officer was handling the radio communication with ATC and was also doing the position reporting.

- Captain’s voice was not heard for the first 1 hour and 40 minutes of the recording. Throughout this period, sounds of deep breathing / snoring / nasal breathing were heard intermittently on the mixed channel recording.

- Aircraft had come in contact with Area Control Mangalore at 05:32:49 hours IST. At 05:32:52 hours IST, the aircraft had transmitted its flight level “FL 370”, SSR squawk code 0544 and position “APPROACHING IGAMA”. The Area Control had intimated the Mangalore weather, runway in use as 24, and had also intimated that ILS DME arc approach was available.

- At 05:38:48 hours IST, aircraft had intimated that it was ready for descent. Area Control had instructed aircraft to report on radial 287 MML and 80 miles from MML for descent.

- At 05:46:53 hours IST, aircraft had reported at 80 DME on radial 287 from MML. At 05:47:21 hours IST, when aircraft was at 77 DME from MML, it was given descent clearance to 7000 feet.
- At 05:54:19 hours IST, aircraft had reported its position as 25 DME from MML.
- At 05:54:24 hours IST, aircraft was given descent to 2900 (entry altitude of DME Arc) feet and was instructed to contact ATC Tower on 122.1 MHz. Aircraft had requested to directly proceed to 338 radial, which was approved by Area Control.
- At 05:54:50 hours IST, aircraft had contacted Mangalore Tower.
- At 05:57:42 hours IST, aircraft had reported established on 10 DME Arc for runway 24. ATC then instructed aircraft to report when established on ILS.
- At 06:00:40 hours IST, a call "VOR-LOC CAPTURED" was recorded on First Officer's channel.
- At 06:03:55 hours IST, "WRONG LOC-LOCALISER……GLIDE PATH" was recorded on Captain's and Mixed Channel recording.
- AT 06:04:06 hours IST, EGPWS warnings of "SINK RATE" and a call for "GO AROUND" and "UNSTABILISED" was recorded on First Officer's and Mixed Channel recording.
- At 06:04:10 hours IST, ATC Tower had asked aircraft "CONFIRM ESTABLISHED ON ILS". To this, the aircraft had replied "AFFIRMATIVE". The EGPWS aural warnings of "SINK RATE" and "PULL UP" were concurrently recorded.
- At 06:04:17 hours IST, ATC Tower had intimated "WINDS CALM" and had cleared the aircraft for landing on runway 24. This was followed by EGPWS aural warnings of "PULL UP".
- At 06:04:38 hours IST, there was a call of "GO-ROUND CAPTAIN" recorded on First Officer's channel, which had also been transmitted on VHF channel to ATC.
- At 06:04:41 hours IST, there was a call recorded on First Officer's Channel "WE DON'T HAVE RUNWAY LEFT". This was followed by configuration warning horn, sound of loud impact and EGPWS warning of "BANK ANGLE". Subsequently, there was no recording.

2.15.4 Data Co-relation of Recorders

The data from all the Recorders was corroborated for time co-relation as well as sequence of events during the flight. Apart from marginal time difference, there were no deviations.

2.16 Circumstances Leading to The Crash of The Aircraft

There were four factors typical to this accident. Firstly, the accident aircraft belonged to Air India Express, a low cost carrier operating under the ambit of Air India, a legacy carrier with different philosophy of operations. Secondly, it was a QTA flight being flown through the night, including the period of Window of Circadian Low. Thirdly, the aircraft was operating from a Table Top airport at Mangalore, which as per the SOP of Air India Express had warranted only the PIC to undertake take off and landing, thereby highlighting the need for higher skill. Lastly, the flight crew was combination of a foreign PIC and an Indian First Officer, who possibly lacked CRM due to mixed cultural issues.

Late First Officer Ahluwalia was known to be a stickler for following SOP. This was reiterated by not only the pilots who had flown with him in Air India Express, but also by pilots of Jet Airways with whom he was employed earlier. During investigation, it came to light that First Officer Ahluwalia had complained in writing about one Foreign Pilot to the management of Air India Express. The management was yet to counsel him and the Foreign Pilot. Possibly, due to such feelings, the First Officer did not try to wake up the Captain, who was sleeping. It is evident from the CVR that there had been practically no conversation between the two pilots for a prolonged period of time, made worse by the Captain having slept for a considerable period.

It is also evident from the CVR that the flight crew had failed to carry out the required Descent Preparation Checks prior to descent. It is pertinent to note that the First Officer, who was known to be a strict follower of SOP, had also failed in this respect. However, the CRM was not effective, as evident in this case; a casual tone set by the Captain might have also affected the First Officer. This was evident from the selection of ‘000’ on the altitude select window of the Mode Control Panel (MCP) instead of Missed Approach Altitude of 2200 ft during approach. Such serious contravention of SOP was apparently not noticed by either of the pilots.

That the CRM has not been effective is also evident from a very steep Trans-Cockpit Authority Gradient. Many Pilots, who had flown with PIC, had mentioned to the Court that although the Captain was quite friendly, he was also more assertive and would display an attitude of ‘I am right’. This aspect is evident when in reply to R/T call by ATC Tower ‘EXPRESS INDIA 812 CONFIRM ESTABLISHED’, although not correctly positioned on the ILS Glide Path, the Captain had somewhat forced the First Officer to give a call, ‘AFFIRMATIVE’.

Such ineffective CRM and the steep Trans-Cockpit Authority Gradient could have affected the First Officer from taking over controls and forcing a ‘Go Around’ in an assertive manner.

The Captain had disconnected the Auto Pilot and was descending at a very high rate of 1500 feet per minute to try and intercept the correct approach path. Apart from this, there had been a series of mistakes right from top of the descent till touchdown. Such gross errors should have been discernable to the Captain considering his vast experience of 10000+ hours. The likely explanation for these errors was sleep inertia caused by long and deep sleep during cruise.

2.17 Why did the Accident Take Place?

The accident was caused by a chain of multiple errors that took place right from the top of descent. This 'error chain' is evident in a series of mistakes committed by both the Flight Crew and in particular the Captain.

There was no pre-flight medical of the flying crew at Mangalore prior to departure for QTA flight Mangalore-Dubai-Mangalore. However, all personnel who had interacted with the flight crew had indicated to the Court that they had not observed any signs of medical illness. The post-mortem carried out after the accident indicated no reports of any alcohol or self-medication by either the Captain or the First Officer. There was, however, a pouch of medicines in the Gateway Hotel Room occupied by the Captain. The Court could not examine the contents of the medicine pouch since these were inadvertently sent back to his family residing in Serbia. However, the family had responded that the Captain was suffering from 'stomach upset and sore throat'. However, the Toxicology Report had not indicated consumption of any medicine by the Captain.

The Captain had slept for a considerable period of time during the cruise phase. It was evident from the CVR recording that the Captain had been sleeping in his seat for about 1 hour and 40 minutes. On waking up, there was a distinct possibility of his transiting into conditions of sleep inertia.

Some of the airlines such as Air Canada allow Controlled Rest in Seat in two-man cockpit like Boeing 737-800. Their SOP spells out a number of activities which must be completed prior to the rest period such as transfer of flight duties, co-ordination with flight attendants etc. The SOP also specifies that the rest period should be for a maximum of 45 minutes to avoid Sleep Inertia. Also, such Controlled Rest should be completed at least 30 minutes prior to planned top of descent. The Canadian Air Regulation also mentions that it takes about 15 minutes after awakening to be fully awake and take over the flight duties.

The Captain, therefore, may have suffered from conditions of sleep inertia resulting into clouding of judgement. Possibly, this was further affected by flying in the Window of Circadian Low (WOCL).

The resultant casual tone in the cockpit was evident with inadequate briefing and not following the SOP correctly. The First Officer had possibly been affected by both induced sleep as well as casual atmosphere in the cockpit.

As evident, there was lack of CRM and crew coordination. Due to this, the accident was in the making on the approach itself. Although the First Officer had been aware of incorrect parameters and unstabilised approach, the steep Trans-Cockpit Authority Gradient had resulted in the Captain overruling suggestions for going around by the First Officer. With the First Officer not showing any signs of assertiveness, the Captain had continued with the faulty approach and landing, possibly due to incorrect assessment of his own ability to pull off a safe landing. This violation of laid down SOP by the Captain can be attributed to fatigue, sleep inertia and the phenomenon of **'GET-OVER-WITH-IT'**.

3. Conclusion

3.1 Findings

3.1.1 The Captain and the First Officer of Air India Express flight IX-812 had appropriate licence to undertake the flight.

3.1.2 The crew had not been subjected to a Pre-flight medical examination. However, based on statements by the witnesses who met/saw the crew prior to the flights, IX-811 from Mangalore and IX-812 from Dubai, there was no evidence indicating any adverse medical or behavioural condition with the flight crew.

3.1.3 As per the flight schedule, flight crew had sufficient off-duty time prior to the flight, to avail adequate rest.

3.1.4 The accident aircraft Boeing 737-800 VT-AXV had a current Certificate of Airworthiness. The aircraft had undergone various inspections as per the required schedule of maintenance.

3.1.5 There was no evidence to indicate any pre-existing failures of the engine, airframe or any other aircraft systems. Two defects, minor in nature, were carried forward under MEL, one relating to passenger seat 25C and other relating to the Right Hand Tail Logo Light from Dubai, for the ill-fated QTA return flight to Mangalore.

3.1.6 As indicated by the DFDR, the aircraft was fully serviceable throughout its flight till the actual crash. As per the CVR, the crew had also not reported any un-serviceability.

3.1.7 As indicated on the CVR, the Captain was asleep with sounds of intermittent snoring and deep breathing heard for the first 1 hour and 40 minutes of the recording, out of the total of 2 hour and 5 minutes. This had possibly led to sleep inertia and impaired judgement.

3.1.8 The descent from FL 370 would have normally been at about 130 DME from MML. However, it was delayed since the Area Radar was unserviceable and the controller had to resort to Procedural Control for ensuring safe separation with other air traffic.

3.1.9 The crew had failed to plan the descent profile so as to arrive at correct altitude for positioning into ILS approach. The First Officer had said on the intercom to the Captain “RADAR NOT AVAILABLE, BUT I DO NOT KNOW WHAT TO DO.” This indicated that he was possibly not aware of procedure in case the radar was not available and in such a scenario, how to plan a descent and approach if not permitted by the Area Control to descent at the desired distance on DME.

3.1.10 In case of fatigue and flying in the period of Window of Circadian Low (WOCL) or for any other reason, it would have been better to programme descent with use of the auto pilot, to arrive correctly for the ILS approach.

3.1.11 Mangalore being a Table Top Airport requiring Special Qualification, the Captain was the PIC and was at the controls during landing and at the time of accident.

3.1.12 The First Officer had correctly identified that the aircraft was in an 'unstabilised approach'. He had also asked the Captain to 'GO AROUND' three times.

3.1.13 At about 1.7 DME on final approach, having realised that the aircraft was too high, the Captain had intentionally disconnected the auto pilot and increased the rate of descent to re-establish on visual profile for Runway 24. Both these actions by the Captain indicate that he was actively engaged in controlling the aircraft. This confirmed that the Captain was not in-capacitated in any manner.

3.1.14 The Captain had failed to cross check the altitude and corresponding distance on approach. In spite of number of warnings to the contrary, the Captain had persisted with approach and landing. He had not only touched down late, but also did not apply the brakes appropriately. Moreover, the PIC had attempted to 'Go Around' after having selected the thrust reversers, which is categorically prohibited in the SOP.

3.1.15 The visibility at the time of landing was 6 km and surface wind calm. The runway surface was dry.

3.1.16 There was no evidence of any bird strike on the aircraft.

3.1.17 There was no evidence to indicate any sabotage to have caused the accident.

3.1.18 There was no evidence of any interference by Portable Electronic Devices such as mobile phones and laptop computers on ground or airborne electronic equipment.

3.1.19 There was no evidence of any pre-impact failure or in-flight fire.

3.1.20 The aircraft overran the runway including the strip and the RESA. It then impacted the concrete mounting structure of ILS Localiser Antenna and fell into a gorge. In the resultant impact and post crash fire, 152 passengers and all 6 crew members lost their lives. There were 8 survivors.

3.1.21 The Court observed that despite the constraints of terrain surrounding the Table Top runway, the Rescue and Fire Fighting operations had been carried out with due diligence.

3.2 Cause of the Accident

3.2.1 Direct Causes

The Court of Inquiry determines that the cause of this accident was Captain's failure to discontinue the 'unstabilised approach' and his persistence in continuing with the landing, despite three calls from the First Officer to 'go around' and a number of warnings from EGPWS.

3.2.2 Contributing Factors to the Accident

3.2.2.1 In spite of availability of adequate rest period prior to the flight, the Captain was in prolonged sleep during flight, which could have led to sleep inertia. As a result of relatively short period of time between his awakening and the approach, it possibly led to impaired judgment. This aspect might have got accentuated while flying in the Window of Circadian Low (WOCL).

3.2.2.2 In the absence of Mangalore Area Control Radar (MSSR), due to un-serviceability, the aircraft was given descent at a shorter distance on DME as compared to the normal. However, the flight crew did not plan the descent profile properly, resulting in remaining high on approach.

3.2.2.3 Probably in view of ambiguity in various instructions empowering the 'co-pilot' to initiate a 'go around', the First Officer gave repeated calls to this effect, but did not take over the controls to actually discontinue the ill-fated approach.

4. Recommendations

As a result of the investigation into the Mangalore air crash, the Court of Inquiry makes the following recommendations:-

4.1 For the Parent Company Air India and the Operator Air India Express

4.1.1 Air India Express Should Operate as a Separate Entity

The DGCA regulations mandate that a separate AOP holder like Air India Express should operate as an independent organisation 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 synergised with the parent company. However, those of operations, training and flight safety should be independently managed by Air India Express.

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 engineering setup to be started at Thiruvananthapuram shortly.

While such growth has its merits, there is a need to ensure that along side 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.

4.1.3 Post-Holders in Air India Express

At the time of accident, the parent company Air India (NACIL-A) continued to depute pilots not qualified on Boeing 737-800 aircraft as Post Holders to supervise various functions of Air India Express. In view of the separate AOP issued to AI Express, there is a need for Post Holders particularly of Operations, Flight Safety and Training to be qualified on type.

Since operating philosophy of the low-cost AI Express is from multiple bases, all supervisors should endeavour to fly from various sectors. This would make them familiar with peculiarities of routes, operating conditions, fatigue issues and in getting to know more number of flying crew stationed at these bases, which will in turn enhance “communication” and rapport.

4.1.4 Computerised Network for all Activities

In view of Multi-base operations of Air India Express, there is an urgent need to computerise both, intra and inter departmental activities. Currently followed use of Pencil and Eraser to maintain crew schedules leads to ambiguity and lack of transparency. In order to obviate this, it is recommended that all crew schedules should be computerised urgently in keeping 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.

During the process of investigation, it was also revealed that the commercial staff was not aware of MEL release on Seat No 25C and the same was wrongly allotted to a passenger from Dubai. With inter-departmental networking, such errors can be overcome.

Use of Computers will also allow an efficient and faster means of communications with the flight crew operating from multiple bases. Changes to operating instructions or any flight safety alerts can also be made known to them at the earliest.

4.1.5 Flight Safety Management

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, 100% FOQA analysis of DFDR takes up to 3 weeks. For faster monitoring of various parameters, this duration could be cut down by Computerisation and Networking.

4.1.5.2 Flight Safety Counselling to Flight Crew

Flight Safety Counselling of flight crew should be participative and aimed at correcting a serious violation or if indicative of any trend of errors. It should be non-punitive, unless absolutely necessary. The session should be non-intimidating and efforts should be made to ensure that flight crew view the process positively. However, errors/ violations and corrections if required should be spelt out clearly and unambiguously. During counselling, flight crew should also be appreciated for positive flight safety enhancement actions or 'Good Shows', if any.

4.1.5.3 Need for Internal Safety Audit

There is a need to carry out Internal Safety Audit of all bases and line stations by Flight Safety Department at frequency as stipulated in CAR Section 5, Series F, Part 1. Such Audit must include all departments like Operations, Engineering, Training and Commercial. The outsourced activities like Ground Handling, Catering/Flight Kitchen and Security etc must also be audited to identify any Safety concerns and to mitigate them.

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 familiarisation training for operating in Indian conditions. There is also a need for recurrent training including various clearances 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 unstabilised 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 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.

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.

Apart from normal emergencies, emphasis during simulator training should also be given to 'Go Around' procedure from both stabilised and unstabilised approach conditions.

4.1.8 Co-ordination Meetings

There is a need for frequent co-ordination meetings between various Post Holders for smooth operations of the Airline. The departments of operations, flight safety, engineering and training need to meet more often, to address various interdepartmental issues and to synergise working environment.

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 sensitised 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 be possible after computerisation and networking of activities at all bases, from which AI Express operates.

4.1.10 Employment of Foreign Pilots

There is a need for Air India Express to carry out a detailed check into background of Foreign Pilots, prior to issuance of FATA by DGCA. Emphasis should be laid especially on flight safety issues for the entire flying career, as well as anomalies during training, if any, from all the previous employers. There is also a need to examine medical history of Foreign Pilots in its entirety. The airline should conduct pre-employment medical examination for all Foreign Pilots similar to Indian pilots.

While proposing the employment of Foreign Pilots, Air India Express should justify such an employment. Yearly Training Plan and quantifiable targets achieved in upgrading Indian pilots to PIC, should accompany such proposal.

Air India Express could re-consider terms and conditions of employment of foreign pilots. Encouraging foreign pilots to stay in India with families, rather than the current practice of serving six weeks followed by a two weeks vacation abroad, is considered most desirable. This would enhance ‘ownership’ and a sense of belonging amongst the foreign flight crew. In addition, this would increase effective utilisation of these pilots, reduce FDTL issues and need to reacclimatise after their vacation. Further, such longer stay within India would reduce the possibility of upsetting crew schedule and the uncertainty, should the foreign pilot not return after his vacation. In turn, it would also reduce the anxiety amongst foreign pilots regarding their continued employment and renewal of FATA.

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.

4.1.12 Pre-flight Medical Check

Air India Express should ensure 100% Pre-flight medical check of all flight crew prior to commencement of a flight/ series of flights. The Operator should provide a suitable designated space for conduct of such pre-flight medical examination in privacy. All doctors performing such examination including those employed on contract basis should be suitably trained for the same.

In addition, a random check for alcohol by use of Breathalyser should be conducted by the doctor as required vide CAR, Section-5, Series-F, Part-3, Issue-I dated 13th November 2009 issued by DGCA.

Role of Airline Doctors as spelt out in the Handbook on Medical Assessment of Civil Flight Crew in India, available on the DGCA website, should be adhered to.

The airline should encourage short-duration training in Aviation Medicine for all doctors. This will aid in early recognition of fatigue and importance of rendering correct advice regarding flying with minor sickness including with medication.

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 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 For Airports Authority of India (AAI)

4.2.1 SOP on Watch Hours

There is a need for AAI to bring out SOP on actions to be completed prior to opening the 'Watch Hours' at all airports. The procedure should clearly bring out various activities which need to be completed prior to declaring an airfield 'operational' viz timely manning of Air Traffic Control Tower after having carried out inspection of runway, communications and other facilities including readiness of crash and fire tenders.

It is recommended that after completion of inspection, the ATC Tower Controller takes his position at least 30 minutes prior to opening of watch hours.

4.2.2 Avoidance of Downward Slope in the Overshoot Area Particularly on Table Top Runways

As per worldwide data published by ICAO, most of the accidents occur during landing and take-off phases, with a large number of runway excursions and aircraft overrunning into the Overshoot Area. Considering the large momentum of these aircraft, a downward slope in the overrun area can worsen the outcome. It is therefore recommended that such downward slopes as obtaining in Mangalore, be brought to the same level of the runway surface. This also needs to be ensured at all table top airports in the country.

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 Localiser Antenna mountings etc to name a few. At Mangalore, the ILS Localiser 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.

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.

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 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.

4.2.6 Installation of Distance to Go Markers (DTGM)

As a visual reference to ascertain the remaining distance, it is recommended to install DTGM on runway shoulders. Such DTGM are made out of frangible material and are installed at not only all Indian Air Force airfields, but also at a number of civil airports abroad.

Since a number of civil air operators also use IAF airfields, use of DTGM could help the pilots to ascertain critical distances such as TODA, ASDA etc. if such runways do not have standard ICAO markings. In this connection, DGCA had also issued a circular in October 1985.

4.2.7 Location of Air Traffic Control Tower at Mangalore

After commissioning of runway 24/06 in 2006, the earlier ATC Tower was not found suitable for controlling air and surface movement operations, safely. Hence, a temporary ATC Tower had been built near 24 dumbbell. However, in addition to limited space, this location does not offer a clear field of view to the ATC controller, especially with commencement of operations from the New Terminal.

It is, therefore, recommended that a new ATC Tower be built at a central location. The Tower should have adequate space to accommodate meteorological officer to facilitate him to take weather observations from all sides.

4.2.8 Approach Radar/Area Radar Repeater in the ATC Tower

Ideally, approach Radars should be installed at all airports. However, in view of its cost effectiveness, if it is not feasible to install approach radar, a repeater display of the Area Radar should be installed in the ATC Tower. This will help in enhancing situational awareness of the ATC Tower Controller.

It is, therefore, recommended that repeater display of the Area Radar be installed in the ATC Tower of Mangalore airport.

4.2.9 Preventing Erosion of Strip Width at Mangalore

Due to the constraints of terrain, the Table Top runway 24/06 has a strip width of 150 metres instead of standard 300 metres. The limited strip width is also one of the permanent concessions being sought by AAI for licensing of airport at Mangalore.

In order to ensure that the strip width does not reduce further, there is a need to initiate engineering measures. Use of nets and strict control over quarry and mining activity in this area are some of the recommended measures.

All Operators should cater to safe crosswind limitation for the type of aircraft operations in view of the narrower strip width. The ATC Controller needs to caution the pilots in this regard.

4.2.10 Suitability of RFF Vehicles for the Type of Terrain

Presently, at Mangalore airport, there are two types of RFF vehicles, namely ‘Agni Shatru’ and ‘Panther’. The newly inducted Panther RFF is bulky in size and it can only be used for fire fighting within the periphery of airport. However, it cannot be used for similar role outside the periphery of airfield due to narrow and winding access roads of this hilly terrain.

It is, therefore, recommended that a mix of small and agile RFF vehicle along with heavier RFF vehicle is made available to cater to all types of contingencies. AAI should examine the feasibility of introducing Rapid Intervention Vehicle (RIV) at such airports.

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.

4.2.12 Follow up Action on Obstruction Surveys

In view of increasing construction activity across the country, there is a need to carry out obstruction survey more frequently. Other than informing the Operators regarding new obstructions, actions such as painting and installing obstruction lights should be followed up with urgency.

At Mangalore, AAI needs to liaise with authorities of State Government to complete the pending action of painting of water tank and pruning of trees, in the vicinity of airport.

4.2.13 Aerodrome Risk Assessment and Condition of Roads outside the Perimeter

Most of the recent accidents indicate that these occur during the landing and take-off phases with large number of runway excursions. Since Mangalore is a Table Top airport, Risk Assessment and mitigation would indicate that it is necessary to build adequate access roads outside the perimeter of Mangalore airport. AAI needs to take up the matter with the State Government in this regard.

4.3 For the Directorate General of Civil Aviation (DGCA)

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 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.

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 X-rays 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.

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.

4.3.3 Inclusion of Experts of Bomb Detection and Disposal Squad (BDDS), Bureau of Civil Aviation Security (BCAS)

There is a need to instruct the BDDS, BCAS to send their experts to the crash site immediately to investigate the possibilities of any explosive material carried on board the aircraft and also to rule out sabotage, if any.

4.3.4 Revision and Distribution of DGCA Air Safety Circular No 3 of 1984

There is a need to revise the DGCA Air Safety Circular on “Action required by Police authorities in case of aircraft accidents” issued to District Police Officials, through State Governments. Inclusion of a specific requirement to analyse post mortem samples of the flight crew for several common prescription drugs is considered essential.

There is also a need to widely circulate the revised Circular to all the District Police Officials. The official designated as the Single Point of Contact should also liaise with the local Police Officials regarding the actions required to be taken by them, as per current circulars.

There is a requirement to create a separate link for Aircraft Accident Investigation on the DGCA website and to include all relevant circulars and manuals on this link. This will facilitate referral by all officials including Inspector of Accident, Airport Directors, Police officers and Doctors.

4.3.5 Revision of AIC 28 of 1992 FDTL for Flying Crew

There is an urgent need to revise the currently used AIC 28 of 1992 regarding FDTL of flight crew. The revised FDTL needs to incorporate issues such as clarification on neighbouring countries as well as change in time zones while operating on international routes. There is also a need to incorporate due allowance for the effect of flying during Window of Circadian Low (WOCL).

In view of rapid growth of Civil Aviation in the country, there is also a need to take a fresh look at the FDTL for Cabin Crew outlined in CAR, Seciton-7, Series-J, Part-I.

4.3.6 Revision of Duty Time Limitation (DTL) for Other Staff Related to Aviation

In keeping with the growth of Civil Aviation Sector, there is a need to formulate Duty Time Limitations (DTL) and fatigue factor for the following groups of personnel:-

a) Air Traffic Controllers
b) Aircraft Maintenance Engineers

4.3.7 Implementation of Fatigue Risk Management System (FRMS)

All operators need to incorporate training on Fatigue Risk Management System, which will enable flight crew to understand and manage the aspects of fatigue and stress.

4.3.8 Regulation on Controlled Rest in Seat

In view of the Captain having slept for a prolonged period in his seat during this accident, DGCA needs to take a comprehensive view into the aspect of Controlled Rest in Seat, especially in a two-man cockpit. After due analysis, a regulation needs to be brought out for its effective implementation.

4.3.9 Employment of Foreign Pilots

There is a need for both, the Operators and DGCA to carry out a detailed check into background of Foreign Pilots, prior to issuance of FATA. Emphasis should be laid especially on flight safety issues for the entire flying career, as well as anomalies during training, if any, from all the previous employers.

In addition, there is a need to examine medical history of Foreign Pilots in its entirety. All Foreign Pilots also need to undertake medical fitness examination at IAM/AF CME, as applicable to the Indian Pilots.

The Foreign Pilots need to be subjected to requisite ground subjects' examination, so as to help them understand the Indian operating conditions, including the operators SOP. At the end of this process, the Foreign Pilots should be endorsed with Indian Civil Pilots License.

Although the terms and conditions for employment of Foreign Pilots are best left to individual Operators, a longer period of engagement may help the Operators as well as the Foreign Pilots, in reducing their current anxiety of renewal of FATA.

While proposing the employment of Foreign Pilots, every Operator should be able to justify such an employment. Yearly training plan and quantifiable targets achieved in upgrading Indian pilots as PIC, should accompany such a proposal.

4.3.10 Pre Flight Medical Check

There is a need to re-draft the current CAR Section 5, Series 'F' Part III on Pre-flight Medical Check, which emphasises only on alcohol consumption. The new CAR should incorporate comprehensive instructions based on 'Hand book on Medical Assessment of Civil Flight Crew in India', available on the DGCA website.

Implementation of pre-flight medical check by Operators needs to be audited by DGCA, periodically.

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.

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 pilot for following incidents:

a) Hard landing.

b) Go Around.

CAR, Section-5, Series 'F' Part II, Issue I dated 13th September 1999 needs to be amended to remove any ambiguity regarding the exceedence limits.

4.3.13 Avoidance of Verbal Instructions Towards Reporting of Flight Safety Incidents

No verbal instructions should be issued either by the officials of DGCA at New Delhi or from Regional Offices of DGCA regarding various limits, which if exceeded, warrant either an OIR or punitive action against a pilot by the Operator and/or DGCA.

4.3.14 Applicability of Regulations to Foreign Airlines Operating in India

DGCA needs to ensure applicability of all Indian Regulations to the Foreign Airlines operating within Indian airspace. There is a need to audit their activities periodically, while operating in India.

4.3.15 Safety Management Training for Executives

In view of rapid growth of aviation in India, both commercial and private, there is a need to ensure that various Executives as well as Post Holders undergo specialised training in Safety Management. This will enhance the necessary awareness amongst senior management, thereby ensuring that requisite importance is given to Flight Safety. In this connection the newly introduced Safety Management System (SMS) by DGCA also needs to be implemented by all operators.

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.

4.4 For Ministry of Civil Aviation

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), 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.

- sd -
(Capt. Ron Nagar)
Senior Vice President (Ops & Trg)
Kingfisher Airlines, Mumbai
(Assessor)

- sd -
(Babu Peter)
Executive Vice President (Engg)
Go Airlines (India) Pvt Ltd, Mumbai
(Assessor)

- sd -
(SS Nat)
Deputy DGCA (Retd),
Club One Air,
New Delhi
(Assessor)

- sd -
(Gurcharan Bhatura)
Executive Director (Ops) (Retd)
Airports Authority of India
New Delhi
(Assessor)

- sd -
(Group Captain Deepak Gaur)
Director Medical Services
(Aviation Medicine),
Air HQs, New Delhi
(Assessor)

- sd -
(Air Marshal BN Gokhale)
PVSM, AVSM, VM
Former Vice Chief of Air Staff,
Indian Air Force
The Court

Place: New Delhi
Date: 31st Oct 2010

5. Appendices

Appendix 'A'

Investigation and Public Hearings

Initial Investigation

On 22nd May 2010 at about 06:05 hours IST, Boeing 737-800 aircraft VT-AXV operated by Air India Express, a brand name of M/s Air India Charters Ltd; was operating a schedule QTA flight IX-812 from Dubai to Mangalore. This aircraft met with an accident during landing on Runway 24 at Mangalore airport. During landing, the aircraft overshot Runway 24, impacted with the ILS Localizer structure and fell downhill into a gorge. In the resultant impact and fire, 152 passengers and all 06 crew members onboard the aircraft lost their lives. There were 08 survivors.

DGCA, New Delhi was informed telephonically about this accident at about 06:15 hours IST. While the DGCA himself along with other officials from Delhi office visited the crash site on the same day, officials from Regional Offices of DGCA from Mumbai and Bengaluru were also instructed to reach the site immediately. These officials had also reached Mangalore on 22nd May 2010 to assist in Search and Rescue work, as well as the Initial Accident Investigation. However, no medical specialist visited the crash site till 7th June 2010.

Inspector of Accident

Shri Bir Singh Rai, Director of Air Safety O/o DGCA, New Delhi was later appointed as the Inspector of Accident. DGCA had also formed five groups to assist the Inspector of Accident and carry out detailed investigation. The following groups were formed:

- Structures and System Group
- Operations Group
- Engineering Record Examination Group
- Air Traffic Control Group
- Flight Recorders Group

The Inspector of Accident had submitted a consolidated report to the Court, which included investigation carried out by the above mentioned groups.

The Court of Inquiry

Assembly of the Court of Inquiry

On 3rd June 2010, the Ministry of Civil Aviation vide Notification No AV.15013/02/2010-DG announced the formation of Court of Inquiry under the Chairmanship of Air Marshal BN Gokhale, former Vice Chief of Air Staff, Indian Air Force. The following Assessors were also nominated to assist the Court:

1. Capt. Ron Nagar,
   Senior Vice President (Ops & Trg),
   Kingfisher Airlines, Mumbai

2. Shri Babu Peter,
   Executive Vice President (Engg),
   Go Airlines (India) Pvt Ltd, Mumbai

3. Shri SS Nat,
   Deputy DGCA (Retd),
   Club One Air, New Delhi

4. Shri Gurcharan Bhatura,
   Executive Director (Ops) (Retd),
   Airports Authority of India, New Delhi

5. Group Captain Deepak Gaur,
   Director Medical Services (Aviation Medicine),
   Air Headquarters, New Delhi

Shri S N Dwivedi, Director of Airworthiness, O/o DGCA, New Delhi was nominated as Secretary to the Court.

Visit to NTSB USA for Retrieval of DFDR and CVR Data

Since the DFDR and CVR were found at the crash site in severely damaged condition, these were taken to NTSB, Washington D.C. USA, to re-build and retrieve the Data.

Simulator Flight To Replicate The Descent and Approach Profile

After having analysed the DFDR and CVR readings, these were correlated with the Mangalore ATC Tape transcript. After this, a reconstructed Flight Simulator session was carried out on Air India Express Simulator by Captain Ron Nagar along with qualified TRE and the Court. The descent was initiated from FL 370 and 77 DME. It was deduced that with proper descent planning on the Auto-pilot as per SOP, the aircraft could have intercepted the correct ILS profile and made a successful landing.

Similar QTA Flight Flown by the Court, Mangalore-Dubai-Mangalore

The Court made a number of visits to the crash site, Mangalore airport and Air India Express office at Mumbai to investigate various issues. In order to understand the effect of QTA flight flown during the Window of Circadian Low (WOCL), the Chairman along with Medical Assessor flew a similar Mangalore - Dubai - Mangalore flight on 6th/7th August 2010. In addition, the personnel involved in certification of Transit Check and dispatch of accident aircraft from Dubai, were also interviewed by the Court during the transit halt at Dubai.

Participants Invited by the Court

The Court invited a number of Participants to assist in investigation, suggest improvements in Flight Safety and to participate in the Public Hearings. These participants included the following:-

S N	Organisation
1.	Air India Ltd, Mumbai - 400 001
2.	Air India Express i.e. Air India Charters Ltd, Mumbai - 400 029
3.	Airports Authority of India, New Delhi -110003
4.	Airport Director, Mangalore Airport (Karnataka)
5.	DGCA, New Delhi - 110003
6.	BCAS, New Delhi - 110001
7.	India Meteorological Department, New Delhi - 110003
8.	Indian Commercial Pilots Association, New Delhi - 110037
9.	Indian Pilots Guild, Mumbai - 400029
10.	Federation of Indian Pilots, Mumbai - 400029
11.	Society for Welfare of Indian Pilots (SWIP), Mumbai - 400029
12.	A T C Guild, New Delhi - 110023
13.	AAI Engineers Guild, New Delhi - 110023
14.	Aeronautical Communication Officers Association, New Delhi - 110023
15.	Airports Authority Officers Association (India), New Delhi - 110023
16.	Air India Aircraft Engineers Association, Mumbai - 400029
17.	District Magistrate, Mangalore (Karnataka)
18.	Commissioner of Police, Mangalore (Karnataka)
19.	Chief Fire Officer, Mangalore (Karnataka)
20.	District Medical Officer, Mangalore (Karnataka)
21.	General Manager, The Gateway Hotel, Mangalore (Karnataka)
22.	Boeing Airplane Company, Seattle, USA
23.	General Electric (CFM International), Cincinnati, USA

Public Hearings

The Court held two Public Hearings, one at Mangalore and other at New Delhi. Both the Public Hearings were chaired by Air Marshal BN Gokhale, the Court along with the Assessors and Secretary to the Court.

Hearing at Mangalore

The Public Hearing at Mangalore was held from 17^{th} to 19^{th} August, 2010. This was done mainly to facilitate the local witnesses including the survivors, staff at Mangalore airport and Civil Administration. A total of 50 witnesses had deposed on oath.

The witnesses included personnel involved in actual events associated with the accident and post crash actions. As such, starting from the dispatch and engineering staff of Air India Express at Mangalore, the Air India Managers at Mangalore and Dubai, Radar and Aerodrome Controllers at Mangalore, as well as rescue and fire fighting crews, both of Mangalore Airport and Civil were asked to depose. In addition, officials of civil administration including the staff of DM and Police involved in Disaster Management also gave their deposition. The Airport Director at Mangalore had also deposed regarding aspects of licensing and safety areas. The detailed list of witnesses examined at Mangalore, is given below:-

S N	Name	Designation	Organisation
1	Samir Pisat	Flight Dispatcher	Air India Ltd
2	S Sudarshan	Load & Trim Sheet Staff	ADB Tours & Travels, GHA
3	V Manjunath	In-Charge of Dispatch	Air India Ltd
4	Bijoy Biswas	AME	AI Express
5	S C Pandit	Aircraft Mechanic	AI Express
6	Ms. Chellam	Station Manager	Air India Ltd
7	Ms. Anita Shetty	Airport Manager, Dubai	Air India Ltd
8	Girish Kamath	WSO	AAI
9	R J Vaz,	Met. Officer	IMD
10	Mahesh Pai	Duty Officer (Tower)	AAI
11	A K Singh	Asst. Mgr. (Tower)	AAI
12	Gaurav Porwal	AME	AI Express
13	Sukhjinder Singh	AME	AI Express
14	Arun Kumar	Traffic Asstt.	Air India Ltd
15	Dhananjay Shanbhag	Asst. Mgr. (Fire)	AAI
16	Mohd. Sharif	Sr. Supdt. (Fire)	AAI
17	M V Mathew	Sr. Asst. (Fire)	AAI
18	Janardhana	Sr. Supdt. (Fire)	AAI
19	Shravan Kumar	Jr. Asst. (Fire)	AAI
20	Krishan Kumar	Jr. Asst. (Fire)	AAI
21	Vijay Kumar	Sr. Supdt. (Fire)	AAI
22	Nishad K M	Jr. Asst. (Fire)	AAI

S N	Name	Designation	Organisation
23	Jacob Thomas	Jr. Asst. (Fire)	AAI
24	Thomas K Thomas	Jt. GM (ATM)	AAI
25	Ummer Farook M	Passenger	Survivor
26	Pradeep GK	Passenger	Survivor
27	Abdulla Puttur Ismail	Passenger	Survivor
28	AHA Shaikh	Inspector (Wireless)	Police Control Room
29	Basavanna	Regional Fire Officer	KSFES
30	Dr. Mrs. P Saroja	District Surgeon and Superintendent	Wenlock District Hospital, Mangalore
31	Dr. K R Nagesh	Associate Professor	Dept of Forensic Medicine, FMMC, Mangalore
32	Dr. Ritesh G Menezes	Associate Professor	Dept of Forensic Medicine & Toxicology, Kasturba Medical College, Mangalore
33	Valentine D'souza	Circle Police Inspector	Bajpe Police Station
34	Harpreet A De Singh	GM, Emergency Response	Air India Ltd
35	A K Mathew	GM, Flight Safety	Air India Ltd
36	Basant Pandey	F&B Service	The Gateway Hotel, Mangalore
37	Vishal Sharma	F&B Manager	The Gateway Hotel, Mangalore
38	Ravi Khandige	General Manager	The Gateway Hotel, Mangalore
39	Group Capt SG Amin	Asst GM, QMS	Air India Ltd
40	K D Keni	Accounts Supdt	Air India Ltd
41	M M Shyam Sundar	Sub Inspector	Bajpe Police Station
42	Venkatesh Prasanna	Police Inspector	Crime Investigation Bureau
43	Girish S	Deputy Supdt of Police	Karnataka State Police, Mangalore
44	M R Vasudeva	Airport Director	AAI
45	P K Shrivastava	Jt GM (CNS)	AAI
46	M Muneer	Asst GM (CNS)	AAI
47	Mrs. P Padma	Manager (Electrical)	AAI
48	J S Rawat	Deputy DGCA	DGCA, New Delhi
49	Sharath Sriniwas	Deputy Commissioner of Security (CA)	BCAS, New Delhi
50	Prabhu Linga Kavelikatti	Asst Commissioner / SDM	Office of District Magistrate, Mangalore

Hearing at New Delhi

During the Public Hearing at New Delhi held from 6th to 8th September 2010, another 45 witnesses had deposed on oath. These were supervisors and various Post Holders of Air India Express as also Pilots and Instructors who had flown with both the deceased Pilots.

In addition, supervisory staff of AAI and finally various functionaries of the Regulatory Authority i.e. the DGCA had also deposed on issues such as punitive and/or non-punitive aspects of 'Hard Landing' and 'Go Around'. Other factors such as Flight and Duty Time Limitations (FDTL), Controlled Rest in Seat etc were also deliberated at length during the DGCA deposition. At Delhi, the representatives of Boeing and Engine Manufacturer GE/CFM had also deposed. The detailed list of witnesses examined at New Delhi, is given below: -

S N	Name	Designation	Organisation
1	A D'souza	Earlier COO	AI Express
2	Capt Rajeev Bajpai	Chief of Operations	AI Express
3	Capt Arvind Sharma	Chief of Flt Safety	AI Express
4	L P Shenoy	Consultant	AI Express
5	N M Shingarpure	Consultant	AI Express
6	Capt R S Pal	In-Charge of Scheduling	AI Express
7	Capt Sharad Dogra	In-Charge of Training & Fleet Captain	AI Express
8	Capt Jagmohan Singh	G M (Ops)	Air India
9	Wg Cdr B S Jadhav	Asst GM	Air India
10	Wg Cdr A K Verma	Asst GM	Air India
11	Capt Sameer Kapoor	Line Captain	AI Express
12	Capt KS Chandrashekhar	S F I	AI Express
13	Capt Sandeep Shekharan	Line Captain	AI Express
14	Capt Sajneesh Sharma	Line Captain	AI Express
15	Capt A. Vasiljevic	Training Captain	AI Express
16	Capt Subir Ghosh	Training Captain	AI Express
17	Capt AS Soman	ED (Flight Safety)	Air India
18	Capt V Kulkarni	In-Charge of Training	AI Express
19	Capt AD Shinde	S F I	AI Express
20	Capt SK Jha	Training Captain	AI Express
21	Capt Uttam Singh	Line Captain	AI Express
22	Capt DS Yadav	Line Captain	AI Express
23	Capt BM Dhall	Line Captain	AI Express
24	Capt Simran Parmar	Line Captain	AI Express
25	Dr. (Mrs.) L P Nakhwa	ED (Medical & HR)	Air India
26	A R Appukuttan	Chief of Engineering	AI Express
27	RB Pandit	GM, Brake & Wheel Shop	Air India
28	A K Datta	GM, CFM Shop	Air India
29	D B Sonawane	GM, Accessories Shop	Air India

S N	Name	Designation	Organisation
30	Harpreet A De Singh	GM, QMS	Air India
31	Piyush Joshi	ED, Flight Safety	AAI
32	S. Raheja,	Member (Planning)	AAI
33	Jyoti Prasad	ED (ATM)	AAI
34	S Bhattacharya	GM (CNS)	AAI
35	Sunder Raman	ED (CNS - Planning)	AAI
36	Dr. R. Suresh,	Director	IMD
37	Bir Singh Rai	Director Air Safety	DGCA
38	Manish Chopra	Deputy Director Air Safety	DGCA
39	Leslie Mc Vey	Investigator, Commercial Flt Safety	G E (CFM)
40	Capt David Carbaugh	Test Pilot	Boeing Co
41	A K Bhardwaj	Director (ATM&ANS)	DGCA
42	Capt H Y Samant	Chief Flt Ops Inspector	DGCA
43	Capt Arvind Kathpalia	Flight Operations Inspector	DGCA
44	AK Sharan	Joint DGCA	DGCA
45	RP Sahi	Joint DGCA	DGCA

Appendix B

Air Traffic Control Tape Recorder

Description of ATC Tape Recorder System

The ATC Tape Recorder system being used at Mangalore airport is a Digital Voice Tape Recorder (DVTR). It has facilities to programme and record various R/T Channels as well as Telephone and Inter-Communication conversation, along with time of recording. The basic details of DVTR are given below:

Description	Details
Make	Ricochet AS, Norway
Model	64 channel, Dual
Date of installation	18.10.2007
Date of commissioning	25.01.2008
Major breakdowns since commissioning	NIL
Maintenance	In house
Type of check being carried out	Daily DVTR Recording Check
Number of channels available on equipment	64
Number of channels being used currently	38

Transcript of the ATC Tape of Air India Flight AX-812 of 22nd May, 2010

Time	Station From	Station to	Text
053248	AXB 812	Mangalore ACC	Mangalore Control Express India 812. Good Morning.
053250	Mangalore ACC	AXB 812	Express India 812 Control. Good Morning. Go ahead.
053259	AXB 812	Mangalore ACC	FL 370, squawking 0544. Approaching IGAMA, 812.
053302	Mangalore ACC	AXB 812	Express India 812 Control. Roger. IGAMA.
053305	AXB 812	Mangalore ACC	Call you IGAMA, Express India 812
053317	AXB 812	Mangalore ACC	Mangalore, Express India 812.Position over IGAMA.FL370
053320	Mangalore ACC	AXB 812	Express India 812. Control. Roger.
053702	AXB 812	Mangalore ACC	Mangalore Control. Express India 812. Requesting Mangalore Weather.
053706	Mangalore ACC	AXB 812	Express India Control. Mangalore 0000. Wind calm. Visibility 6 KM. Cloud few 2000 feet. Temperature 27. Dew point 26. QNH 1006 Hecta Pascals.
053718	AXB 812	Mangalore ACC	1006, runway 24 and confirm we are identified on radar 812

Note: All timings are in Indian Standard Time (IST), which is UTC+ 5 hours 30 minutes.

Time	Station From	Station to	Text
053722	Mangalore ACC	AXB 812	Radar not available sir.
053727	AXB 812	Mangalore ACC	Roger.812
053841	AXB 812	Mangalore ACC	Mangalore Control Express India 812. What kind of approach can we expect for runway 24 in Mangalore?
053848	Mangalore ACC	AXB 812	ILS DME Arc approach.
053850	AXB 812	Mangalore ACC	Roger, ILS DME Arc approach. 812 and is now ready for descent.
053855	Mangalore ACC	AXB 812	Standby.
053948	Mangalore ACC	AXB 812	Express India 812. Control. Report GNSS distance from IGAMA.
053950	Mangalore ACC	AXB 812	Express India 812. Control.
053955	AXB 812	Mangalore ACC	Express India 812. We have already checked IGAMA at 0004.
054004	Mangalore ACC	AXB 812	Report GNSS distance from IGAMA.
054014	AXB 812	Mangalore ACC	We are now at present 48 DME from inbound, 812.
054020	Mangalore ACC	AXB 812	Control, Roger.
054108	Mangalore ACC	AXB 812	Express India 812 report on radial 287 MML and 80 miles from MML for descent.
054111	AXB 372	Mangalore ACC	Understand, Express India 372. Call radial 287 80 miles MML VOR for descent.
054124	Mangalore ACC	AXB 372	Negative.
054125	Mangalore ACC	AXB 812	Express India 812 Mangalore Radar. Report on Radial 287 MML, 80 miles from MML for descent.
054138	AXB 812	Mangalore ACC	Roger. We are on radial 287. Will call you 80 miles for descent. Express India 812.
054139	Mangalore ACC	AXB 812	Affirm
054654	AXB 812	Mangalore ACC	Mangalore Control Express India. We are 80 DME on radial 287 MML.
054715	Mangalore ACC	AXB 812	Break break Express India 812 Control.
054716	AXB 812	Mangalore ACC	812 is now 77 DME inbound sir, request descent.
054720	Mangalore ACC	AXB 812	812 Control Roger. Maintain 287 radial MML. Descent 7000 feet, report leaving FL 370.
054734	AXB 812	Mangalore ACC	Descending 7000 feet leaving 370 now. Express India 812.
055044	Mangalore ACC	AXB 812	Express India Control, Report level.
055048	AXB 812	Mangalore ACC	Descending out of level 295.
055053	Mangalore ACC	AXB 812	Express India 812 Control, roger, report 50 miles inbounds MML.
055055	AXB 812	Mangalore ACC	Express India 812, we are 50 miles 812.
055058	Mangalore ACC	AXB 812	Roger.

Time	Station From	Station to	Text
055420	AXB 812	Mangalore ACC	Mangalore Express India 812, 25 DME MML.
055423	Mangalore ACC	AXB 812	Express India 812 Control, continue descent to 2900 feet, contact Tower 122.1
055430	AXB 812	Mangalore ACC	2900 feet, contact tower and can we proceed directly to 338 radial DME.
055432	Mangalore ACC	AXB 812	Approved, report level now.
055436	AXB 812	Mangalore ACC	Out of level 184
055443	Mangalore ACC	AXB 812	Proceed to 338 radial, 12 DME fix and contact Tower 122.1.
055447	AXB 812	Mangalore ACC	122.1 thank you, Express India 812.
055451	AXB 812	Mangalore Tower	Mangalore Tower Express India 812, Good Morning.
055459	Mangalore Tower	AXB 812	Express India 812 Good Morning, report established 10 DME arc, runway 24.
055500	AXB 812	Mangalore Tower	Call you established 12 DME Arc, runway 24.
055504	Mangalore Tower	AXB 812	10 DME arc.
055508	AXB 812	Mangalore Tower	10 DME arc Express India 812.
055744	AXB 812	Mangalore Tower	Mangalore Tower Express India 812, established on 10 DME arc, runway 24.
055752	Mangalore Tower	AXB 812	Express India 812, report established on ILS.
055758	AXB 812	Mangalore Tower	Call you established on ILS.
060415	Mangalore Tower	AXB 812	Express India 812, confirm established.
060417	AXB 812	Mangalore Tower	Affirmative Express India 812.
060419	Mangalore Tower	AXB 812	Wind calm, runway 24, clear to land.
060422	AXB 812	Mangalore Tower	Clear to land Express.
060438	AXB 812	Mangalore Tower	Go around Captain
060504	Mangalore Tower	AXB 812	Express India 812 back track runway 24, vacate via Delta.
060521			Control (panic voice probably from Cockpit)
060929	Mangalore Tower	AXB 812	Express India 812, Mangalore control correction Express India 812 Mangalore Tower.
060939	Mangalore Tower	AXB 812	Express India 812, Mangalore Tower.

Appendix C

Cockpit Voice Recorder

Description of Cockpit Voice Recorder System

Manufacturing Model	:	Honeywell 980-6022-001
Serial No	:	CVR 120-12117

The actual recording for this CVR was for the last 2 hours and 5 minutes as against the recording of a minimum of 2 hours, as per the requirements stipulated by DGCA and the manufacturer i.e. M/s Honeywell, USA.

Recorder Damage

Solid-state Cockpit Voice Recorder (CVR) fitted on the aircraft was recovered from the accident site on the next day i.e. 23rd May, 2010. The CVR was in a damaged condition and had sustained significant effects of heat and fire. As such, it had to be initially repaired and read at the facilities of National Transportation Safety Board (NTSB), USA and later by the Recorder Group of DGCA in their laboratory at New Delhi.

Audio Quality

The CVR recording quality was rated as Good to Excellent for all channels. Channel designations and quality are listed in the table below.

Channel Number	Content/Source	Quality
1	Spare/Observer	Excellent
2	Co-pilot's Audio Panel	Excellent
3	Captain's Audio Panel	Excellent
4	Cockpit Area Microphone	Good

Timing and Correlation

Timing on the transcript was established by correlating the CVR, DFDR and ATC recording. The time indicated in the CVR transcript is in Indian Standard Time (IST) which is UTC + 05:30 hours.

The total duration of CVR Recording for the accident aircraft was 2 hours and 5 minutes.

Transcript of Cockpit Voice Recorder, Serial Number CVR 120-12117 of Air India Express Boeing B737- 800 VT- AXV Recovered from Wreckage at Mangalore after Accident on 22nd May, 2010

LEGEND

CAM	Cockpit area microphone voice or sound source
HOT	Flight crew audio panel voice or sound source
EGPWS	Callout from the Enhanced Ground Proximity Warning System (synthetic voice)
RDO	Radio transmissions from VT-AXV

For **CAM**, **HOT**, and **RDO** comments:

-1 Voice identified as the Captain
-2 Voice identified as the First Officer
-3 Voice identified as the Flight Attendant

ACC	Radio transmission from Mangalore Area Controller
MR	Radio transmission from the Mumbai Area Controller
TWR	Radio transmission from the Mangalore Airport Tower Controller
??	Radio transmission from another airplane
ATIS	Radio transmission from the Mangalore Automated Terminal Information Service
MIX	Audio heard on the 2-hour Mixed CVR channel
CH3	Audio heard on Captain's Audio Panel CVR channel

***** Unintelligible word
\# Expletive
( ) Questionable insertion or "Sounds Like"
[ ] Editorial insertion

Note: All timings are in Indian Standard Time (IST).
IST is UTC+ 5 hours 30 minutes.

Intra Cabin Transmission		Air to Ground Transmission	
03:59:50 Start of Transcript			
03:59:50 **CAM**	[start of recording]		
04:05:59 **CAM**	[sound similar to cabin to cockpit call tone]		
04:06:08 **CAM**	[sound similar to cockpit door operating]		
04:06:16 **CAM**	[sound similar to cockpit door closing]		
04:10:42 **CAM**	[sound similar to cockpit door opening, then closing]		
04:10:45 **CAM**	[conversation in Punjabi CAM-3 asks CAM-2 if he would like anything, CAM-2 responds 'no thank you' in English]		
04:11:30 **CAM**	[sound similar to cockpit door closing]		
04:15:36 **MIX**	[sound of snoring (check for sure if this is first one)]		
		04:18:14 **RDO-2**	Mumbai Radio Mumbai Radio Express India position.
		04:18:19 **MR**	Express India eight one two Mumbai, go ahead.
		04:18:23 **RDO-2**	Exp India eight one two check position KADOL at four six, maintaining flight level three seven zero..... Estimating LEMAX at zero six, MESAN next.
04:26:48 **CAM**	[sound similar to cabin to cockpit call tone]		
04:27:00 **CAM**	[sound similar to cabin to cockpit call tone]		

Intra Cabin Transmission

04:27:03 **HOT-2**	Yeah?
04:27:03 **CAM-3**	Captain, may I come in? [CAM-3 is addressing the Co-pilot as "Captain". this is customary]
04:27:06 **HOT-2**	Yeah.
04:27:09 **CAM**	[sound similar to cockpit door operating]
04:27:12 **CAM**	[sound similar to cockpit door closing]
04:27:12 **CAM-3**	Captain now the aft cabin is too cold.
04:27:16 **CAM-2**	Cold?
04:27:16 **CAM-3**	Yeah.
04:27:17 **CAM-2**	Aft?
04:27:18 **CAM-3**	Yeah.
04:27:21 **CAM-3**	Even forward.
04:27:23 **CAM-3**	Thank you.
04:27:32 **CAM**	[sound similar to cockpit door closing]

Air to Ground Transmission

04:36:39 **RDO-2**	Mumbai radio Express India eight one two, position.
04:36:42 **MR**	Express India eight one two, confirm.
04:36:47 **RDO-2**	Exp India eight one two check position LEMAX at zero six, maintaining flight level three seven zero..... MESAN at two five.
04:36:58 **MR**	Go ahead, estimate MESAN.
04:37:02 **RDO-2**	Estimate MESAN at two three two five, Express India eight one two.

Time	Source	Intra Cabin Transmission	Air to Ground Transmission
04:37:06	**MR**		MESAN two three two five, you have to report over MESAN, Mumbai.
04:37:12	**RDO-2**		Roger, eight one two.
04:42:42	**MIX**	[example of deep breaths/snoring sounds at relatively consistent cadence]	
04:59:02	**RDO-2**		Mumbai radio Mumbai radio, Express India eight one two, position.
04:59:05	**MR**		Express India eight one two go ahead.
04:59:09	**RDO-2**		Express India eight one two, position MESAN at two five, maintaining flight level three seven zero, NITIX four two, OSIRI next.
04:59:19	**MR**		Express India eight one two, report VHF contact.
04:59:24	**RDO-2**		Eight one two.
05:02:02	**CAM**	[sound similar to cabin to cockpit call tone]	
05:02:07	**CAM**	[sound similar to cockpit door opening, then closing]	
05:02:10	**CAM-3**	do you want your tea and--	
05:02:12	**CAM-2**	(Yes please).	
05:02:13	**CAM-2**	No, I don't feel like eating anything.	
05:02:16	**CAM-3**	not even chai ['chai' is Hindi for 'tea']	
05:02:17	**CAM-2**	kuchh nahi ['kuchh nahi' is Hindi for 'nothing']	
05:02:18	**CAM-3**	kuchh nahi?	

Intra Cabin Transmission		Air to Ground Transmission	
05:02:20 **CAM-2**	* *.		
05:02:21 **CAM-3**	nahi ['nahi' is Hindi for 'no']		
05:02:26 **CAM-2**	You will have nothing?		
05:02:30 **CAM-2**	Yes sir.		
05:02:36 **CAM**	[sound similar to cockpit door closing]		
		05:24:21 **RDO-2**	Mumbai radio Mumbai radio, Express India eight one two.
		05:26:25 **RDO-2**	Mumbai radio Mumbai radio, Express India eight one two, position.
		05:26:29 **MR**	Express India eight one two, Mumbai, go ahead.
		05:26:34 **RDO-2**	Express India eight one two check position OSIRI, at five three, flight level three seven zero.
		05:26:40 **RDO-2**	IGAMA at zero zero four zero, VHF at Mike Mike Lima.
		05:26:46 **MR**	Report in contact with Mangalore control, Mike Lima control.
		05:26:51 **RDO-2**	Affirmative eight one two.
		05:26:54 **MR**	Roger. Change over to Mike Lima control.
		05:27:28 **RDO-2**	Mangalore control Express India eight one two, good morning.
		05:32:45 **RDO-2**	Mangalore control Express India eight one two, good morning.

Intra Cabin Transmission		Air to Ground Transmission	
		05:32:49 **ACC**	Express India eight one two Mangalore control good morning, go ahead.
		05:32:52 **RDO-2**	Flight level three seven zero, squawk zero five four four, approaching IGAMA... eight one two.
		05:32:59 **ACC**	Express India eight one two control, roger. Report IGAMA.
		05:33:02 **RDO-2**	Call you IGAMA, eight one two.
		05:33:15 **RDO-2**	Mangalore Express India eight one two position IGAMA, flight level three seven zero.
		05:33:19 **ACC**	Express India eight one two control, roger.
05:35:50 **HOT-2**	[sound of humming]		
		05:36:47 **ATIS**	Mangalore ATIS information * *.
		05:36:58 **RDO-2**	Mangalore control Express India eight one two requesting Mangalore weather.
		05:37:03 **ACC**	Express India eight one two control Mangalore zero zero zero zero wind calm, visibility six kilometers, clouds few two thousand feet, temperature two seven dewpoint two six, QNH one zero zero six hecta Pascals.
		05:37:16 **RDO-2**	One zero zero six, runway two four, and confirm we are identified on radar, eight one two.
		05:37:22 **ACC**	Radar not available sir.

Intra Cabin Transmission	Air to Ground Transmission	
	05:37:24 **RDO-2**	Roger Exp India [Express India] eight one two.
	05:38:39 **RDO-2**	Mangalore control Express India eight one two, what kind of approach can we expect for runway two four in Mangalore?
	05:38:46 **ACC**	ILS DME arc approach.
	05:38:48 **RDO-2**	Roger. ILS DME arc approach, eight one two and uh now ready for descent.
	05:38:53 **ACC**	Standby.
	05:39:47 **ACC**	Express India eight one two, control. Report GNSS [Global Navigation System??] distance from IGAMA.
	05:39:55 **ACC**	Express India eight one two, control.
	05:39:57 **RDO-2**	Eight one two, we already checked IGAMA at zero zero zero four.
	05:40:01 **ACC**	Report GNSS distance from IGAMA.
	05:40:12 **RDO-2**	uhhh, we are now at present four eight DME uh from inbound, eight one two.
	05:40:19 **ACC**	Express India eight one two, control, roger.
	05:41:07 **ACC**	Express India eight one two, report on radial two eight seven Mike Mike Lima [MML - the Mangalore VOR], and eight zero miles from Mike Mike Lima for descent.

Intra Cabin Transmission		Air to Ground Transmission	
		05:41:15	
		??	[another airplane incorrectly accepts and responds to this transmission]
		05:41:23	
		ACC	Negative, Express India eight one two Mangalore radar, report on radial two eight seven Mike Mike Lima, eight zero miles from Mike Mike Lima for descent.
		05:41:33	
		RDO-2	Uh roger. We are on radial two eight seven, and we'll call you eight zero miles for descent, eight one two.
		05:41:38	
		ACC	Affirm. Maintain flight level three seven zero. [this transmission was stepped on by another airplane's transmission]
05:41:50			
CAM-2	This is the weather, Captain.		
05:42:20			
CAM-2	This uh.... point, two five DME then DME to the left, radar not available, (but I uh do not know what to do).		
05:42:32			
CAM-2	(This is the) point five.		
05:42:35			
CAM-1	*.		
05:42:39			
CAM-2	* *.		
05:42:44			
CAM-1	What?		
05:42:48			
CAM-2	* *.		
05:42:51			
CAM-1	*.		
05:43:20			
CAM-2	uhh. At eighty miles from Mike Mike Lima.		
05:43:50			
CAM	[Click sound followed by clunk sound on area mic, and click on Captains channel.]		

Time	Intra Cabin Transmission		Air to Ground Transmission	
05:44:00	**CAM**	[sound of 2 clicks]		
05:44:58	**CAM**	[sound of click]		
05:46:53			**RDO-2**	Mangalore control, Express India eight one two, eight zero DME on radial two eight seven Mike Mike Lima.
05:46:57	**CAM**	[Sound of thump].		
05:47:14			**ACC**	Break break. Express India eight one two, control.
05:47:16			**RDO-2**	Eight one two is now seven seven DME inbound sir requesting descent.
05:47:21			**ACC**	Express India eight one two, control roger. Maintain two eight seven radial Mike Mike Lima, descend to seven thousand feet, report leaving flight level three seven zero.
05:47:28			**RDO-2**	Descending seven thousand feet, leaving three seven zero now, Express India eight one two.
05:47:35	**CH3**	[radio monitoring level on Captain's channel increases at this time]		
05:49:21	**CAM**	[sound similar to cabin to cockpit call chime]		
05:49:26	**CAM**	[sound of click]		
05:49:30	**CAM**	[sound similar to cockpit door operating]		
05:49:31	**CAM-3**	* * *.		

Intra Cabin Transmission | **Air to Ground Transmission**

05:49:39
CAM [Conversation between CAM-2 and CAM-3, largely unintelligible. Discussion of landing time (two two) and temperature (two seven). CAM 2 can be heard saying "after landing" and "no thank you" near the end of the conversation]

05:50:15
CAM-2 Five- five eight. [5.8 DME is the final approach fix for an LOC approach to runway 24 at Mangalore]

05:50:43
ACC Express India eight one two, report level.

05:50:46
RDO-2 Eight one two descending out of level two niner five.

05:50:49
ACC Express India eight one two, control, roger. Report five zero miles inbound Mike Mike Lima.

05:50:54
RDO-2 We are five zero miles *, eight one two.

05:50:57
ACC Roger.

05:51:00
CAM-1 [sound similar to cockpit door closing]

05:51:57
CAM-2 * (check).

05:52:00
CAM-2 * Procedure * recall.

05:52:04
CAM-2 * * auto brake. * landing *

05:52:08
HOT-1 * * flaps forty one hundred thirty nine, minima five hundred sixty.

05:52:13
RDO-2 Set....approach briefing * *.

05:54:19
RDO-2 Mangalore this is Express India eight one two, two five DME Mike Mike Lima.

Intra Cabin Transmission		Air to Ground Transmission	
		05:54:24 **ACC**	Express India eight one two control, continue descent to two thousand nine hundred feet, contact tower one two two decimal one.
		05:54:30 **RDO-2**	Two niner hundred feet, contact tower, and can we proceed directly to three three eight radial uh DME?
		05:54:35 **ACC**	Approved and report level?
		05:54:37 **RDO-2**	Out of level one eight four *.
		05:54:39 **ACC**	Roger. Proceed to three three eight, one two DME fix, and contact tower one two two decimal one.
		05:54:44 **RDO-2**	One two two one. Thank you, Express India eight one two.
		05:54:50 **RDO-2**	Mangalore tower Express India eight one two, good morning.
		05:54:54 **TWR**	Express India eight one two, Mangalore tower good morning. Report established one two DME arc runway two---two four.
		05:54:59 **RDO-2**	Call you established, one two DME arc, runway two four. Express India eight one two.
		05:55:03 **TWR**	One zero DME arc.
		05:55:05 **RDO-2**	One zero DME arc, Express India eight one two.
05:55:13 **HOT-2**	huh huh ho.		
05:55:23 **HOT-2**	[sound of exhale/yawn, Co-pilot's channel]		
05:55:45 **HOT-1**	[sound of two exhale/yawn followed by sound of clearing throat, Captain's channel]		

Time	Source	Intra Cabin Transmission	Source	Air to Ground Transmission
05:56:40	**HOT-2**	[Sound of whistling, Co-pilot’s channel].		
05:57:27	**HOT-1**	[3 breath sounds]		
05:57:30	**HOT-2**	* * .		
05:57:42			**RDO-2**	Mangalore tower Express India eight one two, established on one zero DME arc, for runway two four.
05:57:49			**TWR**	Express India eight one two report established ILS.
05:57:52			**RDO-2**	Call you established ILS, Express India eight one two.
05:58:00	**HOT-2**	[sound of whistling - Co-pilot’s channel]		
05:58:05	**CAM**	[sound of clunk, followed by click]		
05:58:17	**CAM**	[sound of click and faint chime - twice, similar to cockpit call to cabin]		
05:58:39	**HOT-2**	[sound of whistling - Co-pilots channel]		
05:58:56	**HOT-1**	[sound of clearing of throat - Captain's channel]		
05:59:02	**CAM**	[sound of click]		
05:59:25	**HOT-2**	Transition.		
05:59:27	**HOT-2**	One zero zero six. [altimeter setting is metric in India]		
05:59:27	**HOT-1**	*.		
05:59:31	**HOT-1**	Speed two ten.		
05:59:39	**HOT-1**	Gear down.		
05:59:41	**CAM**	[sound of 2 clicks followed by increase in ambient air noise]		

Time	Source	Intra Cabin Transmission	Air to Ground Transmission
05:59:53	**CAM**	[sound of 2 chimes similar to cabin to cockpit call chime]	
05:59:55	**HOT-2**	Cabin and galley is secure.	
06:00:02	**HOT-2**	ILS your side?	
06:00:06	**HOT-2**	ILS coming on my side. [co-pilot's channel]	
06:00:20	**HOT-2**	Cleared for the approach.	
06:00:24	**HOT-1**	VOR-LOC	
06:00:27	**HOT-1**	[sound of throat clearing]	
06:00:32	**HOT-1**	Flaps one.	
06:00:34	**CAM**	[sound of click similar to flap handle]	
06:00:40	**HOT-2**	VOR-LOC captured.	
06:00:41	**HOT-1**	Flaps five.	
06:00:42	**CAM**	[sound of 2 clicks similar to flap handle]	
06:00:48	**HOT-2**	VOR-LOC capturrrrrrrrrrrrrrrrrrrrrrrrrrrred. * (there).	
06:01:01	**HOT-1**	Ten.	
06:01:03	**HOT-2**	Ten?	
06:01:04	**HOT-1**	Wait a minute.	
06:01:07	**HOT-1**	(two/to)-uh, yeah flaps ten.	
06:01:10	**CAM**	[sound of click similar to flap handle]	
06:01:34	**HOT-1**	[Sound of cough]... ahhh.	
06:01:57	**HOT-1**	Fifteen.	
06:02:03	**HOT-1**	Flaps fifteen..... Yeah.	

	Intra Cabin Transmission	Air to Ground Transmission
06:02:04 **HOT-1**	[sound of 2 clicks similar to flap handle]	
06:02:27 **HOT-2**	[sound of humming - Co-pilot's channel]	
06:02:30 **CAM**	[sound similar to altitude alerter tone]	
06:02:32 **HOT-2**	Level out.	
06:02:43 **HOT-1**	Flaps twenty five.	
06:02:45 **CAM**	[sound of click similar to flap handle]	
06:03:05 **HOT-1**	(point five DME) * * * (one two three zero).	
06:03:14 **HOT-1**	Flaps....forty.	
06:03:17 **HOT-1**	Landing checklist.	
06:03:20 **HOT-2**	Landing checklist..... Engine start switches?	
06:03:23 **HOT-1**	Continuous.	
06:03:24 **HOT-2**	Speed brake?	
06:03:26 **CAM**	[sound of click]	
06:03:26 **HOT-1**	Armed.	
06:03:27 **HOT-2**	Landing gear?	
06:03:28 **HOT-1**	Down.	
06:03:29 **HOT-2**	Flaps?	
06:03:30 **HOT-1**	Forty, green light.	
06:03:31 **HOT-2**	Forty, green light.	
06:03:33 **HOT-2**	It's too High!	
06:03:35 **EGPWS**	Twenty five hundred.	
06:03:40 **HOT-2**	Runway straight down.	

Intra Cabin Transmission		Air to Ground Transmission	
06:03:42 **HOT-1**	Oh my God.		
06:03:43 **HOT-1**	Okay..... (ops)		
06:03:43 **CAM**	[sound similar to autopilot disconnect tone]		
06:03:48 **HOT-1**	Okay.		
06:03:53 **HOT-2**	Go around?		
06:03:54 **HOT-1**	(izzzup)		
06:03:55 **HOT-1**	wrong loc--localizer-		
06:03:56 **HOT-2**	(There).		
06:03:57 **HOT-1**	-glide path.		
06:04:02 **CAM**	[sound of two clicks]		
06:04:05 **EGPWS**	sink rate-		
06:04:06 **HOT-2**	go around-		
06:04:06 **EGPWS**	-sink rate.		
06:04:07 **HOT-2**	-Captain.		
06:04:08 **HOT-2**	Un-stabilised.		
		06:04:10 **TWR**	Express India eight one two confirm established.
06:04:12 **HOT-1**	Affirmative.		
06:04:14 **HOT-1**	Affirmative.		
06:04:15 **EGPWS**	Sink rate.		
		06:04:15 **RDO-2**	affirmative (Ex-India) eight one two
06:04:15 **EGPWS**	Pull up.		
		06:04:17 **TWR**	Uh wind calm, runway two four clear to land.
06:04:17 **EGPWS**	[six iterations of "Pull Up"]		

Intra Cabin Transmission		Air to Ground Transmission	
		06:04:20	
		RDO-2	cleared to land (Ex-India eight one two) [may have closed the mic key after "cleared to land"]
06:04:26			
EGPWS	Sink rate. Sink rate.		
06:04:29			
EGPWS	Forty.		
06:04:30			
EGPWS	Thirty.		
06:04:31			
EGPWS	Twenty.		
06:04:32			
EGPWS	Ten.		
		06:04:38	
		RDO-2	go around Captain.
06:04:40			
CAM	[Sound of 3 clicks and a squeal. - (speed brake handle? /MG TD?)]		
06:04:41			
HOT-2	We don't have runway left.		
06:04:44			
CAM	[Ambient noise level increases and remains increased until end of recording. (Nose gear TD?)]		
06:04:50			
HOT-1	eee ahhhh.		
06:04:52			
HOT-1	Oh my God.		
06:04:54			
CAM	[Configuration warning horn begins and continues for approx 6.9 sec.]		
06:04:57			
HOT-1	awww. Big One!		
06:04:59			
HOT-?	* *. [on spare channel]		
06:05:00			
HOT-1	ohhhh.		
06:05:01	[sound of an impact/loud crunching]		
CAM			
06:05:03			
EGPWS	bank angle		
06:05:05			
CAM	[recording ends Elapsed time 02:05:14.973]		
[end of recording]			
06:05:05			

Appendix 'D'

Accident Aircraft Performance Report by M/s Boeing

Item No 1. Stabilized approach assessment (glide slope, localizer, airspeed, descent rate, configuration etc.)

The Boeing Flight Crew Training Manual (FCTM), Attachment 1, includes Stabilized Approach Recommendations. The attached Figures 1 and 2 show time-history data, from approximately 1000 feet above field elevation (AFE), through touchdown and a portion of the rollout. Figures 3-5 show similar data versus longitudinal distance from the Runway 24 threshold.

Since the conditions at the time of the event were reportedly Visual Meteorological Conditions (VMC), the FCTM recommendation is that the approach be stabilized by 500 feet AFE and continue to be stabilized through touchdown. The FCTM states that an approach is considered stabilized when all of the listed criteria are met.

The first criterion is "the airplane is on the correct flight path." As can be seen in Figure 3, the airplane was never on a 3 degree flight path during final approach. In order to be on a 3 degree flight path, the airplane should have crossed the final approach fix (FAF) at 2200 feet geometric altitude (airplane's true altitude above mean sea level (MSL)) but instead crossed at approximately 4475 feet, as can be seen in Figure 6.

The second criterion is "only small changes in heading and pitch are required to maintain the correct flight path." Figures 1 and 3 show a significant change in pitch during final approach. At 500 feet AFE, the pitch attitude was -6 degrees and increased to +2 degrees at touchdown. During a stabilized approach at Flaps 40, the nominal pitch attitude is -0.5 degrees at 500 feet AFE, per the 737NG Flight Crew Operations Manual (FCOM).

The third criterion is "the airplane speed is not more than VREF + 20 knots indicated airspeed and not less than VREF." For this approach, VREF was 139 knots. In Figures 1-5, a line is shown that denotes VREF + 20 knots (159 knots). At 500 feet AFE, the airplane's computed airspeed was 164 knots and increased to a maximum of 166 knots before decreasing to 145 knots at touchdown. This excessive airspeed also resulted in flap load relief activation, which retracted the flaps from 40 to 30 degrees upon exceeding the flaps 40 placard speed (162 knots).

The fourth criterion is "the airplane is in the correct landing configuration." Correct landing configuration includes landing gear down, flaps extended and speed brakes stowed. Figures 1 and 3 show Speed brakes extended in the air at and below 500 feet.

The fifth criterion is "the airplane's sink rate is no greater than 1000 fpm (feet per minute)." Figures 1 and 3 show the airplane's sink rate (labelled 'Calculated Vertical Speed (ft/min)') was approximately 3300 fpm at 500 feet AFE and it remained above 1000 fpm until approximately 60 feet AFE. Numerous Ground Proximity Warning System (GPWS) discrete also annunciates during this time, "SINK RATE" and "PULL UP" warnings were recorded on both the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR).

The sixth criterion is "thrust setting is appropriate for the airplane configuration." Figures 1-5 show that throughout final approach, the thrust setting was idle, N1 = 32%. During a stabilized approach at Flaps 40, the nominal thrust setting should have been N1 = 64%, per the 737NG FCOM.

The seventh criterion is "all briefings and checklists have been conducted." According to the Cockpit Voice Recorder transcript, the approach briefing was abbreviated and not conducted in accordance with the FCTM. Portions of the Descent and Approach checklists were accomplished, but were not called "Complete." The Landing checklist was not conducted in accordance with the FCOM procedures. Additionally, the Landing checklist was the only checklist called for by the Captain (PF).

The ILS approach criterion states "ILS and GLS approaches should be flown within one dot of the glide slope and localizer, or within the expanded localizer scale." Figure 2 shows the airplane was within one dot of the localizer all the way through the approach, but Figures 1 and 3 shows the airplane was not within one dot of a 3-degree glide slope.

The first runway-threshold-crossing criterion reads "as the airplane crosses the runway threshold, it should be . . . stabilized on target airspeed to within + 10 knots until arresting descent rate at flare." Thus, the airplane should have been crossing the threshold at no more than 10 knots above the target speed (144 knots) and at approximately 50 feet AFE. However, Figures 3-6 show the airplane crossed the runway threshold at approximately 200 feet AFE and at 164 knots airspeed (20 knots above target speed).

The second runway-threshold-crossing criterion reads "as the airplane crosses the runway threshold, it should be . . . on a stabilized flight path using normal manoeuvring." As described above, the airplane was not on a stabilized flight path.

The third runway-threshold-crossing criterion reads "as the airplane crosses the runway threshold, it should be . . . positioned to make a normal landing in the touchdown zone (the first 3000 feet or first third of the runway, whichever is less)." The airplane did not touch down within the touchdown zone. For Runway 24, the touchdown zone is the first third of the runway (~ 2679 feet). The airplane initially touched down approximately 4500 feet from the Runway 24 threshold (Figures 3 and 5). Thus, the touchdown point was approximately 1800 feet beyond the touchdown zone.

As described in the analysis above, many elements of the event approach did not satisfy the stabilized approach criteria. The FCTM states that if all of the stabilized approach criteria cannot be maintained, an immediate go-around should be initiated.

Item No. 2. Touchdown location (relative to the runway 24 approach threshold)

The airplane initially touched down approximately 4500 feet from the Runway 24 threshold. See Figures 3, 5 and/or 7.

Item No. 3. Airplane stopping performance capability: Given the calculated touchdown location, airspeed/ground speed does the airplane have adequate stopping performance to come to a complete stop on the improved surface available? This LSPS/AFM/QRH assessment should evaluate dry runway surface conditions using nominal Boeing deceleration device sequence and time schedules (except as noted), ground spoilers deployed, maximum manual wheel braking or auto brakes max, detent 2 or maximum reverse thrust maintained to a complete stop (unless the thrust transition to reverse idle at 60 to 30 knots is sufficient to stop the airplane on the improved surface).

The airplane does have adequate stopping performance to come to a complete stop on the improved surface available using a dry runway assumption. Based on the data from Figure 8 (described in the next paragraph) and the event airplane's weight (~143,000 pounds), the airplane could stop in approximately 2400 feet with the following assumptions: max manual braking, detent reverse thrust, Speedbrakes deployed, and reverse thrust maintained until fully stopped. Since the airplane's final touchdown point was approximately 5200 feet from the Runway 24 threshold, the airplane could have come to a complete stop at 7600 feet from the threshold (438 feet of runway remaining).

Figure 8 includes two plots showing airplane stopping capability. The upper plot assumes no reverse thrust, and the lower plot assumes detent reverse thrust. On both the upper and lower plots there are lines for auto brake settings of 1, 2, 3, and max along with maximum manual braking. The vertical scale shows the distance from touchdown to a complete stop. Transition from touchdown to full braking assumes: brake initiation (auto brakes) at touchdown (manual braking is one second after touchdown), speed-brake select one second after touchdown, and reverse thrust (if applicable) select one second after spoiler select. No flare distance is included.

The conditions are labelled in Figure 8 and are meant to reflect the actual conditions of the event: Flaps 40, 450 feet pressure altitude, 83° F outside air temperature, touchdown speed of VREF40+6 knots and a reported 7 knot tail wind. The wind value was conservatively factored by 1.5, so that the calculation assumed a 10.5 knot tailwind. This is consistent with the Airplane Flight Manual and FCOM calculation method. In addition, all airplane parameters used in the calculation are consistent with the databases used to develop the airplane flight manual and operational performance data provided in the FCOM.

Item No. 4. Simulation match for the accident approach (trim at flaps 10 or earlier, fly the approach to the runway 24 approach threshold and terminate the simulation, match engine N1/EPR and airplane configuration changes, calculate the control input/control surface increments to the applicable FDR parameters required to match the airplane position and attitudes as a function of time, plot ALL relevant FDR and PSIM longitudinal and lateral directional parameters).

The 737-800 short field package with winglets desktop simulation offers flexibility in being able to drive the simulation controls with FDR data and use mathematical pilot models to produce the desired airplane state/flight path. The simulation is a six degree of freedom non-linear model that has been updated with flight data. A mathematical pilot applies inputs to track a specified parameter(s) (e.g. pitch) in an attempt to zero the error between the flight data and simulation.

The simulation match was conducted from flaps 10 and terminated upon crossing the threshold (Figures 9 and 10). The simulation was driven with the recorded stabilizer position, column position, rudder deflection, wheel position, speed-brake handle, flap handle position, and throttle resolver angles. Mathematical pilot models were also used on column, wheel, and rudder to assist in matching the pitch attitude, bank angle, and heading, respectively. The simulation winds were driven with KINCON calculated winds.

The resulting simulation data matched the airplane's recorded flight path very well for all longitudinal axis and lateral-directional axis parameters evaluated, demonstrating the airplane's motion was due to the recorded control inputs.

Boeing 737 NG Flight Crew Training Manual

When conducting an instrument approach from the holding pattern, continue on the same pattern as holding, extend flaps to 5 on the outbound track parallel to final approach course. Turn inbound on the procedure turn heading. This type of approach is also referred to as a race track approach.

Procedure Turn

On most approaches the procedure turn must be completed within specified limits, such as within 10 NM of the procedure turn fix or beacon. The FMC depicted procedure turn, or holding pattern in lieu of procedure turn, complies with airspace limits. The published procedure turn altitudes are normally minimum altitudes. The FMC constructs the procedure turn path based upon predicted winds, 170 knot airspeed and the "excursion" distance in the Nav database for the procedure. Adjust time outbound for airspeed, wind effects, and location of the procedure turn fix. If the procedure turn fix is crossed at an excessively high ground speed, the procedure turn protected airspace may be exceeded. The procedure turn should be monitored using the map to assure the airplane remains within protected airspace.

Stabilized Approach Recommendations

Maintaining a stable speed, descent rate, and vertical/lateral flight path in landing configuration is commonly referred to as the stabilized approach concept. Any significant deviation from planned flight path, airspeed, or descent rate should be announced. The decision to execute a go-around is no indication of poor performance.

Note: Do not attempt to land from an unstable approach.

Recommended Elements of a Stabilized Approach

The following recommendations are consistent with criteria developed by the Flight Safety Foundation.

All approaches should be stabilized by 1,000 feet AFE in instrument meteorological conditions (IMC) and by 500 feet AFE in visual meteorological conditions (VMC). An approach is considered stabilized when all of the following criteria are met:

- The airplane is on the correct flight path
- Only small changes in heading and pitch are required to maintain the correct flight path
- The airplane speed is not more than VREF + 20 knots indicated airspeed and not less than VREF
- The airplane is in the correct landing configuration
- Sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted
- Thrust setting is appropriate for the airplane configuration
- All briefings and checklists have been conducted.

Specific types of approaches are stabilized if they also fulfil the following:

- ILS and GLS approaches should be flown within one dot of the glide slope and localizer, or within the expanded localizer scale
- During a circling approach, wings should be level on final when the airplane reaches 300 feet AFE.

Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

Note: An approach that becomes un-stabilized below 1,000 feet AFE in IMC or below 500 feet AFE in VMC requires an immediate go-around.

These conditions should be maintained throughout the rest of the approach for it to be considered a stabilized approach. If the above criteria cannot be established and maintained at and below 500 feet AFE, initiate a go-around.

At 100 feet HAT for all visual approaches, the airplane should be positioned so the flight deck is within, and tracking to remain within, the lateral confines of the runway edges extended.

As the airplane crosses the runway threshold it should be:

- Stabilized on target airspeed to within + 10 knots until arresting descent rate at flare
- On a stabilized flight path using normal manoeuvring
- Positioned to make a normal landing in the touchdown zone (the first 3,000 feet or first third of the runway, whichever is less).

Initiate a go-around if the above criteria cannot be maintained.

Manoeuvring (including runway changes and circling)

When manoeuvring below 500 feet, be cautious of the following:

- Descent rate change to acquire glide path
- Lateral displacement from the runway centreline
- Tailwind or crosswind components
- Runway length available.

Mandatory Missed Approach

On all instrument approaches, where suitable visual reference has not been established and maintained, execute an immediate missed approach when:

- A navigation radio or flight instrument failure occurs which affects the ability to safely complete the approach
- The navigation instruments show significant disagreement
- On ILS or GLS final approach and either the localizer or the glide slope indicator shows full deflection

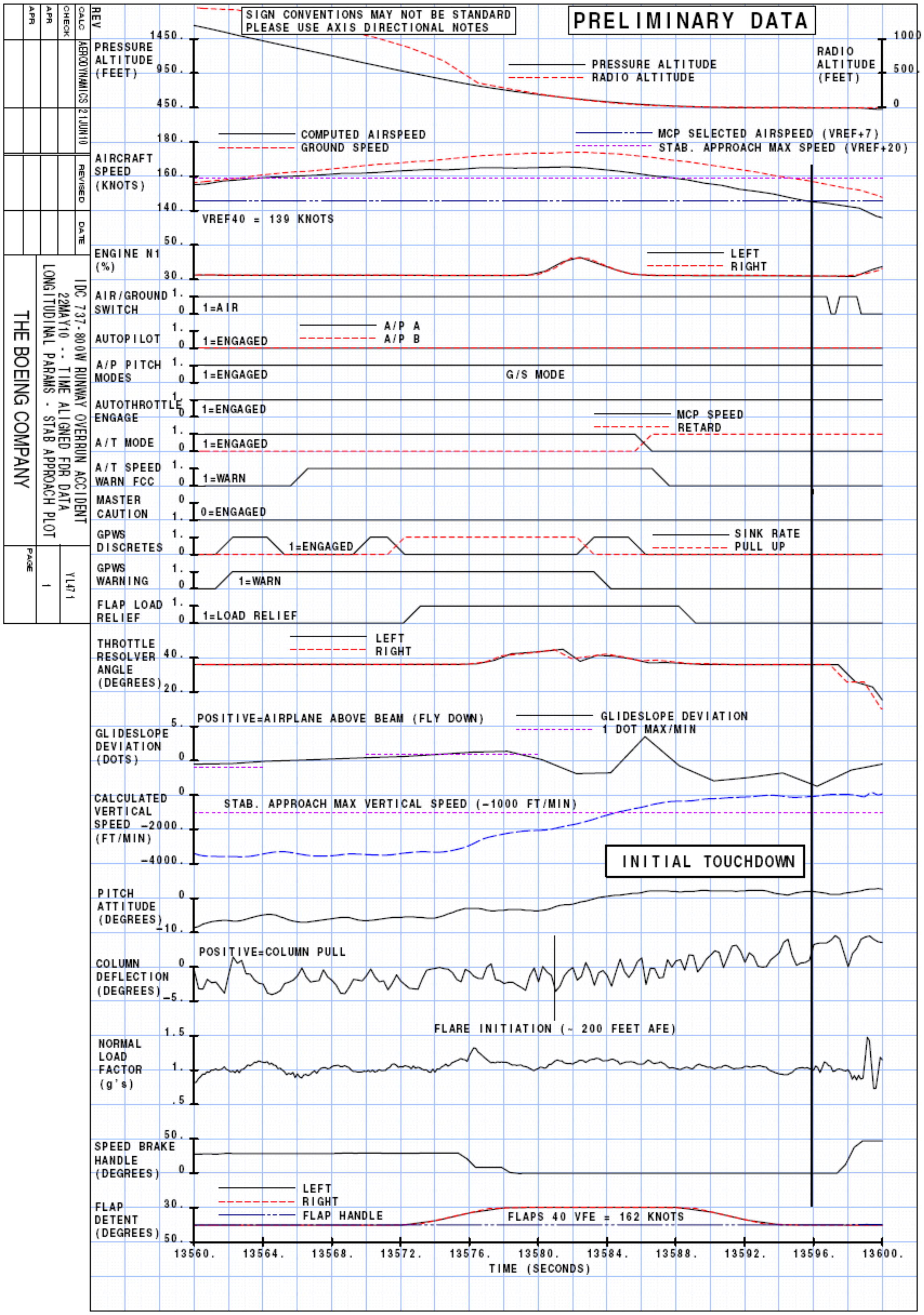
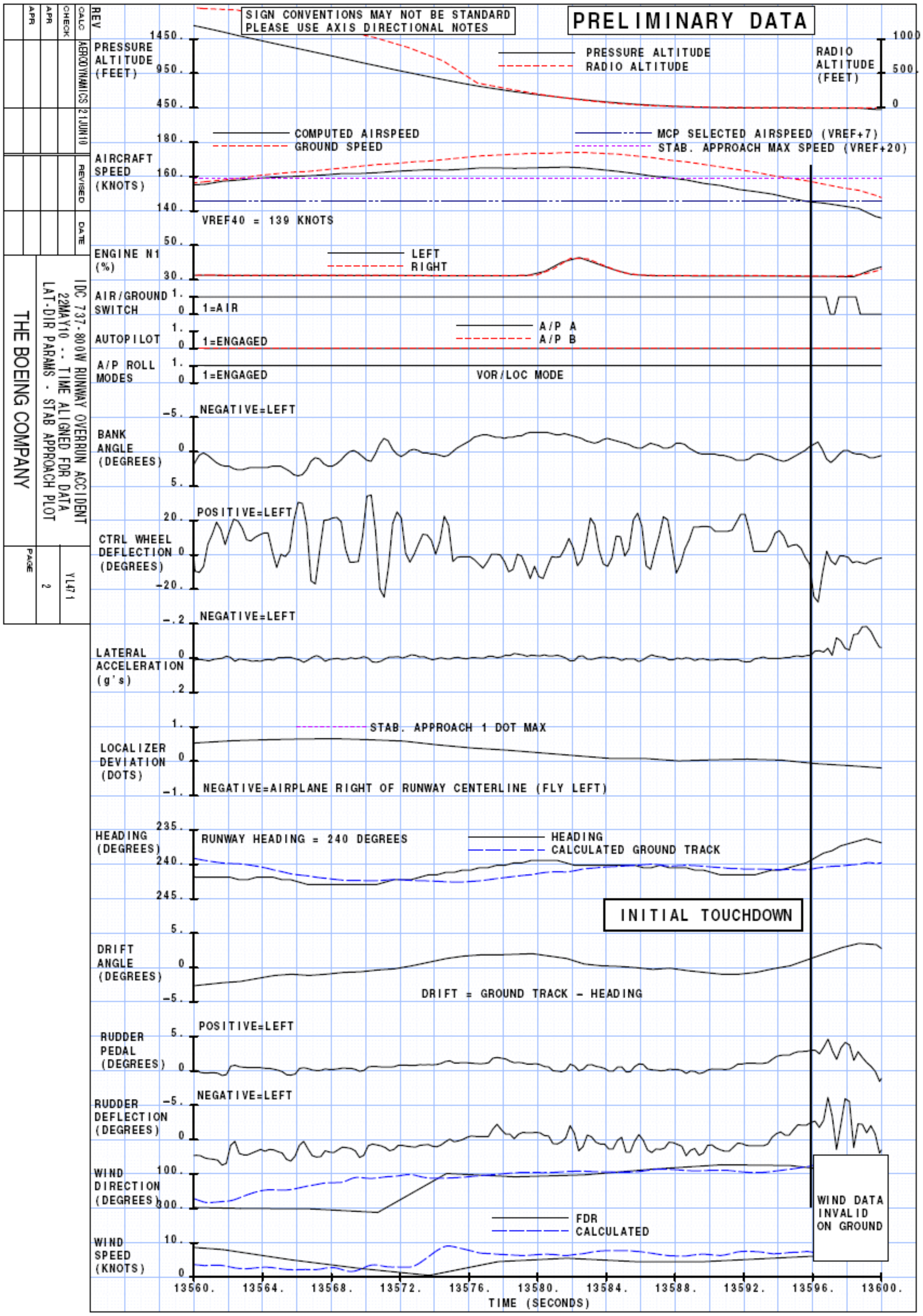

SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
PRELIMINARY DATA
APR
APR
CHECK
CALC
REV
AERODYNAMICS
21JUN10
REVISED
DATE
THE BOEING COMPANY
IDC 737-800W RUNWAY OVERRUN ACCIDENT
22MAY10 -- TIME ALIGNED FOR DATA
LONGITUDINAL PARAMS - STAB APPROACH PLOT
PAGE
1
YL471
PRESSURE ALTITUDE (FEET)
PRESSURE ALTITUDE
RADIO ALTITUDE
RADIO ALTITUDE (FEET)
AIRCRAFT SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED AIRSPEED (VREF+7)
STAB. APPROACH MAX SPEED (VREF+20)
VREF40 = 139 KNOTS
ENGINE N1 (%)
LEFT
RIGHT
AIR/GROUND SWITCH
1=AIR
AUTOPILOT
1=ENGAGED
A/P A
A/P B
A/P PITCH MODES
1=ENGAGED
G/S MODE
AUTOTHROTTLE ENGAGE
1=ENGAGED
A/T MODE
1=ENGAGED
MCP SPEED
RETARD
A/T SPEED WARN FCC
1=WARN
MASTER CAUTION
0=ENGAGED
GPWS DISCRETES
1=ENGAGED
SINK RATE
PULL UP
GPWS WARNING
1=WARN
FLAP LOAD RELIEF
1=LOAD RELIEF
THROTTLE RESOLVER ANGLE (DEGREES)
LEFT
RIGHT
GLIDESLOPE DEVIATION (DOTS)
POSITIVE=AIRPLANE ABOVE BEAM (FLY DOWN)
GLIDESLOPE DEVIATION
1 DOT MAX/MIN
CALCULATED VERTICAL SPEED (FT/MIN)
STAB. APPROACH MAX VERTICAL SPEED (-1000 FT/MIN)
INITIAL TOUCHDOWN
PITCH ATTITUDE (DEGREES)
COLUMN DEFLECTION (DEGREES)
POSITIVE=COLUMN PULL
FLARE INITIATION (~ 200 FEET AFE)
NORMAL LOAD FACTOR (g's)
SPEED BRAKE HANDLE (DEGREES)
FLAP DETENT (DEGREES)
LEFT
RIGHT
FLAP HANDLE
FLAPS 40 VFE = 162 KNOTS
13560. 13564. 13568. 13572. 13576. 13580. 13584. 13588. 13592. 13596. 13600.
TIME (SECONDS)

Figure: 1


SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
PRELIMINARY DATA
PRESSURE ALTITUDE (FEET)
PRESSURE ALTITUDE
RADIO ALTITUDE
RADIO ALTITUDE (FEET)
AIRCRAFT SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED AIRSPEED (VREF+7)
STAB. APPROACH MAX SPEED (VREF+20)
VREF40 = 139 KNOTS
ENGINE N1 (%)
LEFT
RIGHT
AIR/GROUND SWITCH
1=AIR
AUTOPILOT
1=ENGAGED
A/P A
A/P B
A/P ROLL MODES
VOR/LOC MODE
BANK ANGLE (DEGREES)
NEGATIVE=LEFT
CTRL WHEEL DEFLECTION (DEGREES)
POSITIVE=LEFT
LATERAL ACCELERATION (g's)
LOCALIZER DEVIATION (DOTS)
STAB. APPROACH 1 DOT MAX
NEGATIVE=AIRPLANE RIGHT OF RUNWAY CENTERLINE (FLY LEFT)
HEADING (DEGREES)
RUNWAY HEADING = 240 DEGREES
HEADING
CALCULATED GROUND TRACK
INITIAL TOUCHDOWN
DRIFT ANGLE (DEGREES)
DRIFT = GROUND TRACK - HEADING
RUDDER PEDAL (DEGREES)
RUDDER DEFLECTION (DEGREES)
WIND DIRECTION (DEGREES)
WIND SPEED (KNOTS)
FDR
CALCULATED
WIND DATA INVALID ON GROUND
TIME (SECONDS)
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IDC 737-800W RUNWAY OVERRUN ACCIDENT
22MAY10 -- TIME ALIGNED FDR DATA
LAT-DIR PARAMS - STAB APPROACH PLOT
AERODYNAMICS 21JUN10
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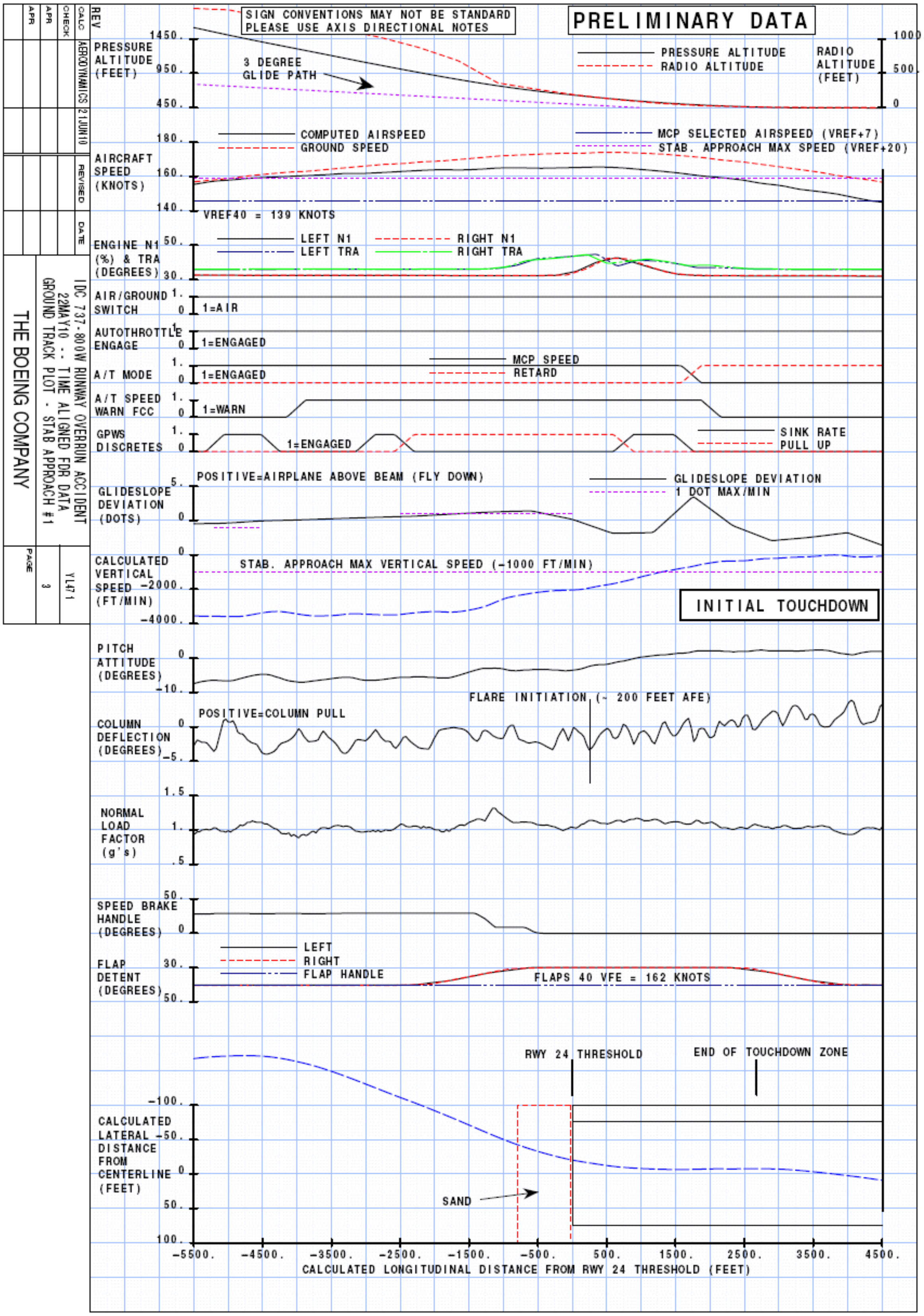
Figure: 2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PLEASE USE AXIS DIRECTIONAL NOTES
PRELIMINARY DATA
THE BOEING COMPANY
IDC 737-800W RUNWAY OVERRUN ACCIDENT
22MAY10 -- TIME ALIGNED FDR DATA
GROUND TRACK PLOT - STAB APPROACH #1
PRESSURE ALTITUDE (FEET)
3 DEGREE GLIDE PATH
PRESSURE ALTITUDE
RADIO ALTITUDE
RADIO ALTITUDE (FEET)
AIRCRAFT SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED AIRSPEED (VREF+7)
STAB. APPROACH MAX SPEED (VREF+20)
VREF40 = 139 KNOTS
ENGINE N1 (%) & TRA (DEGREES)
LEFT N1
LEFT TRA
RIGHT N1
RIGHT TRA
AIR/GROUND SWITCH
1=AIR
AUTOTHROTTLE ENGAGE
1=ENGAGED
A/T MODE
MCP SPEED
RETARD
A/T SPEED WARN FCC
1=WARN
GPWS DISCRETES
SINK RATE
PULL UP
GLIDESLOPE DEVIATION (DOTS)
POSITIVE=AIRPLANE ABOVE BEAM (FLY DOWN)
GLIDESLOPE DEVIATION
1 DOT MAX/MIN
CALCULATED VERTICAL SPEED (FT/MIN)
STAB. APPROACH MAX VERTICAL SPEED (-1000 FT/MIN)
INITIAL TOUCHDOWN
PITCH ATTITUDE (DEGREES)
FLARE INITIATION (~ 200 FEET AFE)
COLUMN DEFLECTION (DEGREES)
POSITIVE=COLUMN PULL
NORMAL LOAD FACTOR (g's)
SPEED BRAKE HANDLE (DEGREES)
FLAP DETENT (DEGREES)
LEFT
RIGHT
FLAP HANDLE
FLAPS 40 VFE = 162 KNOTS
RWY 24 THRESHOLD
END OF TOUCHDOWN ZONE
CALCULATED LATERAL DISTANCE FROM CENTERLINE (FEET)
SAND
CALCULATED LONGITUDINAL DISTANCE FROM RWY 24 THRESHOLD (FEET)

Figure: 3

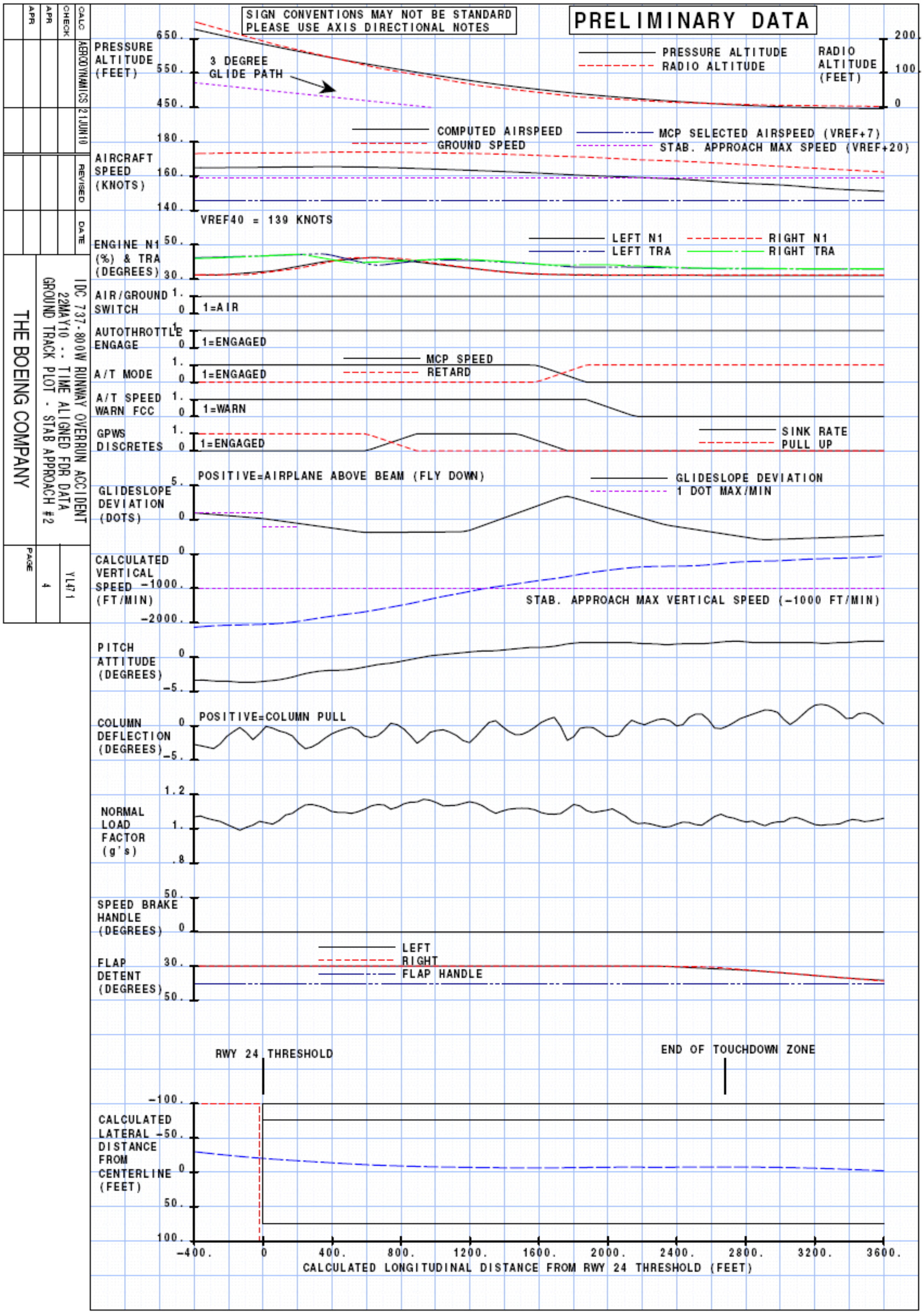
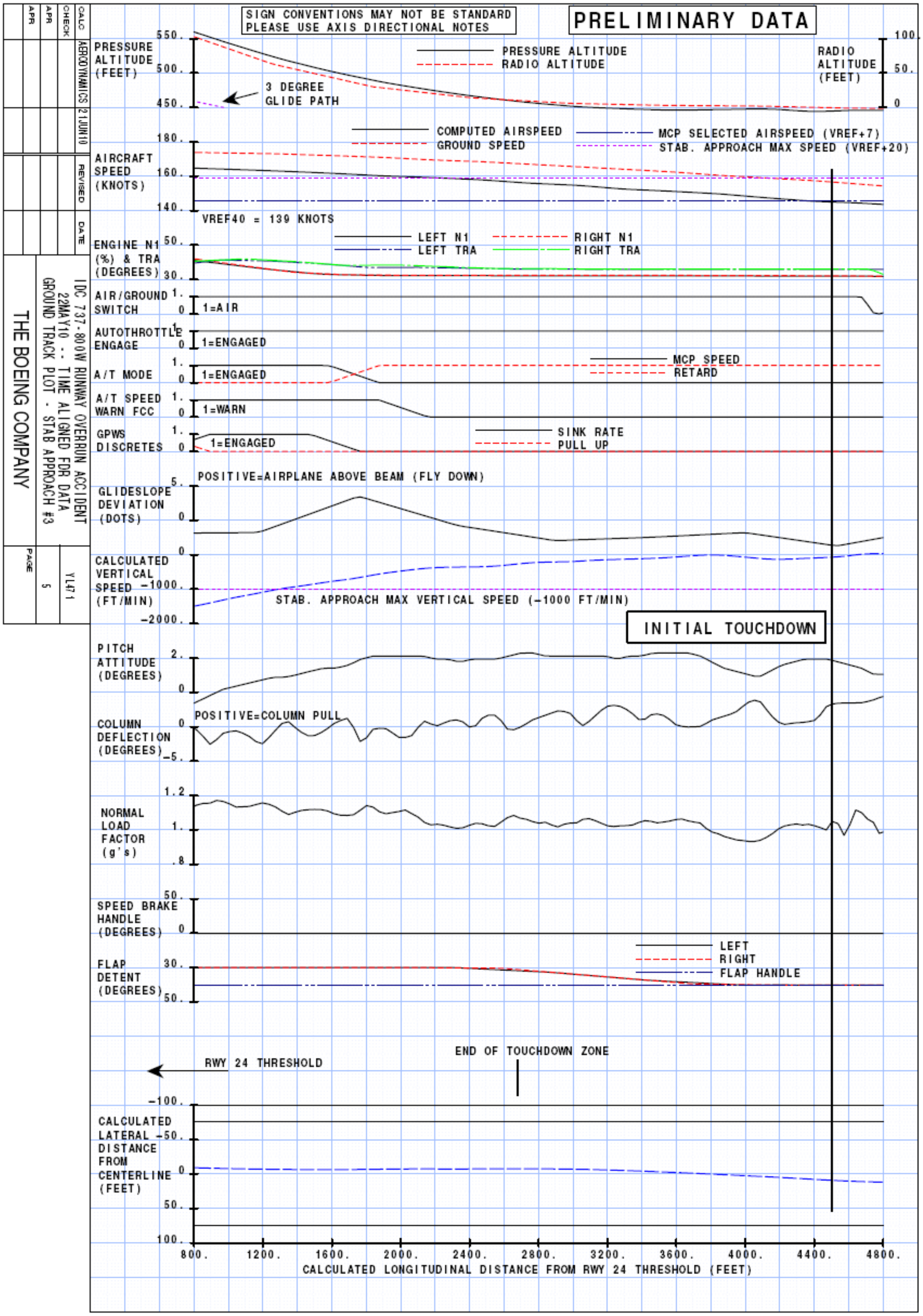

SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
PRELIMINARY DATA
THE BOEING COMPANY
IDC 737-800W RUNWAY OVERRUN ACCIDENT
22MAY10 -- TIME ALIGNED FOR DATA
GROUND TRACK PLOT - STAB APPROACH #2
PRESSURE ALTITUDE (FEET)
3 DEGREE GLIDE PATH
PRESSURE ALTITUDE
RADIO ALTITUDE
RADIO ALTITUDE (FEET)
AIRCRAFT SPEED (KNOTS)
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED AIRSPEED (VREF+7)
STAB. APPROACH MAX SPEED (VREF+20)
VREF40 = 139 KNOTS
ENGINE N1 (%) & TRA (DEGREES)
LEFT N1
LEFT TRA
RIGHT N1
RIGHT TRA
AIR/GROUND SWITCH
1=AIR
AUTOTHROTTLE ENGAGE
1=ENGAGED
A/T MODE
MCP SPEED
RETARD
A/T SPEED WARN FCC
1=WARN
GPWS DISCRETES
SINK RATE
PULL UP
GLIDESLOPE DEVIATION (DOTS)
POSITIVE=AIRPLANE ABOVE BEAM (FLY DOWN)
GLIDESLOPE DEVIATION
1 DOT MAX/MIN
CALCULATED VERTICAL SPEED (FT/MIN)
STAB. APPROACH MAX VERTICAL SPEED (-1000 FT/MIN)
PITCH ATTITUDE (DEGREES)
COLUMN DEFLECTION (DEGREES)
POSITIVE=COLUMN PULL
NORMAL LOAD FACTOR (g's)
SPEED BRAKE HANDLE (DEGREES)
FLAP DETENT (DEGREES)
LEFT
RIGHT
FLAP HANDLE
RWY 24 THRESHOLD
END OF TOUCHDOWN ZONE
CALCULATED LATERAL DISTANCE FROM CENTERLINE (FEET)
CALCULATED LONGITUDINAL DISTANCE FROM RWY 24 THRESHOLD (FEET)

Figure: 4



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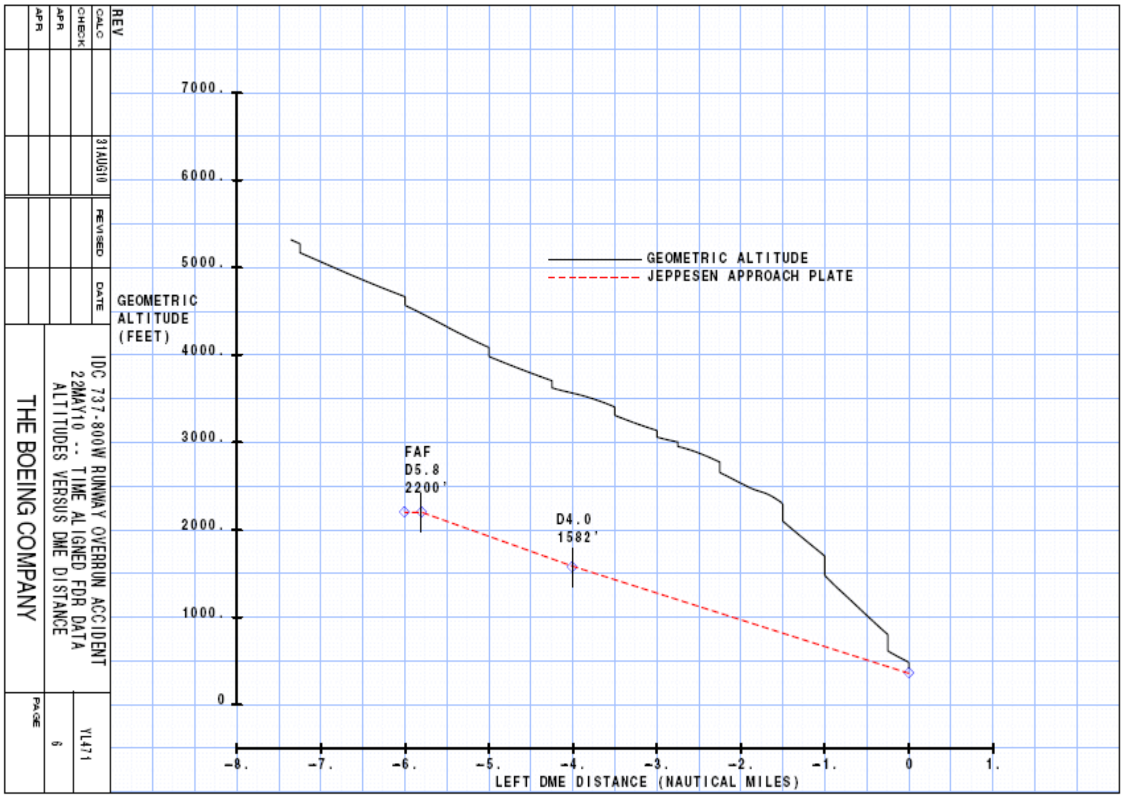
22MAY10 .. TIME ALIGNED FDR DATA
GROUND TRACK PLOT - STAB APPROACH #3
PRESSURE ALTITUDE (FEET)
RADIO ALTITUDE (FEET)
3 DEGREE GLIDE PATH
COMPUTED AIRSPEED
GROUND SPEED
MCP SELECTED AIRSPEED (VREF+7)
STAB. APPROACH MAX SPEED (VREF+20)
AIRCRAFT SPEED (KNOTS)
VREF40 = 139 KNOTS
ENGINE N1 (%) & TRA (DEGREES)
LEFT N1
RIGHT N1
LEFT TRA
RIGHT TRA
AIR/GROUND SWITCH
1=AIR
AUTOTHROTTLE ENGAGE
1=ENGAGED
A/T MODE
MCP SPEED
RETARD
A/T SPEED WARN FCC
1=WARN
GPWS DISCRETES
SINK RATE
PULL UP
POSITIVE=AIRPLANE ABOVE BEAM (FLY DOWN)
GLIDESLOPE DEVIATION (DOTS)
CALCULATED VERTICAL SPEED (FT/MIN)
STAB. APPROACH MAX VERTICAL SPEED (-1000 FT/MIN)
INITIAL TOUCHDOWN
PITCH ATTITUDE (DEGREES)
POSITIVE=COLUMN PULL
COLUMN DEFLECTION (DEGREES)
NORMAL LOAD FACTOR (g's)
SPEED BRAKE HANDLE (DEGREES)
FLAP DETENT (DEGREES)
LEFT
RIGHT
FLAP HANDLE
END OF TOUCHDOWN ZONE
RWY 24 THRESHOLD
CALCULATED LATERAL DISTANCE FROM CENTERLINE (FEET)
800. 1200. 1600. 2000. 2400. 2800. 3200. 3600. 4000. 4400. 4800.
CALCULATED LONGITUDINAL DISTANCE FROM RWY 24 THRESHOLD (FEET)

Figure: 5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31AUG10
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DATE
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22MAY10 .. TIME ALIGNED FDR DATA
ALTITUDES VERSUS DME DISTANCE
THE BOEING COMPANY
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YL471
GEOMETRIC ALTITUDE
JEPPESEN APPROACH PLATE
GEOMETRIC ALTITUDE (FEET)
FAF D5.8 2200'
D4.0 1582'
LEFT DME DISTANCE (NAUTICAL MILES)

Figure: 6

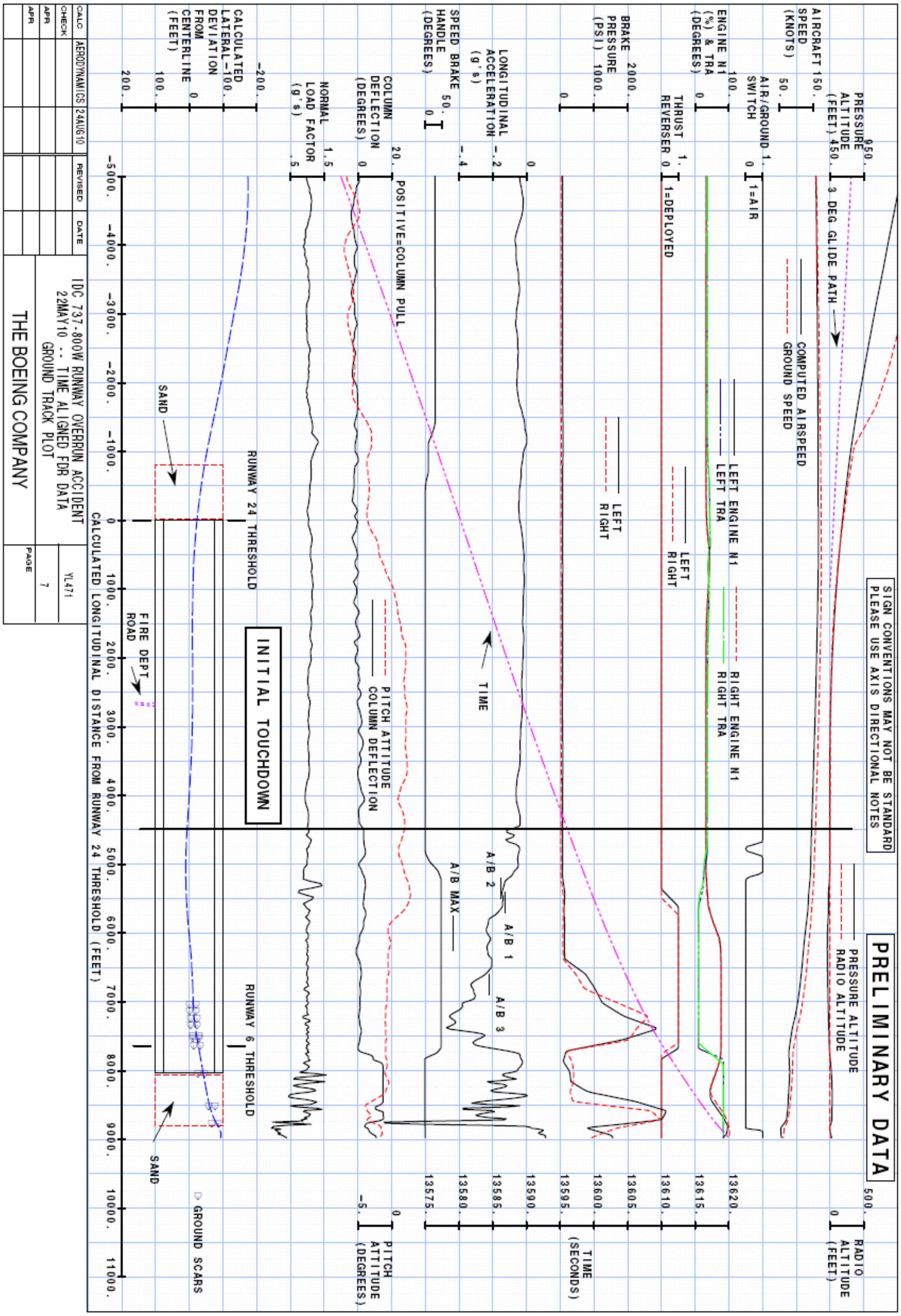
PRELIMINARY DATA
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
INITIAL TOUCHDOWN
RUNWAY 24 THRESHOLD
RUNWAY 6 THRESHOLD
CALCULATED LONGITUDINAL DISTANCE FROM RUNWAY 24 THRESHOLD (FEET)
TIME (SECONDS)
GROUND SCARS
SAND
FIRE DEPT ROAD
IDC 737-800W RUNWAY OVERRUN ACCIDENT
22MAY10 -- TIME ALIGNED FDR DATA
GROUND TRACK PLOT
THE BOEING COMPANY

Figure: 7

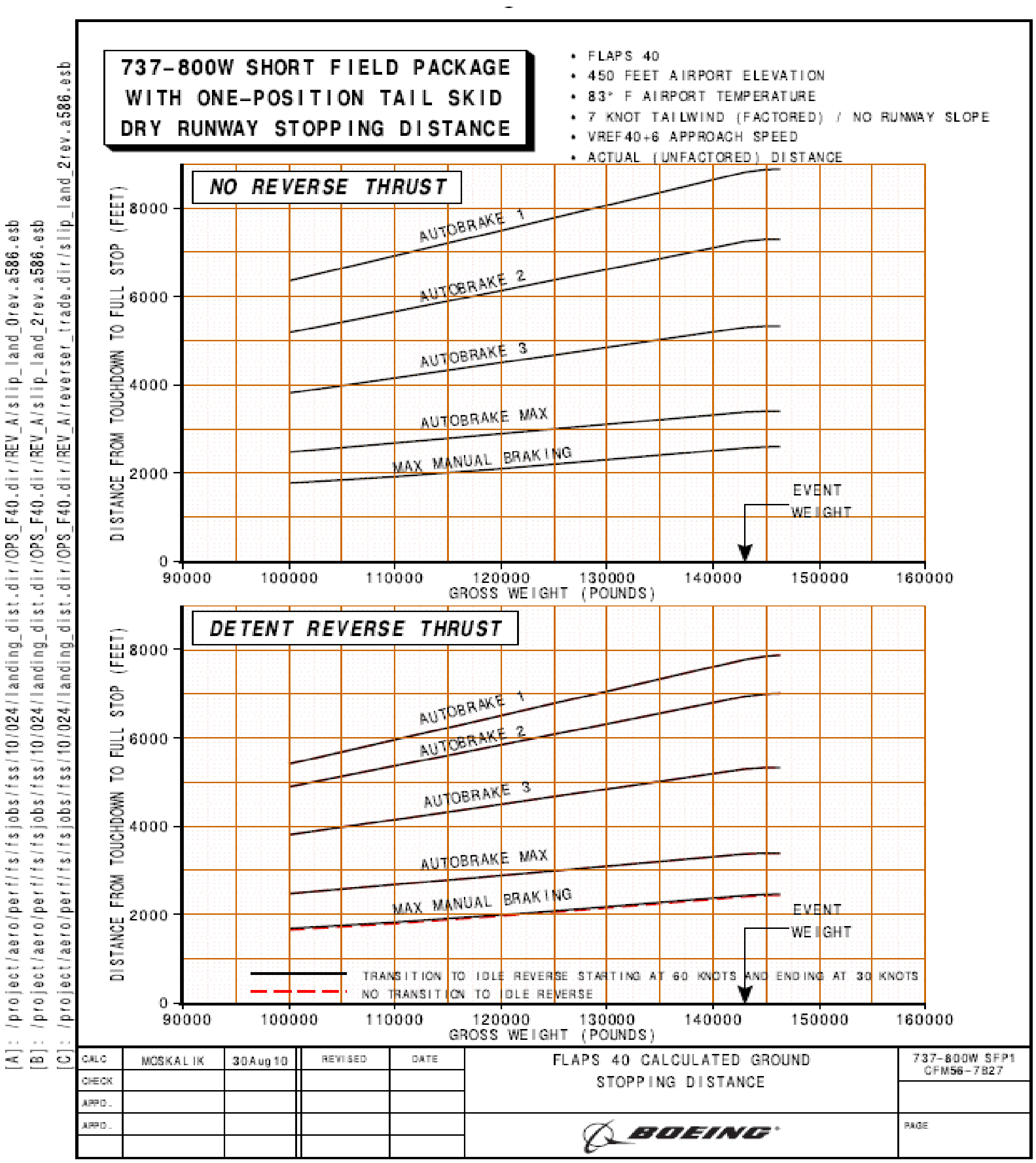
737-800W SHORT FIELD PACKAGE
WITH ONE-POSITION TAIL SKID
DRY RUNWAY STOPPING DISTANCE
• FLAPS 40
• 450 FEET AIRPORT ELEVATION
• 83° F AIRPORT TEMPERATURE
• 7 KNOT TAILWIND (FACTORED) / NO RUNWAY SLOPE
• VREF40+6 APPROACH SPEED
• ACTUAL (UNFACTORED) DISTANCE
NO REVERSE THRUST
AUTOBRAKE 1
AUTOBRAKE 2
AUTOBRAKE 3
AUTOBRAKE MAX
MAX MANUAL BRAKING
EVENT WEIGHT
DISTANCE FROM TOUCHDOWN TO FULL STOP (FEET)
GROSS WEIGHT (POUNDS)
DETENT REVERSE THRUST
TRANSITION TO IDLE REVERSE STARTING AT 60 KNOTS AND ENDING AT 30 KNOTS
NO TRANSITION TO IDLE REVERSE
[A]: /project/aero/perf/fs/fsjobs/fss/10/024/landing_dist.dir/OPS_F40.dir/REV_A/slip_land_0rev.a586.esb
[B]: /project/aero/perf/fs/fsjobs/fss/10/024/landing_dist.dir/OPS_F40.dir/REV_A/slip_land_2rev.a586.esb
[C]: /project/aero/perf/fs/fsjobs/fss/10/024/landing_dist.dir/OPS_F40.dir/REV_A/reverser_trade.dir/slip_land_2rev.a586.esb
CALC MOSKALIK 30Aug10
CHECK
APPD.
REVISED DATE
FLAPS 40 CALCULATED GROUND STOPPING DISTANCE
737-800W SFP1 CFM56-7B27
PAGE
BOEING

Figure: 8

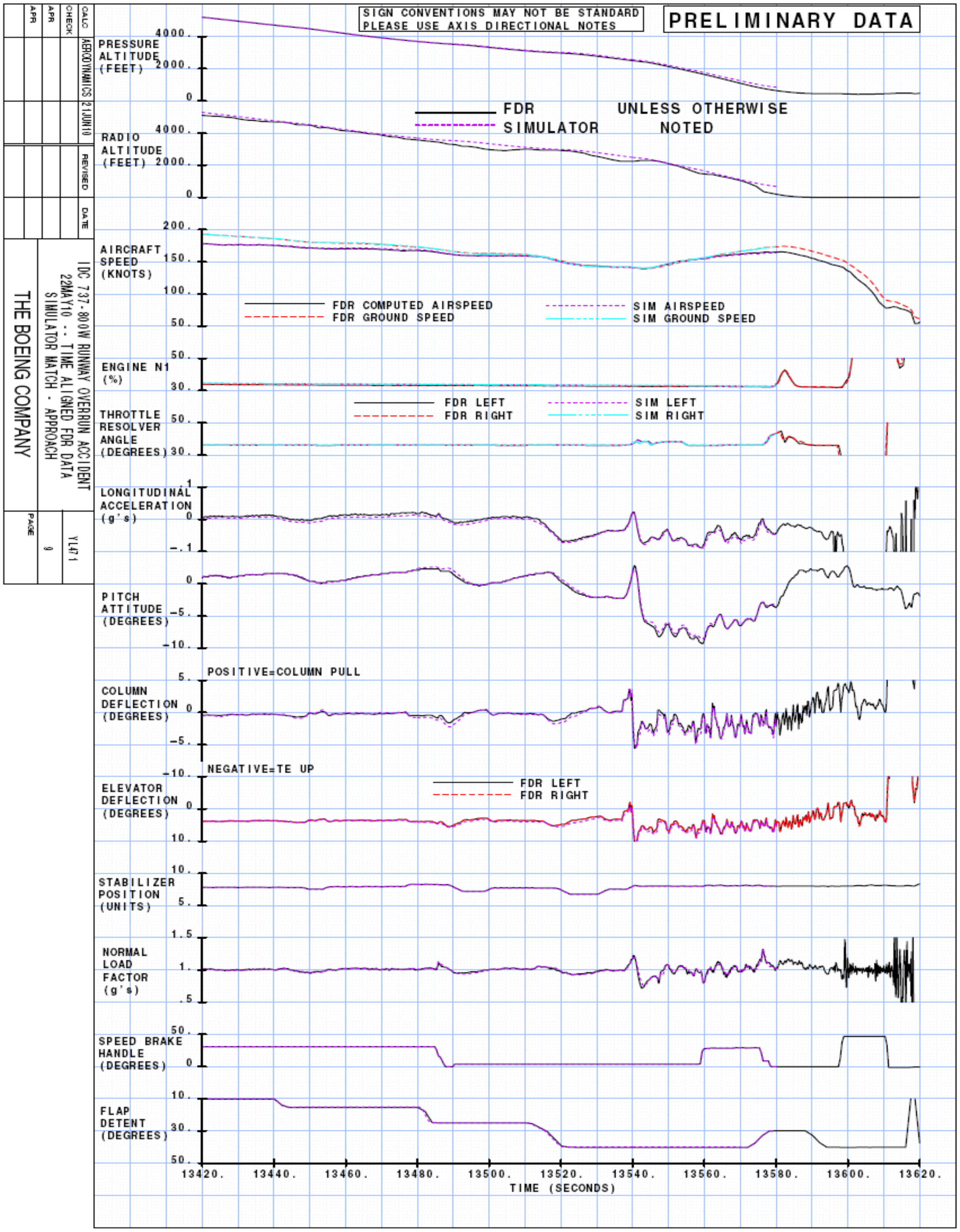
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
PRELIMINARY DATA
FDR
SIMULATOR
UNLESS OTHERWISE NOTED
PRESSURE ALTITUDE (FEET)
RADIO ALTITUDE (FEET)
AIRCRAFT SPEED (KNOTS)
FDR COMPUTED AIRSPEED
FDR GROUND SPEED
SIM AIRSPEED
SIM GROUND SPEED
ENGINE N1 (%)
FDR LEFT
FDR RIGHT
SIM LEFT
SIM RIGHT
THROTTLE RESOLVER ANGLE (DEGREES)
LONGITUDINAL ACCELERATION (g's)
PITCH ATTITUDE (DEGREES)
POSITIVE=COLUMN PULL
COLUMN DEFLECTION (DEGREES)
NEGATIVE=TE UP
ELEVATOR DEFLECTION (DEGREES)
STABILIZER POSITION (UNITS)
NORMAL LOAD FACTOR (g's)
SPEED BRAKE HANDLE (DEGREES)
FLAP DETENT (DEGREES)
TIME (SECONDS)
THE BOEING COMPANY
IDC 737-800W RUNWAY OVERRUN ACCIDENT
22MAY10 .. TIME ALIGNED FDR DATA
SIMULATOR MATCH - APPROACH
AERODYNAMICS
21JUN10
YL471

Figure: 9

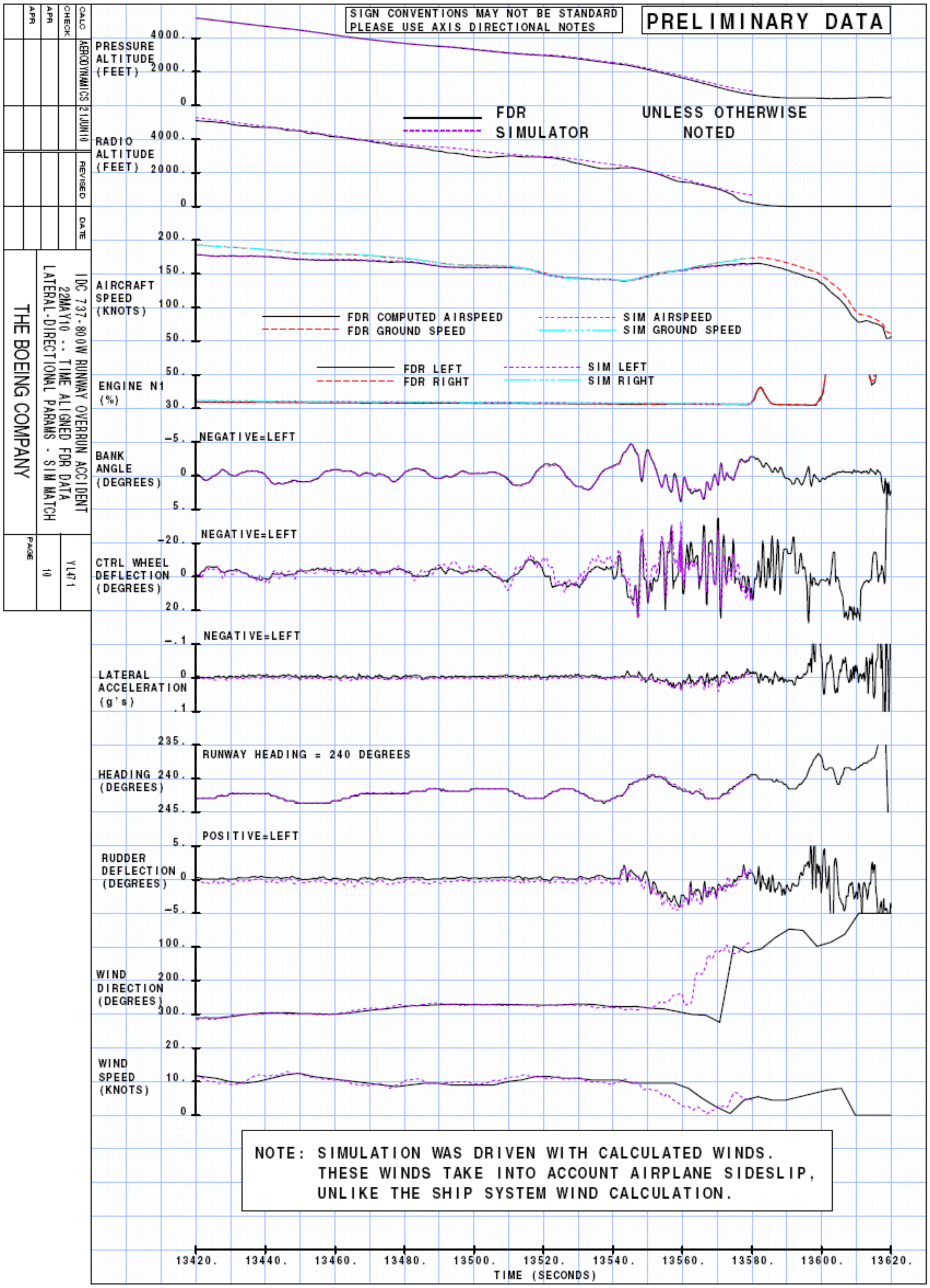
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
PRELIMINARY DATA
FDR
SIMULATOR
UNLESS OTHERWISE NOTED
PRESSURE ALTITUDE (FEET)
RADIO ALTITUDE (FEET)
AIRCRAFT SPEED (KNOTS)
FDR COMPUTED AIRSPEED
FDR GROUND SPEED
SIM AIRSPEED
SIM GROUND SPEED
ENGINE N1 (%)
FDR LEFT
FDR RIGHT
SIM LEFT
SIM RIGHT
BANK ANGLE (DEGREES)
NEGATIVE=LEFT
CTRL WHEEL DEFLECTION (DEGREES)
NEGATIVE=LEFT
LATERAL ACCELERATION (g's)
NEGATIVE=LEFT
HEADING (DEGREES)
RUNWAY HEADING = 240 DEGREES
RUDDER DEFLECTION (DEGREES)
POSITIVE=LEFT
WIND DIRECTION (DEGREES)
WIND SPEED (KNOTS)
NOTE: SIMULATION WAS DRIVEN WITH CALCULATED WINDS.
THESE WINDS TAKE INTO ACCOUNT AIRPLANE SIDESLIP,
UNLIKE THE SHIP SYSTEM WIND CALCULATION.
TIME (SECONDS)
THE BOEING COMPANY
IDC 737-800W RUNWAY OVERRUN ACCIDENT
22MAY10 .. TIME ALIGNED FDR DATA
LATERAL-DIRECTIONAL PARAMS - SIM MATCH
AERODYNAMICS
21JUN10

Figure 10

ACKNOWLEDGEMENT

Before closing this report, I wish to place on record my deep appreciation and grateful thanks to the Assessors Capt Ron Nagar, Shri Gurcharan Bhatura, Shri Babu Peter, Shri SS Nat and Group Capt Deepak Gaur. They have made invaluable contribution towards this investigation and finalisation of the report.

I am also grateful to Shri M Madhavan Nambiar, Secretary, Ministry of Civil Aviation, Dr Nasim Zaidi, DGCA and Shri VP Agrawal, Chairman, AAI for their valuable support towards functioning of the Court. I must specifically mention about their positive attitude in accepting various suggestions made during the course of the investigation.

I must also express my gratitude to Mr Joseph Sedor and his staff of NTSB, USA for their wholehearted support in re-building the damaged DFDR and CVR of the accident aircraft. Without this, it would not have been possible to retrieve and down-load the recorded data.

I received a great deal of support from Shri Bir Singh Rai, Director Air Safety, O/o DGCA, who has also functioned as the Inspector of Accident.

I am also thankful to Shri VK Yadava of AAI and Shri AK Mathew of Air India, who were of great help in co-ordinating various activities related to their organisations.

I am grateful to all participants and their learned counsels towards their contribution and in particular, for the orderly conduct of Public Hearings, both at Mangalore and New Delhi. Their free and frank views including various suggestions for enhancing Flight Safety are indeed praiseworthy.

And finally, I am extremely appreciative of the sincerity displayed and hard work put in by Shri SN Dwivedi, Director of Airworthiness, DGCA and Secretary to the Court.

- sd -

(Air Marshal BN Gokhale)
PVSM, AVSM, VM
Former Vice Chief of the Air Staff
Indian Air Force
The Court

New Delhi
31st October 2010

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