

Republic of Lebanon
Ministry of Public Works & Transport

Investigation Progress Report

Ethiopian 409 Accident – Boeing 737-800

25th January 2010

Beirut - Lebanon

Presented by the IIC on 10th February 2011

FOREWORD

This document presents an update on the progress of the technical investigation as of 25th February 2010. It has been prepared on the basis of the information gathered during the investigation, which is not yet complete; therefore, some of the points covered may evolve with time.

In accordance with Annex 13 to the Convention on International Civil Aviation, of which Lebanon is a signatory, and with the Lebanese Air Regulations (LAR), the investigation has not been conducted so as to apportion blame, nor to assess individual or collective responsibility. The sole objective of this investigation is to establish the cause(s) of the accident, draw lessons from what happened and come with appropriate recommendations that may help to prevent future accidents.

Consequently, nothing in the presentation of this report or the points that are raised herein should be interpreted as an indication of the orientation or conclusions of the investigation. Furthermore, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.

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Figure 1: ET 409 Horizontal Tracks

Figure 2: ET 409 Vertical Tracks

Figure 3: CVR Chassis

Figure 4: CVR Chassis with CSMU

Figure 5: ET 409 Radar Tracks

Glossary

ACC	Area Control Centre
ADD	Addis Ababa Bole International Airport
AOA	Angle of Attack
ATC	Air Traffic Control
ATPL	Airline Transport Pilot License
AVSEC	Aviation Security
BEA	Bureau d'Enquêtes et d'Analyses
BITE	Built-In Test Equipment
BRHIA	Beirut Rafic Hariri International Airport
CAM	Cockpit Area Microphone
CB	Cumulonimbus Cloud
CG	Centre of Gravity
CPL	Commercial Pilot's License
CSMU	Crash Survivable Memory Unit
DFSD	Director of Flight Safety Department
ECAA	Ethiopian Civil Aviation Authority
ECAR	Ethiopian Civil Aviation Regulations
ET 409	Ethiopian Airlines flight 409
FCL	Flight Crew Licensing
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FIR	Flight Information Region
FL	Flight Level
FMC	Flight Management Computer
F/O	First Officer/Co-pilot
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFSO	In-Flight Security Officer
IOSA	IATA Operational Safety Audit
Knots	Nautical Miles
LARs	Lebanese Air Regulations
LAT	Lebanese Air Transport
LCAA	Lebanese Civil Aviation Authority
LT	Local Time
MAC	Mean Aerodynamic Chord

MCP	Mode Control Panel
MEL	Minimum Equipment List
METAR	Meteorological Airport Report
MHz	Mega Hertz
MTOW	Maximum Takeoff Weight
NM	Nautical Mile
NOTAM	Notice to Air Men
NTSB	National Transportation Safety Board (USA)
PA	Public Address
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring (Ethiopian Airlines)
P/N	Part Number
RCC	Rescue Coordination Centre
ROV	Remotely Operated Vehicle
SAR	Search and Rescue
SID	Standard Instrument Departure
SIGMET	Significant Meteorological information
S/N	Serial Number
SSCVR	Solid State Cockpit Voice Recorder
SSFDR	Solid State Flight Data Recorder
SSR	Sea Search & Rescue
STD	Scheduled Time of Departure
TAF	Terminal Area Forecast
TEMSI	Significant weather chart
ULB	Underwater Locator Beacon
UTC	Universal Time Coordinated
VHF	Very High Frequency

Synopsis

Date of accident 25th January 2010 at 00:41:30 ¹	Aircraft Boeing 737-800
	Registered ET-ANB
Site of accident About 5 NM south west of Beirut airport, Mediterranean Sea	Owner CIT Aerospace International Corporation
Type of flight International public transport of passengers. Scheduled flight ET 409	Operator Ethiopian Airlines
	Persons on board
	Flight crew: 2 Cabin crew: 5 IFSO: 1 Passengers: 82

Summary

On 25 January 2010, flight ET409 took off from Beirut Rafic Hariri International Airport (Lebanon) bound for Addis Ababa Bole International Airport (Ethiopia) on a regularly scheduled revenue flight. Less than four minutes after take-off the plane crashed into the sea.

Consequences

	People			Equipment
	Fatally Injured	Injured	Unhurt	
Crew	8	-	-	Destroyed
Passengers	82	-	-	
Third parties	-	-	-	

⁽¹⁾ All times in this report are UTC, except where otherwise specified. Two hours should be added to obtain the local time (LT) applicable in Lebanon on the day of the accident.

Executive Summary

On 25 January 2010, at 00:41:30 UTC, Ethiopian Airlines flight ET 409, a Boeing 737-800 registered ET-ANB, crashed into the Mediterranean Sea about 5 NM west of Beirut Rafic Hariri International Airport (BRHIA), Beirut, Lebanon.

ET 409 was being operated under the provisions of the Ethiopian Civil Aviation Regulations (ECAR) and as a scheduled international flight between BRHIA and Addis Ababa Bole International Airport (ADD) - Ethiopia. It departed Beirut with 90 persons on board: 2 flight crew (a Captain and a First Officer), 5 cabin crew, an IFSO (registered as a passenger) and 82 regular passengers.

Instrument meteorological conditions prevailed for the flight, which was dispatched at night on an instrument flight plan. Isolated cumulonimbus and thunderstorms were reported in the area.

The flight was initially cleared by ATC on a Lateb 1 D departure from Runway 21. Just before take-off ATC changed the clearance to an “immediate right turn direct Chekka”.

The flight took-off at 00:37:08 and just after take-off ATC (Tower) instructed ET 409 to turn right on a heading of 315° and change to Control (ATC) 119.3. ET 409 acknowledged the clearance and heading 315° was selected on the MCP.

ET 409 continued right turn, ATC instructed ET 409 to turn left heading 270°. ET acknowledged and 270 was selected on the MCP. Maximum heading reached prior to left turn was 003°.

ET-409 continued left turn to heading 270° after acknowledgment and continued to a southerly track then on a sharp left turn until it disappeared from the radar screen and crashed into the Mediterranean Sea about 4 minutes after take-off.

The aircraft impacted the water surface at 00:41:30 around 6 NM South West of BRHIA and all occupants were fatally injured. SAR operations were initiated at 00:47:41.

The DFDR and CVR were retrieved from the sea bed and read, as per the Lebanese Government decision, at the BEA facility at Le Bourget, France. The recorders data revealed that ET 409 encountered two stick shakers respectively at time 00:40:01 for a period of 29” and at 00:40:56 for a period of 26”. 10 “Bank Angle” warnings were registered between 00:38:41 and 00:40:54; an over-speed clacker was also registered from time 00:41:25 till the end. The maximum registered AOA was 32° at 00:40:14, maximum registered bank angle was 118° Left at 00:41:14, the maximum registered speed was 407.5 knots at 00:41:28, the maximum registered G load was 4.412 at 00:41:28 and the maximum registered nose down pitch value was 63.1° at 00:41:16.

The DFDR recording stopped at 00:41:28 with the aircraft at 1291’. The last radar screen recording was at 00:41:28 with the aircraft at 1300’. The last CVR recording was a loud noise just prior to 00:41:30.

Organization of the investigation

On Monday 25th January 2010 at around 00.47, the Lebanese DGCA was informed of the loss of radio and radar contact with flight ET409 a few minutes after take-off from Beirut.

After having established without doubt that the airplane had disappeared the Lebanese Authorities launched a technical investigation. In accordance with Annex 13 to the Convention on International Civil Aviation, a Committee from Lebanese investigators was formed by a ministerial decree issued by the Minister of Public Works and Transport in order to lead the technical investigation.

As per Annex 13 provisions, American and Ethiopian accredited representatives were invited and associated with the Investigation Committee as the State of Manufacture (USA - NTSB) and the State of Registry and Operator (Ethiopia - CAA).

Following the existence of a Memorandum of Understanding between the Lebanese DGCA and the French Bureau d'Enquêtes et d'Analyses (BEA), the BEA was also invited to assist the Lebanese authorities to conduct the investigation.

The Investigation Committee composition was as follows:

Lebanon – State of occurrence:

BEA -Technical Adviser to the state of occurrence

Ethiopia – State of registration / operator

USA – State of manufacturer:

Two working groups were formed as follows:

- Operations
- Engineering & Maintenance

The Sea Search & Rescue (SSR) team was also formed by the Ministry of Public Work & Transportation in conjunction with the Lebanese Army. All Sea Search & Rescue operations were conducted in full coordination with Investigation Committee with daily briefings being given by the SSR team to the members of the Investigation Committee.

As per the Lebanese Government decision and in accordance with the MOU signed between the Lebanese DGCA and the French BEA, the DFDR and CVR were read at the BEA facilities at Le Bourget, Paris, France. Both recorders were transported directly to the BEA under the custody of the State of Occurrence accompanied by members from the Investigation Committee and readings were performed by BEA personnel in association with and under the direct supervision of the full Investigation Committee.

It was also decided that media relations were to be handled by the Lebanese Ministry of Public Works & Transportation with factual data and information relayed through the IIC directly to the Minister.

1. FACTUAL INFORMATION

1.1 History of Flight

On Monday 25 January 2010, Ethiopian flight 409 (ET 409) Boeing 737-800, registration ET-ANB operated by Ethiopian Airlines was a scheduled flight between Beirut and Addis Ababa, with 82 passengers (80 adults & 2 children) and 8 crew members (2 flight crew, 5 cabin crew & 1 IFSO).

The departure was planned at 00:30 hours. The crew was given clearance to start the engines at 00:30:14 hours; air traffic controllers issued taxi instructions at 00:30:29.

The flight departed at 00:36 UTC from Rafic Hariri International Airport Beirut, Lebanon, destined for Addis Ababa, Ethiopia.

Instruments meteorological conditions prevailed for the flight, and the flight was on an instrument flight plan. The accident occurred at night in dark lighting conditions with reported isolated cumulonimbus clouds and thunderstorms in the area.

ET 409 was initially cleared by ATC on a LATEB 1 D SID from Runway 21. Just before take-off, ATC changed the clearance to an “immediate right turn direct Chekka”.

After take-off ATC instructed ET 409 to turn right on a heading of 315° and change to Control 119.3. ET 409 acknowledged the clearance and continued right turn. ATC instructed ET 409 to turn left heading 270°. ET-409 acknowledged.

The Flight continued left turn to heading 270° after acknowledgment but did not maintain that heading. The aircraft continued on southerly track making a sharp left turn until it disappeared from the radar screen and crashed into the Mediterranean Sea at 00:41:30 around 6 NM South West of BRHIA and all occupants were fatally injured. SAR operations were initiated at 00:47:41. All 90 people on board were fatally injured and the airplane was destroyed.

The DFDR and CVR were retrieved from the sea bed and read, as per the Lebanese Government decision, at the BEA facility at Le Bourget, France. The recorders data revealed that ET 409 encountered two stick shakers respectively at time 00:40:01 for a period of 29” and at 00:40:56 for a period of 26”. 10 “Bank Angle” warnings were registered between 00:38:41 and 00:40:54; an over-speed clacker was also registered from time 00:41:25 till the end. The maximum registered AOA was 32° at 00:40:14, maximum registered bank angle was 118° Left at 00:41:14, the maximum registered speed was 407.5 knots at 00:41:28, the maximum registered G load was 4.412 at 00:41:28 and the maximum registered nose down pitch value was 63.1° at 00:41:16.

The following two figures developed by the French Bureau d'Enquêtes et d'Analyses (BEA) reproduce the entire flight horizontal and vertical tracks as derived from the DFDR data:



Figure 1: ET 409 horizontal tracks

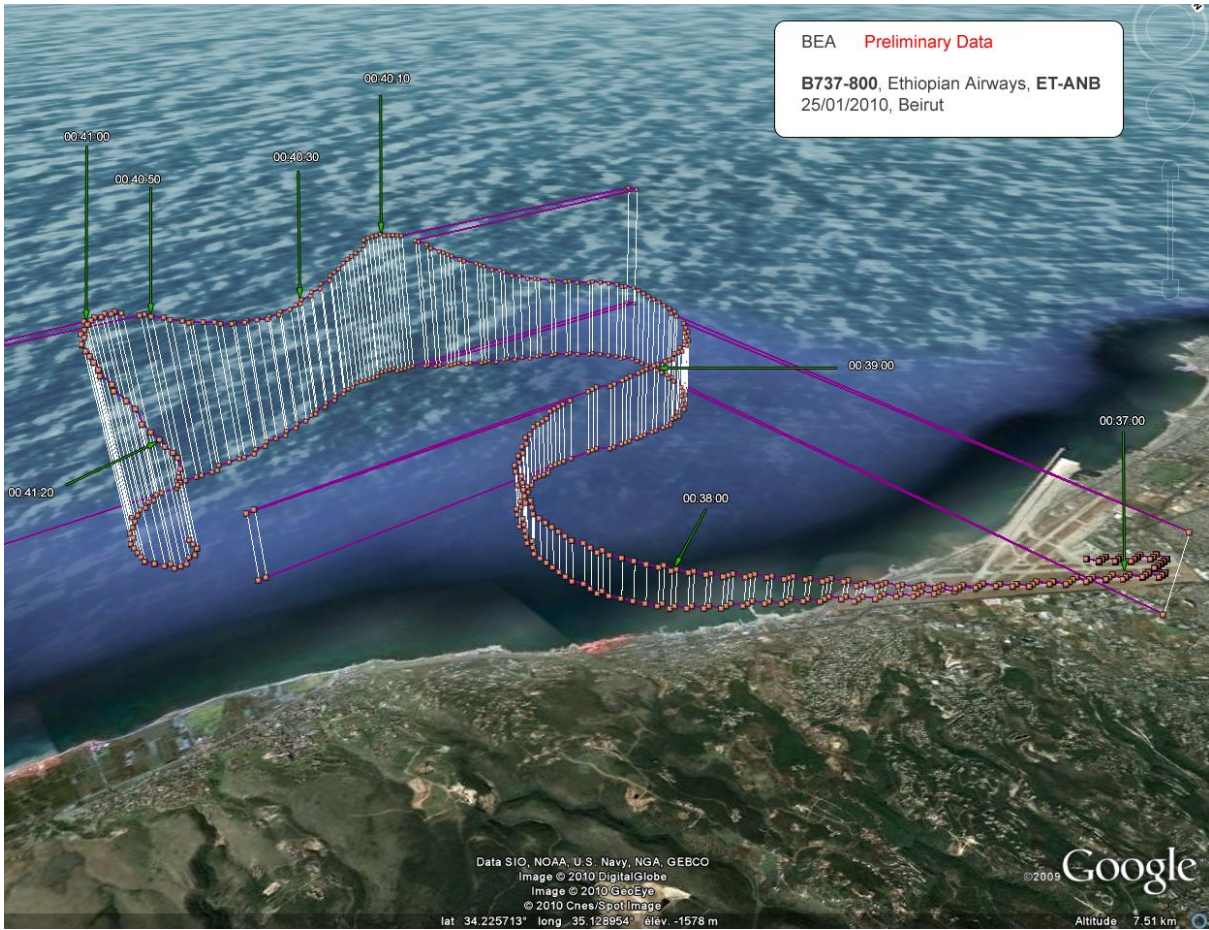


Figure 2: ET 409 vertical tracks

1.2 Injuries to Persons

Injuries	Crew Members	Passengers	Others
Fatal	8 ²	82 ³	0
Serious	0	0	0
Light/none	0	0	0

² Including 1 IFSO listed on the passengers' manifest

³ Including 2 children

1.3 Damage to Aircraft

The aircraft was completely destroyed.

1.4 Other Damage

Not applicable.

1.5 Personnel Information

1.5.1 Flight Crew

The flight crew consisted of the captain and the first officer. Five flight attendants and an IFSO were also on duty aboard the airplane. All crew were certified in accordance with the ECAA requirements.

1.5.1.1 Captain

Male, according to records provided by Ethiopian Airlines, he joined the company on 27 January 1989 and started operations on agricultural spraying aircraft.

He holds an Ethiopian ATPL number AA 333, issued 10 June 2008, showing the date of birth as 17 October 1965 and ratings as PIC for Multi-Engine Land on 22 December 1988, for Single Engine Land on 4 January 1989, for Fokker 50 on 10 June 2008 and for Boeing 737-700/800 on 16 October 2009. It also shows ratings as co-pilot for DHC 6 on 31 December 1998, for B 737-200 on 23 July 2002 and for B757/767 on 4 September 2003.

According to records provided by Ethiopian Airlines the captain completed company training and was released to operate solo as PIC on Fokker 50 as of 7 July, 2008. He also completed company training consisting of 120 hours of ground school, 56 hours of simulator and 1 hour of base training prior to commence and then complete his route training and be released to operate solo as PIC on B737-700/800 type aircraft on 3 December 2009. His last recurrent/type rating training was satisfactory completed on 14 October 2009 and last proficiency check satisfactory completed on 15 October 2009. His last CRM was done on 11 October 2009 and the last Adverse Weather and Upset Recovery training done on 06 October 2009. His total flying experience is 10,233 hours including 3,718 hours as PIC of which 2,488 hours are on different light and spray aircraft, 1,042 hours on Fokker 50 and 188 hours on B 737-700/800.

Records provided by Ethiopian Airlines show his flying hours in the previous 6 months as 340 hours, 3 months as 236 hours, 30 days as 99 hours and 24 hours as 4.7 hours. His most recent medical certificate was issued on 25 November 2009 and he was found to be medically fit to fly in accordance with the standards specified in ICAO Annex 1, "Medical Standards and Certification."

The Captain arrived in Beirut, Lebanon on the early morning (around 01:30 LT) of 24 January 2009 while serving as PIC on Ethiopian Airlines flight 408.

1.5.1.2 First Officer

Male, according to records provided by ET, he joined the company on 16 January 2009. He holds an Ethiopian Commercial Pilot license number AC 1012, issued 7 April 2009, showing the date of birth as 16 September 1986 and ratings for Single Engine Land on 7 April 2009 and for B 737 700/800 on 25 June 2009. He held a first-class ECAA airman medical certificate with no limitations or restrictions, dated 11 June 2009.

According to records provided by ET, the First Officer graduated from Ethiopian Aviation Academy on 15 January 2009 and was transferred to the ET Flight Operations Division on 16 January 2009. His initial operation training consisted in part of 80 hours course in Jet Conversion, 60 hours of Basic Instrument Flying (Simulator) completed on 16 March 2009 and Adverse Weather Upset Recovery training done on 12 March 2009. He completed company training on B737-700/800 consisting of 120 hours of ground school, 60 hours of Simulator, 1 hour of base training and 64 hours of route training and was fully released to fly solo as First Officer on B737-700/800 on 30 August 2009. His most recent re-currency and proficiency checks were satisfactorily completed respectively on 16 and 17 December 2009.

His total flying experience was 673 flying hours, of which 350 were as released First Officer on B737-700/800 type aircraft. The records show his total flying hours in the previous 6 months as 394 hours, 3 months as 178 hours, 30 days as 56 hours and 24 hours as 4.7 hours.

The First Officer arrived in Beirut, Lebanon on the morning (around 01:30 LT) of 24 January 2009 while serving as First Officer on Ethiopian Airlines flight 408.

1.5.2 Cabin crew

According to records provided by ET, the cabin crew consisted of 5 female flight attendants. All 5 cabin crew were fully licensed in accordance with the provisions of the ECAA.

1.5.3 IFSO

The IFSO was seated in the front passengers' cabin amongst the passengers and listed on the passengers manifest under a coded name. He was counted for the load-sheet as a passenger and listed on the passengers manifest under a coded name. However, he was listed on the Crew General Declaration and his official status on board was "extra-crew".

The IFSO has been licensed in accordance with the provisions of the ECAA national regulations after completing the appropriate AVSEC courses and has been authorized to fly on board of Ethiopian airplanes in the capacity of IFSO sitting and mixing with the regular passengers.

1.5.4 ATC Personnel

All ATC personnel handling ET 409 were properly licensed by the Lebanese DGCA in accordance with ICAO standards and the LAR.

1.6 Aircraft information

The aircraft was owned by CIT Aerospace International Corporation. It had been operated by an Irish operator from its entry into service in 2002 until April 2009. Ethiopian Airlines had operated the aircraft since September 2009. The aircraft was configured to seat a maximum of 16 first class, and 138 economy-class passengers and also to carry cargo.

1.6.1 Airframe

Manufacturer	Boeing
Type	B737-800
Serial number	29935
Entry into service	February 2002
Change of registration	ET-ANB (11 September 2009)
Certificate of registration	12/09/2009
Registration	ET-ANB
Certificate of Airworthiness	valid until 11/9/2010
Utilization till 24 January 2010	26,459 flying hours and 17,823 cycles

1.6.2 Engines

Manufacturer: CFM International
Type: CFM56-7B27

	Engine No. 1	Engine No. 2
Serial number	890932	890963
Engine time since new	18,110	18,137
Engine cycles since new	11,728	11,757

1.6.3 Weight and balance

The aircraft weight and balance record was reviewed and no deficiencies or anomalies were noted.

1.6.4 Condition of the aircraft before departure

No defect or deferred maintenance item was reported on the technical log after the arrival and before departure of the plane from Beirut.

1.6.5 Maintenance operations follow-up

The last four months of the maintenance records were examined within the framework of the investigation.

Ethiopian Airlines have conducted two maintenance checks since the introduction of ET-ANB to the fleet on 12 September 2009. The first check, conducted during November 20-22 time frame, included a '2A' and a '3A' check. The second check, conducted during the December 24-25 timeframe, included a '1A' and a '4A' check.

Transit checks are conducted after each flight segment and include review of the technical log for any discrepancies noted during the flight. A flight mechanic may be included with the Flight crew for stations with no Ethiopian airlines ground personnel. There was no flight mechanic on board the accident flight as Ethiopian airlines has a technical station engineer stationed in Beirut.

Daily checks are completed prior to the first flight of the day and include routine examination of the serviceability of the airplane for the day's flights.

Weekly checks are similar to daily checks however include more detailed tasks and are conducted on 50 flight hour intervals. Documentation is retained only for the most recent checks; older check documents are destroyed per the Ethiopian documentation retention policy.

As pertinent to the accident airplane, Ethiopian airlines conduct 'block' checks. There are 'A' checks (system zonal and structural), each with a defined interval of flight hours and cycles. Typical 'A' checks include a general visual inspection of the airframe components (systems and interior components), filter changes, general visual inspection (including baroscopic) of the engines, etc...

A review of the maintenance records for the above mentioned 'A' checks denoted activities associated with airplane preparation (panel access), routine maintenance actions (filter changes, engine oil and hydraulic fluid quantities, etc...), and results of inspection items. Inspection items are noted either as 'no finding' or 'finding' with a reference to a non-routine task card which outlines the anomalous finding and the corrective action taken. All items are signed by both the mechanic and the inspector.

A summary review of all non-routine findings from both the November and December checks noted no significant airframe component issues or interior component issues.

Ethiopian airlines are also certified for 'C' checks. There are 'C' checks (system zonal and structural) and, like 'A' checks, are in 'blocks'. 'C' checks are conducted on an interval of flight hours and cycles. Such checks include detailed airframe and component checks. The accident airplane had not been subject to a 'C' check whilst being operated by Ethiopian airlines as it was not due for one.

The engines logbooks and the airframe and engines airworthiness directives (AD) status were also examined.

The examination of the maintenance documents on this aircraft did not reveal any significant anomalies.

1.7 Meteorological Conditions

The Lebanese Civil Aviation Authority reviewed the data from the Lebanese Meteorological Services that was collected on 25 January, 2010 after the accident. Meteorological data revealed some significant meteorological conditions in the area at the time of the accident. Relevant meteorological documents are included in the investigation file and will be analyzed during the investigation.

1.7.1 General meteorological situation

At the time of the accident, there was thunderstorms activity southwest and west of the field, as well as to the northwest on the localizer path for runway 16.

1.7.2 Local meteorological situation

The meteorological conditions at the airport were fair and the surface wind recorded at the take-off time was calm, no rain over the field and visibility > 10 km. Cloud base was recorded as 2000’.

METAR and TAFOR reports indicate significant meteorological conditions were in the area South West, North West and North East of the airport with isolated CB and thunderstorm activities beyond 10 km from the airport. The D-ATIS was transmitting the METAR.

A SIGMET number 03, valid 242020/250220 was also issued by the Met office.

ATIS weather information transcript is found in Appendix B and was heard by the Flight Crew prior to start-up.

1.7.3 Information collected by the crew

A weather package which include the METAR, TAF of the departure airport and airports along the flight plan route, wind/temperature charts for FL300, 340 and 390 and significant weather chart for FL100-450 were delivered to the handling agent. SIGMET number 03, valid 242020/250220 was also issued by the MET office and made available to flight crews through VOLMET.

1.8 Aids to Navigation

The Lebanese Civil Aviation Authority reviewed that the primary and secondary radar was checked and verified for accuracy. All systems tested normal. No other navigation aids were reported to be abnormal.

1.9 Communications

ET409 has been in contact consecutively with the ground controller (Ground), the tower controller (Tower) and the radar controller (Control). All communication between ET 409 and the 121.9 Ground, 118.9 Tower, and 119.3 Control and Emergency frequency 121.5, have been recorded by the ATC facilities and on the CVR and are being used to produce this factual report and will be analyzed for further investigation.

1.10 Aerodrome Information

1.10.1 Aerodrome layout

BRHIA, (OLBA), Beirut, Lebanon, is an international airport with a field elevation of 85' MSL.

The airport has three runways:

- Runway 03-21 is 12,467' long, 3,800 meters.
- Runway 17-35 is 10,663' long, 3,250 meters.
- Runway 16-34 is 11,138' long, 3,395 meters.

Runways 03, 16, 17 are served by an Instrument Landing System (ILS). An Airport lay-out map is included in this report as Appendix C.

The airport is also served by a primary Raytheon Radar system, ASR-10SS and a Secondary radar system, MMSR Condor, MK-2 and with automatic Auto tract 2 Display.

1.10.2 Aviation Security

Aviation Security issues raised during the first days of the crash through some eye witness reports will be further evaluated by the Investigation Committee during the analysis phase.

1.11 Flight Recorders

The DFDR was recovered from the Mediterranean Sea by the Lebanese Navy divers and turned over to the Investigation Committee IIC on 7 February, 2010 and was immediately packed in water to prevent/delay the onset of corrosion and transported on the same day under the custody of State of Occurrence accompanied by members representing all parties in the Investigation Committee to the BEA laboratory in Paris, France, for readout and analysis on 8 February 2010.

The CVR was recovered from the Mediterranean Sea on 10 February, 2010 but was missing the memory part. The memory part was also recovered by the Lebanese Navy divers and handed over to the Investigation Team D/ICC on 16 February and was immediately packed in water to prevent/delay the onset of corrosion and transported under the custody of the D/IIC accompanied by members from the Investigation Committee to the BEA laboratory in Paris France, for readout on 16 February, 2010. A second readout was also conducted at the BEA on 17

September 2010 in the presence of members from the Investigation Committee in order to validate more data.

1.11.1 Digital Flight Data Recorder

The DFDR installed on the accident airplane was a Honeywell Aerospace Electronic SSFDR, Make & Model Allied Signal 4700, P/N 980-4700-042, and S/N 3986. This model records at least 25 hours of flight data on a solid state memory. The opening and read-out operations were performed following BEA procedures and Honeywell “*Reference Procedure for SSFDR Data Recovery after an Incident or Accident*” document. The memory extraction operations were successful and videotaped.

The CSMU was attached to the chassis. The chassis was damaged but the CSMU was in good condition. A complete set of accident flight data, from take-off through the last recorded DFDR parameters was prepared. There were 1000+ parameters available for the analysis.

Flight performance parameters recorded by the DFDR included but were not limited to the following: pressure altitude; airspeed (computed); engine N1; pitch; roll; heading; AOA (Angle of attack); normal (vertical), longitudinal, and lateral acceleration (load factors); left and right elevator positions; left and right inboard and outboard aileron positions; left and right trailing edge flap positions; rudder position; horizontal stabilizer position, stabilizer trim operations and stick shaker activation. In addition, the DFDR recorded speed brake handle position, throttle resolver angle, autopilot engagement/disengagement, engine low oil pressure, and engine fuel cut signals. A graphical plot of essential parameters is included in this report as Appendix D.

A trajectory was computed based on the “*LATITUDE POSITION*” and “*LONGITUDE POSITION*” parameters recorded on the DFDR. These parameters, recorded every 4 seconds, were interpolated in order to get one position per second. Two Google Earth files were generated to represent this trajectory starting at 00 h 30 min until the end of the DFDR recording at 00 h 41 min 28 s. These files are published in this report as Figure 1 and Figure 2.

1.11.2 Cockpit Voice Recorder

The CVR installed on the accident airplane was a Honeywell Electronic Systems SSCVR Make and Model Honeywell 6022, P/N 980-6022-001, S/N 05449. The CSMU of the CVR exhibited P/N 617-6096-006, S/N 8922. This model records at least 2 hours of flight on a solid state memory.

The CVR unit chassis exhibited external and internal structural damage with the CSMU detached from the chassis; the CSMU was in good condition. The opening, extraction of the double memory board from the CSMU and the read-out operations were performed following BEA procedures and Honeywell “*Reference Procedure for SSCVR Data Recovery after an Incident or Accident*” document. The memory extraction operations were successful and videotaped.

The CVR recording consisted of five audio files identified as follows: 3 files containing at least 30’ of recording of Captain, First Officer and PA, everyone mixed with VHF communication

channels 1, 2 & 3; 1 file containing a mix of at least 2 hours of recordings of the 3 tracks described above; and 1 file containing at least 2 hours of recording of the CAM.

The quality of the audio information recorded by the CAM was good. Synchronization with the DFDR was performed using VHF communications recording on the DFDR allowing a preliminary transcription. Nevertheless, 1 of the 24 memory chips (U16) was found externally cracked and is likely to be the unreadable memory chip that is causing a 10 seconds gap every 4 minutes of recording on the CAM channel. Additional work is needed to confirm this and to assess how a read-out of the chip could be attempted.

The CVR recording was heard a first time on 17 February 2010 and a preliminary transcript developed in the presence of BEA personnel, Lebanese, USA and Ethiopian members of the Investigation Committee and as an independent expert requested by the Lebanese party to translate the Amharic conversation recorded during the event.

A second hearing of the CVR was conducted on 17 September 2010 at the same BEA location in the presence of BEA personnel, Lebanese, USA and Ethiopian members of the Investigation Committee. Amharic conversation was translated by Ethiopian members of the Investigation Committee.



Figure 3: CVR Chassis



Figure 4: CVR chassis with CSMU

1.12 Wreckage and Impact Information

The airplane wreckage was located in debris field about 300 meters long and 100 meters wide centered about 33° 44.6' North Latitude and 035° 24.58' East Longitude on a heading of 210° magnetic. The water depth in this area was approximately 45 meters.

About 8 percent of the airplane was recovered during the initial recovery operations, which began on the morning of 25 January and ended on 19 February 2010.

The largest pieces found consisted of the tail section including the horizontal and vertical stabilizer and aft fuselage section extending forward to the #2 left entry door. These sections were found at the north eastern portion of the wreckage field. A number of pieces of floating wreckage were recovered from the water's surface near the last recorded radar point.

Many evaluation visits to examine the wreckage were conducted by the Airworthiness Group. A full report of the last visit conducted by the Airworthiness Group including recommendations for further evaluation of some parts (such as the stabilizer trim tab control mechanism bearings, APU housing black soot, etc...) is being addressed by the Investigation Committee.

1.12.2 Identification of the floating items recovered

As of 4 February 2010, 97 pieces of debris were recovered and recorded by the Lebanese Navy. The debris consists of airplane interior and exterior items as well as items not belonging to the airplane. The following observations were made:

Identified interior components:

- Two bulkheads associated with lavatories (sink & toilet). One tentatively identified as from the forward section of the airplane. The other then must be from the rear section of the airplane (it is equipped with one fwd and two aft lavatories)
- Galley floor mat (rubber)
- Miscellaneous interior floor panels (location in airplane not identified)
- A number of seat covers and cushions from first and economy class
- Crew oxygen cylinder (valve installed but stem broken off)
- One escape slide
- Two life rafts (independent from escape slides)

Identified exterior components:

- One winglet upper portion (fractured approximately 2/3 way towards the attach point). Logo on both sides of winglet; no determination of left or right winglet
- A/C pack door
- NLG door (partial) – left side
- Two composite panels from vertical stabilizer (with logo paint)

- 1 MLG wheel + tire (inflated)
- Portion of elevator and elevator tab

General observations of wreckage:

- Significant damage to most components as there is a high degree of fragmentation. Most components were not found fully intact
- Identified seats consisted mainly of loose padding and covers. No seat structure was identified

1.12.3 Additional wreckage observations

Based on underwater video recorded from a ROV, the following was observed:

- Aft fuselage section extending from the # 2L passenger door to approximately the rear pressure bulkhead
- Vertical Stabilizer (composite rudder missing)
- Horizontal Stabilizer (centre section & both stabilizer surfaces with approximately 1 meter missing from each end)
- Trailing Edge Flap portion
- Portions of the forward fuselage cockpit section (cockpit window frames and structure)

The horizontal stabilizer section was recovered (during the search for the DFDR and CVR); this portion was relocated to Beirut Naval Station. The Airworthiness Group has recommended the removal of the Trim Tab section and sending it to the NTSB for further investigation.

1.13 Medical and Pathological Information

A visual examination of the bodies showed that most of them were severely affected. All of the bodies and remains were handed over to the Beirut Rafic Hariri Governmental Hospital morgue. A DNA analysis and bank were established by the Medical Authorities to facilitate the positive body identification process.

At this stage of the investigation, the Investigation Team has had access to autopsy and body examination data made available by the Lebanese Ministry of Health, they include 10 full legal medical autopsies of bodies which were found in conditions allowing this operation to be conducted, and of DNA analysis of body parts allowing the identification of persons who were on board the flight.

1.14 Fire

Based on the elements recovered up to 24 Feb, 2011 and the visual observation, **no evidence of fire has been brought up**. All components appeared clean except for some black soot traces found around the APU which will be addressed and analyzed during the analysis phase. Besides information captured from eye witnesses, ATC incident report and interviews will be technically reviewed before the end of March 15, 2011.

1.15 Survival Aspects

Beirut Control contacted Beirut Tower to inform them they felt something went wrong with Ethiopian 409 due to loss of contact. Beirut Control asked Beirut Tower to activate the emergency response plan. The alarm bell was activated then the tower contacted the fire fighting and rescue to give them information about the airplane with souls on board and possible emergency at 00:43. The medical department was notified at 00:45. Others were notified in the chain of command by 00:47.

A brief description of the SAR operations was prepared by the Lebanese Army Command and is included in this report as Appendix E. Other survival aspects will be addressed during the analysis phase of the investigation.

1.16 Tests and Research

1.16.1 Reconstruction of the aircraft track based on the Radar recorded data

Prior to the retrieval of the CVR and DFDR data, a reconstruction of ET flight path was carried out by the Lebanese CAA IT technician. This is shown in figure 5 below.

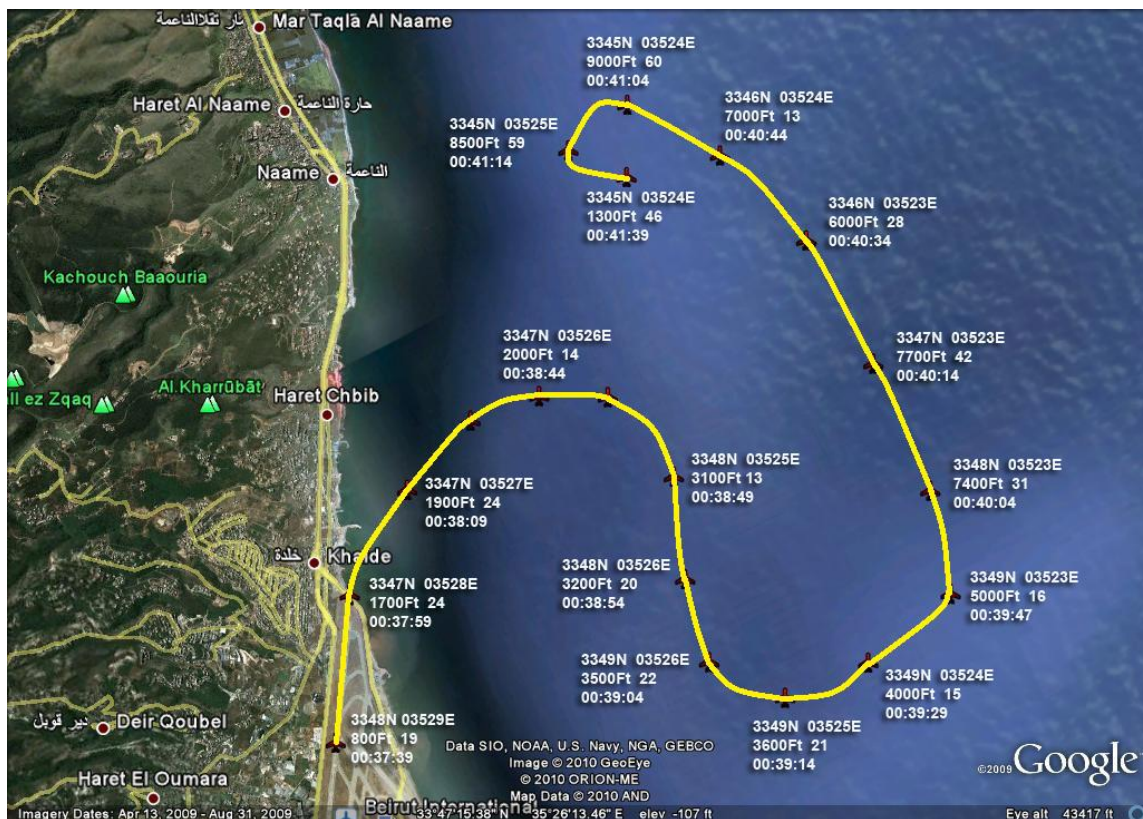


Figure 5: ET 409 Radar Tracks

1.16.2 Reconstruction of the aircraft track based on the DFDR recorded data

A reconstruction of ET horizontal and vertical track were developed by the BEA based on the data retrieved from the DFDR recording. These reconstructions are incorporated as Figure 1 and Figure 2 of this report.

1.16.3 Simulation of the Accident

Upon the Investigation Committee decision and in cooperation with the NTSB, a session was conducted at the Boeing facilities on their Engineering Simulator (M-Cab) in order to simulate the accident based on the recorded data and perform operations that could help during the analysis phase.

All parties participating in the investigation were notified of the dates and invited to participate in that session, which was conducted in Seattle on 22-23 September 2010. Only the USA and Lebanese parties participated.

1.16.4 Planned tests and research

The Investigation Committee plans to carry any further tests and research found necessary for the investigation in cooperation with the French BEA, the NTSB, and Boeing in order to explore and analyze the data retrieved from the DFDR, CVR, ATC Radar and the wreckage lay out as video tapped and photographed by the Lebanese Navy, the Ocean Alert and the Ocean Explorer.

At this stage of the investigation, the following actions have been planned by the Investigation Committee and should be accomplished prior to 15 March 2011:

1.16.4.1 Removal and Analysis of the Trim Tab section:

ADs were issued (Emergency AD, AD 2010-09-05, AD 2010-17-19) by the FAA respectively on March and August 2010 regarding trim tab control mechanism and this airplane (with serial number 29935) was found affected by these ADs.

Therefore, and in accordance with the Airworthiness Group recommendation, the Investigation Committee decided the removal of the trim tab control mechanism for further test and research.

1.16.4.2 Recovery Attempts of the CVR damaged Chip:

Upon the request of the Investigation Committee, a recovery attempt of the information on the externally cracked CVR chip U16 will be carried by the BEA in coordination with Honeywell. This will include additional work required to assess the extent of damage to that chip and how a read-out could be attempted.

1.16.4.3 Investigation of the sooth near the APU exhaust:

An investigation into the sooth near the APU exhaust has also been launched by the Investigation Committee upon the recommendation of the Airworthiness Group.

1.17 Information on Organizations and Management

1.17.1 Ethiopian Airlines

Ethiopian Airlines is a scheduled passenger and freight air operator incorporated in Ethiopia under the ECAA provisions and supervision to operate commercially in accordance with the Operations Specifications specified in their AOC. The airline has services to over 50 destinations worldwide as well as domestic services.

1.17.1.1 ET Air Operator Certificate (AOC)

ET has a current AOC issued by the ECAA.

1.17.1.2 History

Ethiopian Airlines was founded on December 29, 1945, by Emperor Haile Selassie with assistance from TWA. It commenced operations on April 8, 1946, with a weekly service between Addis Ababa and Cairo with five Douglas DC-3 propeller-driven aircraft.

The airline started long-haul services to Frankfurt in 1958 and inaugurated its first jet service in January 1963 from Addis Ababa to Nairobi. In 1965, it changed from a corporation to a share company and changed its name from Ethiopian Air Lines to Ethiopian Airlines. In the early 1960s it provided some initial aviation support to the Ethiopia-United States Mapping Mission in its operation to provide topographic maps of Ethiopia. It is wholly owned by the government of Ethiopia and has 4,700 employees (at March 2007).

Although it relied on American pilots and technicians at the beginning, by its 25th anniversary in 1971 Ethiopian Airlines was managed and staffed by Ethiopian personnel. In 1998, it started transatlantic services. The airline was featured by *The Economist* as an example of excellence in late 1987, and Ethiopians Paul B. Henze recognized it in 2000 as being "one of the most reliable and profitable airlines in the Third World", Ethiopia Airlines also provides pilot and aviation maintenance training to trainees from different countries.

1.17.1.3 Personnel Training and Authorization

According to the documents provided by ET and interviews conducted at Addis Ababa 24-27 January 2011, all personnel involved with ET 409 were trained and authorized as per the provisions of the ECAA.

1.17.1.4 Preparation of ET flight at Beirut

According to the documents provided by ET and their handling agent in Beirut LAT, all documents required in accordance with ET procedures were provided to the crew prior to departure from Beirut.

1.17.1.5 Work cycles and flight crew rest

The crew arrived to Beirut 25 hours before the SDT and had their full rest at the Beirut Commodore Hotel.

The crew work cycles and rest have also been investigated by the Investigation Committee during their visit to Addis Ababa 24-27 January 2011 to confirm compliance with the ECAA regulations and Ethiopian Airlines requirements regarding Flight Crew weekly, monthly and yearly limitations.

1.17.1.6 Procedure for use of on-board Weather Radar

ET provided its SOP and Boeing procedure for the operation of the weather radar during departure. The procedure will be addressed during the analysis phase.

1.17.1.7 Procedure for Flight Crew pairing

ET provided their procedure for crew pairing. The procedure will be addressed during the analysis phase.

1.17.1.8 The Maintenance Organization

In accordance to documents provided by ET, the company is a FAR 145 Approved Maintenance Organization (AMO). It covers the maintenance from light checks (e.g. transient checks) to heavy checks (C checks). The operator's maintenance program data, drawn up on the basis of the manufacturer's recommended maintenance program, is approved by the ECAA and subject to its oversight. It is also audited by the FAA in line with their FAR 145 approval requirements.

1.17.2 Review of oversight by the ECAA

At this stage of the investigation, the Investigation Team has had access to relevant oversight documents by the ECAA during their visit to Addis Ababa 24-27 January 2011.

1.17.3 The ATC

The Lebanese CAA controls the ATC Services located at BRHIA. According to documents provided by the Lebanese CAA, the ATC system consists of a Manager, a chief for the ACC and a chief for the aerodrome control. Thirty six air traffic controllers work as three groups; each group works for twenty four hours and rests for forty eight hours. The working shift and rest periods for each group are planned by the supervisor.

Each group working at the ACC consists of a supervisor, six air traffic controllers who work as area and approach controllers and as assistants. The tower group consists of a supervisor and four controllers who work as tower and ground controllers. In addition there is the flight information centre where there are some personnel from the ATC staff & telecom department handling the work.

According to ATC records, at the time of the accident there was one ground controller, one tower controller and a supervisor handling the traffic in the tower. There was also an approach controller, an assistant controller and a supervisor handling the traffic in the ACC. All controllers reported for duty at 0700 LT on the morning of 24 January 2010 and were scheduled to come off duty at 0700 LT on 25 January 2010. During this twenty four work period, the supervisor scheduled all shift and rest times. The Lebanese CAA confirmed these times as correct.

All the controllers handling Ethiopian Airlines flight 409 (ETH409) on 25 January, 2010 have licenses issued by Lebanon DGCA in accordance with the LARs provisions and ICAO standards.

In accordance with records provided by the Lebanese CAA, all the above mentioned controllers completed the required initial and recurrent training. Their last recurrent training was completed on in March 2009.

The relevant controllers' most recent medical certificates were checked. They carried a certification stipulating they were conducted in accordance with the standards specified in ICAO Annex 1, "Medical Standards and Certification."

1.18 Additional information

At this stage of the investigation additional information is being verified for consistency with recorded data and wreckage examination findings prior to use in the investigation.

This information includes various documents, testimonies and interviews conducted since the accident happened till, at this stage, the trip to Addis Ababa 24-27 January 2011.

The Investigation Committee is planning a Technical Review meeting before 15 April 2011 in order to evaluate and validate all factual information that is found necessary for the analysis phase.

The Investigation Committee is planning to conclude the analytical part by 15 May 2011 and to have a final draft report ready for review by all participating States by 30 May 2011.

In accordance to ICAO requirements, participating States will have 60 days to comment on the final report, which should then be published by the Investigation Committee. A deadline has been set to publish that report by the end of July 2011, unless new information requires further examination and evaluation by the Committee.

1.19 New Investigation Techniques

At this stage of the investigation, new techniques are considered for relevance in the various investigation requirements.

2. INITIAL FINDINGS

On the basis of the factual elements gathered in the course of the investigation, the following factual findings have been established:

- The airplane possessed a valid Certificate of Airworthiness, and had been maintained in accordance with the relevant regulations.
- The airplane had taken off from Beirut without any known technical problems.
- The Flight Crew and Cabin Crew were licensed in accordance with the ECAA regulations.
- The documents received by the Flight Crew prior to departure, including weather information, were in accordance with the relevant requirements.