

REPUBLIC OF NAMIBIA

MINISTRY OF WORKS AND TRANSPORT

DIRECTORATE OF AIRCRAFT ACCIDENT INVESTIGATION

CIVIL AIRCRAFT ACCIDENT REPORT

ACCID/112913/1-12

OPERATION: SCHEDULED

AIRCRAFT : C9-EMC

LOCATION : BWABWATA NATIONAL

PARK, NAMIBIA

DATE : 29 NOVEMBER 2013



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AIRCRAFT ACCIDENT INVESTIGATION

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Date: 30 March 2016

To

Minister of Works and Transport

Deputy Minister of Works and Transport PS: Ministry of Works and Transport Deputy PS. Ministry of Works and Transport

From:

Director: Aircraft Incident Investigation

RE: CIVIL AIRCRAFT ACCIDENT REPORT

Please find attached the final report on the above subject accident. In accordance with the International Civil Aviation Organization Annex 13 – Aircraft Accident and Incident Investigation – Standard 6.13, final reports shall be published as soon as possible in the interest of accident prevention.

It is recommended that copies of these final reports be made available to the public and other interested parties upon request. Your approval is therefore sought to release the said reports.

Engksson M. Nengola 35/00/6
DIRECTOR: AIRCRAFT ACCIDENT INVESTIGATION

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3 0 MAR 2016

Namibia Ministry of Works and Transport

"Effective and Efficient Delivery of Service"

All official correspondence must be addressed to the Permanent Secretary

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FOREWORD

This report presents the factual information, data analysis, conclusions, and safety recommendations reached during the investigation. The purpose of the investigation was to establish the circumstances surrounding this accident.

In accordance with the provisions of Annex 13 to the convention on International Civil Aviation Organization, and Aviation Act, 1962 (Act No. 74 of 1962) as amended, the accident's analysis, conclusions, and safety recommendations contained therein are intended neither to apportion blame nor to single out any individual or group of individuals. The main objective was to identify the systematic deficiencies and draw lessons, from the occurrence, which might help to prevent accidents and incidents in the future. To this end, many a time, the reader may be interested in whether or not an issue was a direct cause of the accident (that has already taken place), whereas the investigator is mainly concerned with the prevention of future accidents/incidents.

As a result, usage of this report for any purpose other than (the latter and spirit of Annex 13 and Aviation Act, 1962 Act No. 74 of 1962 or other relevant statutes) prevention of similar occurrences in the future might lead to erroneous interpretations and applications.

Note: It should be noted that this occurrence is not a typical accident and does not strictly fall into the accident definition of ICAO Annex 13. Annex 13 defines an accident as:-

Accident. An occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

- a) a person is fatally or seriously injured as a result of:
- being in the aircraft, or
- direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
- direct exposure to jet blast,

except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or

Based to the above definition and subsequent investigation process, DAAI continued with the investigation of the occurrence with the sole purpose of prevention.

ABBREVIATIONS

AC - ADVISORY CIRCULAR

ACCID - ACCIDENT

ACC - AREA CONTROL CENTRE

AD - AIRWORTHINESSDIRECTIVE

AFCS - AUTO FLIGHT CONTROL SYSTEM

AGL - ABOVE GROUND LEVEL

AMO - AIRCRAFT MAINTENANCE ORGANIZATION

AMM - AIRCRAFT MAINTENANCE MANUAL

AMSL - ABOVE MEAN SEA LEVEL

ATPL - AIRLINE TRANSPORT PILOT LICENSE

ATC - AIR TRAFFIC CONTROLLER

ATNS - AIR TRAFFIC AND NAVIGATION SERVICES

ATS - AIR TRAFFIC SERVICES

ATSB - AUSTRALIAN TRANSPORT SAFETY BOARD

°C - DEGREE CENTIGRADE

CAAB - CIVIL AVIATION AUTHORITY OF BOTSWANA

CAVOK - CEILING AND VISIBILITY OKAY

CENIPA - AERONAUTICAL ACCIDENTS INVESTIGATION AND

PREVENTION CENTRE (BRAZIL)

CFIT - CONTROLLED FLIGHT INTO TERRAIN

CG - CENTRE OF GRAVITY

C of A - CERTIFICATE OF AIRWORTHINESS

C of R - CERTIFICATE OF REGISTRATION

CPL - COMMERCIAL PILOT LICENSE

CSN - CYCLES SINCE NEW

CVFDR - A COMBINED COCKPIT VOIVE AND FLIGHT DATA

RECORDER

CVR - COCKPIT VOICE RECORDER

DAAI - DIRECTORATE OF AIRCRAFT ACCIDENT INVESTIGATION

DELTA P - THE PRESSURE DIFFERENCE BETWEEN INSIDE THE

CABIN AND THE OUTSIDE ATMOSPHERIC PRESSURE

DRU - DATA RECOVERY UNIT

DVI - DISASTER VICTIM IDENTIFICATION

ELT - **EMERGENCY LOCATOR TRANSMITTER**

EGPWS - ENHENCED GROUND PROXIMITY WARNING SYSTEM

ETA - ESTIMATED TIME OF ARRIVAL

FAA - FEDERAL AVIATION ADMINISTRATION

FADEC - FULL AUTHORITY DIGITAL ENGINE CONTROL

FDR - FLIGHT DATA RECORDER

FIR - FLIGHT INFORMATION REGION

FL - FLIGHT LEVEL

FLCH - FLIGHT LEVEL CHANGE

F/O - FIRST OFFICER

GMT - GREENWITCH MEAN TIME

GP - GUIDANCE PANEL

GPWS - GROUND PROXIMITY WARNING SYSTEM

IACM - MOZAMBIQUE CIVIL AVIATION AUTHORITY

ICAO - INTERNATIONAL CIVIL AVIATION ORGANIZATION

KMs - KILOMETERS

MCP - MODE CONTROL PANEL

MHz - MEGA HERTZ

LAM - MOZAMBIQUE AIRLINE

N/A - NOT APPLICABLE

NFSI - NATIONAL FORENSIC SCIENCE INSTITUTE

NM - NAUTICAL MILES

NTSB - NATIONAL TRANSPORTATION SAFETY BOARD

OVSP - OVERSPEED

PSI - PRESSURE PER SQUARE INCH

RPA - REMOTELY PILOTED AIRCRAFT

SAR - SEARCH AND RESCUE

SATCO - SENIOR AIR TRAFFIC CONTROLLER

TLA - THROTTLE LEVEL ANGLE

TSN - TIME SINCE NEW

USA - UNITED STATE OF AMERICA

UTC - CO-ORDINATED UNIVERSAL TIME

Vmo - MAXIMUM CERTIFIED OPERATING SPEED LIMIT

VNAV - VERTICAL NAVIGATION

VS - VERTICAL SPEED

Z - ZULU TIME



Ministry of Works and Transport

ACCID/112913/1-12

DIRECTORATE OF AIRCRAFT ACCIDENT INVESTIGATION ACCIDENT REPORT – EXECUTIVE SUMMARY

Aircraft Registration	C9-EMC	Date of Accident	29 Nove	mber 2013		Time of Accide	nt	11:16
Type of Aircraft EMBRAER 190			Type of Operation			Scheduled		
Pilot – In - Command License Type		ATPL	Age	49	License Valid Yes			
Pilot – In - Command Flying Experience		Total Flying Hours	9052.87		Н	ours on Type	2519.8	33
Last point of departure	uto International Airpo	rt, Mozaml	oique (FQMA	A)				

Next point of intended landing 4 de Fevereiro International Airport, Luanda – Angola (FNLU)

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

Bwabwata National Park, Namibia S 18° 14′ 24″ E 021° 55′ 02″

Meteorological Information	Wind: 140°, Wind speed: 11kts, Visibility: CAVOK, Temperature: 32°C, Cloud cover: Scattered, Cloud base: Few @3000ft, Dew point: 14°C				
Number of people on board $6+27$		No. of people injured	0	No. of people killed	6 +27
Synonsis					

The Directorate of Aircraft Accident Investigations (DAAI) under the Ministry of Works and Transport was notified by the Namibia Air Traffic Control (ATC) at 14:30 UTC on the 29th Nov 2013 about the accident. In accordance with Annex 13 of the Chicago Convention, Namibia as a state of occurrence notified Mozambique, state of registry and operator, Brazil, state of manufacturer and design, Botswana, the state that was controlling the accident aircraft, Angola, the state of final destination and USA, state of power plant manufacturer. The five (5) countries sent accredited representatives and advisors. DAAI was responsible for organizing and conducting the investigation as well as releasing the final report.

On the 29th November 2013 at 09:26 UTC, an Embraer ERJ 190-100 IGW aircraft with registration number C9-EMC departed Maputo International Airport on a scheduled flight to Luanda, Angola. On board the aircraft were a total of 33 people comprised of the following: Six (6) crew members (two pilots, one engineer and three flight attendants) plus 27 passengers. The flight operations were normal and the aircraft was in radio communication with Gaborone Area Control Centre (ACC) on frequency 126.1 MHz and was cruising at FL380 (38000 ft). At position EXEDU, a mandatory reporting point in Gaborone FIR (Flight Information Region) which is at 72 Nautical Miles (nm) south of the point called AGRAM in the Zambezi strip, the Namibian radar data revealed that the aircraft commenced a sudden descent from the normal cruising level of FL 380. Radar contact and voice contact were lost with ATS (Air Traffic Services). Search and Rescue was instituted but could not locate the accident site the same day of the crash due to bad weather that developed in the region and nightfall. The Search and Rescue team only managed to locate the accident site the following day (30 November 2013) at around 08:00 UTC, in Bwabwata National Park. Due to the high rate of impact with terrain and post-impact fire, the aircraft was totally destroyed and there were no survivors.

The team led by Namibian investigators was dispatched to commence with the on-site investigations. CVR and FDR recorders were retrieved and send to the National Transportation Safety Board (USA) laboratories for further investigations.

The pilot was a holder of a valid Airline Transport Pilot License with Class I medical certificate valid until 02 September 2014. No restrictions were endorsed in his license. His English proficiency check was also valid until 18 March 2014 and the aircraft type was endorsed in his license. The en-route weather was fine with unrestricted visibility. The aircraft had undergone last inspection certified on the 28 of November 2013 at 2902.00 airframe hours. At the time of the accident, the aircraft had accumulated a further 3.0 hours since its last inspection was certified. According to available records, the Aircraft Maintenance Organization (AMO) that certifies the last inspection prior to the accident was in possession of a valid AMO approval number 02/OMA/2011 issued on the 20 September 2013 with an expiry date of 19 September 2014.

The Regulatory Authority (IACM) conducted an AMO audit on the 06 May 2013 and no discrepancies were identified. As per LAM's Maintenance and Technical Log Records, the aircraft had not yet undergone any major services apart from some Intermediate Checks, Out of Phase Check as per the Job Card No: 296/13 that was completed on 24 October 2013 and as per MPD Rev. 5 19/13, the 14 days/120 hrs Check that was carried and certified on 28 November 2013 (the previous day prior to the accident) as per the Job Card No: 0332/13. The aircraft was purchased brand new and has been in operation for at least a year since it was type accepted on the Mozambique Civil Aircraft Register on 25th October 2012.

Probable Cause

1. The inputs to the auto flight systems by the crew member believed to be the Captain who remained alone in the cockpit when the person believed to be the co- pilot requested to go to the lavatory, caused the aircraft to depart from cruise flight to a sustained controlled descent and subsequent collision with the terrain.

Contributing factors

1. The non-compliance to company procedures that resulted in a sole crew member occupying the flight compartment.



CIVIL AIRCRAFT ACCIDENT REPORT

Name of Owner : ALC E190 581 LLC

Name of Operator : Mozambique Airline (LAM)

Manufacturer : Embraer

Model : ERJ 190-100IGW

Nationality : Mozambican Registration Marks : C9-EMC

Place : Bwabwata National Park, Namibia

Date : 29 November 2013

Time : 11:16

All times given in this report are in Co-ordinate Universal Time (UTC).(Namibian daytime +1 GMT)

Disclaimer:

This report is given without prejudice to the rights of the Directorate of Aircraft Accident Investigation, which are reserved.

Purpose of the Investigation:

In terms of the Aviation Act (Act 74 of 1962) as amended, and ICAO Annex 13, this report was compiled with sole interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and <u>not to apportion blame or establish legal liability</u>.

This report contains fact relating to aircraft accidents or incidents which have been determined at the time of issue. The report may therefore be revised should new and substantive facts be made available to the investigator(s).

1. FACTUAL INFORMATION

1.1 History of Flight

- 1.1.1 On the 29th November 2013 at 09:26, an Embraer ERJ 190-100 IGW aircraft with registration number C9-EMC departed Maputo International Airport on a scheduled flight to Luanda, Angola. On board the aircraft were a total of 33 people comprised of the following: Six (6) crew members (two pilots, one engineer and three flight attendants) plus 27 passengers. The flight operations were normal and the aircraft was in radio communication with Gaborone Area Control Centre on frequency 126.1 MHz and was cruising at FL380 (38000 ft).
- 1.1.2 At position EXEDU, a mandatory reporting point in the Gaborone FIR (Flight Information Region) which is at 72 nautical miles (nm) south of the point AGRAM which is the boundary position between Gaborone FIR and Luanda FIR (18' 56S 02' 228E), the Namibian Radar Data (after it was played back) revealed that the aircraft commenced a sudden descent from the normal cruising level of FL380 at 11:09:07. Radar footage from the Namibian Air Traffic Services (ATS) during the investigation indicated that the target was lost at 11:15:49 at an altitude of 6 600 ft AMSL while on its abrupt descent. The aircraft impacted the ground at 11:16:04 at an altitude of 3 390ft Above Mean Sea Level (AMSL) as indicated by the Flight Data Recorder (FDR).

- 1.1.3 There were no distress calls made by the pilot to declare an emergency nor was there any signal transmitted from the Emergency Locator Transmitter (ELT) due to the fact that its antenna cable was cut during the time the aircraft impacted the terrain.
- 1.1.4 Namibian authorities (police) at the Eastern Kavango and Zambezi regions were informed about the missing aircraft at around 12:00.
- 1.1.5 Search and rescue operation was instituted by Namibia Air Traffic Services but could not locate the accident site the same day due to bad weather and darkness in the area. Eyewitnesses from villagers on the Botswana side near the border heard explosions and observed smoke coming from the Namibian territory then informed the Namibian Authorities.
- 1.1.6 The accident site was located the following day (30 November 2013) at around 07h00, in Bwabwata National Park (Namibia). The Namibian Investigators responded immediately after the crash site was located.
- 1.1.7 The Government of Mozambique and the Mozambique Airline were informed by the Namibian Government on Saturday 30 November 2013 that the wreckage has been located and identified as that of C9-EMC, an Embraer ERJ 190-100IGW and that there were no survivors. Both CVR/FDR recorders were retrieved from the accident site on Saturday 30th November 2013.
- 1.1.8 DAAI lead a team of accredited representatives and advisors from Mozambique, the state of operator and registry; Brazil, the state of design and manufacture; Botswana, the state that was controlling the accident aircraft; Angola, the states of final destination; and USA, state of power plant manufacturer.
- 1.1.9 Based on the outcome of the CVR/FDR readout, the Directorate of Aircraft Accident Investigation (DAAI) in Namibia issued a Preliminary report on 18 December 2013 which stated as follow;
 - a) The aircraft was operating at normal conditions and no mechanical faults were detected.
 - b) Minutes before the crash, the F/O (first officer) left the cockpit for the lavatory and only the Captain remained on the Flight Deck.
 - c) The aircraft flight altitude was manually selected three (3) times from 38000 feet where the aircraft was cruising, to 592 feet (below ground elevation).
 - d) Auto throttle was manually re-engaged and throttle level automatically retarded and set to idle.
 - e) The airspeed was manually changed several times until the end of the recording, which remained close to Vmo (maximum certified operating speed limit).
 - f) The speed brake handle parameter indicates it was commanded to open the spoiler panels and remained in that position until the end of the recording. This was manually commanded as the parameter monitors the handle position.
 - g) During all these actions there was audible low and high chimes as well as repeated banging, an indication for call to enter the cockpit.
- 1.1.10 According to the statement in LAM's Manual of Flight Operation Chapter 10.1.4, Page 5 of 36, Edition 3 Revision 8, (Absence from Flight Deck) which is in Portuguese but was translated in English as follows;- "A pilot can only leave the Flight Deck when the aircraft is above 10 000 feet, for physiological reason or when carrying out his operational task. He or she shall, for that matter, first call a cabin attendant who will remain in the Flight Deck until his return. At the moment of the pilot's exit, the other (pilot) shall lock the door, to only re-open it for the return of the absent pilot".

"The pilot remaining in the Flight Deck should be in a state of alert and situational awareness, have free and clear access to the commands of the flight". **Refer to Appendix 1.**

- 1.1.11 All passengers in Mozambique flight 470 were issued with passenger tickets.
- 1.1.12 The weather at the altitude where the aircraft was cruising was fine.

1.2 Injuries to Persons

Injuries	Pilots	Crew	Pass.	Other
Fatal	2	4	27	-
Serious	-		-	-
Minor	-	-	-	-
None	-	-	-	-

Passengers by nationalities

1.	Mozambique	10
2.	Angola	9
3.	Portugal	5
4.	Brazil	1
5.	China	1
6.	French	1

The crew consisted of two pilots, three cabin attendants, and an engineer (all Mozambican citizens).

1.3 Damage to Aircraft

1.3.1 The aircraft was destroyed by impact forces and post impact fire.

1.4 Other Damage

1.4.1 There were substantial damage to surrounding vegetation.

1.5 Personnel Information

- 1.5.1 The captain was a holder of an Airline Transport Pilot License (ATPL) while the first officer was a holder of a Commercial Pilot License (CPL). Their Medical Certificates Category I were all valid. The aircraft type was also endorsed into their licenses.
- 1.5.2 A Medical report from the National Director of the Medical Assistance in the Ministry of Health in Maputo, Mozambique stated that the Captain has gone through evaluation and physical aptitude for carrying out pilot duties. The last time he was examined was in August 2013 when he came for a routine medical check-up including psychological evaluation where he was advised to change his eating patterns and practice physical exercise regularly, (at least 3 times a week for 45 to 60 minutes).

1.5.3 Captain

Nationality		Mozambican				
Licence No	451/ PLAA/169	Gender	Male	Age	49	
Licence Valid		Yes	Type Endorsed	Yes		
Ratings		ATPL				
Medical Expiry Date		02 September 2014				
Restrictions		None				
Previous Accidents		None				

Captain's Flying Experience:

Total Hours	9052.87
Total Past 90 Days	239.73
Total on Type Past 90 Days	239.73
Total on Type	2519.83

1.5.4 First Officer

Nationality		Mozambican			
License No	485/PCA/457	Gender	Male	Age	24
License Valid		Yes	Type Endorsed	Yes	
Ratings		CPL (with Ir	nstrument Ratings)		
Medical Expiry Date		17 November 2014			
Restrictions		None			

First Officer's Flying Experience:

Total Hours	1183.25
Total Past 90 days	101.26
Total on Type Past 90 Days	101.26
Total on Type	101.26

1.5.5 Air Traffic Controller

- 1.5.5.1 The Air Traffic Controller responsible for the flight was suitably trained and was in possession of a valid Air Traffic Controller License No: TC 1806503 issued by the Civil Aviation Authority of Botswana (CAAB) on 31 July 2013 and with an expiry date of 31 July 2018.
- 1.5.5.2 His Medical Certificate was valid until 28 February 2014 and his English Language Proficiency valid until 18 April 2014.
- 1.5.5.3 The Controller also has the following Ratings in his License:
 - 1. Aerodrome Control Rating
 - 2. Approach Radar Control Rating
 - 3. Area Radar Control Rating and,
 - 4. Approach & Area non-radar rating

1.6 Aircraft Information

1.6.1 Airframe:

Туре	ERJ 190-100 IGW		
Manufacturer	Embraer S.A		
Aircraft Serial Number	19000581		
Year of Manufacture	2012		
Total Airframe Hours (At time of Accident)	2905.00 Hrs and 1877 cycles since new		
Last Annual Inspection (Date & Hours)	28 November 2013 2902.00 Hrs		
Hours since Last Annual Inspection	3.0 Hrs		
C of A (Issue Date)	16 November 2012		

C of A (Expiry Date)	15 November 2014
C of R (Issue Date)	16 November 2012 (Present owner)
Operating Categories	Normal (a, b, c)

1.6.2 **Engines:**

LH	RH		
Manufacturer: General Electric	Manufacturer: General Electric		
Model : CF34-10E5	Model : CF34-10E5		
Serial Number: 424388	Serial Number: 424408		
Date Installed: 08 October 2012	Date Installed: 08 October 2012		
Time Since New (TSN): 2905.00	Time Since New (TSN): 2905.00		
Cycles Since New (CSN): 1877.00	Cycles Since New (CSN): 1877.00		

The aircraft had completed a 14 days/120 flight hrs inspection as per Job Number 332/13 dated 28 November 2013 which consisted of general visual inspection. **Refer to Appendix 2.**

1.6.3 **Auto flight**

1.6.3.1 Autopilot

The Embraer 190 features the Honeywell Primus Epic Avionics System which encompasses the Automatic Flight Control System (AFCS). The AFCS is an integrated system that processes inputs from several airplane systems and sensors. The AFCS is comprised of the Flight Director, Auto Pilot and Yaw Damper.

The autopilot is engaged by the operation of pushbutton switches on the Guidance Panel (GP). Once engaged, the autopilot can control the aircraft in various modes selected on the GP. The autopilot has several pitch modes, including Vertical Navigation (VNAV) and Vertical Speed (VS).

In VS mode, the auto throttle modulates the engine thrust to maintain the speed set on the GP. The autopilot uses elevator commands to control the aircraft's vertical speed to the vertical speed/flight path angle set on the GP.

1.6.4 Emergency Locator Transmitter (ELT)

ELT's are radio beacons installed on aircraft used to transmit signals through emergency frequencies so that in the event of an aircraft accident in a remote location Search and Rescue Operations (SARs) can locate the aircraft with ease. The word "Beacon" is associated with these devices.

The information contained in the message may include:

- (a) Serial number assigned to the ELT by the beacon manufacturer or the national beacon registration authority, or
- (b) Aircraft identification or registration number, and
- (c) Country of registration and country code.

1.7 Meteorological Information

1.7.1 The following weather information was obtained from Maun weather station in Botswana at 11H00Z which is nearest weather station and 140nm south of the crash site. The Namibian Weather Bureau's weather information for the area at the time of the crash also indicated that the weather on 29/11/2013 was fine. There were some scattered clouds at 3000 ft AGL which was far below the 38000 ft to which the aircraft was cruising and wouldn't have any adverse affect to the aircraft flight path.

Wind direction	140°	Wind speed	11kts	Visibility	≥ 10 KMs
Temperature	32°C	Cloud cover	Scattered	Cloud base	Few@3000
Dew point	14°C				

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigation equipment required for that type and no difficulties with Navigation Aids were reported.

1.9 Communications.

ATC Recordings

- 1.9.1 At 10:18:58 Mozambique Airline Flight LAM 470 entered the Gaborone Flight Information Region (FIR) at Point ETMIT FL 380.
- 1.9.2 The flight was in communication with Gaborone Area Control Centre (ACC) on Frequency 126.1 MHz and was cleared to maintain Flight Level 380 and to report when at point AGRAM.
- 1.9.3 At 10:19:19 Mozambique 470 responded by acknowledging and repeating the ATC instructions.
- 1.9.4 At 10:19:26 the ATC requested the estimate for AGRAM as well as the aircraft registration.
- 1.9.5 At 10:19:32 Mozambique 470 gave the estimate and registration.
- 1.9.6 At 11:17:33 almost an hour later, Gaborone ATC transmission to aircraft "Mozambique 470 you can continue with Luanda 8888, 5565 good day".
- 1.9.7 At 11:17:44 Gaborone ATC called Mozambique 470 and the aircraft didn't respond. There was no further communication with the aircraft.
- 1.9.8 At 11:22:29 Gaborone ATC phoned Luanda and said "LUANDA, Gabs, just advice if you are in contact with Mozambique 470, he is not talking to me, are you in contact there?" Luanda's response was inaudible.
- 1.9.9 There was no further communication between Gaborone ATC and Luanda ATC until 13:05. About 5 minutes before the estimated time of arrival (ETA), Luanda ACC called Gaborone ACC at 13:05 to inform them that the aircraft (LAM 470) was still not in contact with them.

CVR recordings

1.9.10 The aircraft was equipped with two CVR's which were integral with the FDR's to function as a CVFDR unit. The CVFDR unit was hand carried for decoding at National Transportation Safety Board (NTSB) Vehicle Recorder Division's Audio Laboratories in Washington DC, USA.

1.9.11 The CVR retains only approximately two hours of recordings. Its recordings started with 00:01:55 and ended 02:02:27 (these time are not in or any other time but are just CVR elapsed time).

These are the most significant events as recorded on the CVR:-

- After 11min and 51sec into the recording, the CVR indicate the aircraft took-off from Maputo.
- ➤ After 00:14:57, LAM 470 acknowledged squawk 2651.
- ➤ After 00:17:10 the aircraft was cleared by Maputo ATC to FL 150 and then cleared for FL 380 at 00:20:20.
- After 01:50:27 the first officer said that he has to go to the toilet and then asks the captain if he has the controls, on which the Captain responds, no problem.
- After 01:50:37 there is sounds of the door unlocking and headphones manipulations
- ➤ After 01:52:16 there is sounds to door locking followed by sound similar to electric door locking
- ➤ After 01:53:31 sound of clicks, similar to altitude preselect rolling
- After 01:56:46 to 01:56:48 [sound of two thumps, similar to trying to open door]
- After 01:57:33 auto voice ['high speed, high speed, high speed']
- ➤ After 02:00:28 [sound similar to 7 knocks]
- ➤ After 02:01:25 Auto voice [High Speed High Speed.]
- ➤ After 02:01:27 sound of loud knocking
- ➤ After 02:02:05 multiple [sounds of hi/lo chime]
- After 02:02:15 EGWPS [sink rate, sink rate, sink rate, Pull-up! Pull-up! Pull-up!]

The CVRs did not pick any conversation from the flight deck after the first officer left the cockpit until the aircraft impacted the terrain.

1.10 Aerodrome Information

1.10.1 N/A as the accident did not take place at an aerodrome.

1.11 Flight Recorders

1.11.1 Introduction

The aircraft was equipped with two recorders (CVFDR)¹, each being a combined Cockpit Voice Recorder and Flight Data Recorder.

¹Model 1605-00-xx Manufactured by Universal Avionic Systems Corporation. The FDR component can receive data in the ARINC 573/717/747 configurations and can record a minimum of 25 hours of flight data The Universal CVFDR is designed to meet the crash-survivability requirements of TSO C124b

The FDR component records airplane flight information in digital coded data format using solid state flash memory as the recording medium. Both recorders were manufactured by Universal Avionics Systems Corporations and had recorded approximately 141 hours of Data. The event flight was the last flight on the recording and its duration was approximately 1 hour and 50 minutes.

The CVR component of the CVFDR records two hours of digital audio to solid state memory in a four channel format, one channel for captain one for first officer, one for third crew member and/or passenger address system and one channel for the cockpit area microphone.

1.11.2 Flight recorder opening operations and read-out

The two flight recorders were hand carried by DAAI investigator to Washington DC on December 11, 2013. It was evident on inspection of the heat and structural damage. The serial number could not be identified therefore they were identified as Recorder 'A' and Recorder 'B'. Recorder A's memory module was found to have the ribbon connector cable still intact and was attached to the DRU and downloaded as shown in figure 2. Recorder B's memory module had a damaged ribbon connector and was downloaded using a hardware connection to the DRU using the chip itself as shown in figure 3. The downloading² was conducted successfully. The recorders were disassembled and downloaded in accordance with procedures defined by Universal Avionics Systems Corporation, the recorder's manufacturer.

1.11.3 Description

The FDR's recorded approximately 141 hours of data. Both recorders terminate at the same moment showing a last recorded time³ of 11:16:26.

The event flight was the last flight of the recording and its duration was approximately 1 hour and 50 minutes. For this report, the data from recorder A is used. A review of data from recorder B indicated no significant difference in data values.

²The download procedures included the use of a Universal Data Recovery Unit (DRU), Universal part number 1605-75.

³ Timing of the FDR data is measured in sub-frame reference number (SRN), where each SRN equals one elapsed second.



Figure 1. Extraction of memory module for recorder A.

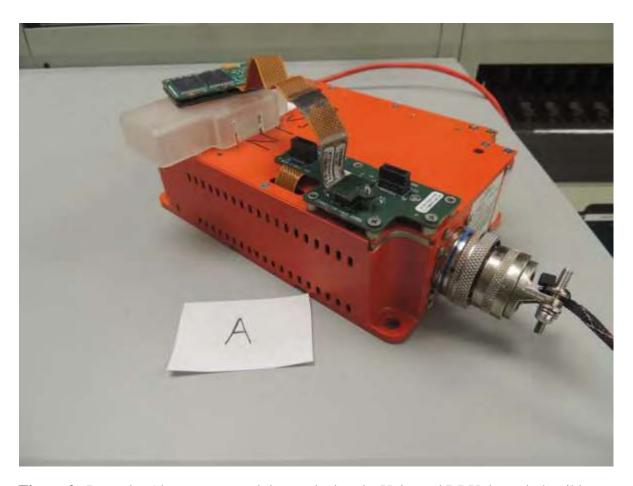


Figure 2. Recorder A's memory module attached to the Universal DRU through the ribbon cable.

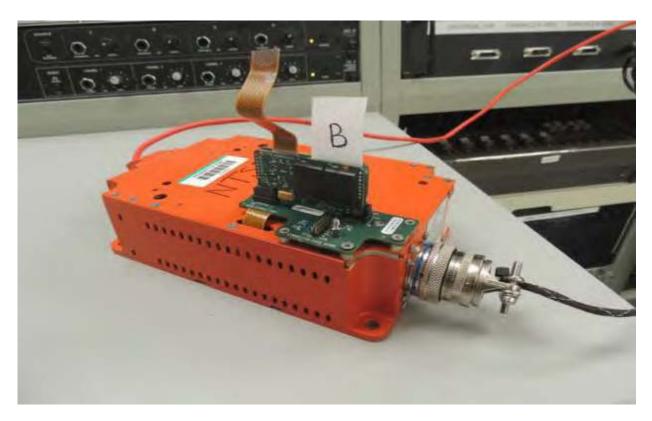


Figure 3. Recorder B's memory module attached to the Universal DRU via a direct chip connection.



Figure 4. Illustrates heat and structural damage on the CVFDR, A (left) and B (right).

The aircraft descent was characterized by a stable descent along its longitudinal and lateral axis and maintained its course though out the flight.

The aircraft cabin were adequately pressurized for the entire flight and no rapid depressurization was detected. There was no cabin pressure loss warning which actuates an EICAS message and a voice alert whenever the cabin altitude approaches 9,700 ft.

1.11.4 The following are the chronological order of events of flight during the final 12 minutes before the accident, calculated from **11:04:04** to **11: 16:25**: This does not include the last recorded second (**11:16:26**) as it contains invalid data due to the impact:

All times cited herein are in UTC

At **11:04:04**, the aircraft was flying at FL380, with ALTITUDE PRE-SELECTOR set to 38,000 ft. The autopilot was engaged (and remained engaged until the end of the recording), with flight director vertical mode VALT (FMS altitude hold). The indicated airspeed was 246 knots and the cabin altitude was 7,050 ft. The cabin altitude remained below 8,000 ft until the end of recording.

The CVR picked click sounds of the altitude preselect rolling at 1hour 53 minutes and 31 seconds into the flight. These sounds are consistent to the FDR outputs which showed that:

At 11:06:36, the altitude pre-selector adjustment adjusted from FL380 to 4,288 ft.

At 11:06:52, the altitude pre-selector adjustment adjusted from 4,288 ft to 1,888 ft.

At 11:07:08, the altitude pre-selector adjustment adjusted from 1,822 ft to 592 ft.

Note: These adjustments require the pilot to manually select the desired value by the use of the ALT SEL rotary knob on the guidance panel. The selected altitude readout is displayed in the PFD.

At 11:07:41, AUTOTHROTTLE ENGAGED parameter transitioned from ENGAGED to NOT ENGAGED. As the parameter MASTER CAUTION remained not active by the time of the disengagement, it is possible to infer that this action was manually performed while the system remained operating normally.

At 11:07:25 to 11:08:41- For the duration of 1 minute and 16 seconds period, the parameter PACK 2 FLOW drops to zero with no associated CAS message. PACK 1 FLOW parameter also assumes higher values indicating that the AMS system was operating without fault, following pilot's inputs.

At **11:08:31**, the engaged autopilot vertical mode transitioned from FMS altitude hold (VALT) to FMS flight level change (VFLCH) and subsequently to flight level change (FLCH).

At 11:08:42, the auto-throttle was manually reengaged and the throttle levers were automatically retarded. This is the expected behavior as the FLCH mode was engaged and the desired altitude (altitude pre-selector) was below the current aircraft altitude.

At 11:09:01 – After the throttle levers were reduced, the auto-throttle was disengaged. The MASTER CAUTION parameter remained off, indicating that this disengagement was manually performed.

At 11:09:26, the TLA (throttle lever angle) parameters indicate and advance and subsequent retard back to IDLE at 11:09:35. This action was manually accomplished as the auto-throttle was disengaged.

⁴ The pressure difference between inside the cabin and the outside atmospheric pressure, pressure inside the cabin can be about 8 psi higher than the pressure outside. Eight psi is about half an atmosphere. At lower altitude delta p is lower increasing as the cabin altitude increases to a ceiling of 7.8psi with a max cabin altitude of 8,000 at 37000 feet then 8.34psi to 41,000ft.

INACTIVE at the same time that the SELECTED AIRSPEED MANUAL transitioned from INACTIVE to ACTIVE.

At 11:10:54, the SPEED BRAKE HANDLE parameter indicates that it was commanded to open the spoiler panels and remained in this position until the end of recording. This was manually commanded as the parameter monitors the handle position.

Note: After the speed brakes were commanded open, the vertical speed rises reaching a maximum value of 10560 fpm at **11:11:34**. Also, the indicated airspeed rises, leading to the automatic transition of the flight director vertical mode from FLCH to OVSP (over-speed) at **11:11:34**; **11:13:57**; **11:15:01**; **11:15:08** and **11:15:15**.

At 11:12:52, the BLEED 1 PRESS and BLEED 2 PRESS drop simultaneously to near zero. The fact that there is no MASTER CAUTION parameter activation indicates that both bleeds were intentionally deactivated.

Between 11:13:27 and 11:13:33, while the aircraft was cruising at 17,000 ft, the parameter MASTER CAUTION was activated. Technical analysis revealed that this MASTER CAUTION is associated with the detection of icing conditions. In this situation the anti-ice system will be automatically activated. However, since the pilot turned off both bleeds, the anti-ice system activation was not feasible. In response, the A-I WING FAIL caution message was generated.

At 11:16:01 (25 seconds before the end of recording), the GPWS CAUTION parameter indicates that the first GPWS alert was triggered as the aircraft crossed 2,010 ft AGL (5,150 ft ASL), followed by a second activation at 11:16:06 at which height, recovery maneuver to level flight was still achievable.

At 11:16:14, the parameter GPWS WARNING was activated and at 11:16:24, the GPWS TERRAIN PULL-UP parameter was activated.

Note: All the actions observed in the DVDR requires knowledge on the EMB-190 system, specially on the automatic flight control system, as the entire descent was performed with the autopilot engaged and with the CONTROL COLUMN PILOT/COPILOT FORCE remaining near zero.

1.12 Wreckage and Impact Information

1.12.1 Wreckage site

The accident occurred in a remote national park which is a seasonal dry savanna / wetland, with patchy shrub and tree coverage. The site was only accessible with all terrain vehicles and was far from any settlement.

The aircraft pitch nose down angle was approximately at -8° degrees just before impact. The first point of impact with the ground was evident by two smooth almost identical pits which are consistent with the distance between the two engines.

The ensuing debris were distributed further forward for about 487 meters where the left main landing gear was located. The landing gear were retracted and found upstream of the main crash site.

The aircraft crashed wings level facing in a north westerly direction of approximately 341° Magnetic north.

The trunions were relatively intact and the tyres did not display evidence of rolling and not punctured. Flights control surfaces i.e. flap and slats were retracted. Turbine blades were damaged, indicating that the engines were running at the time of impact, which is consistent with FDR data. Soot

patterns were largely vertical.



Figure 5. The main part of C9-EMC airframe that was found on the accident scene.

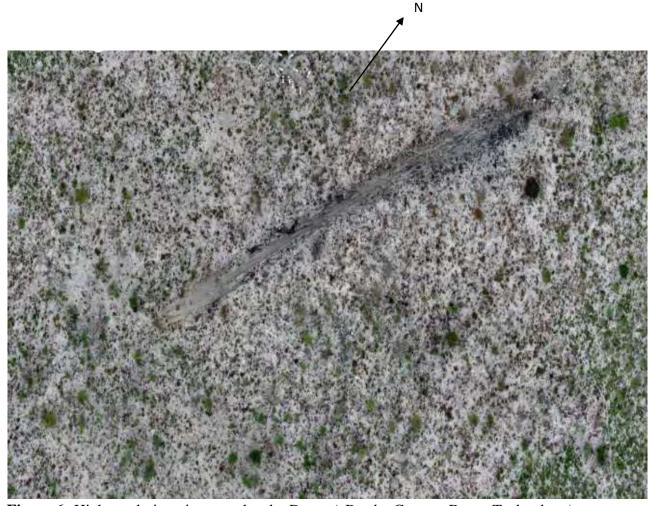


Figure 6. High resolution pictures taken by Drone (eBee by Copture Drone Technology).



Figure 7. Illustrates the nominal angle of impact.



Figure 8. Illustrates the tremendous impact forces of the crash.



Figure 9. Illustrates one of the first trees the aircraft impacted before impacting the ground.



Figure 10. One of the main landing gear tyres exhibiting little signs of ground roll.



Figure 11. Stripped turbine blades



Figure 12. Opposite engine stripped turbine blades

1.13 Medical and Pathological Information.

- 1.13.1 The National Forensic Science Institute of Namibia (NFSI) conducted a Disaster Victim Identification Process and completed the Forensic testing of 1022 post mortem samples on the human remains recovered from the crash site of LAM 470 at Bwabwata National Park in Namibia.
- 1.13.2 These were compared against the profiles provided as direct references or by families, in an attempt to make identifications based on morphological, dental or genetic analysis. The NFSI has successfully identified the remains for all victims of the air crash of LAM 470.
- 1.13.3 The remains of the pilot was collected, examined and identified both morphologically as well as genetically. Specific emphasis was placed on the collection of viable biological tissue or residue sufficient to perform blood alcohol analyses and or toxicological analyses on. None was found given the degree of fragmentation and degradation discussed supra.
- 1.13.4 The high degree of fragmentation of the bodies of the victims of the crash was indicative of the forces exerted at the time of impact. The said high degree of fragmentation turned a Disaster Victim Identification (DVI) examination of a relatively small number of victims into a DVI project with a massive scope considering that large number of human remains that have resulted from the crash.
- 1.13.5 The remoteness and environmental conditions of the crash site itself also contributed to the complexity of the analyses and posed major challenges. In fact the high degree of degradation of the human remains posed a major challenge for the morphological and genetic analyses of the remains resulting in a relatively protracted and complex process.
- 1.13.6 Some of the identified remains were repatriated in observance of the recorded wishes of the families and loved ones. This was performed in accordance with international DVI guidelines. The non-identifiable remains were interred at a location in Windhoek Namibia on the 28th of April 2014.

1.14 Fire

1.14.1 The aircraft wreckage was destroyed by post impact fire. The surrounding vegetation was also destroyed by the fire. Due to the remoteness of the accident site and the time the wreckage was found, the fire rescue services could not be carried out.

1.15 Survival Aspects

1.15.1 The pilot did not declare any emergency with ATC services nor did he squawk the international emergency code 7700 on the aircraft transponder. No signals were received from the ELT after the aircraft crashed. Search and Rescue was initiated at 16:50 by Namibia Air Traffic Services. Due to high rate of impact forces the accident was not survivable.

1.16 Tests and Research.

- 1.16.1 The FDR/CVR recorders were sent to the National Transport Safety Board (NTSB) Laboratories in Washington DC, USA for readout. **Refer to Appendix 3.**
- 1.16.2 Engineering Data taken from the FDR analysis at NTSB containing various commands and inputs of the flights controls as well as Auto-Pilot were plotted against the time frame analysis of the last 12 minutes of the flight.

- 1.16.3 Level D flight simulator investigations were conducted at the Azul Flight Training Centre in Brazil in coordination with CENIPA and Embraer (manufacturer) as well as the accredited representative and advisors from Mozambique Airline and Mozambique's Ministry of Transport. The investigation flights on the simulator were performed by manufacturer's test pilots. The objective of the simulator investigation was to reproduce the accident sequence, observe the pilots inputs to the aircraft controls against the autopilot and the reaction of the aircraft and determine if consistent with the outputs as seen on the FDR Data, as well to determine existence of any system deficiencies for the sole purpose of improvement to safety. **Refer to Appendix 4.**
- 1.16.4 Four sets of descents were conducted in the simulator which consisted of the last 12 minutes of the flight.
 - First decent was performed and was regarded as the training flight for the Embraer test pilots to perfect the inputs as per FDR (Flight Data Recorder) analysis and the time frame reference.
 - The second flight was conducted and recorded on camera; no motion was imputed in the simulator so as to accommodate more participants on the cockpit.
 - The third flight was performed as per FDR (Flight Data Recorder) outputs and included a full recovery before impact to access if mitigation actions were possible even after the first EGPWS (Electronic Ground Proximity Warning System) 'PULL-UP' commands with speed brakes deployed and engines at idle.
 - The fourth and final descent was conducted with full motion activated and with all action being performed by one crew member sitting on the left as per FDR Data outputs.

1.16.5 Emergency Locator Transmitter

ELT's are designed to activate automatically during an accident which is typically when certain G-forces are exceeded it will activate.

Locating an aircraft which has crashed, quickly, is critical in increasing the survivability of its occupants who may be injured and unable to assist themselves or transmit distress signal for rescue.

This is particular true especially in hostile environment from further effects of the environment such as weather and hostile environment.

However many a times ELTs have failed to activate and leading to the questions how effective are these devices to fulfilling their functions. This investigation revealed this particular weakness in these devices.

According to a research done by Australian Transport Safety Board (ATSB) 'ELTs function as intended in about 40 to 60 per cent of accidents in which their activation was expected' (Australian Transport Safety Bureau 2013). The research further claims that ELT did not work for a number of reasons such as:-

- > not selecting the ELT activation to armed before flight
- disconnection of the co-axial antenna cable from the unit during impact
- ➤ damage and/or removal of the antenna during impact
- > and aircraft coming to rest inverted after impact.

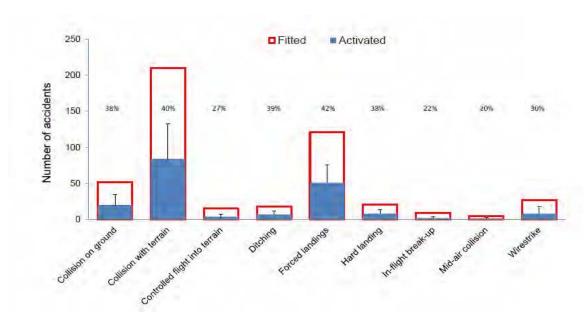


Figure 13. Number of fitted ELTs which activated for high G-force accidents by occurrence type 1993-2012

Most accidents involving high energy impact such as CFIT (controlled flight into terrain), mid air collision and wire strike had lower proportion of ELT activation, the report attribute this to a number of reasons, including the crew not 'arming ' the ELT before flight, incorrect installations and flat batteries, a lack of water proofing or fire protection however for this particular case (LAM 470) one ELT was found intact and flashing indicative of functioning but the disconnection of the co-axial antenna cable from the unit during impact prevented any transmission.

Antennas are located usually on a remote part of the aircraft fuselage away from the actual ELT transmitter which then requires a long cable that raises the possibility of disconnection when there is an accident

Summary

ELTs are safety devices which present a great opportunity to increase survivability of occupants whose aircraft crashes on remote locations. Search and rescue operations can be very expensive and an effective ELT can greatly reduce the precious time and resources needed to perform this action.

There is a need to increase their affectivity even on a high energy crash. Technology exist such as in mobile phones and satellite phones that enable transmission through an integral antenna as opposed to the remote fuselage fixed antenna that requires a routing to the unit.

1.16.6 Environment Impact

After the onsite investigation was completed, DAAI contracted BCG Aircraft Recoveries B.V from Holland which recovered all the aircraft wreckages and move them to a safe storage facility. The area was again scrutinized for composite materials, metal contaminations and plastic residues. All these debris that was contaminated were removed to a safe storage. DAAI revisited the site almost a year later to access the presence of any significant debris that might have been exposed by seasonal rain in that area.

DAAI used Drones to take aerial pictures and access progression of the clean-up and ensure that as much debris as possible was removed to try and restore the environment to its original pristine conditions.

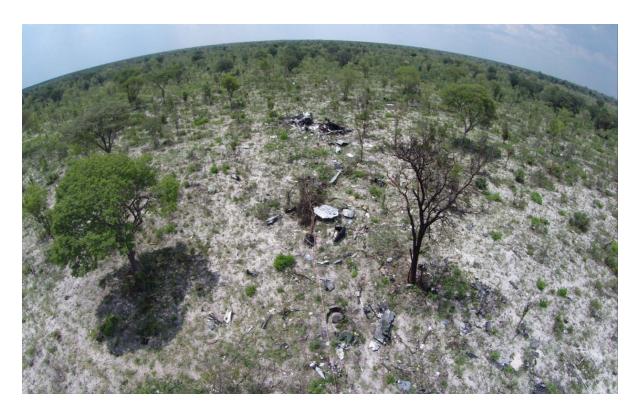


Figure 14: Second stage of clean-up



Figure 15: Drone picture of third stage of clean-up



Figure 16: Drone picture of fourth stage of clean-up

The Ministry of Agriculture, Water and Forestry

As per the request from DAAI, the team of experts from the Analytical Services and Production Development of the Ministry of Agriculture, Water and Forestry travelled to the crash site at Bwabwata National Park and collected the samples of soil for analysis. This was to determine the level of environmental impact (possible damages and contamination to the soil) which is in line with the Government policies on Environmental impact and assessments. The report made available to the investigation team by the Analytical Services and Production Development of the Ministry of Agriculture water and Forestry stated the following:-

- a) The soil reaction (Ph) is slightly alkaline
- b) Phosphorous and Potassium are very low
- c) Calcium is low
- d) Magnesium low
- e) Sodium low
- f) Electrical conductivity (EC) is very high

This team of expert from the Ministry of Agriculture, Water and Forestry recommended that the area be fenced and soil and plant samples to be taken every year (for at least 3 to 5 years) in order to monitor if there will be any changes with the soil and plants since there were no any samples taken from this specific place before the crash, to determine the level of impact caused to the environment after the crash.

The Ministry of Mines and Energy

The other soil samples were sent to the Geochemistry and Laboratory Division in the Ministry of Mines and Energy for them to carry out another analysis to determine the level and the presence of Heavy Metal. Using the handheld Notion XRF Analyzer which uses the wavelength

dispersive x-ray fluorescence technique, the following were the findings made available to the investigation team:-

- a) The geochemical values (in parts per million (ppm)) for heavy metals such as Lead, Vanadium, Cobalt, Manganese, Barium and Arsenic were low and did not exceed the required limits for soil.
- b) Whereas Copper, Chromium, Nickel and Zinc exceeded the required limit.
- c) Cadmium (Cd) recorded the highest concentration of heavy metals which exceeded the required limit in most of the bottles with soil samples analyzed.

Although the heavy metal concentration on the elements listed in (b) and (c) were recorded high, it could not be directly associated with the aircraft impact.

1.17 Organizational and Management Information

- 1. LAM 470 was on a scheduled flight operating on the TM 470 route.
- 2. The aircraft was owned by ALC E190 581 LLC and was operated by Mozambique Airline (LAM).
- 3. The last Inspection was certified on 28 November 2013 at 2902.00 airframe hours. At the time of the accident the aircraft had accumulated a further 3.0 hour since its last Inspection was certified.
- 4. The Aircraft Maintenance Organization (AMO) which carried out the last Inspection to the aircraft prior to the accident was in possession of a valid AMO Approval Number 02/OMA/2011 issued on 20 September 2013 and having an expiry date of 19 September 2014.
- 5. LAM had advanced proactive safety procedures that were way above the international minimum standards. Such procedures such as "more than one person in the cockpit" are only being adopted by most airlines after 2014.

1.17.1 **Operator**

The aircraft has been operated and maintained by Mozambique Airline under AMO Approval No. 02/OMA/2011 issued by Mozambique Civil Aviation Authority (IACM) on 20 September 2013 with an expiry date of 19 September 2014.

The aircraft was purchased new and has been in operation for at least a year since it was type accepted on the Mozambique Civil Aircraft Register on 25 October 2012.

As per Mozambique Airline (LAM)'s Maintenance and Technical Log Records, the aircraft has not yet undergone any major service apart from several Intermediate Checks. The aircraft also had an Out of Phase Check carried out which was completed and certified on 24 October 2013 as per the Job Card No. 296/13. **Refer to Appendix 5.**

There was also a 14 days/120 hrs Check that was carried out and certified on 28 November 2013 at 2902.0 airframe hours (the previous day prior to the accident), as per MPD Rev. 5 19/13 and as per Job Card No. 0332/13. **Refer to Appendix 2.**

The Regulatory Authority (IACM) conducted an Aircraft Maintenance Organization (AMO) Audit at LAM on the 6^{th} day of May 2013 and no discrepancies were identified.

1.17.2 Air Traffic Services

Mozambique 470 departed Maputo at 09:26 for Luanda estimated for 13:10 . Mozambique 470 entered Gaborone FIR (Botswana airspace) at 1018:58 and it was in normal radio communication with Gaborone ACC (Area Control Centre) on frequency 126.1 MHz and was maintaining FL 380. Gaborone ACC was operating a combined Area east 126.1MHz and Area West 127.1MHz.

The flight was uneventful until position EXEDU from where the radar playback revealed the aircraft descending rapidly. EXEDU is a mandatory reporting point in the Gaborone FIR (Flight Information

Region) which is at 72 nautical miles (nm) south of the point AGRAM, which is the boundary position between Gaborone FIR and Luanda FIR (18' 56S 02' 228E).

The controller who was on duty at Gaborone ACC did not notice that the aircraft has commenced a rapid descent as he was busy with other conflicting traffic on the radar and had informed Luanda to advice once communication with LAM 470 is established.

- 13:21 SATCO (Senior Air Traffic Controller) was informed of the missing aircraft.
- 13:25 SATCO checked with Lusaka (Zambia) ACC.
- 13:29 SATCO checked with Windhoek ACC.
- 13:35 SATCO informed CAAB management.
- 13:38 SATCO established flight details with the morning shift controller.
- 13:46 Windhoek advised that they had received calls of sightings of a crash in Rundu.
- 14:42 Windhoek confirmed the crash reported in Rundu but due to the remote area could not positively identify it as LAM 470.

1.17.3 Airport and aerodromes

The accident did not take place on an airport but in a remote national park with dense vegetation.

1.17.4 Regulatory Authorities

The aircraft was type accepted in the Mozambican Civil Aviation Register on 25 October 2012.

The Regulatory Authority (IACM) conducted an AMO audit on the AMO at Maputo International Airport on the 06 May 2013 and no discrepancies were identified.

Mozambique Civil Aviation Authority (IACM) issued an AMO Approval No. 02/OMA/2011 to Mozambique Airline on 20 September 2013 with an expiry date of 19 September 2014.

As per the Mozambique Civil Aviation Authority and LAM's Maintenance and Technical Log Records, the aircraft has not yet undergone any major services apart from some Intermediate Checks, Out of Phase Check as per the Job Card No: 296/13 that was completed on 24 October 2013 and, as per MPD Rev. 5 19/13, the 14 days/120 hrs Check that was carried and certified on 28 November 2013 (the previous day prior to the accident) as per the Job Card No: 0332/13.

1.17.5 Other weather agencies

As per the weather information obtained at 11H00Z from Maun, Botswana which was the nearest weather station and 140nm from the crash site, it indicated that the weather was fine with unrestricted visibility and the temperature at the area where the accident took place, ranging up to 32°C maximum.

The Namibian Weather Bureau indicated the same as the Botswana obtained weather information from Maun that the weather at around 11:00 at the area and altitude of the crash on 29 November 2013 as fine with an unrestricted visibility therefore was not considered as a factor contributing to the accident. There was some scattered clouds cover at 3000 ft AGL which was far below the 38000 ft to the aircraft was cruising and could have no any affect to an aircraft flying at that altitude.

1.18 Additional Information

Human Factors

- 1.18.1 During the investigation, the team travelled to Maputo in Mozambique looked into Mozambique Airline, the Institute of Civil Aviation of Mozambique (IACM), the Immigration department at Maputo International Airport and also interviewed the family members and friends of the two pilots.
- 1.18.2 The investigation team found out that all passengers were issued with passenger tickets and no evidence shows that there was any passenger who did not pass through security screening.
- 1.18.3 The Investigation team also discovered through the interview that the captain went through numerous life experiences ranging from:
 - a) The separation from the first wife on which the divorce process had not been dissolved to almost (10) years after separation.
 - b) The death of a son who passed away in a car accident on a suspected suicide on the 21st of November 2012.
 - c) The captain was reported as not to have attended his son's funeral.
 - d) The captain's youngest daughter underwent heart surgery in one of the hospitals in South Africa not long time ago.

1.9 Useful or Effective Investigation Techniques

1.19.1 Remotely Piloted Aircraft (RPA)

Due to the remoteness of the accident site which made it challenging for the investigators to gain access and survey the entire site effectively, DAAI utilized an RPA (Remotely Piloted Aircraft) to take aerial photographs for further investigations and surveying. DAAI contracted *Copture FotoGrammetri* a company that specializes in high resolution precision aerial photography using Remotely Piloted Aircraft (RPA) and incorporated Google earth system. The images along with elevation data and GPS positions were then merged to generate a geo-referenced photomosaic. This involved taking many high resolution photographs and then combining the pictures into a clear precise photographic map. This technology was critical in the reconstruction stage and helped identify critical pieces of wreckage that could have been missed by ground survey of the site.

The technology also enabled the investigators to conclude the on-site investigation much faster and start the environmental clean-up of the site to enable the restoration of the site to its pristine condition, especially due to the fact that it is a very important national park with all kinds of animals roaming freely.



Figure 17. Copture's eBee Remotely Piloted Aircraft (RPA).

Quad-copter drones were used to assess the progress of the clean up on the accident site to ensure all debris was removed and as much as possible try and restore the environment to its original condition.

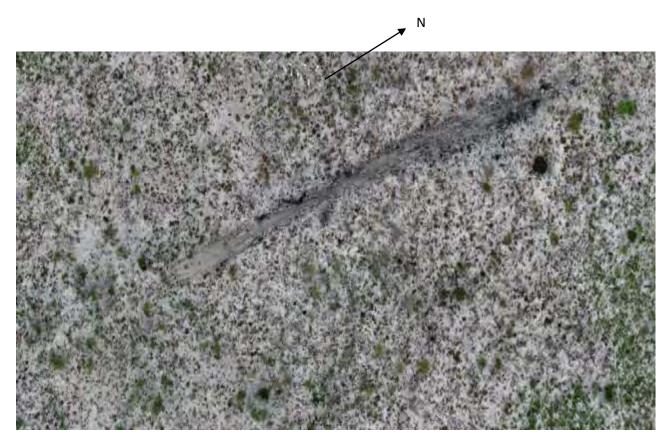


Figure 18. High resolution geo-referenced photo mosaic by *Copture Fotogrammetri* using an eBee Remotely Piloted Aircraft (RPA).

1.19.2 Flight Path Reconstruction

Flight path reconstruction that utilizes flight data to construct 3D animation incorporating flight deck instruments is an essential investigation technique that enables an investigator to quickly understand exactly what transpired overcoming weakness in traditional methods such as graphs charts and tables that require considerable amount of time and knowhow to absorb the extensive information and show an accurate picture of what happened. Interpretation can dilute the content of the information which is why this method is most useful.

DAAI utilized the Embraer FLYBACK animation software. This enable the investigation to visualize the last critical moment of the occurrence and with the combinations of other methods have a better understanding of the last phases of the flight. This clearly shows how the controls were manipulated and the reaction of the aircraft to those inputs.

Below is a snapshot from the Animation which depicted the 'controlled' descent of the aircraft auto flight system. This snapshot illustrates that the altitude was selected at 592ft which is below the area's field elevation of around 3600ft AMSL. It also displays the excessive descent of the vertical speed at 10158ft/minute.

The speed was selected at 309 knots and because of the high rate of descent the actual speed was way higher than the selected speed. The cabin altitude remained at a comfortable 6300ft ruling out any rapid decompression as a motive to descend. At this point the aircraft was still in an altitude flight level change mode meaning the aircraft is trying to achieve selected altitude of 592 ft given the selected speed of 309 knots.

Speed brakes are displayed as being deployed, an indication of desire to achieve the highest rate of descent in autopilot mode to counter corrective autopilot maneuver that would level the aircraft as a speed protection to prevent the aircraft reaching Vmo (over speed).

The throttle level at this point were at flight idle which confirmed by the N1 (engine fan speed) N2 engine rotor speed indication. The angle of attack was normal ruling any possibilities of stall.



Figure 19. LAM 470 at peak of descent with the VS of -10158 ft/m

1.19.3 Embraer 190 Simulator Reconstruction Flight

The FDR/CVR recorders were sent to the National Transport Safety Board (NTSB) laboratories in Washington DC, USA for readout. Engineering Data taken from the FDR analysis at NTSB containing various commands inputs of the flights controls as well as Auto-Pilot were plotted against the time frame analysis so as to recreate the last 12 minutes of the flight in a flight simulator.

Level D⁵ flight simulator investigations were conducted at the Azul Flight Training Centre in Brazil in coordination with CENIPA (accredited representative from state of manufacturer) and Embraer (manufacturer). There were also accredited representatives from Mozambique Airline and Government.

The Flight Investigations on the simulator were performed by manufacturer's test pilots. The objective of the simulator investigation was to reproduce the accident sequence, observe the pilots

inputs to the aircraft controls against the autopilot and the reaction of the aircraft and determine if consistent with the outputs as seen on the FDR Data. The investigation also wanted to determine the existence of any system deficiencies.

2 ANALYSIS

2.1 Flight Operations

2.1.1 Flight crew qualifications

The flight crew were suitably qualified and experienced in their respective roles. At the time of the accident they were within their allowable duty time and they were suitably rested.

2.1.2 Conduct of the Flight

LAM 470 departed Maputo at 09:26 for Luanda estimated their arrival at **13:10**. The Flight operations were normal and the aircraft was cleared by Gaborone ATC for FL380 (38000ft) which was maintained from **9:55** till **11:09** just before the position EXEDU.

Most of the conversation in the cockpit for the first one hour and fifty minutes of the flight was dominated by general discussion about the country's politics and social activities. There was a cordial if not pleasant conversation between the two crew members in the cockpit, at no point was there a hint of any un-procedural activities or other deviation.

After 1hour 50 minutes into the flight the First Officer stated he had to go to the toilet and asked the captain if he had controls to which he responded "no problem" and thereafter sounds similar to door unlock jingle are heard and then immediately after, the electromechanical door latch are closing.

From this time there was no other intra-cockpit conversation recorded on the CVR indicating that the Captain remained alone in the cockpit which is not in line with the company procedures.

At **11:04** The aircraft was flying at FL380, with ALTITUDE PRESELECTOR set to 38000 ft. Autopilot was engaged (and remained engaged until the end of recording) with flight director vertical mode VALT (FMS altitude hold).

⁵ There are currently four levels of full flight simulator, level A – D; level D being the highest standard. A Level D/Type 7 FFS also provides motion feedback to the crew through a motion platform upon which the simulator cabin is mounted. The motion platform must produce accelerations in all of the six degrees of freedom (6-DoF) that can be experienced by a body that is free to move in space.

- At 1:53:31 hours into the flight the CVR picked click sound of the altitude preselect rolling, these sounds are consistent to the FDR outputs which showed that at;
- 11:06:36 the altitude preselect adjustment (from FL380 to 4,288 ft,
- 11:06:52 the altitude preselect adjustment (from 4,288 to 1,888 ft,
- 11:07:08 the altitude preselect adjustment (from 1,888 ft to 592 ft,
- At 11:07:41 the FDR recorded the AUTOTHROTTLE ENGAGE parameter being transitioned from ENGAGED to NOT ENGAGED at this time the MASTER CAUTION remained inactive. This can be attributed to the action being performed manually i.e. through commanded input rather than inadvertently⁶.
- **11:08:31** The engaged autopilot vertical mode transitioned from FMS altitude hold (VALT) to FMS flight level change (VFLCH) and thereafter flight level change (FLCH)⁷.
- **11:08:42** The auto-throttle was manually reengaged and the throttle levers were automatically retarded. This is the expected behavior as the FLCH mode was engaged and the desired altitude (altitude pre-selector) was below the current aircraft altitude.
- **11:09:01** After the throttle levers were reduced, the auto-throttle was disengaged. The MASTER CAUTION parameter remained off, this can be attributes as the disengagement was manually performed.
- 11:09:26 The TLA (throttle lever angle) parameters indicate an advance and subsequent retard back to IDLE at 11:09:35. This action was manually accomplished as the auto-throttle was disengaged.
- **11:09:52** The parameter SELECTED AIRSPEED AUTO transitioned from ACTIVE to INACTIVE at the same time that the SELECTED AIRSPEED MANUAL transitioned from INACTIVE to ACTIVE⁸.
- **11:10:54** The SPEED BRAKE HANDLE parameter indicates that it was commanded to open the spoiler panels and remained in this position until the end of recording. This was manually commanded as the parameter monitors the handle position.

After the speed brakes were commanded open, the vertical speed rises reaching a maximum value of 10560 fpm at 11:11:34. Also, the indicated airspeed rises, leading to the automatic transition of the flight director vertical mode from FLCH to OVSP (over-speed) at 11:11:34; 11:13:57; 11:15:01; 11:15:08 and 11:15:15.

At 11:12:52, the BLEED 1 PRESS and BLEED 2 PRESS drop simultaneously to near zero. The fact that there is no MASTER CAUTION parameter activation indicates that both bleeds were intentionally deactivated.

Between 11:13:27 and 11:13:33, while the aircraft was crossing 17,000 ft, the parameter MASTER CAUTION was activated. Technical analysis revealed that this MASTER CAUTION is associated with the detection of icing conditions. In this situation the anti-ice system will be automatically activated. However, since the pilot turned off both bleeds, the anti-ice system activation was not feasible. In response, the A-I WING FAIL caution message was generated.

⁶ In case of an auto-throttle failure, a caution CAS message would be displayed to the crew and would be recorded in the DFDR. As the parameter MASTER CAUTION remained not active by the time of the disengagement, it is possible to infer that this action was manually performed.

⁷ There are two conditions to consider: an FMS failure or a manual selection. In a FMS failure, the vertical mode would drop to the AFCS basic mode (FPA), which was not observed. Moreover, the lateral mode remained engaged in the LNAV, what indicates that the FMS was available along the whole descent. Therefore it is possible to infer that these transitions were manually commanded by pressing the FLCH pushbutton and subsequently the VNAV pushbutton on the guidance panel

At **11:16:01** (25 seconds before the end of recording), the GPWS CAUTION parameter indicates that the first GPWS alert was triggered as the aircraft crossed 2,010ft AGL (5,150ft ASL) followed by a second activation at **11:16:06**.

At 11:16:14, the parameter GPWS WARNING was activated and at 11:16:24 the GPWS TERRAIN PULL UP parameter was activated.

The pilot switched the Speed outer knob from AUTO to MAN in the guidance panel then rotated the inner knob to desired airspeed (SELECTED SPEED). This is evident by the SELECTED AIRSPEED AUTO transitioned from ACTIVE to INACTIVE at the same time the SELECTED AIRSPEED AUTOSPEED MANUAL transitioned from INACTIVE to ACTIVE. The SELECTED AIRSPEED parameters indicated that the desired speed was manually selected several times until the end of the FDR recording. This speed remained close to VMO⁸ throughout the remaining portion of the descent.

At around 1:56:46 into the flight, sounds were heard of someone trying to open the door. Spoiler panels were then commanded open and remained in this condition for the rest of descent.

This action (deploying speed brakes) raised the vertical speed to maximum value of 10560ft/m seen at 11:11:34 as well as increasing the vertical mode from FLCH to OVSP (over speed).

The MASTER CAUTION was activated at 17000 ft between 11:13:27 and 11:13:33. Technical analysis revealed that this MASTER CAUTION is associated with the detection of icing conditions. In this situation the anti-ice system will be automatically activated. However, since the pilot turned off both bleed, the anti-ice system activation was not feasible. In response, the A-I WING FAIL caution message was generated.

EGPWS WARNINGS were heard and parameter warnings activated at 11:16:06 and "TERRAIN PULL- UP" sounded but no action by the captain was evident. Test results from the simulator indicate even at this point the aircraft would have been recovered

⁸ The AFCS (auto flight control system) automatically limits the manual selected speed to VMO. This is evident from the Speed Brake Handle parameter indicator which gets its pick up from proximity sensor on the Handle as it transition from one position to next.

2.1.3 Weather

Both the Botswana and Namibian Weather Bureau where contacted and reported that the en-route weather at around 11:00 on 29/11/2013 was fine. There were some scattered clouds at 3000 ft AGL which way far away below the 38000 ft to where the aircraft was cruising and was considered not having any affect to an aircraft flying at that level. (Refer also to Paragraph 1.7 Meteorological Information and 1.17.5 (1-3) Any other Weather Service or Agencies). **Refer to Appendix 6.**

2.1.4 Air Navigations Services

The aircraft entered Gaborone FIR (Flight Information Region) at 10:18:58 and was in radio communications with Gaborone Area Control centre on frequency 126.1 MHz while maintaining FL380.

Gaborone FIR was manned by one controller who was operating a combined Area East 126.1 MHz and Area West 127.1 Mhz which is the entire upper airspace of Botswana. These sectors are normally separated and would have required two separate controllers.

At 10:19 LAM 470 was cleared direct to position AGRAM at FL380 and the crew estimated they would be at that position by 11:19 (an hour later).

This was the last communication with the aircraft evident by ATC tape recordings.

Information obtained during the investigation from Namibian radar systems review indicated that the aircraft started descending at approximately 11:09 until it disappeared from Radar passing FL141 at 11:14. The Namibian (Wide Area Multirateration) WAM radar recorded the loss of target at 6600ft at 11:15. **Refer to Appendix 7.**

Gaborone ATC reported receiving false conflict alerts on the UB540 route at position AXIKO and that required his attention on the far eastern side of the Radar display. At that time ATC switched to the eastern sector whilst the aircraft on the western sector deviated from its flight plan route when it started an abrupt descent.

At 11:17:33 the Botswana ATC instructed the aircraft to continue en-route and contacted Luanda ATC on frequency 8888 or 5565 HF. The aircraft never acknowledged. At position AGRAM the aircraft also never reported its position at the estimated time of 11: 19 as per the Botswana ATC request.

At 13:05 just five minutes before Luanda ETA (estimated time of arrival) Luanda ATC called Gaborone ACC and informed them that LAM 470 had not made contact.

Gaborone ATC who was alone on duty controlling two sectors (Area East and Area West) had failed to initiate Alerting services of any Phase e.g. Uncertainty phase due to focus being on the eastern side of the airspace.

There was no reception of the Emergency Locator Transmitter (ELT) signal transmission by the global emergency centers due to the fact that its antenna cable was found cut off from the ELT unit when the aircraft impacted the terrain.

Namibian Authorities received information about a low flying aircraft and thereafter smoke column in the National Park at around 12:40 who then contacted Botswana ATC to confirm missing Aircraft in its FIR.

The Namibian Air Traffic Controller on duty immediately instituted a search and rescue, however due to the prevailing bad weather conditions the search was called off until the next morning The accident site was located on Saturday 30 November 2013 at around 09:00 local time.

There was enough evidence to suggest that the fire that consumed the aircraft was post-impact fire. Soot patterns on the wreckage parts lay evidence to this analysis which is further supported by lack of fire warnings on any of the CVFDR recordings.

2.2 Aircraft

2.2.1 Mass and Balance

Based on the load sheet and Flight dispatch documents that this Directorate was provided with by the Mozambique's Institute of Civil Aviation and the Mozambique Airline (LAM), the position of the centre of gravity was determined using the attached Balance Chart.

The following data were used to determine the position of the centre of gravity and was calculated as follows:

Actual Take-Off Weight	44,222 kg
Basic Index	65.2
After Cargo Compartment	0 kg
Forward Cargo Compartment	473 kg
PAX OA	03
PAX OB	15
PAX OC	PAX
Take-Off Fuel	12,700 kg (= - 10IU)

According to the load sheet, it is stated that there were 27 adults and one infant ("27/0/1"), these numbers indicating that there were 27 adults, no children and one infant. As per item 24(c) of page 3 on Appendix 1 of the FAA Advisory Circular (AC-120-27E), Aircraft Weight and Balance Control dated 6/10/05, infants are children who have not reached their second birthday and are considered part of the adult standard average and segmented passenger weight. **Refer to Appendix 8.**

Given that data, using the balance chart, the Centre of Gravity (CG) should be located approximately 14% of the MAC (mean aerodynamic chord). Therefore the take-off weight and CG were located inside the aircraft operating envelop and was not considered as a factor contributing to the accident.

2.2.2 Engines

The turbine blades were examined on site and indicated considerable damage which is consistent with high energy impact at high rotational speed. This suggested that the engine were still running at the time of impact. This analysis was further confirmed by FDR DATA which illustrates that the engine No. 2 TLA (throttle Lever Angle) was retarded from 60° to around 20° at approximately 11:09. The Engine 1 and 2 N1 (% RPM) reduced from around 85% at 11:09 to about 40% for the last 11 minutes of the flight.

2.2.3 Maintenance

Amongst the other Intermediate Checks performed on aircraft, there was an Intermediate -5 (5A) CHECK "3375 F/hrs" that commenced on 14/11/13 and was completed the same day as per the Job Nr: 317/13. **Refer to Appendix 9.**

According to the Technical delays and Cancellation details report, the aircraft C9-EMC had several technical delays ranging from 30 to 50 minutes. The major delay was the one for the 31st October 2013 that lasted for an hour and thirty minutes (1:30) and caused flight No. 312 not to be dispatched and due to Engine No.1 FADEC which was faulty and was replaced with another one in accordance with Aircraft Maintenance Manual (AMM) Task 73-21-01-400-801. **Refer to Appendix 10.**

2.2.4 Simulator analysis of the flight

The last 12 minutes of the flight was replicated on a simulator as from 11:04:04 to 11:16:25.

The behavior of the simulator was very close to the parameters recorded of the occurrence on the FDR.

NOTE: The behavior of aircraft was deemed identical although the flight dynamics revealed very small differences which can be attributed to the limitations of replicating all environmental conditions as they prevailed at the time such as actual avionics loads, wind component at actual area, systems logics etc.

2.3.1 The Captain's 72 hrs history before the accident

Information provided to the investigation team by Mozambique Airline stated that only information related to the captain that pertain the airline could be obtain and listed as follow:

- ♦ 26th November flew on the rout Maputo Tete Maputo (TM 136 137)
- ♦ 27th November flew Maputo Johannesburg Maputo (TM 315 306)
- ♦ 28th November Leave
- ♦ 29th November flew TM 470

NB: Although information on the Financial and Insurance position of the Captain was requested from Mozambique through their accredited representative, DAAI could not obtain this information due to huge bureaucratic and legal/judicial huddles until the finalization of the final report.

3.0 CONCLUSION

3.1 Findings

FLIGHT OPERATIONS

- 3.1.1 The flight crew members were licensed and qualified for the flight in accordance with the Mozambique Institute of Civil Aviation's existing Regulations.
- 3.1.2 Their medical certificates were valid and the aircraft type endorsed into their licenses.
- 3.1.3 The aircraft's Certificate of Airworthiness (C of A) and that of Registration (C of R) were valid at the time of accident.
- 3.1.4 The crew were properly rested and well within their duty times.
- 3.1.5 The en-route weather at 38000 ft which was the selected aircraft cruising level was fine and was not considered to be a contributory factor to the accident. However, the deteriorating weather at

- the accident site due to rain and thunderstorms that started building up late in the afternoon causing search and rescue to be called off until the next morning.
- 3.1.6 There was no evidence to indicate that some passengers didn't pass through security screening as all passengers were issued with passenger tickets and had boarding passes.
- 3.1.7 1hour 50 minutes into the flight, the first Officer (F/O) left the cockpit for the lavatory and only the Captain remained on the Flight Deck. The cockpit-door was then electronically locked and there were no further conversation in the cockpit.
- 3.1.8 The Captain manually selected the ALT SEL three (3) times from 38000 feet cruising altitude, to the final 592 feet setting.
- 3.1.9 The Captain manually disengaged the Auto throttle then later manually reengaged it which caused the throttle levers to retard automatically. The speed was then altered manually, several times until the end of recording, which remained close to Vmo (Maximum Operating limit speed).
- 3.1.10 The speed brake handle parameter that monitors the handle position indicates it was manually commanded to open the spoiler panels and remained in that position until the end of recording.
- 3.1.11 Actions performed by the Captain indicate explicit knowledge of the EMB-190 Systems and specifically the automatic flight control system that is evident as the entire descent was conducted with the Auto-pilot engaged and no force applied to the control columns.
- 3.1.12 The Emergency Locator Transmitter (ELT) was found relatively intact but due to the fact that its antenna cable was cut off from the ELT during the aircraft impacted the terrain, there was no reception of ELT transmission by the global emergency centers which operates on satellite relays.
- 3.1.13 Alerting services were not activated as per procedure by Gaborone ACC i.e. when aircraft failed to report at AGRAM, Gaborone ACC did not commence Uncertainty Phase as per procedure but rather waited for Luanda ACC to report when they have established contact.
- 3.1.14 There was no communication difficulties reported. The pilot last communicated with Gaborone Area Control Centre on frequency 126.1 MHz at around 10:19:32 as the aircraft was cruising at FL380 before it made an abrupt descent.
- 3.1.15 Gaborone Air Traffic Controller (ATC) who was alone on duty and operating a combined Area East 126.1 MHz and Area West 127.1 MHz which is the entire upper airspace of Botswana, could have coupled the two frequencies together for him to be able to control these sectors effectively.
- 3.1.16 The Botswana Radar failed the controller by not flushing a red light or setting of an alarm for him to signal that the aircraft has started commencing a sudden descent and deviated from it flight plan route, therefore could not execute an emergency or any alerting alarm.

SIMULATOR INVESTIGATIONS FINDINGS

3.1.17 The behavior of the simulator was deemed identical as the actual flight although the flight dynamics revealed very small differences which can be attributed to the limitations of replicating all environmental conditions as they prevailed at the time such as actual avionics loads, wind component at actual area, systems logics etc.

- 3.1.18 It was also evident that actions recorded on the FDR were commanded rather than inadvertent as it required cognitive effort to input.
- 3.1.19 Logical sequences of inputs were commanded as a counter response to the corrective actions initiated by the Auto-Pilot.

SYSTEMS AND MAINTENANCE INVESTIGATIONS

- 3.1.20 Aircraft Maintenance Organization (AMO) that certified the last Inspection on the aircraft prior to the accident was in possession of a valid AMO Approval Number 02/OMA/2011 issued on 20 September 2013 and having an expiry date of 19 September 2014.
- 3.1.21 The Mozambique Regulatory Authority (IACM) conducted an AMO audit on the AMO at Maputo International Airport on the 6^{th} of May 2013 and no discrepancies were identified.
- 3.1.22 Maintenance records indicated that the aircraft was maintained in accordance with existing regulatory and approved procedures.
- 3.1.23 There was no evidence of airframe failure or system malfunction prior to the accident.
- 3.1.24 There was no evidence of in-flight fire or explosion.
- 3.1.25 Damages to the engines were consistent with high energy rotation at impact. There was no evidence to suggest in-flight uncontained or contained engine failure.
- 3.1.26 The aircraft was type accepted in the Mozambican Civil Aircraft Register on 25 October 2012.
- 3.1.27 Weight and Balance Calculation was within the required limit as the CG was within the operating envelope, therefore will not be considered as a factor contributing to the accident.
- 3.1.28 All passengers were issued with passenger tickets and had boarding passes with them, therefore there were no evidence indicating that some passengers did not go through security screening.
- 3.1.29 There was no weather related difficulties experienced therefore weather was not considered as a factor contributing to this accident.
- 3.1.30 There was no evidence to suggest that ATNS (Air Traffic and Navigational Services) procedures and actions contributed to this accident.
- 3.1.31 The aircraft was intact before the first impact with the terrain.

HUMAN FACTORS

3.1.32 There were no evidence forthcoming to the investigations that suggest physiological factors or incapacitation affected the performance of flight crew members.

3.2 Probable Cause/s

3.2.1 The inputs to the auto flight systems by the person believed to be the Captain, who remained alone on the flight deck when the person believed to be the co-pilot requested to go to the lavatory, caused the aircraft to departure from cruise flight to a sustained controlled descent and subsequent collision with the terrain.

3.2 Contributing factors

3.2.1 The non-compliance to company procedures that resulted in a sole crew member occupying the flight compartment.

4. SAFETY RECOMMENDATIONS

As a result of the investigation of this accident the DAAI make the following Safety Recommendations:

TO THE MOZAMBIQUE CIVIL AVIATION AUTHORITY:

Safety recommendation number 001/2015 LAM

DAAI recommends that Mozambique Civil Aviation Authority should come up with a mechanism to ensure that the procedure of two people in the flight deck is adhered to at all times as laid out in LAM's Manual of Flight Operation Chapter 10.1.4, Page 5 of 36, Edition 3 Revision 8, (Absence from Flight Deck).

TO ICAO

Safety recommendation number 002/2015 LAM

DAAI recommends that ICAO should establish a working group that should look into the operation and the threat management emanating from both side of the cockpit door.

Safety recommendation number 003/2015 LAM

DAAI recommends that ICAO should establish standards that implement recommendations of the working group, formed under safety recommendations number 002/2015 LAM to suitably avert the locking out of the cockpit of authorized crew members.

Safety recommendation number 004/2015 LAM

DAAI recommends that ICAO should establish a working group to review the installation of visual recording inside and outside the cockpit that should provide information on who was in the cabin, who exactly was controlling the plane at the time of the accident and even where their hands were in relation to the plane's controls.

Safety recommendation number 005/2015 LAM

DAAI recommends that ICAO should expedite the implementation of international requirements on global tracking of airline flights providing early warning of, and response to, abnormal flight behavior information to ensure that search and rescue services, recovery and accident investigation activities are conducted timely.

Safety recommendation number 006/2015 LAM

DAAI recommends that ICAO working group (Global Tracking 2014-WP/6) speeds up the research and implementation of aircraft tracking and localization other than ELT system.

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Date: 30 03 2016

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Date: 30/03/2016

Released by:

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0 5 APR 2016 MINISTER: MINISTRY OF WORKS AND TRANSPORT

Date 2016/04/05

4.LIST OF APPENDICES

- 4.1 **Appendix 1.** LAM's Manual of Flight Operation Chapter 10.1.4, Page 5 of 36, Edition 3 Revision 8.
- 4.2 **Appendix 2.** 14 days/120 flight hours inspection dated 28 November 2013 (Job No. 332/13).
- 4.3 **Appendix 3.** Flight Data Recorder (FDR) Parameters.
- 4.4 **Appendix 4.** AZUL Flight Training Centre Simulator Technical Report.
- 5.5 Appendix 5. Out of Phase Check dated 23 October 2013 (Job No. 296/13).
- 5.6 **Appendix 6.** Weather information as provided by Botswana and Namibia Meteorological Services.
- 5.7 **Appendix 7.** Namibia Wide Area Multirateration (WAM) radar recorded information.
- 5.8 **Appendix 8.** Aircraft Weight and Balance Control (FAA Advisory Circular AC-120-27E)
- 5.9 **Appendix 9.** Intermediate -5 (5A) CHECK "3375Fhrs" dated 14 November 2013 (Job N. 317/13).
- 6.0 **Appendix 10.** Technical delays and Cancellation details report.
- 6.1 **Appendix 11.** The Captain's 72 hrs history before the accident.

LAM's Manual of Flight Operation, Chapter 10.1.4, Page 5 of 36, Edition 3 Revision 8, Dated 05 April 2012.

MANUAL DE OPERAÇÕES DE VOO



Capítulo 10 - Parte A

1

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Data: 30 Abril 2011 Página 1 de 36 Edição: 3 Revisão: 6

& LAW

MANUAL DE OPERAÇÕES DE VOO

Capítulo 10 - Parte A

5

Segurança

As comunicações PNT/PNC poderão ser directas desde que observado disposto anteriormente para o acesso ao Flight Deck.

0

10.1.4. AUSÊNCIA DO FLIGHT DECK

Um piloto só pode ausentar-se do Flight Deck acima dos 10.000 pés por razões fisiológicas ou no desempenho de suas tarefas operacionais. Deverá para tal, primeiro chamar um PNC que ficará no Flight Deck até ao regresso daquele. À saída do piloto, o outro deverá bloquear a porta só voltando a abri-la para o regresso do piloto ora ausente.

O piloto que fica no *flight deck* deverá manter um estado de alerta e *situational* awareness, ter acesso livre e desobstruído aos comandos do voo.

10.1.5. SERVIÇO AO PNT NO FLIGHT DECK

O serviço ao PNT é feito antes da porta bloqueada no chão ou acima dos 10.000 pés. Depois da descolagem qualquer serviço ao flight deck deverá ser precedido dum contacto com o PNT que deverá autorizar a entrada no flight deck. Se o PNC chamar o PNT só deverá abrir a porta depois de confirmar visualmente ou por interfone a identidade da pessoa que estiver junto à porta (B737). No caso do Embraer 190 deverá ser usada a monitoria através do circuito fechado de TV.

10.1.6. CABIN STERILE

Significa que:

a. O discurso de segurança e as respectivas demonstrações estão feitas.

Data: 05 Abril 2012 Página 5 de 36 Edição: 3 Revisão: 8

Job No. 332/13:- Details of the last inspection (14 days/120 Flight Hours) conducted on 28 November 2013 (a day before the accident).

LAM MOZAMBODE AIRTNES TECHNICAL DIRECTION ENGINEERING & PLANNING DEPARTMENT PLANNING & PRODUCTION CONTROL SECTION

Unions Arreas on Moçaminque

EMBRAER 190

START DATE: XX /111/13 A/Reg. C9-EMC Job Nr: 0332/13 " 14 Days / 120 FHrs Check" [19 Cartes]

COMPLETION DATE: 28/11/13

MPD REV 5 19/13

NEXT DUE ONLY 12-2013

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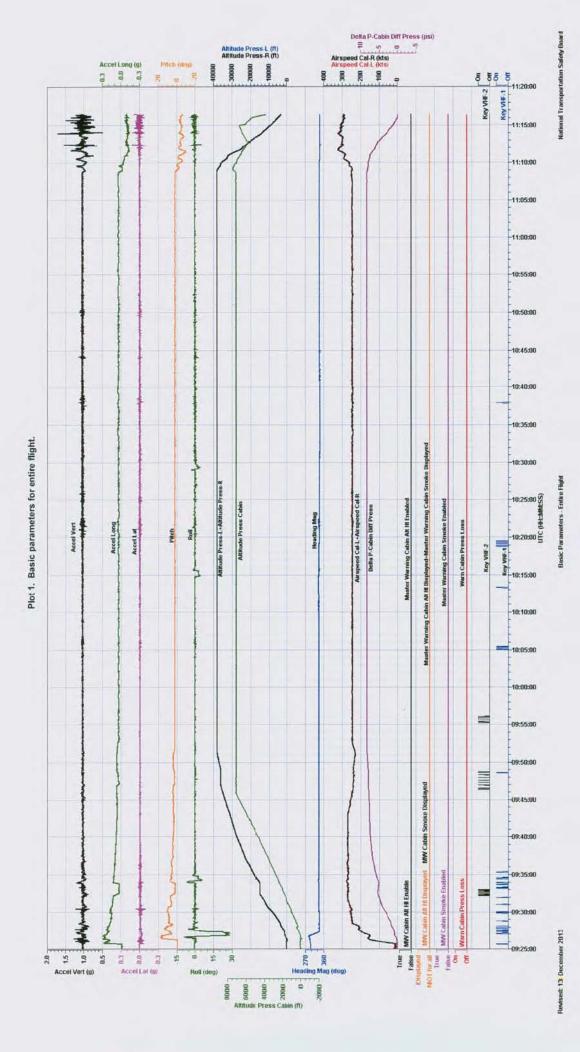
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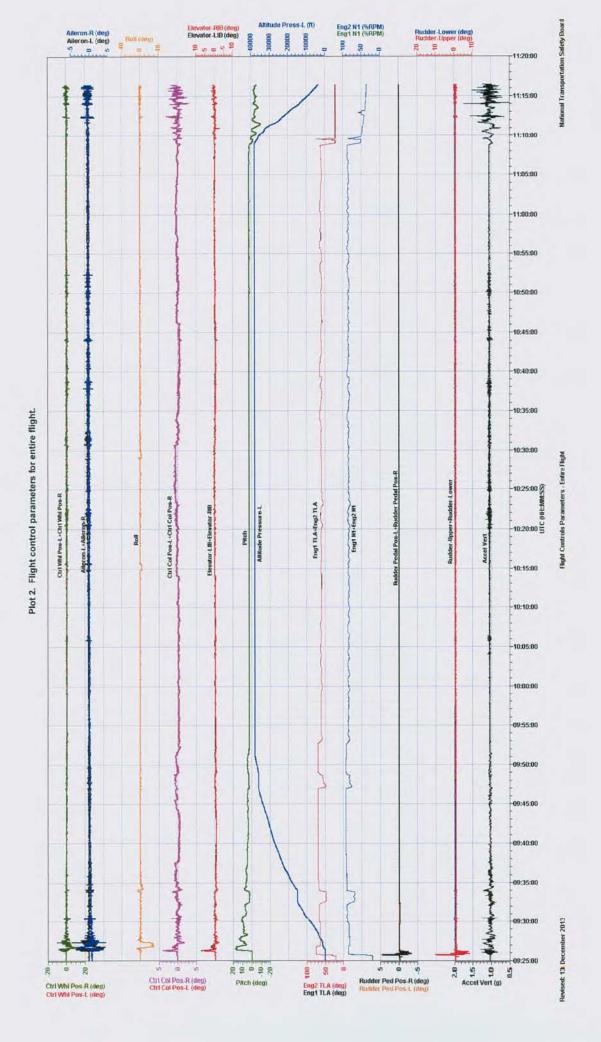
1.83

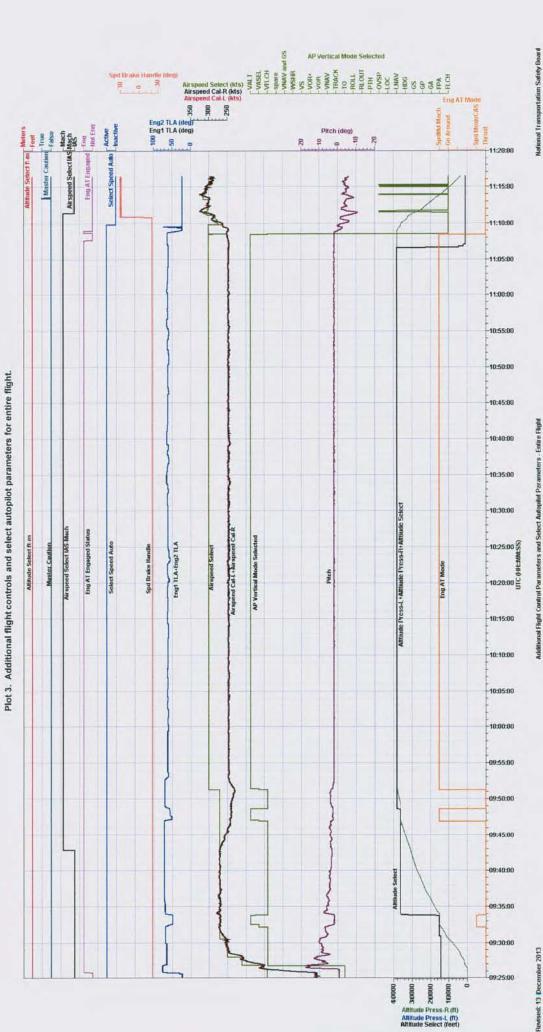
TOTAL

Flight Data Recorder (FDR) Parameters.

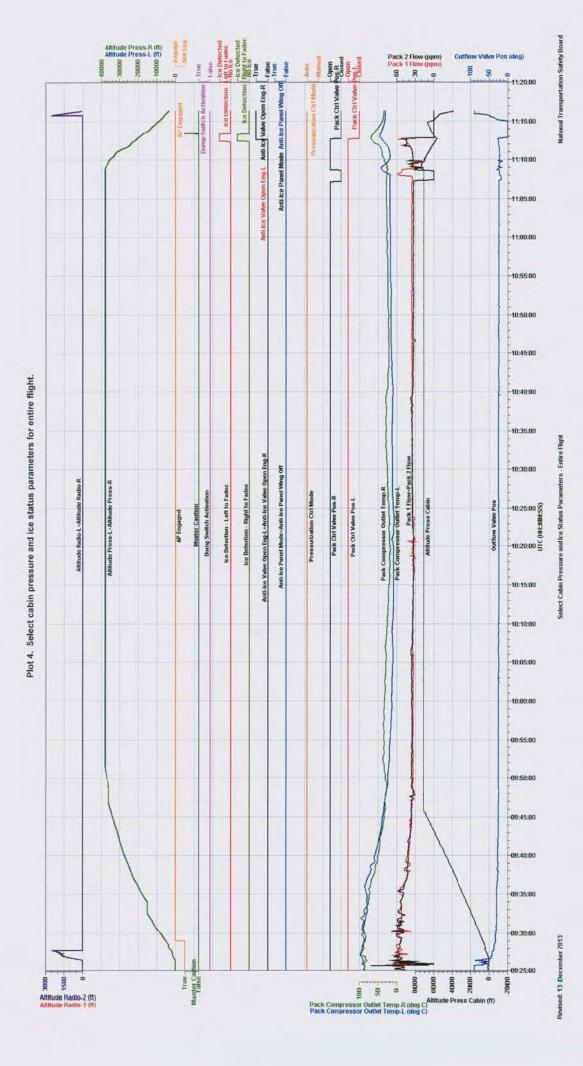
- Plots 1 and 5 show the basic parameters recorded. The three accelerations (longitudinal, lateral, and vertical) are displayed in addition to pitch and roll data. Pressure altitude and calibrated airspeed information are shown along with information about cabin pressure and discrete parameters showing warning states.
- Plots 2 and 6 show the flight control parameters recorded.
- Plots 3 and 7 show additional flight control parameters as well as information pertaining to the aircraft's autopilot input settings and autopilot state.
- ♦ Plots 4 and 8 contain select cabin pressure and ice status parameters.

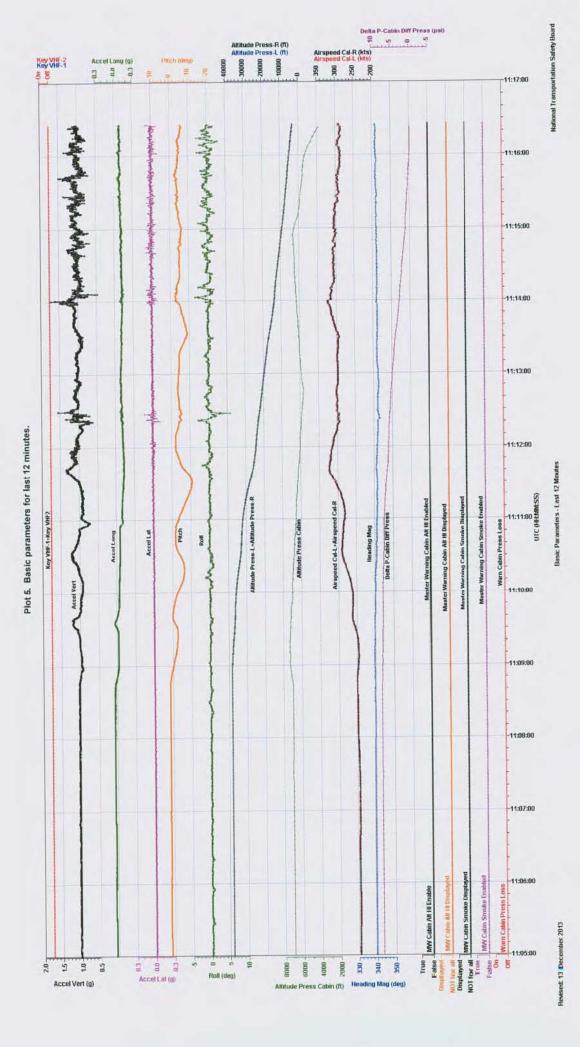


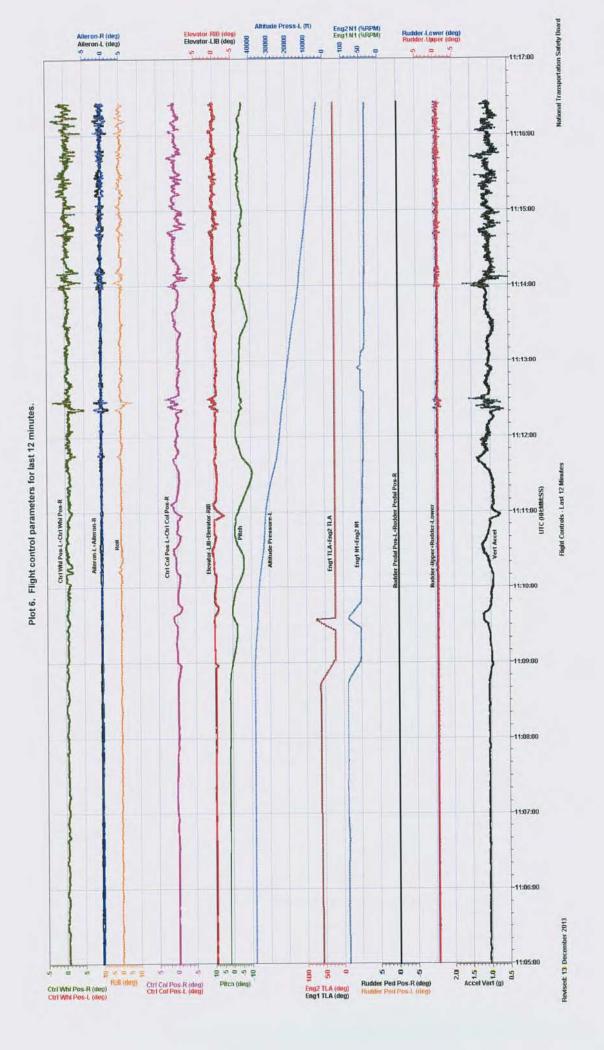


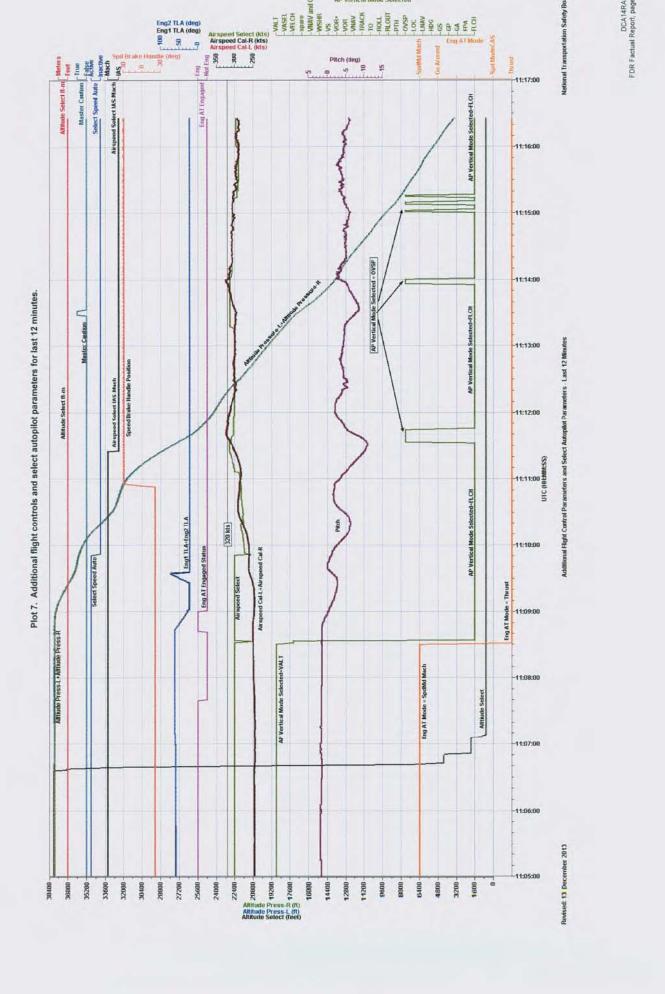


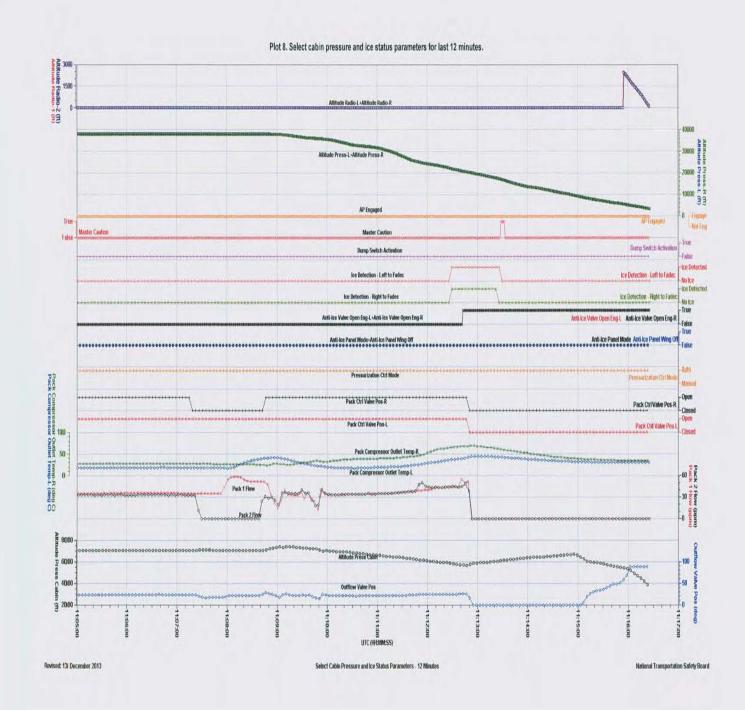
Entire Flight Additional Flight Control Parameters and Select Autoplint Perameters -











DCA14RA018 FDR Factual Report, page 14

<u>AZUL Flight Training Centre Simulator</u> <u>Technical Report.</u>



REPUBLIC OF NAMIBIA

MINISTRY OF WORKS AND TRANSPORT

Directorate of Aircraft Accident Investigations

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DAAI 021 Privat

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11 September 2014

TO : The Director

Directorate of Aircraft Accident Investigations

SUBJECT: TECHNICAL INVESTIGATIONS ON FLIGHT LAM470 AT AZUL AIRLINE SIMULATOR, SAO JOSE. BRAZIL

Background

Flight LAM470 crashed at Bwabwata national park in Kavango East region on the 29th November 2013. An investigation was immediately instituted by Namibia as a state of occurrence. Several investigation activities were conducted and preliminary report issued. The CVR/FDR (Black Boxes i.e. Flight Data and Cockpit Voice Recorders) was decoded and information raised several questions that necessitated further investigations. A simulated flight was deemed the best method to addressing the specific concerns.

Objective

The objective of the simulator investigation was to reproduce the accident sequence, evaluate the inputs to the aircraft controls against the autopilot and the reaction of the aircraft if it is consistent to the outputs as seen on the FDR Data, as well to determine existence of any system deficiency for the sole purpose of improvement to safety.

Reinforced door locking mechanism investigations was also performed. The objective being the determination of whether the second crew member was locked out and whether there was a possibility of opening the door from the outside the cockpit or a deliberate inhibit command was initiated.

Organization

The simulator investigation were instituted by Namibia as the State of Occurrence .DAAI was the Authority leading the investigations and involved:

1. Mozambique Ministry of Transport - Authority State of Operator

2. Mozambique Airline Airline/ Operator

Cenipa Authority state of manufacture

Embrear Manufacturer

Azul Airlines Company contracted for simulator investigations

The simulator was developed by Flight Safety International and certified by ANAC (Brazilian Civil Aviation Authority). It was a level D full authority simulator registration ANAC FFS-E190-008.

NB: There are currently four levels of full flight simulator, levels A - D, level D being the highest standard. A Level D/Type 7 FFS also provides motion feedback to the crew through a motion platform upon which the simulator cabin is mounted. The motion platform must produce accelerations in all of the six degrees of freedom (6-DoF) that can be experienced by a body that is free to move in space

1 Analysis

Azul simulator technician received engineering data from the accident FDR which were used to replicate the condition present at the last 12 minutes of the flight. A time frame analysis was used derived from the preliminary analysis by the NTSB (National Transportation Safety Board) which was from 11:04:04 UTC to 11:16:25 UTC.

Four descents were conducted which consist of the last 12 minutes of the flight.

- First decent was performed and was regarded as the training flight for the Embrear test pilots to perfect the inputs as per FDR (Flight Data Recorder) analysis and the time frame reference.
- The second flight was conducted and recorded on camera, no motion was imputed in the simulator so as to accommodate more participants on the cockpit.
- The third flight was performed as per FDR (Flight Data Recorder) outputs and included a
 full recovery before impact to access of mitigation actions were possible even after the
 first EGPWS (Electronic Ground Proximity Warning System) 'PULL-UP' commands with
 speed brakes deployed and engines at idle while.
- The fourth and final descent was conducted with full motion activated and will all action being performed by one crew member sitting on the left as per FDR Data outputs.

Reinforced door locking mechanism investigations was also performed a live aircraft was used where several aural tones were required to determine the sequence of events pertaining to locking and inhibiting opening of the door from outside the cockpit by the other crew member.

Findings

The investigations revealed that at all times during the descents

- The behavior of the simulator was very close to what was recorded on the FDR from the real occurrence.
- II. The behavior was deemed identical although the flight dynamics revealed very small differences which can be attributed to the limitations of replicating all environmental conditions as they prevailed at the time such as actual avionics loads, wind component at actual area, systems logics etc.

It was also evident that actions recorded on the FDR were commanded rather than inadvertent as it required cognitive effort to input at several locations on the cockpit.

It was deduced that logical sequence of inputs were commanded which was a response to corrective actions initiated by the Auto-Pilot.

Findings of the door operations and aural signatures were not concluded as the live aircraft availed by the manufacturer (Embrear) was not fully serviceable.

Finally all participants displayed above concurred that the results were consistent with the Data from the aircraft main Data recorders.

NB: All examinations test and research performed reinforced the facts included in the preliminary report issued earlier by DAAI

Hafeni Mweshixwa Aircraft Accident Investigator Directorate of Aircraft Accident Investigations



MEETING MINUTES - INVESTIGATION

August/19th 2014

Subject: 190-0581 (C9-EMC) Collision with the ground - Simulator Session

Objectives

To reproduce the accident sequence of the LAM accident in Namibia (Nov, 29th 2013) in a simulator of the same aircraft type in Azul training facilities.

Simulator Setup

The simulator was developed by Flight Safety International and certified by ANAC (Brazilian Civil Aviation Authority). It is a level D full flight simulator, registration ANAC FFS-E190-008.

Findings

In total, four simulated descents were performed. All of them were recorded with two cameras. The data of the last two sessions from the simulator were also downloaded. During the third descent, it was conducted a full recovery before impact. The fourth session was conducted with impact, simulator motion activated and with all actions being conducted by one crew member seating on the left seat. All recorded data were shared between the participants. The descents were guided by a script of actions obtained from actual FDR data.

During the third descent, the pilot recovered the airplane by manually applying noseup command when the EGPWS issued the first "PULL UP" alert. The aircraft reached the height of 1,000 ft agl, with the engines remaining in idle setting during the recovery maneuver, which was performed with the speed brakes fully open.

During all simulated descents, the behavior of the simulator was very close to what was recorded on the FDR from the real occurrence. In terms of reactions of aircraft systems, the behavior was identical. In terms of flight dynamics, small differences were observed and can be explained by differences in the environmental conditions of the simulator and the actual occurrence. The participants agreed that no further investigation is necessary because such differences are expected between real and simulated environments.

Also during the simulated descents, it became clear that the actions recorded on the FDR, were commanded rather than inadvertent, since it requires cognitive effort to access the controls on the glareshield and overhead panels. These actions seemed to counteract the corrective responses by the auto-pilot.

Jaxa.

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MEETING MINUTES - INVESTIGATION August/19th 2014

Participants

Name	Signature	Organization
Francisco José Azevedo de Morais	(d)	CENIPA
Eugenio Cara	- end 1°	EMBRAER S.A.
Frederico Moreira Machado	-17-	EMBRAER S.A.
João Rafael Silva	Trans	EMBRAER S.A.
Nilson Perini		EMBRAER S.A.
Sergio George Fell	ALA.	EMBRAER S.A.
João Carlos Pó Jorge	Julin	LAM
Hilário Devis Tembe	SLEDIFI	LAM
Hafeni Mweshixwa	allo	DAAI Namibia
Theo Shilongo	The Orace	DAAI Namibia
Avelino Chiche	Att	IACM Mozambique

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0	Ref.	ALI (II)	MACH / KIAS	VS (rpm)	Pilot Actions	Aircraft Events	LAI MODE	VEHI MODE	AF	AI
5:40	00:00	FL380	0.78	-80	Start		LNAV	VALT	NO	NO
6:36	95:00	FL380	0.78	-64	ALT SEL set to 4,300 ft		LNAV	VALT	NO	NO
6:51	01:11	FL380	0.78	32	ALT SEL set to 1,900 ft		LNAV	VALT	NO	NO
7:06	01:26	FL380	0.78	-64	ALT SEL set to 600 ft		LNAV	VALT	NO	NO
7:20		FL380		32	PACK 2 OFF		LNAV	VALT	NO	NO
7:40	02:00	FL380	0.78	-48	AT NOT ENG		LNAV	VALT	NO	OFF
8:31	02:51	FL380	0.79	-64	FLCH pushbutton	FD: VALT to VFLCH	LNAV	VFLCH	NO	OFF
8:34	02:54	FL380	0.79	-64	VNAV pushbutton	FD: VFLCH to FLCH	LNAV	FLCH	NO	OFF
8:40	03:00	FL380		-16	PACK 2 ON		LNAV	FLCH	NO	OFF
8:42	03:05	FL380		-16	AT ENG	TLA decreases	LNAV	FLCH	NO	NO
8:47	03:07	FL380		-32		PITCH DOWN	LNAV		NO	NO
9:02	03:22	FL379		-1312	AT NOT ENG		LNAV	FLCH	NO	OFF
9:27	03:47	FL367	0.78	-3200	TLA manual increase to near TO/GA		LNAV	FLCH	NO	OFF
9:32	03:55	FL363		-1904	TLA manual decrease to IDLE		LNAV	FLCH	NO	OFF
9:51	04:11	FL359	0.79	-1968	SPD MODE set to Manual		LNAV	FLCH	NO	OFF
9:52		FL359		-1968	SPD SEL set to Mach 0.82		LNAV	FLCH	NO	OFF
0:50		FL339	0.80	-5920	SPD SEL set to Mach 0.79		LNAV	FLCH	NO	OFF
0:27	04:47	FL333		-5056	SPD SEL set to Mach 0.78		LNAV	FLCH	NO	OFF
0:54		FL321	62.0	-2400	Speed Brake Open		LNAV	FLCH	NO	OFF
1:06		FL311		-5440	SPD SEL set to Mach 0.81		LNAV	FLCH	NO	OFF
1:25		FL286	0.77 / 302	-9744	SPD TYPE set to IAS (SEL 315)		LNAV	FLCH	NO	OFF
1:33		FL272	314	-10560		MAX DESCENT RATE	LNAV	FLCH	NO	OFF
1:39		FL262	324	-8656	SPD SEL set to 303 knots		LNAV	FLCH	NO	OFF
1:57	06:17	FL245	317 .	-4304	SPD SEL set to 300 knots		LNAV	FLCH	NO	OFF
2:30	06:50	FL220	303	-5328		ICE DETECTED	LNAV	FLCH	NO	OFF
2:50	07:10	FL201	300	-4448	PACK 1/2 OFF	,	LNAV	FLCH	NO	OFF
2:54	07:14	FL200		-4608			LNAV	FLCH	NO	OFF
3:17	07:37	FL181		-4944	SPD SEL set to 313 knots		LNAV	FLCH	NO	OFF
3:28	07:48	FL171	298	-6352		MASTER CAUTION	LNAV	FLCH	NO	OFF
3:30		FL170		-6352		ICE NOT DETECTED	LNAV	FLCH	NO	OFF
4:05	08:25	FL134	316	-3248	SPD SEL set to 307 knots		LNAV	FLCH	NO	OFF
5:14	09:34	FL081		-3936	SPD SEL set to 293 knots		LNAV	FLCH	NO	OFF
5:20	09:40	FL077		-3584	set to		LNAV	FLCH	NO	OFF
5:29	09:49	FL071		-3824	SPD SEL set to 289 knots		LNAV	FLCH	NO	OFF
6:01	10:21	FL051		-4352	set to		LNAV	FLCH	NO	OFF
6:01		FL051		-4352		EGPWS CAUTION	LNAV	FLCH	NO	OFF
6:14		FL042		-3840		EGPWS WARNING	LNAV	FLCH	NO	OFF
6:26	10:46	FL034	293	-5168		END OF RECORDING	LNAV	FLCH	NO	OFF

THE SEQUENCE OF EVENTS PRESENTED HEREIN WERE OBTAINED FROM FDR DATA PITCH TRIM -1.76° GROSS WEIGHT @ TO 97300 lb

022° 49' 19.19" E

Job No. 296/13:- Out of Phase Check dated 23 October 2013.



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LAM MOZAMBIQUE AIRLINES
TECHNICAL DIRECTION

ENGINEERING & PLANNING DEPARTMENT PLANNING & PRODUCTION CONTROL SECTION EMBRAER 190

OUT OF PHASE - CHECK "6 Months" (07 Cartas) Linhas Aereas de Moçambique A/C TYPE AND MODEL ERJ-190-100IGW / C9-EMC SN 19000581

Job Nr: 296 /13 A/Reg. C9-EMC

START DATE: 23 / 10/13

COMPLETION DATE: 24/10/13

Station: MPM

0.25
GVI MECHANIC 0.25
M.K.A.
GUI MECHANIC 025
DIS MECHANIC 0.33
DIS MECHANIC 033 (17)
RST MECHANIC 1

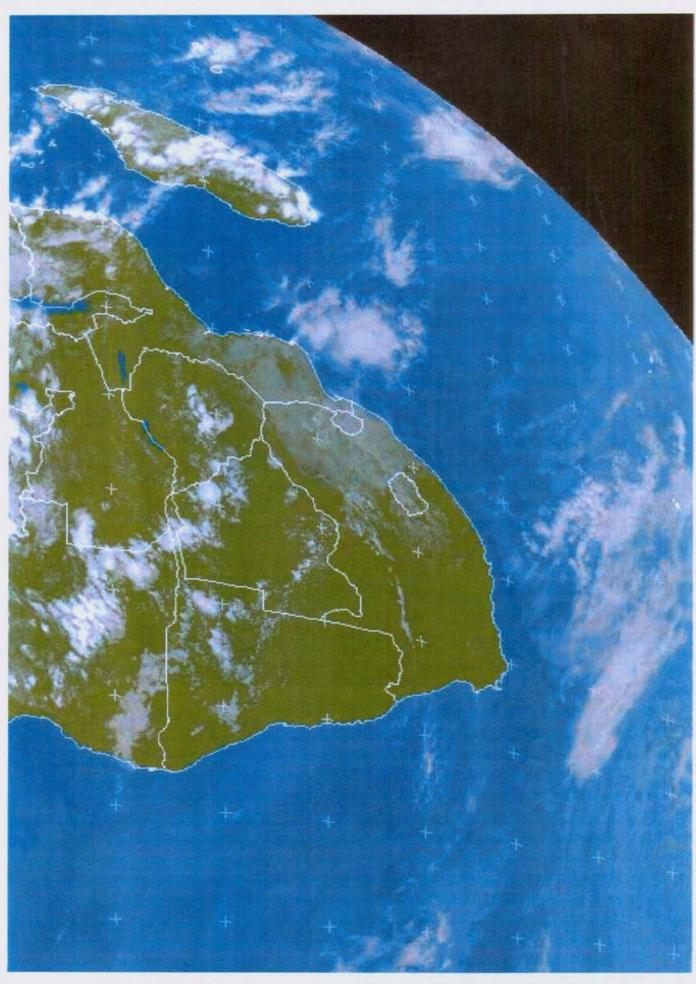
2.66

TOTAL

Weather information as provided by Botswana And Namibia Meteorological Services.

Prevailing Weather at the time of crash

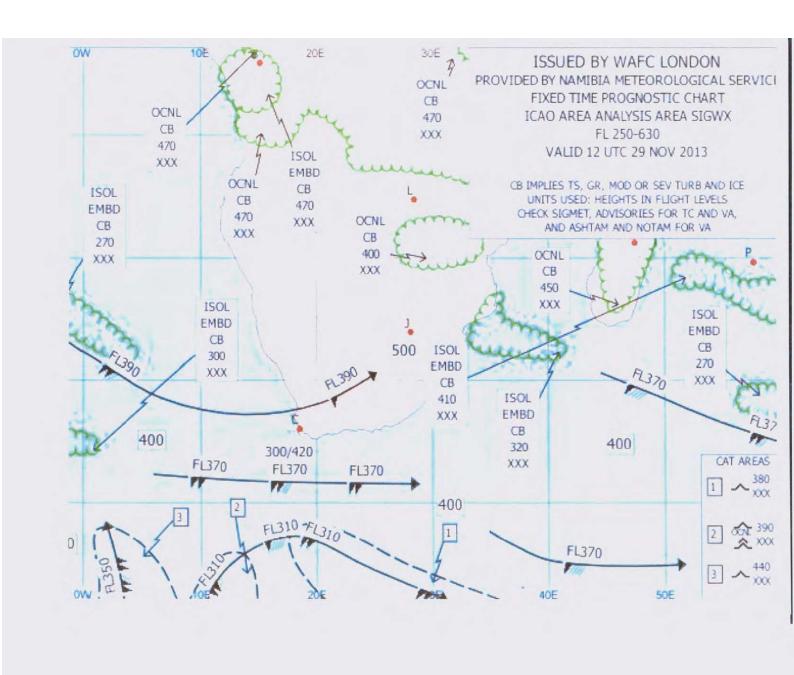
- METAR FYRN 290800Z 26004KT CAVOK 27/15 Q1018=
- METAR FYRN 290900Z 27004KT CAVOK 31/12 Q1017=
- METAR FYRN 291000Z 05006KT CAVOK 33/12 Q1017=
- METAR FYRN 291100Z 09008KT 9999 FEW045TCU 34/12 Q1016=
- METAR FYRN 291200Z 36008KT 9999 FEW045TCU 35/12 Q1014=
- METAR FYRN 291300Z 36010KT 9999 FEW045TCU 35/11 Q1013=
- METAR FYRN 291400Z 09006KT 9999 SCT040CB 35/11 Q1012=

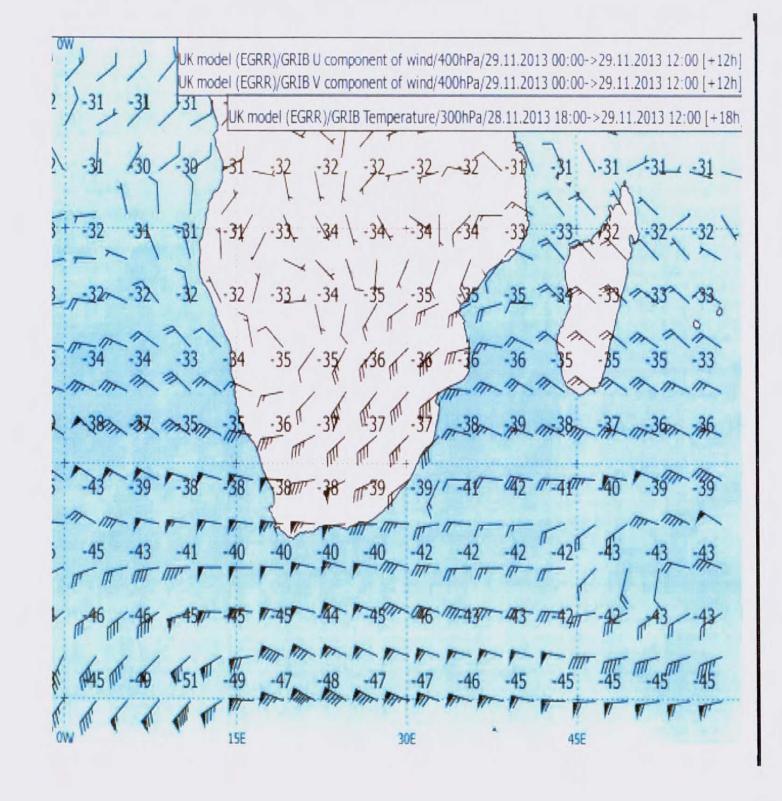


IR108 2013-11-29 12:00 UTC

IR108 2013-11-29 10:00 UTC

FIIMFTCAT





METAR FBMN 291100Z 14011KT CAVOK 32/14 Q1015=

METAR FBMN 291000Z 16012KT 8000 29/15 Q1017=

TAF FBMN 290900Z 2912/2921 33008KT 9999 SCT025 FEW035CB= METAR FBMN 290900Z 17007KT CAVOK 30/14 Q1017=

METAR FBMN 290800Z 08010KT 8000 29/14 Q1017=

METAR FBMN 290700Z 07012KT CAVOK 27/15 Q1017=

TAF FBMN 290600Z 2909/2915 35010KT CAVOK BECMG 2912/2914 FEW035CB=

METARS

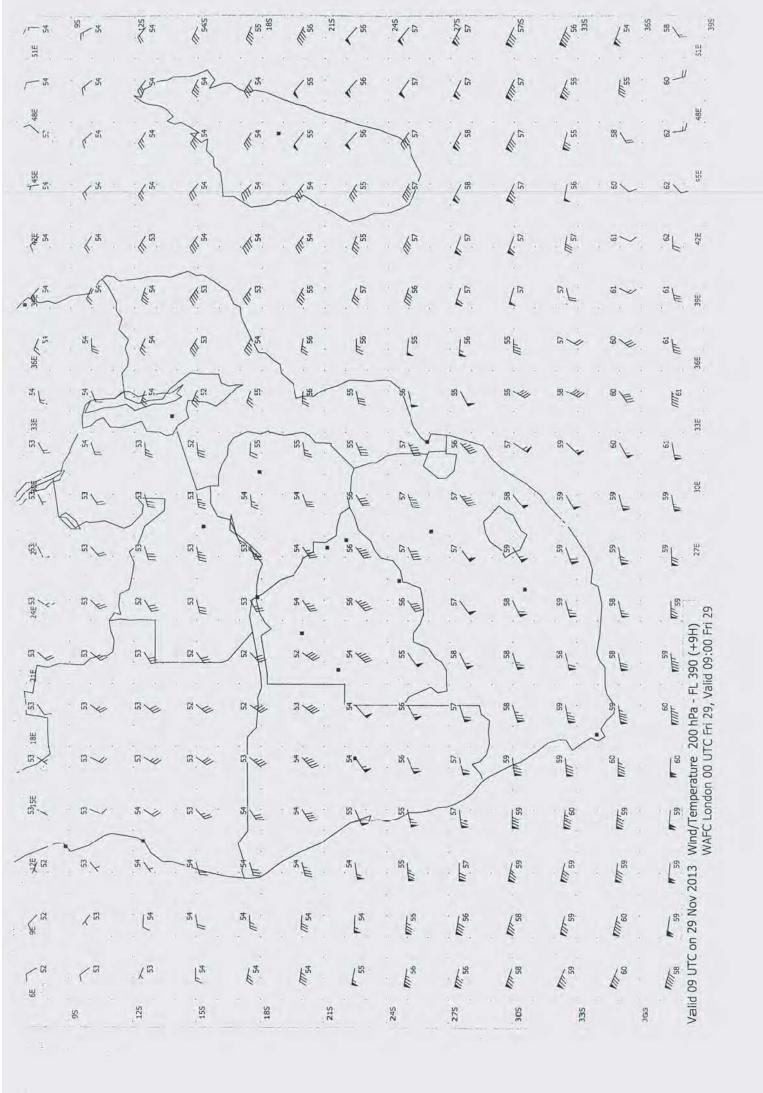
29/11/2013

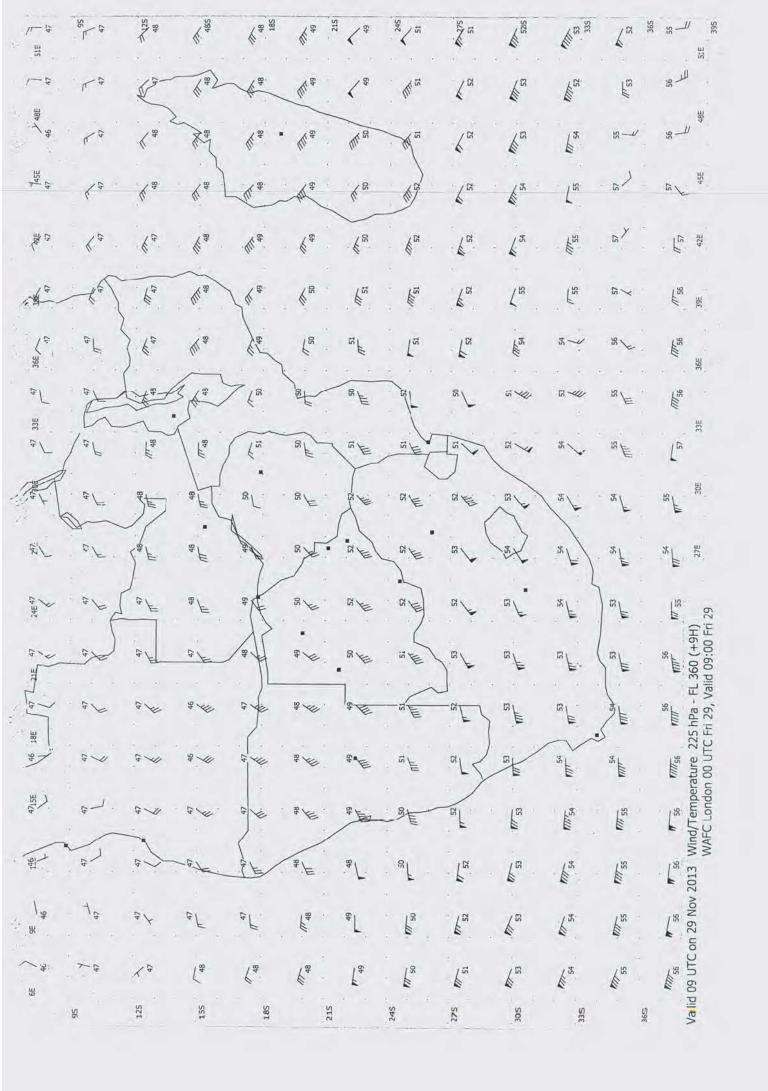
FBSW 290900Z 02007KT 9999 SCT030 33/12=

FBSW 291000Z 27008KT 9999 SCT030 34/12=

FBSW 291100Z 14004KT 9999 SCT030 35/12=

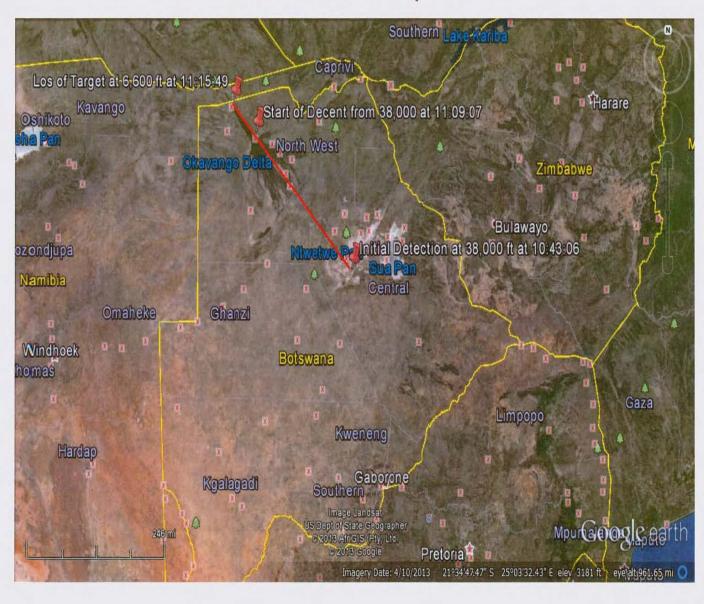
FBSW 291200Z 27005KT 9999 SCT030 36/09=



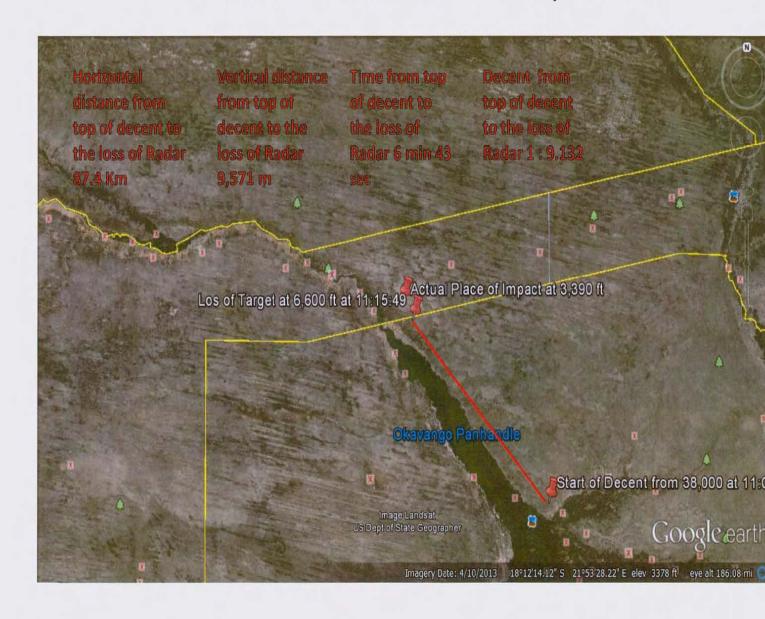


Namibia Wide Area Multirateration (WAM) radar recording information.

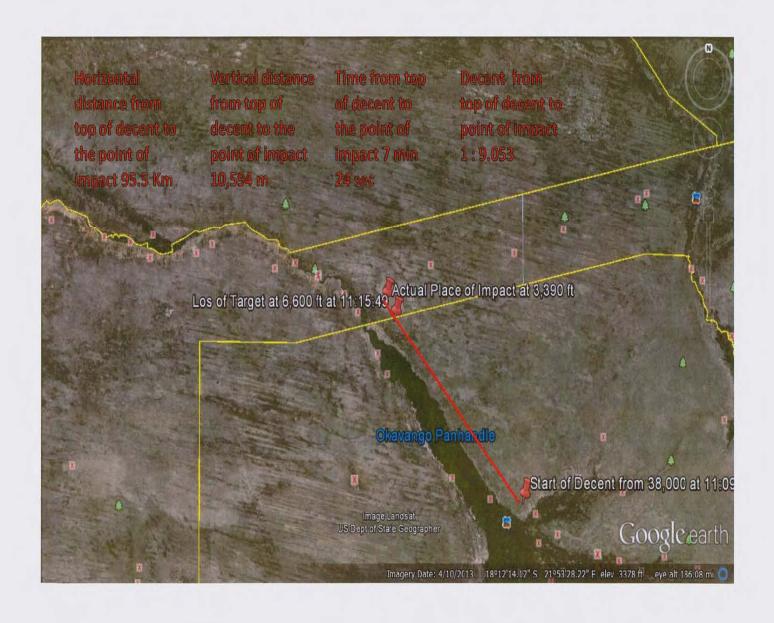
Mozambique (LAM 470)Radar loss of target Gaborone Airspace



Estimates from Descent point to Radar loss while still in Gaborone Airspace



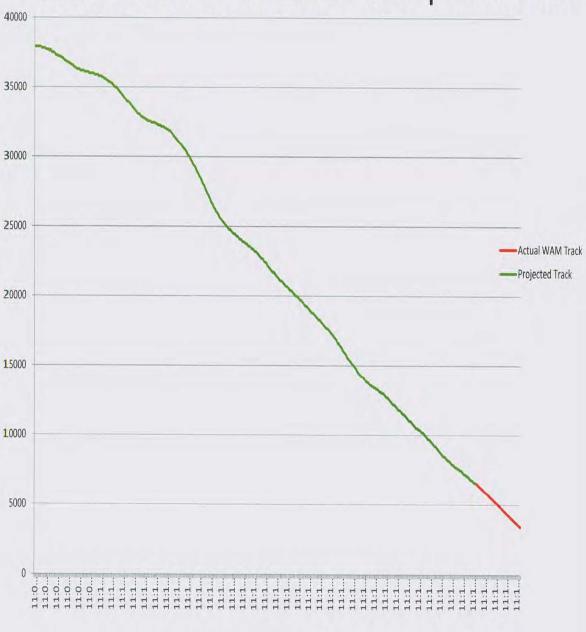
Calculations from descend to point of impact



Measurements from Boarder



Recorded WAM Track from top of decent



Recorded WAM Track from detection



FAA Advisory Circular AC-120-27E: Aircraft Weight and Balance Control.



AC 120-27E

DATE: 6/10/05

ADVISORY CIRCULAR



AIRCRAFT WEIGHT AND BALANCE CONTROL

Flight Standards Service Washington, D.C.

Initiated By: AFS-200/AFS-300

APPENDIX 1. DEFINITIONS

- 1. Basic empty weight. The aircraft empty weight, adjusted for variations in standard items.
- 2. Cargo. As used in this advisory circular (AC), cargo refers to everything carried in the cargo compartments of the aircraft. This includes bags, mail, freight, express, and company material. It also includes live animals, dangerous goods, and hazardous materials as subcategories of the above.
- 3. Carry-on bag. A bag that the operator allows the passenger to carry onboard. It should be of a size and shape that will allow it to be stowed under the passenger seat or in a storage compartment. The operator establishes the exact dimensional limits based on the particular aircraft stowage limits.
- 4. Certificated weight and CG limits. Weight and center of gravity (CG) limits are established at the time of aircraft certification. They are specified in the applicable aircraft flight manual (AFM).
- **5.** Checked bags. Checked bags are those bags placed in the cargo compartment of the aircraft. This includes bags that are too large to be placed in the cabin of the aircraft or those bags that are required to be carried in the cargo compartment by regulation, security program, or company policy. For bags checked plane-side, see the definition for plane-side loaded bags.
- **6. Curtailment.** Creating an operational loading envelope that is more restrictive than the manufacturers' CG envelope, to assure the aircraft will be operated within limits during all phases of flight. Curtailment typically accounts for, but is not limited to, in-flight movement, gear and flap movement, cargo variation, fuel density, fuel burn-off, and seating variation.
- 7. Fleet operational empty weight (FOEW). Average operational empty weight (OEW) used for a fleet or group of aircraft of the same model and configuration.
 - 8. Freight. Cargo carried for hire in the cargo compartment that is not mail or passenger bags.
 - 9. Heavy bags. Heavy bags are considered any bag that weighs more than 50 pounds but less than 100 pounds. Bags that are 100 pounds or more are considered freight.
- 10. Large cabin aircraft. Aircraft originally type-certificated with a maximum seating capacity of 71 or more passenger seats.
 - 11. Loading envelope. Weight and CG envelope used in a loading schedule. Loading the aircraft within the loading envelope will maintain the aircraft weight and CG within the manufacturer's type-certificated limits throughout the flight.
 - 12. Loading schedule. Method for calculating and documenting aircraft weight and balance prior to taxiing, to ensure the aircraft will remain within all required weight and balance limitations throughout the flight.

13. Maximum landing weight. The maximum weight at which the aircraft may normally be landed.

- 14. Maximum takeoff weight. The maximum allowable aircraft weight at the start of the takeoff run.
- 15. Maximum taxi weight. The maximum allowable aircraft weight for taxiing.
- 16. Maximum zero-fuel weight. The maximum permissible weight of an aircraft with no disposable fuel and oil.
- 17. Mean Aerodynamic Chord (MAC). The MAC is established by the manufacturer, which defines its leading edge and its trailing edge in terms of distance (usually inches) from the datum. The CG location and various limits are then expressed in percentages of the chord. The location and dimensions of the MAC can be found in the aircraft specifications, the type certificate data sheet, the AFM, or the aircraft weight and balance manual.
- **18. Medium cabin aircraft.** Aircraft originally type-certificated with a maximum seating capacity between 70 and 30 passenger seats, inclusive.
- 19. Moment. The moment is the product of a weight multiplied by its arm. The moment of an item about the datum is obtained by multiplying the weight of the item by its horizontal distance from the datum.
- **20. Onboard weight and balance system.** A system that weighs an aircraft and payload, then computes the CG using equipment onboard the aircraft.
- 21. Operational empty weight (OEW). Basic empty weight or fleet empty weight plus operational items.
- **22. Operational items.** Personnel, equipment, and supplies necessary for a particular operation but not included in basic empty weight. These items may vary for a particular aircraft and may include, but are not limited to, the following:
 - a. Crewmembers, supernumeraries, and bags:
 - b. Manuals and navigation equipment:
 - c. Passenger service equipment, including pillows, blankets, and magazines:
 - d. Removable service equipment for cabin, galley, and bar;
 - e. Food and beverage, including liquor;
 - f. Usable fluids, other than those in useful load;
 - g. Required emergency equipment for all flights;
 - **h.** Life rafts, life vests, and emergency transmitters;
 - i. Aircraft unit load devices:

- j. Potable water:
- k. Drainable unusable fuel;
- 1. Spare parts normally carried aboard and not accounted for as cargo; and
- m. All other equipment considered standard by the operator.
- 23. Passenger assist/comfort animals and devices. These include, but are not limited to, canes, crutches, walkers, wheelchairs, medically-required animal comfort companions, or animals required to assist the vision impaired.
- 24. Passenger weight. Passenger weight is the actual weight or the approved average weight of the passenger.
 - a. An adult is defined as an individual 13 years or older.
 - b. A child is defined as an individual aged 2 to less than 13 years of age.
- c. Infants are children who have not yet reached their second birthday and are considered part of the adult standard average and segmented passenger weight.
- 25. Personal item. Items the operator may allow a passenger to carry aboard, in addition to a carry-on bag. Typically, an operator may allow one personal item such as a purse, briefcase, computer and case, camera and case, diaper bag, or an item of similar size. Other items, such as coats, umbrellas, reading material, food for immediate consumption, infant restraining device, and passenger assist/comfort animals and devices, are allowed to be carried on the aircraft and are not counted against the personal item allowance.
- 26. Plane-side loaded bag. Any bag or item that is placed at the door or steps of an aircraft and subsequently placed in the aircraft cargo compartment or cargo bin.
- 27. Reference Balance Arm (BA). The horizontal distance from the reference datum to the CG of an item.
- 28. Segmented weights. Passenger weights derived by adding a portion of the standard deviation to an average weight to increase the confidence that the actual weight will not exceed the average weight.
- **29. Small cabin aircraft.** Aircraft originally type certificated with a maximum seating capacity between 5 and 29 passenger seats, inclusive.
- **30. Standard deviation.** One of several indexes of variability that statisticians use to characterize the dispersion among the measures in a given population.
- 31. Standard items. Equipment and fluids not considered an integral part of a particular aircraft and not a variation for the same type of aircraft. These items may include, but are not limited to, the following:

- a. Unusable fuel and other unusable fluids;
- b. Engine oil;
- c. Toilet fluid and chemical;
- d. Fire extinguishers, pyrotechnics, and emergency oxygen equipment;
- e. Structure in galley, buffet, and bar; and
- f. Supplementary electronic equipment.
- **32.** Useful Load. Difference between takeoff weight and OEW. It includes payload, usable fuel, and other usable fluids not included as operational items.

Job No. 317/13:- Intermediate -5(5A) Check "3375 Flight Hours" Dated 14 November 2013.

7 142	START DATE: 14 11/13 COMPLETION DATE: 14/1/13	M	REMARKS																	
A/Reg. C9-EMC	START DATE: 14 11/113 COMPLETION DATE: 14/1/	Station: MPM	INSPECTION	E	3	1	2	2	3	3	3	3	1	200	18					
A/Reg.	STAR		Labour																	
	A) CHECK Cartas)		Estimated	0.25	0.25	0.06	0.00	2 6	140		0.35	0.35	0.30	1 56	2					
	INTERMEDIATE 5 (5A) CHECK "3375 FHIS" (60 Cartas)		SKILL	MECHANIC	MECHANIC	MECHANIC	MECHANIC	MECHANIC	MECHANIC	AVIONIDE	TANKING S	AVIONICS	AVIONICS	INTERIOR	INTERIOR	Charles and an annual section of the				
j		100	Type	OPIC	OPC	SVC	SVC	SVC	SVC	SAC	Column Column	Oper Coper	OPC	FNC	Dec	Odo				
ES DEPARTMENT	PPARTMENT WIROL SECTION ERJ-190-1001GW / C9-EMC SN 19000581			Lorward-Cargo-Compartment Check Valve- Operational Test	Forward-Cargo-Compartment Check Valve Operational Test	Integrated Drive Generator Oil Level - Chock	Integrated Drive Generator Oil Livici Check	Integrated Drive Generator Oil Level - Change	Integrated Drive Generator Oil Level - Check	Servicing of Main Batteries	Servicing of Main Batteries	Essential Contactor (EC) and Essential Tie Contactor (ETC). Organization of Essential Tie	Operational Check of EL1 System	Functional Check of Engine Fire Extinguishing Handle Check if handle is sending the correct signal to trigger Engine Fire Extinguishing Bottle Cannows	Operations Check of Engine Fire Extinguishing Bottle Temperature Compensated Pressure Switch (TCPS). Press the switches button and check fifthe related message is triggered on	Operational Chack of APU Fire Extinguishing Boffic Pressure Switch (TCPS), Press the switch Duffici and chack if the				
E AIRLINES THON ANNING DE UCTION CO OGRAPHICA			P05	0	2	LH	Η̈́	H)	RH	AFT	FWD	0	b	n	0	2				
LAM - MOZAMBIQUE AIRLINES TECHNICAL DIRECTION ENGINEERING & PLANNING DEI	ENGINEERING & PLANNING DEPARTMENT PLANNING & PRODUCTION CONTROL SECTION EMBRAER 190 Linhas Adress de Moçambique A/C TYPE AND MODEL ERJ-190-10010	Task Number	-	21-27-03-710-801-A	21.27.03.710.801.A	12-13-09-210-801-A	12-13-09-210-801-A	12-13-09-210-801-A	12-13-09-210-801-A	24 36-01-610-801-A	24-36-01-610-801-A	24-61-00-710-801-A	25.61 00-710-881-A	26-21-00-700-801-A	26 21 03 700 801.A	26-22-01-700-891-A				
W// //	WPD Task		MPD Task		WPD Task			41-27 03-001	21-27-03-001C	21 21 00:001	24.21-00-001	24-21.11.001	24-21-11-001	24-36 00-001	24-36-00-001	24-61-00:001	25-61-01-001	26-21-01 001	26-21-05-902 2	26-22 03-002 2
COLUMN TO A STATE OF THE STATE		y ATA	-	2100	2100	2400	2400	2400	2400	2400	2400	2400	2500	2600	2600	2600				
-161	×137	Q.	0	2	02	03	De	02	8	20	80	60	0	22	24	13				

<u>Technical delays and Cancellation details</u> <u>report.</u>

TECHNICAL DELAYS AND CANCELLATION DETAILS

A/REG	ATA FLT NO DELAY DELAY DATE STN REA		REASON	ACTION PWR UP PWR DOWN AND RETURN TO SERVICE				
C9-EMC	27	27 470 41 0:30 23-Jan-13 MPM FLT CTRL NO DISPATCH						
C9-EMC		467	41	0:50	3-Feb-13	MPM	FIRST AID KIT MISSING	FIRST AID KIT PLACED
C9-EMC	32	4463	44	0:00	19-Mar-13	NBO	LANDING GEAR NO DISPATCH (NIC+PRO)	THE FLIGHT CANCELED
C9-EMC	52	4462	41	0:50	25-Jun-13	мем	AUXILIARY CATRIDGE OPENING DOOR PRESSURE BELOW LIMIT	AUXILIARY PNEUMATIC CATRIDGE RECHARGED
C9-EMC	35	130	41	0:42	8-Jul-13	MPM	BLEED #2 FAIL	A/C DISPACHED PER MMEL 35-1-ITM 00-00
C9-EMC	32		41	0:30	31-Jul-13	МРМ	NOSE LANDING GEAR DOOR OPEN	ON NLG FOUND ROD ASSY DOOR BROKEN DUE THE BIRD STRACK, THE EQUIPMENT CHANGED
C9-EMC	36	130	41	0:40	26-Aug-13	МРМ	ADS 1 HTR FAIL	SYSTEM RESET PERFORMED P/UP AND P/DOWN C/OUT
C9-EMC	36	155	41	0.25	9-Aug-13	MPM	A.T.B DUE TO ECS PRESSURIZATION AT 21000FT, 28000FT (SIGNS OF ALL EMERGENCY EXIT DOORS OPENED DURING FUGHT)	BOTH LH AND RH EMERGENCY EXIT DOORS SEALS CLEANED
C9-EMC	73	312 41 1:30 31-Oct-13 MPM ENGINE # 1 NO DISPATCH		ENGINE # 1 NO DISPATCH	ENGINE FADEC #1 REPLACED IAW AMM TASK 73 21-01-400-801			

TECHNICAL INCIDENTS DETAILS

A/CREG	serial number	Station Hight	Occurance	Defect found	Date	Action
C9-EMC	19000581	MPM	A.T.B*	NLG REAR DOOR LINKAGE BROKEN P.N 170-70760-401 (BIRD STRIKE)	30/07/013	NLG REAR DOOR LINKAGE REPLACED IAW AMM TASK 32-22-03-400-801-A
C9-EMC	19000581	МРМ	A.T.B*	A.T.B. DUE TO ECS PRESSURIZATION AT 21000FT, 28000FT (SIGNS OF ALL EMERGENCY EXIT DOORS OPENED DURING FLIGHT)	9/08/013	BOTH LH AND RH EMERGENCY EXIT DOORS SEALS CLEANED

^{*}A.T.B - AIR TURN BACK

The Captain's 72 Hrs history before the accident.



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Exmo. Senhor Director Nacional de Transportes Att.: Dr. Chiche

Maputo

Ref^a 88/ATO-LAM/2014

5 de Dezembro de 2014

ASSUNTO: <u>Prestação do Comandante Hermínio Fernandes 72 horas antes do acidente</u> de 29 de Novembro de 2013

Exmo. Senhor.

Relativamente ao assunto identificado em epígrafe, serve a presente para informar que a empresa apenas conseguiu obter informações relacionadas ao vínculo do comandante à empresa:

- 26 de Novembro -v\u00f3o no percurso Maputo-Tete-Maputo (TM 136-137)
- 27 de Novembro -vôo Maputo-Joanesburgo-Maputo (TM 315-306)
- 28 de Novembro-folga
- 29 de Novembro -vôo TM 470

Esperando de V. Excia o melhor acolhimento, aproveitamos para endereçar os nossos melhores cumprimentos.

João Carlos Pó Jorge

Administrador Técnico Operacional

Dear Sir

Att: Mr. Chiche

National Director of Transports

Maputo

Ref: 88/ATO-LAM/2014

5 December 2014

Ref: Rendering of service by Captain Herminio Fernandes 72 hours before the accident on the 29th November 2013

Dear Sir

With reference to the above matter, it is hereby informed that, the Airline could only obtain information related to the captain that pertain the airline:

- 26th November flew on the rout Maputo Tete Maputo (TM 136 137)
- 27th November flew Maputo Johannesburg Maputo (TM 315 306)
- 28th November Leave
- 29th November flew TM 470

Sincerely yours,

João Carlos Pó Jorge

Technical Operational Administrator