AIRCRAFT INCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/3/2/1281		
Aircraft Registration	**ZS-SJD**	**Date of Incident**	2 September 2019		**Time of Incident**	0625Z	
Type of Aircraft	Boeing 737-800		**Type of Operation**		Air Transport Operation (Part 121)		
Pilot-in-command Licence Type	Airline Transport Pilot Licence		**Age**	43	**Licence Valid**	Yes	
Pilot-in-command Flying Experience	Total Flying Hours		12 345.2		Hours on Type	3 696.4	
Last Point of Departure	O.R. Tambo International Aerodrome (FAOR), Gauteng Province						
Next Point of Intended Landing	Cape Town International Aerodrome (FACT), Gauteng Province						
Location of the incident site with reference to easily defined geographical points (GPS readings if possible)							
At waypoint UTEBA on GPS co-ordinates: 26° 57’ 08.34” South 027° 02’ 10.63” East at flight level (FL) 360.							
Meteorological Information	Wind direction and speed: 280° at 6kts; Visibility: 9999m; Temperature: 13°C; Dew point: 4°C; QNH: 1029hpa.						
Number of People On-board	2+4+141	**No. of People Injured**	0	**No. of People Killed**	0		
Synopsis							

On 2 September 2019 at approximately 0554Z, a Boeing 737-800 aircraft with registration ZS-SJD departed O.R. Tambo International Aerodrome (FAOR) in Gauteng on a scheduled domestic flight to Cape Town International Aerodrome (FACT) in the Western Cape. There were two pilots (pilot-in-command and first officer), four crew members and 141 passengers on-board the aircraft.

The crew reported that just before the aircraft levelled off at Flight Level (FL) 360 overhead Bothaville (Free State Province), the “stab out of trim” light illuminated in the instrument panel and remained on. The crew actioned the recommendation stated in the Quick Reference Handbook (QRH) by disengaging the autopilot. Following the disengagement of the autopilot, the aircraft’s nose pitched down, indicating a significant horizontal stabiliser out of trim condition. Again, the crew referenced the QRH and followed the instructions to override the horizontal stabiliser electric motor clutch by applying force to the trim wheels to keep it in the set position; thereafter, manual horizontal stabiliser trim was achieved. The crew stated that they were able to control the aircraft, but the automated horizontal stabiliser electrical trim was not responsive. The pilot-in-command (PIC) advised the Johannesburg radar controller that the autopilot had been disengaged and that they were no longer compliant with the requirements of the Reduced Vertical Separation Minimum (RVSM). The radar controller then cleared the aircraft to descent to FL280 (28000 feet). After considering that FL280 will have an impact on fuel planning, the crew declared an emergency by broadcasting a “PAN PAN PAN” on frequency 128.3 megahertz (MHz) and requested to return to FAOR. The radar controller approved their request and provided the crew with vectors back to FAOR. Emergency services were requested to be on standby during the landing phase as the maximum flap setting was limited to 15°. The crew carried out an instrument landing system (ILS) approach with the aircraft trimmed manually. The aircraft landed safely on Runway 03L at 0649Z. The aircraft was not damaged, and no occupants were injured during the incident.

The investigation revealed that whilst levelling off at top of climb, the elevator continued to move in the nose up direction without the stabiliser moving in unison, causing the “stab out of trim” light to illuminate. After the crew had disconnected the autopilot, the elevator moved further to a nose up position (original position) in response to the manual column input. The cause of the stab trim not moving with the elevator could not be determined as all tests conducted on the system were satisfactory.

SRP Date	1 December 2020	Publication Date	3 December 2020

ABBREVIATION	DESCRIPTION
^{o}C	Degree Celsius
AC	Approval Certificate
AIID	Accident and Incident Investigations Division
AMO	Approved Maintenance Organisation
AOC	Air Operator Certificate
AR	Accredited Representative
ATC	Air Traffic Control
ATNS	Air Traffic and Navigation Services
ATPL	Airline Transport Pilot Licence
B737 NG	Boeing 737 Next Generation
CAR	Civil Aviation Regulations
CAVOK	Ceiling and Visibility OK
CoA	Certificate of Airworthiness
CVR	Cockpit Voice Recorder
DFCS	Digital Flight Control System
DFDR	Digital Flight Data Recorder
DVOR	Doppler Very High Frequency Omni Range
FACT	Cape Town International Aerodrome
FAOR	O.R. Tambo International Aerodrome
FCC	Flight Control Computer
FDAU	Flight Data Acquisition Unit
FL	Flight Level
FO	First Officer
ft	Feet
GPS	Global Positioning System
hPa	Hectopascal
IFR	Instrument Flight Rules
ILS/DME	Instrument Landing System/ Distance measuring equipment
ILS LOC	Instrument Landing System Localiser
ILS GP CAT II	Instrument Landing System Glide Path Category II
IQSMS	Integrated Quality and Safety Management System
kt	Knot
MHz	Megahertz
PAN PAN PAN	International Standard Urgency Signal
PIC	Pilot-in-command
PWA	Printed Wire Assembly
QNH	Query: Nautical Height
QAR	Quick Access Recorder
QRH	Quick Reference Handbook
RVSM	Reduced Vertical Separation Minimum
SACAA	South African Civil Aviation Authority
SOC Ltd	State-owned Company Limited
STM	Stabiliser Trim Motor
TOC	Top of Climb
UHF DME	Ultra High Frequency Distance Measuring Equipment
USA	United States of America
UTC	Co-ordinated Universal Time
VHF	Very High Frequency

Reference Number	**:** CA18/3/2/1281
Name of Owner	**:** Mango Airlines SOC Ltd
Name of the Operator	**:** Mango Airlines
Manufacturer	**:** Boeing Aircraft Company
Model	**:** Boeing 737-800
Nationality	**:** South African
Registration markings	**:** ZS-SJD
Place	**:** Overhead waypoint UTEBA (near Bothaville)
Date	**:** 2 September 2019
Time	**:** 0625Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to apportion blame or liability****.*

Investigations process:

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was informed about an incident involving a Boeing 737-800 aircraft, which occurred overhead waypoint UTEBA (near Bothaville Free State Province) on 2 September 2019. The AIID was notified of the incident through the Integrated Quality and Safety Management System (IQSMS) on 2 September 2019 at 1130Z.

The AIID appointed an investigator-in-charge with an investigation team. A notification was sent to the State of Manufacture and Design, which is the United States of America (USA). The State (USA) had assigned an Accredited Representative to the investigation. The AIID will lead the investigation and issue a final report.

Notes:
1. Whenever the following words are mentioned in this report, they shall mean the following:

- *Incident – this investigated incident*
- *Aircraft – the Boeing 737-800 involved in this incident*
- *Investigation – the investigation into the circumstances of this incident*
- *Pilot – the pilots involved in this incident*
- *Report – this incident report*

2. Photos and figures used in this report were taken from different sources and may be adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report are limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows or lines.

Disclaimer:

This report is produced without prejudice to the rights of the AIID, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On 2 September 2019 at approximately 0554Z, a Boeing 737-800 aircraft with registration ZS-SJD and an allocated flight number JE129 departed O.R. Tambo International Aerodrome (FAOR) on a scheduled domestic flight to Cape Town International Aerodrome (FACT) with two pilots, four crew members and 141 passengers on-board. The aircraft was flown under Instrument Flight Rules (IFR) and the weather conditions were reported to be fine. The flight was conducted under the provisions of Part 121 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2 According to available information, the aircraft took off from Runway 03L at FAOR, and the pilot-in-command (PIC) reported that just before the aircraft levelled off at Flight Level (FL) 360 overhead Bothaville in the Free State province, the *stab out of trim* light illuminated in the cockpit and remained on with the autopilot engaged. The crew then referenced and actioned the Quick Reference Handbook (QRH) instructions by disengaging the autopilot (see Appendix A). Following the disengagement of the autopilot, the crew noticed that there was a significant out of trim condition as well as limited pitch control, and thus, the aircraft's nose pitched down.

1.1.3 The crew then referenced and followed the QRH instructions to override the electric horizontal stabiliser motor clutch by applying force to the trim wheels to achieve manual horizontal stabiliser mode. The crew stated that they were able to control the aircraft, but the automated electric horizontal stabiliser trim was not responsive.

1.1.4 The PIC then advised the radar controller that the autopilot had been disengaged and that they were no longer compliant with the requirements of the Reduced Vertical Separation Minimum (RVSM). The radar controller then cleared the crew to make a descent to FL280 (28000). Because of the calculated fuel on-board the aircraft, which was planned for FL360, the crew noted that the alternative flight level (FL280) would have a negative impact on fuel. Also, considering that the aircraft had no horizontal electric trim and the flight controls were no longer in a normal state of flight, the crew decided to request an air turn back to FAOR. The crew declared an emergency by broadcasting a *PAN PAN PAN* on frequency 128.3 megahertz (MHz) and requested to return to FAOR. The radar controller then approved their request and provided the crew with vectors back to FAOR. The crew was advised to turn left on waypoint NIBEX and route direct approach to FAOR. Emergency services were requested to be on standby as the maximum flap setting was limited to 15° for landing. The crew carried out a normal instrument landing system (ILS) approach utilising manual trimming.

1.1.5 The aircraft landed safely on Runway 03L at 0649Z. After vacating the runway, the aircraft was taxied to the apron and the emergency services stood down. No injuries were reported, and all crew and passengers disembarked the aircraft safely. The aircraft's damage was limited to the stab trim motor. The aircraft was towed to a hangar where troubleshooting was carried out.

1.1.6 The incident occurred during daylight at waypoint UTEBA, which is 77 nautical miles (nm) from Bram Fisher International Aerodrome in the Free State province at Global Positioning System (GPS) co-ordinates: 26° 57’ 08.34” South 027° 02’ 10.63” East and at an altitude of 36000 feet (FL360).

Figure 1: The Boeing 737-800 with registration ZS-SJD. (Source: www.airliners.net)

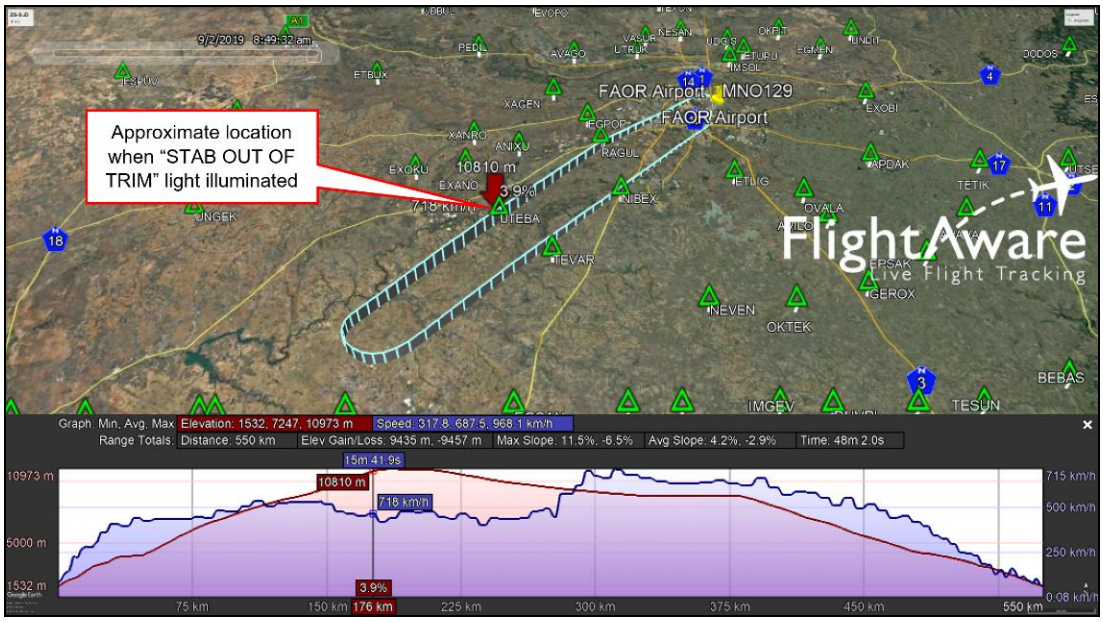


Figure 2: An overlay of the flight profile.
(Source: https://flightaware.com and https://www.google.com › earth)

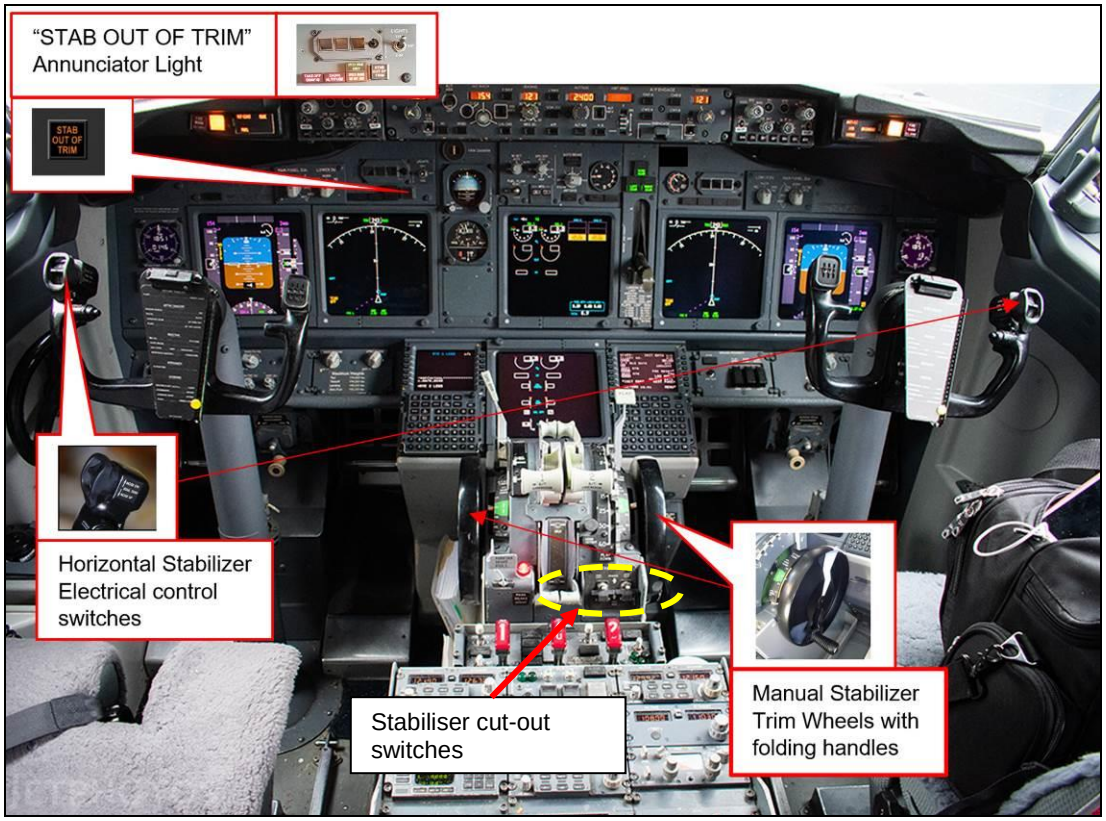


Figure 3: The B737-800 cockpit layout showing horizontal stabiliser controls and annunciator light. (Source: https://www.jetphotos.com)

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	4	141	-

1.3 Damage to Aircraft

1.3.1 None.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1. Pilot-in-command (PIC)

Nationality	South African	Gender	Male	Age	43
Licence Number	0270275845	Licence Type	ATPL		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument				
Medical Expiry Date	30 January 2020				
Restrictions	None				
Previous Incidents	None				

1.5.1.1 The PIC was initially issued an Airline Transport Pilot Licence (ATPL) on 26 February 2001 with an expiry date of 30 April 2020, and the aircraft type was endorsed on his licence. The PIC had a valid Class 1 medical certificate issued on 18 January 2019 with an expiry date of 31 January 2020, and with no restrictions. The PIC's last skills test was carried out on 26 March 2019 with an expiry date of 30 April 2020.

Flying experience:

Total Hours	12 345.2
Total Past 90 Days	61.2
Total on Type Past 90 Days	61.2
Total on Type	3 696.4

1.5.2. First officer (FO)

Nationality	South African	Gender	Male	Age	29
Licence Number	0272410473	Licence Type	ATPL		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument				
Medical Expiry Date	31 October 2019				
Restrictions	None				
Previous Incidents	None				

1.5.2.1The first officer (FO) was issued an ATPL on 5 February 2018 with an expiry date of 31 January 2020. The aircraft type was endorsed on his licence. The FO had a valid Class 1 medical certificate issued on 25 October 2018 with an expiry date of 31 October 2019, and with no restrictions. The FO's last skills test was carried out on 7 January 2019 with an expiry date of 31 January 2020.

Flying experience:

Total Hours	2 592.9
Total Past 90 Days	140.2
Total on Type Past 90 Days	140.2
Total on Type	1 888.8

1.6 Aircraft Information

Airframe

Type	Boeing 737-800	
Serial Number	28829	
Manufacturer	Boeing Aircraft Company	
Year of Manufacture	2000	
Total Airframe Hours (at time of incident)	47 837.1	
Last CKC (hours & date)	46 593.5	8 November 2018
Last CKA (hours & date)	47 703.0	1 August 2019
Hours Since Last A Check	134.1	
C of A (issue date)	30 June 2000	
C of A (expiry date)	30 June 2020	
C of R (issue date) (present owner)	12 October 2018	
Operating Categories	Standard Part 121	

1.6.1 Maintenance history and defects relating to elevator and horizontal stabiliser system (ZS-SJD):

(i) It was noted that between 22 May and 26 July 2019, maintenance was carried out on the aircraft ZS-SJD following a flight crew report that the aircraft started oscillating in-flight. The following inspections were conducted:

- Horizontal Stabiliser centre section hinge bearing
- Horizontal Stabiliser jackscrew
- Elevator control pushrod
- Elevator Pitch Control Unit input rod
- General inspection (damaged part, loose parts or objects that prevent smooth movement)
- Quadrant stops
- Feel force
- Elevator tab control
- Torque tube

All tests and inspections (above) were found to be satisfactory by the aircraft maintenance organisation (AMO).

(ii) It was also noted that the horizontal stabiliser trim motor with serial number 3329 was removed by the contracted AMO on 5 August 2019 from ZS-SJD to service another aircraft (ZS-SJA) in the operator's fleet. According to the work order (WO) 2939403, the horizontal stabiliser trim motor with serial number (S/N): 3680 was fitted on ZS-SJD on 8 August 2019 following the repair as it was due for modification embodiment. The stab trim motor S/N: 3680 was later removed on 2 September 2019 at 47830:25 airframe hours following the *stab out of trim* warning in the cockpit. Since installation of S/N: 3680 on 8 August 2019, the stab trim motor only accrued 125.11 hours in 26 days. According to the operator, the aircraft averages 200 flight hours in a month cycle.

(iii) The repair history of the stabiliser trim motor (S/N: 3680) dates to 10 July 2019 when the component was released on a Federal Aviation Administration (FAA) form 8130-3 (authorised release certificate) after the control Printed Wire Assembly (PWA) board (P/N: 6355-230-13R) was replaced. According to the material certification form, modifications 7 & 9 were embodied on the S/N: 3680. The control PWA was replaced because it was reported by another operator that *"no electrical movement of stab during flight from time to time"* on a Boeing 737-400 (VQ-BVF). The time since new (TSN) and time since overhaul (TSO) as well as cycles since new (CSN) and cycles since overhaul (CSO) of the component were recorded as unknown in the inspection and repair report on the FAA form 8130-3. However, according to the repair label supplied by the AMO, the date of manufacture is 1 January 1972 and TSN is recoded as 125 hours and CSN as 96 cycles.

(iv) Following the incident, the AMO conducted troubleshooting. The fault isolation manual (FIM) 22-11 task 801 para. (A) 1-4 was used to isolate the fault. It was stated that the faults that were showing on the Multifunction Control Display Unit (MCDU) were:

- Suspected line replacement unit (LRU)
- Stab trim cut out relay
- Stab limit SW/module
- Pre-elect Act-stab trim
- Col SW/module

(v) According to the WO 2974260, the gears/sprockets and stabiliser control cable and chain were inspected for correct play, adjustment and free routing; they were found to be satisfactory. The chain play and measurement were found to be within limits at 7.9mm; cable tension was checked and found to be within limits at 122 pounds; there were nil defects found. All related system components (Automatic Flight Control System [AFCS], flight control cables and functional checks) were satisfactory. All work carried out was in accordance with (IAW) task 27-41-00-820-801. In the jackscrew compartment, visual inspection of the stabiliser trim ball nut and jackscrew gearbox were carried out and no defects were found; there was also no evidence of cable jamming or foreign object damage (FOD). Following troubleshooting, the fault was isolated to be the stabiliser trim motor as it could not trim manually and electrically during operation. The stabiliser trim motor S/N: 3680 was removed and replaced with S/N: 6246 on 3 September 2019 at 47830.25 airframe hours and 31813 aircraft cycles. The S/N: 6246 was cannibalised from ZS-SJB and was fitted to ZS-SJD. According to the component release certificate (FAA Form 8130-3), it was released on 24 March 2014. The failed stab trim motor was retrieved and sent to the AIID for testing and analysis. The AIID collaborated with the manufacturer to conduct testing of the stab trim motor in the presence of the Accredited Representative. The testing report is covered under paragraph 1.16. All work carried out was in accordance with the maintenance manual Task 27-47-71-400-801 Rev 69 as recorded on the WO 2974260, however, not all the values were recorded on the WO as required by the Civil Aviation

Regulations (CAR) 43.03.1 (d).

(vii) According to Fleet Team Digest booklet generated on 7 October 2019 by Boeing and Eaton aerospace, the manufacturer (Eaton aerospace) of the stab trim motor along with the aircraft manufacturer initiated the investigation on stabiliser trim motor P/N: 6355C0001-01 low reliability. “Numerous operators had reported early removals of the stabiliser trim motor (STM) P/N: 6355C0001-02 and 6355C0001-01 (units removed with less than 10.000 flight hours). The stabiliser trim motor exhibited a high rate of no fault found, >50%, when tested at Eaton, and an investigation was initiated. Boeing and Eaton held an initial face-to-face meeting in September 2012 and had formed a working together team to improve the overall reliability of the current production STM P/N: 6355C0001-01. The final action, which was the interim solution, was a design change of the control Printed Wire Assembly (PWA) which is STM P/N: 6355C0001-02, interchangeable with P/N: 6355C0001-01. For reference, a summary of changes made to the P/N: 6355C0001-01 stabiliser trim motor can be found in 737-SL-27-225-A” (see Annexure 4).

(viii) On 3 March 2020, a fleet inspection on stab trim motor part number 6355C0001-01 and modification status level 9 was carried out by the operator, and modification 9 was found to have been embodied on S/N: 3680, 2811 and 6246 in accordance with service letter 737-SL-27-267 and 737-SL-27-225-A. It was also noted that the operator had reliability stats for the fleet on which all defects sustained by the fleet were recorded and analysed. The reports from April until June 2019 were shared with the investigators. The reports verify all the activities recorded on the WOs for the STM. All related system components (AFCS, flight control cables and functional checks) were satisfactory. The aircraft maintenance engineer (AME) who signed out the installation of the STM task was in possession of the company certificate of approval (Boeing 737/800 and engine CFM 56 series) and the type was endorsed on his SACAA-issued AME licence (0272223231). His AME licence was issued on 28 July 2018 with an expiry date of 27 August 2020, and the aircraft type was endorsed on his licence.

1.6.2 The weight and balance of the aircraft was within limits and below the maximum landing mass of 65317kg (144000lbs). The aircraft took off at 0554Z and landed at 0649Z and had been airborne for approximately 0.7 of an hour, excluding taxiing time. The total fuel at take-off was recorder as 9000kg and at landing as 6350kg.

Engine No. 1

Type	CFM56-7B27
Serial Number	P877311
Hours Since New	43 570.2
Hours Since Overhaul	Modular assembly

Engine No. 2

Type	CFM56-7B27
Serial Number	P876424
Hours Since New	44 536.4
Hours Since Overhaul	Modular assembly

1.7 Meteorological Information

1.7.1 The weather information on the table (below) was obtained from the pilot questionnaire and the mandatory occurrence report (MOR) submitted by the Air Traffic and Navigation Services (ATNS) on 2 September 2019 at 0621Z.

Wind direction	280º	Wind speed	6kts	Visibility	9999
Temperature	13ºC	Cloud cover	Nil	Cloud base	Nil
Dew point	4ºC	QNH	1029 hPa		

1.8. Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational equipment as approved by the Regulator (SACAA) for the aircraft type. There was no record indicating that the navigation system was unserviceable prior to or during the incident.

1.8.2 The aircraft was vectored to turn left to waypoint NIBEX, NIBEX 1 Bravo and route for a direct approach Runway 03L where a normal ILS manual approach was carried out.

1.9 Communication

1.9.1 The aircraft was equipped with standard communication equipment as approved by the Regulator. There were no recorded defects prior to or during the incident.

1.9.2 The aircraft was in communication with Johannesburg South-west radar control on the very high frequency (VHF) 128.3 MHz and had declared an emergency by broadcasting a PAN PAN PAN.

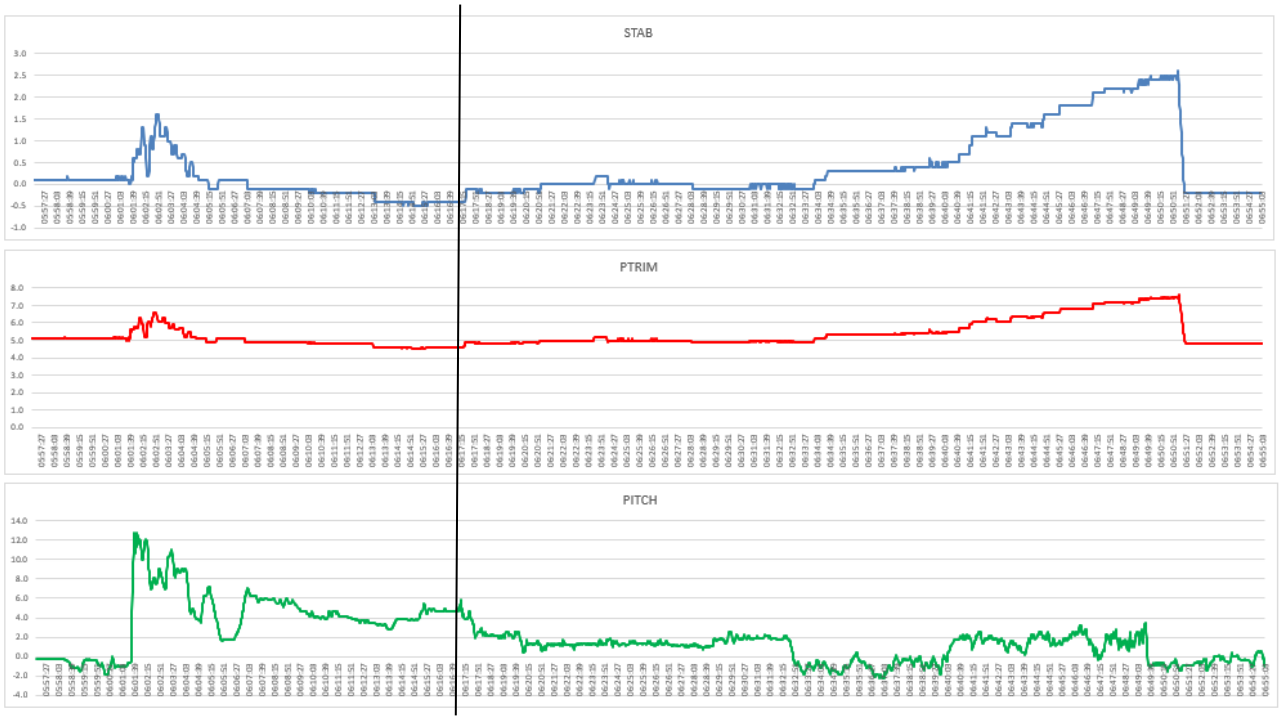
1.10 Aerodrome Information

1.10.1 The incident did not occur at or near a licensed aerodrome. The incident occurred at waypoint UTEBA at GPS co-ordinates: 26° 57’ 08.34” South 027° 02’ 10.63” East at FL360.

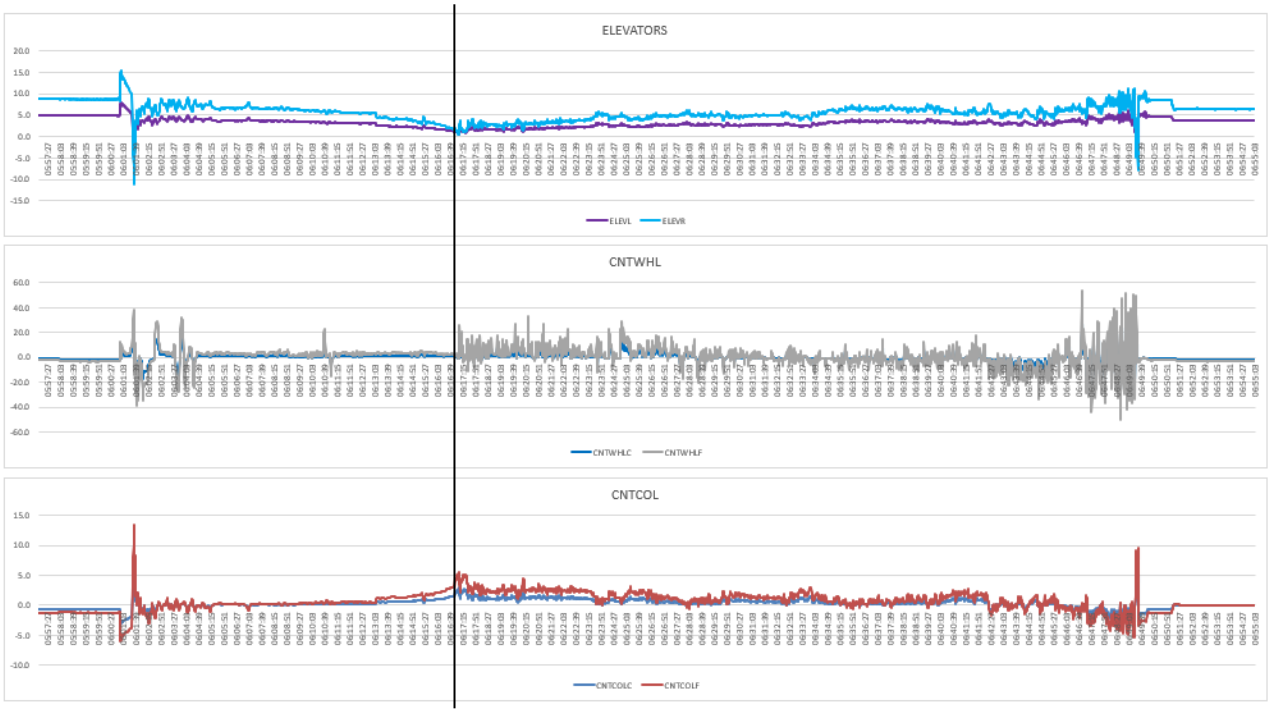
1.11 Flight Recorders

1.11.1 The aircraft is equipped with a Quick Access Recorder (QAR), Digital Flight Data Recorder (DFDR) and a Cockpit Voice Recorder (CVR). The AIID received the QAR data from the operator. Below is the downloaded data from the QAR.

Stabiliser position, pitch trimmer position and pitch angle



Elevator position, control wheel position and control column position



Engine speed, calibrated air speed and pressure altitue

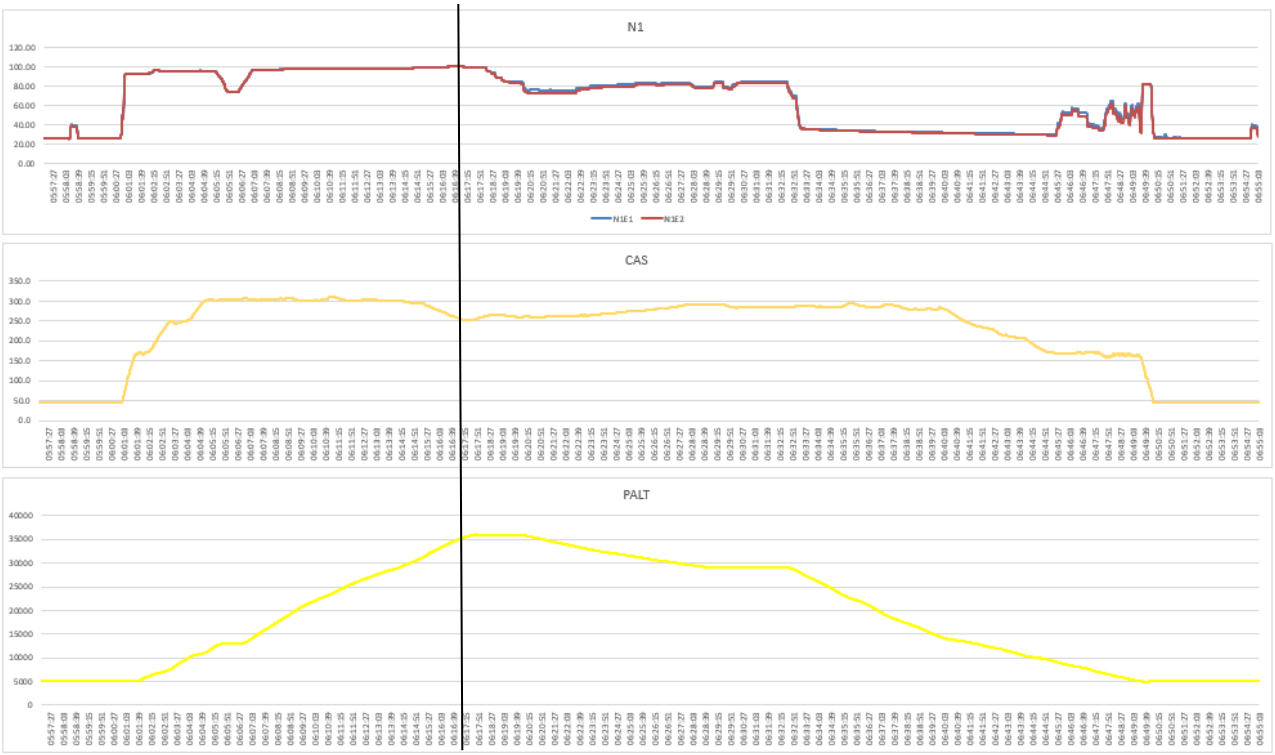


Figure 5: The downloaded QAR data of the incident flight. The (vertical) line shows where the event took place.

1.11.2 The QAR data depicted in Figure 5 indicates that at top of climb (TOC) after levelling off at FL360 at 0616:55, the horizontal stabiliser out of trim occurred as indicated by the manual reversions on the graph of control wheel and control column.

1.11.3 Boeing Analysis of QAR data:

Autopilot was engaged shortly after takeoff and disengaged around time 6:16:51 Auto throttle disengaged around time 6:17. The stabilizer position sensor was reporting -0.4 deg at time of AP disconnect. Stabilizer position was 0.1 deg at takeoff and as high as 1.6 deg during climb. The data indicates this stabilizer activity was through electric trim operation during this time window and operating appropriately until 6:13:07. Stabilizer moved between -0.4 deg and 2.4 deg between 6:16:51 (A/P disconnect) and landing. Based on the pilot report, this data suggests the flight crew was positioning the stabilizer manually during this period. Maximum Trailing Edge Up (TEU) elevator positions recorded were -5.1 deg (left) and -6.2 deg (right). Maximum TEU positions were recorded around time of rotation. Maximum Trailing Edge Down (TED) elevator positions recorded were 6.1 deg (left) and 5.2 deg (right). Just prior to the crew disconnecting the autopilot the elevator continued to move in the nose up direction without stabilizer movement, suggesting the Stab-out-of-Trim annunciation as appropriate. After the crew disconnected the autopilot the elevator moved further nose up in response to the manual column pull. The nominal elevator positions and low column deflections suggest the flight crew was able to position the stabilizer (manually) to offload elevator after the autopilot was disconnected.

1.11.4 *On ground prior to aircraft lining up on runway, difference between left and right elevator position values were observed between 0.9 and 1.1 deg on ground, after leaving the runway, there are recorded differences in the left and right elevator position values between 0.9 and 1.3 deg. During the flight the difference between the elevators became less due to loading compliance, except for the expected transient due to switching elevator tabs to/from the balance position. This observation suggests there is not an issue with the elevator system.*

Note: Elevator position synchro's are provided for recorder purposes only. They are not utilized in the control system and their accuracy is not actively monitored. Boeing provides Operators AMM subtask 31-31-00860-361 to confirm the elevator position analog signals are within an expected range with full column deflection.

1.12 Wreckage and Impact Information

1.12.1 Not applicable.

1.13 Medical and Pathological Information

1.13.1 None.

1.14 Fire

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The incident was considered survivable as no damage was caused to the cockpit or cabin structure of the aircraft.

1.16 Tests and Research

1.16.1 Following the incident, the horizontal stabiliser trim motor was removed from the aircraft and was sent for examination at the manufacturer's facility through AIID. The test and analysis were conducted in the presence of an accredited representative (AR) from the National Transportation Safety Board (NTSB) on behalf of the AIID. The summary of the details of the investigation of the stabiliser trim motor were as follows:

- Incoming visual inspection performed
- Bonding insulation resistance and back-driving tests performed and passed

- Removal of cover to read non-volatile memory (NVM) for fault codes, if any. Two different faults were stored in the memory, invalid hall and frame overrun. Manufacturer described the frame overrun “as to be expected”; and related to Invalid Hall fault (Hall sensors are used to control operation of the motor)
- Functional test performed with no faults found
- Three axis vibration tests performed with no faults found
- Thermal cycling tests performed, which ran through the night on an automated test chamber (approximately 12-hour test)
- Second functional test performed with no faults found

1.16.2 The stabiliser trim motor tests were found to be satisfactory.

1.17 Organisational and Management Information

1.17.1 The operator had a valid Air Operator Certificate (AOC) which was issued on 27 November 2018 by the SACAA with an expiry date of 30 November 2019. The aircraft was duly authorised to operate under the AOC. The operator was the holder of the following Air Service Licences: S890D, N890D, N 891D, I/S266 and I/N 238 issued by the Department of Transport.

1.17.2 The AMO that carried out the last C-check maintenance inspection on the aircraft prior to the incident flight was in possession of a valid AMO-approval certificate that was issued by the SACAA on 19 October 2018 with an expiry date of 30 October 2019.

1.17.3 Following the incident, the operator conducted a stab trim motor reliability programme on their fleet to identify the stab trim motors that were not modified to current modification status level 9 in accordance with the service letter 737-SL-27-267. The three STMs that were not modified to status level 9 were removed from the affected aircraft on the operator’s fleet (ZS-SJO with STM S/N: 1248, ZS-SJC with STM S/N: 4573 and ZS-SJA with STM S/N: 3329). These STMs were scheduled to be sent to the original equipment manufacturer (OEM) for the modification status level 9 embodiment in accordance with the service letter 737-SL-27-267 during Quarter 1 of 2020 and Quarter 3 of 2020.

1.18 Additional Information

1.18.1 Horizontal Stabiliser Trim Control System (737-600/700/800/900 AMM 27-41-00-002):

General

The pilots control the horizontal stabilizer manually by the stabilizer trim wheels or electrical by the stabilizer trim switches. The autopilot controls the stabilizer automatically through the digital flight control system (DFCS)

Manual Operation-Stabilizer Trim wheels
The pilots use the stabilizer trim wheels on the control stand to manually move the forward and aft cable drums. The aft cable drum moves the gearbox and jackscrew. When the jackscrew moves, the horizontal stabilizer moves. The stabilizer also gives a mechanical input to the elevator, through the neutral shift rods. Movement of the manual trim wheels also moves the stabilizer indicator pointer.

Electric Operation – Stabilizer Trim Switches
The pilots operate two stabilizer trim switches for main electric trim control. The switches are on the outboard side of each control wheel. The switches control electric input to the stabilizer trim motor and send signals to the flight data acquisition unit (FDAU). When the stabilizer trim motor operates, it moves the stabilizer gearbox. When the stabilizer gearbox moves, it moves the stabilizer jackscrew which moves the horizontal stabilizer. The gearbox also back drives the stabilizer aft and forward cable drums. Movement of the forward cable drum moves the manual trim wheels and stabilizer indicator pointer. Limit switches control the main electric and autopilot movement of the stabilizer.

See the digital flight recorder system section for more information about the stabilizer position sensor A and the FDAU. (Section 31-31)

Autopilot Operation
The DFCS gives electric input to the stabilizer trim motor. During autopilot operation, stabilizer trim motor operates at different speeds than during manual electric operation. Stabilizer position sensors A and B send signals to the flight control computers (FCCs) in the DFCS. Stabilizer position sensor A sends stabilizer position to FCC A and the FDAU. Stabilizer position sensor B sends stabilizer position to FCC B.

Column Cut-out Switches
The column cut-out switches stop the stabilizer trim motor when the pilot moves the control column in a direction opposite to the trim direction.

Stabilizer Trim Override Switch
The pilots use the stabilizer trim override switch on the aisle stand to bypass the column cut-out switches if one or both fail.

Stabilizer Trim Cut-out Switches
The pilots use the stabilizer trim cut-out switches on the control stand to stop the main electric and autopilot runaway trim inputs to the stabilizer trim motor.

Stabilizer Trim Limit Switches
The stabiliser trim limit switches limit the range of horizontal stabilise motion. There are different limits for manual, autopilot, and for flaps up and flaps down. The take-off warning switches tell the pilot of incorrect stabiliser position at take-off. There are five stabiliser trim limit switches mount on vertical brackets attached to structure.

They are cam operated microswitches. The cam mounts to a support tube which connects to the stabiliser section jackscrew attach fitting. There are three limit switches (S144, S145, and S844) and two stabiliser take-off warning switches (S132 and S546) on the brackets along the stabiliser jackscrew.

Functional description of Trim Limit Switches

- *S145 – Nose down autopilot and flaps not up electric limit switch, operates at 0.05 units*
- *S844 – Nose down flaps up electric limit switch, operates at 3.95 units*
- *S132 – Nose up take-off warning switch, operates at 8.75 units*
- *S144 – Nose up autopilot limit switch, operates at 14.50 units.*
- *S546 – Nose down take-off warning switch, operates at 2.4. units*

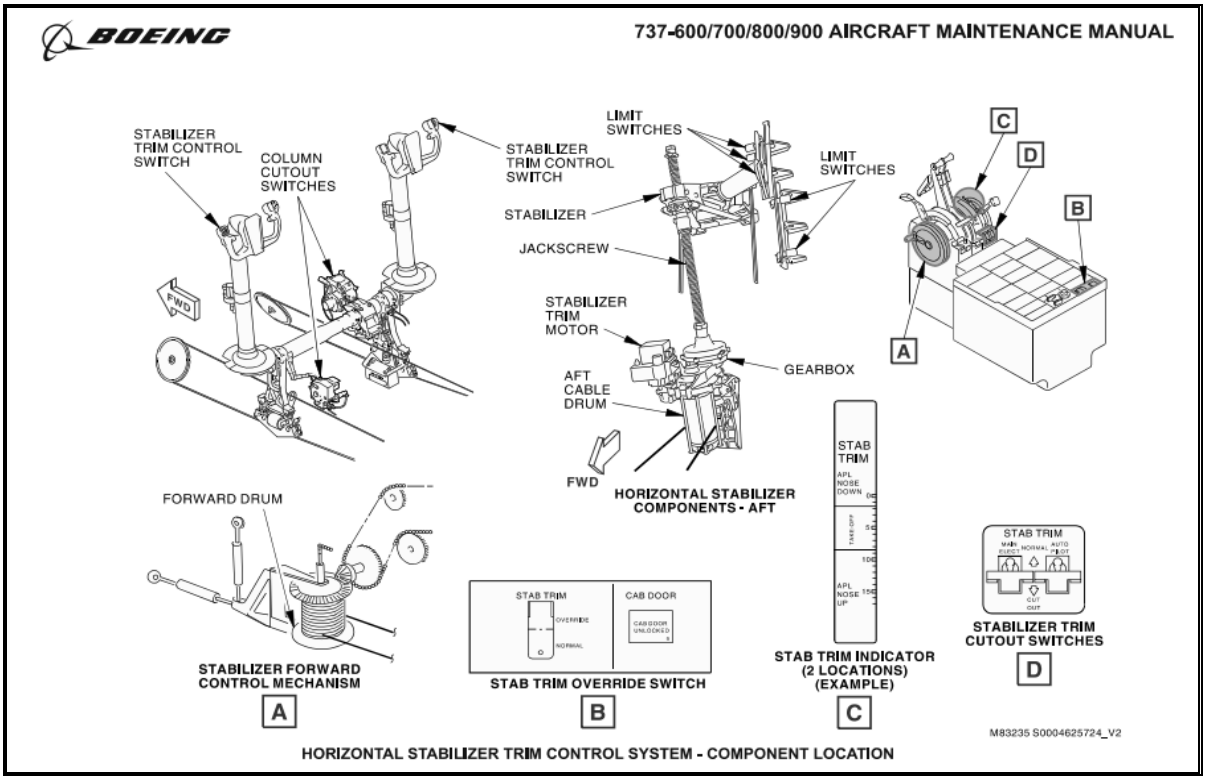


Figure 6: Horizontal stabiliser control system.
(Source: 737-600/700/800/900 Aircraft Maintenance Manual chapter 27-41-00)

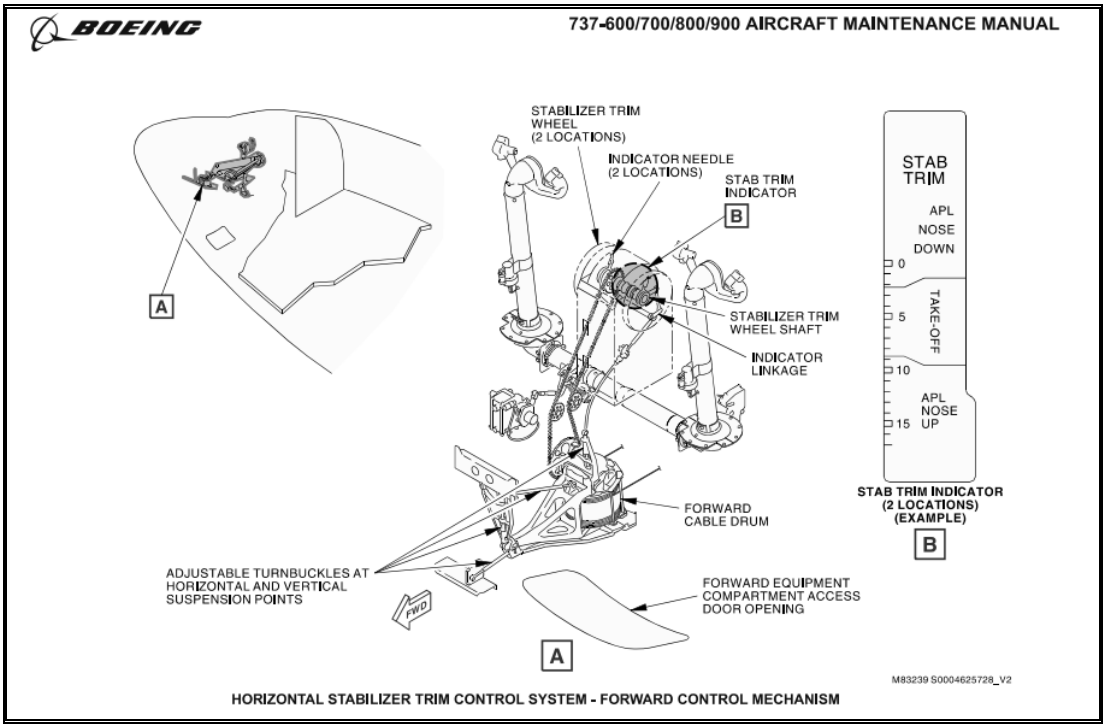


Figure 7: Trim control system. (Source: 737-600/700/800/900 AMM chapter 27-41-00)

Figure 7: The electrical horizontal stabiliser trim motor.
(Source: https://www.eaton.com › ecm › idcplg)

1.18.2 Pitch control system components (AMM 327-41-505-02)

The jackscrew gearbox has three input capabilities:

i. Manual
ii. Main electric
ii. Autopilot

Manual input is applied through the cable system driving the aft cable drum. Rotation of the drum is transmitted through the splined lower clutch member to the gear draft shaft. Operation of the gear drive unlocks the auxiliary brake and rotates the jackscrew.

Main electric inputs are supplied through a uni-directional motor and two magnetic directional clutches. Directional drive is transmitted from the selected clutch to the trim servo input gear through a torque limiter. This is used to provide protection against overloading the jackscrew. Stall torque is 460±20 inch/lb. The clutch drive gear and upper clutch member will have an input to the drive gear shaft through the spring-loaded lower clutch member, driving the jackscrew and the total manual drive system. If the cable drum is prevented from rotating (for any reason) the lower cam member will cam down compressing the spring. When this occurs, the jackscrew drive will be disconnected from the clutch drive gear, stopping stabilizer movement.

Autopilot servo motor input is to the same clutch drive gear as is used by the main electric motor. The autopilot input operates under the same conditions as the main electric except its torque limiter is a separate magnetic clutch.

When the main electric system is selected, as autopilot interlock circuit is actuated which causes a pitch channel trip. This prevents the possibility of two drive inputs to the same drive mechanism.

Auxiliary and primary brake assemblies are installed to prevent servo dynamic loading repositioning the stabiliser.

1.18.3 **Stab Out of Trim Warning (AMM)**

The stab out of trim warning circuit looks at these conditions and if any occur, the warning may be set:

- *Stabilizer does not move in 10 seconds when commanded*
- *Too much A/P actuator movement for 10 seconds*
- *Too much elevator command for 10 seconds*

Too much actuator movement means the difference between the elevator A/P actuator position and the elevator position sensor is greater than 3 degrees. If in single channel operation, the difference between the elevator A/P actuator position and the neutral shift sensor position plus a bias is more than 5 degrees. The bias is

zero unless these conditions are present and then the bias is 3 degrees nose up:

- *Flare is armed*
- *Radio altitude is less than 400 feet*
- *A/P is engaged*
- *A/P G/S is engaged.*

These conditions cause the stab out of trim annunciator to come on:

- *Warning ready to set*
- *A/P engaged*
- *Radio altitude more than 50 feet or G/S not engaged or stab out of trim warning already set.*

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 General

From the evidence available, the following analysis was made with respect to this incident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

2.2 Man

2.2.1 The PIC was initially issued an ATPL on 26 February 2001 with an expiry date of 30 April 2020. The aircraft type was endorsed on his licence. The pilot had a valid Class 1 medical certificate issued on 18 January 2019 with an expiry date of 31 January 2020, and with no restrictions. The PIC's last skills test was carried out on 26 March 2019 with an expiry date of 30 April 2020.

2.2.2 The FO was issued an ATPL on 5 February 2018 with an expiry date of 31 January 2020. The aircraft type was endorsed on his licence. The pilot had a valid Class 1 medical certificate on 25 October 2018 with an expiry date of 31 October 2019, and with no restrictions. The FO's last skills test was carried out on 7 January 2019 with an expiry date of 31 January 2020.

2.2.3 While the crew was levelling off at TOC FL360, a stab out of trim warning light illuminated in the cockpit with the autopilot engaged. The crew referenced and actioned the QRH instructions; later, a decision was taken to return to FAOR after an emergency was broadcasted on frequency 128.3MHz. The decision for an air turn back was a result of a faulty horizontal stabiliser trim control and the alternative flight level (FL280) which rendered the crew non-compliant with RVSM, as well as

an impact on the calculated fuel planning, combined with the flight controls that were no longer in a normal state. The crew conducted a manual ILS approach and landed safely on Runway 03L.

2.2.4 The engineer who had signed out the STMs was issued a company certificate (CFM56) and was current to work on the aircraft. He was issued a SACAA AME Licence (0272223231) on 28 July 2018 with an expiry date of 27 August 2020. The aircraft type was endorsed on his licence.

2.3 Machine

2.3.1 The aircraft had a valid Certificate of Airworthiness which was initially issued on 30 June 2000 with an expiry date of 30 June 2020. The aircraft had undergone its mandatory inspection (A-Check) and a Certificate of Release to Service was issued on 1 August 2019 at 47 703.0 airframe hours. The aircraft only accrued 134.1 hours since its last inspection.

2.3.2 There was no fault found with the rigging of the elevator control chain and cable. The differences stated in paragraph 1.11.4 regarding the position of the left and right elevator had no bearing to this incident.

2.3.3 During levelling off at FL360, the *stab out of trim* warning light illuminated in the cockpit and remained on. The crew then referenced and followed the QRH instructions and disengaged the autopilot. Following the disengagement of the autopilot, the crew noticed that there was a significant out of trim on the flight controls with limited manual trim control, and the aircraft had a nose-dive attitude. The crew controlled the horizontal stabiliser trimming manually using the trim wheel. The cause of the significant out of trim condition was likely due to the horizontal stabiliser that was not supplying long-term pitch control of the aircraft at TOC when the elevators were moved (nose up), consistent with the QAR data. The cause of the horizontal stabiliser not moving with the elevator trim could not be established as all horizontal stabiliser and elevator systems were checked and no fault was found. The aircraft was controllable after the crew had disengaged the autopilot and had overrode the trim switches, but the electrical system of the horizontal stabiliser trim was still unresponsive.

2.3.4 When manually trimming the horizontal stabiliser, the trim wheel jumps back to its original position. It is likely that during the electrical trimming, the stab trim cut out switch was not selected to the “off” position. More force had to be applied (exerted) to achieve manual trimming.

2.3.5 The AMO conducted vigorous troubleshooting IAW AMM. The recorded faults on the MCDU were reviewed which resulted in the LRU change. There were no faults found on the gears/sprocket and chain. The chain play was measured and found to be within limits at 7.9mm; the cable tension was checked and was found to be within limits at 122 pounds.

2.3.6 The removed STM (S/N: 3680) was sent to the OEM for testing and there were no faults found. The cause of the stab out of trim was inconclusive as there were no other warnings in the cockpit prior to *stab out of trim* warning and the only LRU that was changed was the STM. All related system components (AFCS, flight control cables and functional checks) were satisfactory.

2.3.7 Since installation of STM (S/N: 6246), no further defects were reported, and the aircraft was released back to service.

2.3.8 The differences between the recorded figures on the FDR data analysis had no bearing on the incident.

2.4 Management

2.4.1 The operator had processes and procedures in place for cannibalisation of STM between the fleet.

2.4.2 The installation and interchangeability of STMs which had no traceability record became a standard practise for the AMO and the operator. Although the STM had an FAA authorised release certificate (form 8130-3) and certificate of conformity and material certification form, the TSN, TSO, TSI and TST were unknown. These units were removed from the affected aircraft. The lack of tracking of hours of STM S/N: 3680 made it difficult for the investigators to make conclusions regarding the reliability and failure rate of this component. The operator had reliability stats programme for the fleet available.

It was discovered that the previous part numbers were susceptible to primary failure of the solder joint fatigue crack of the non-volatile memory (NVM) chip due to a combination of uncontrolled environment conditions, causing bending, vibration and thermal expansion stresses. The STM in question was not a factor in this case as there were no faults found during testing. A fleet inspection was carried out by the operator following the incident and it was discovered that there were three STMs that were not modified to status level 9 and they were removed from the affected aircraft on the operator's fleet (ZS-SJO with STM S/N: 1248, ZS-SJC with STM S/N: 4573 and ZS-SJA with STM S/N: 3329). These STMs were scheduled to be sent to the OEM for modification status level 9 embodiment IAW the service letter during Quarter 1 of 2020 and Quarter3 of 2020.

2.5 Investigation results

2.5.1 The investigation revealed that whilst levelling off at top of climb, the elevator continued to move in the nose up direction without the stabiliser moving in unison, causing the "stab out of trim" light to illuminate. After the crew had disconnected the autopilot, the elevator moved further to a nose up position (original position) in

response to the manual column input. The cause of the stab trim not moving with the elevator could not be determined as all tests conducted on the system came out satisfactory.

3. CONCLUSION

3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this incident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusions heading:

- **Findings –** are statements of all significant conditions, events or circumstances in this incident. The findings are significant steps in this incident sequence, but they are not always causal or indicate deficiencies.
- **Causes –** are actions, omissions, events, conditions, or a combination thereof, which led to this incident.
- **Contributing factors –** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 The PIC was initially issued an ATPL on 26 February 2001 with an expiry date of 30 April 2020. His last validation check was carried out on 26 March 2019. He was also issued a Class 1 aviation medical certificate on 18 January 2019 with an expiry date of 31 January 2020.

3.2.2 The FO was issued an ATPL on 5 February 2018 with an expiry date of 31 January 2020. His last validation check was carried out on 7 January 2019. He was also issued a Class 1 aviation medical certificate on 25 October 2018 with an expiry date of 31 October 2019.

3.2.3 The AME was issued an AME Licence on 26 July 2018 with an expiry date of 27 August 2020. The aircraft type was endorsed on his licence.

3.2.4 The last maintenance inspection was an A-check which was carried out on 1 August 2019 at 47 703.0 hours. The aircraft had flown a further 134.1 hours since its last maintenance inspection.

3.2.5 The aircraft was initially issued a Certificate of Airworthiness (CoA) on 30 June 2000 with an expiry date of 30 June 2020.

3.2.6 The operator was issued an Air Operating Certificate (AOC) No. CAA/N942D on 26 April 2019 with an expiry date of 30 April 2020. The aircraft was duly authorised to operate under the AOC.

3.2.7 The AMO that was contracted to do the maintenance on the aircraft was issued an Approval Certificate (AC: 0001) on 19 October 2018 with an expiry date of 30 October 2019.

3.2.8 Weather conditions at the time had no bearing on this incident.

3.2.9 The STM with serial number 3329 was removed on 5 August 2019 from ZS-SJD to service another aircraft (ZS-SJA) in the operator's fleet.

3.2.10 The STM with serial number 3680 was installed on ZS-SJD on 8 August 2019 as new at 47705:14 after repairs. Since installation, it only accrued 125:11 hours before it was replaced on 2 September 2019 following this incident by S/N: 6246. The STM had FAA form 8130-3 release certificate, however, there was no traceability of TSN, TSO, TSI and TST as they were entered as unknown on the certificate of conformity and material certification form.

3.2.11 After the incident flight, the STM S/N: 3680 was recovered and sent for testing at the manufacturer's facility in the presence of an Accredited Representative. The test results came back satisfactory with no fault found. The recorded figures on the FDR data had no bearing on this incident. However, the cause of the stab out trim warning was because of the elevator that continued to move in the nose up direction without the stabiliser moving as well.

3.2.12 The installation of the STM S/N: 6246 was carried out in accordance with AMM task 27-47-71-400-801 Rev 69 including sub-tasks; the task was signed out by a qualified engineer.

3.2.13 Since the installation of STM S/N: 6246 on 2 September 2019, there had been no defects reported by the operator regarding AFCS thus far.

3.2.14 A fleet inspection was carried out by the operator following the incident and it was discovered that there were three STMs that were not modified to status level 9 in accordance with the service letter. These were removed from the affected aircraft on the operator's fleet (ZS-SJO with STM S/N: 1248, ZS-SJC with STM S/N: 4573 and ZS-SJA with STM S/N: 3329). These STMs were scheduled to be sent to the OEM for modification status level 9 embodiment IAW the service letter during Quarter 1 of 2020 and Quarter 3 of 2020.

3.2.15 The AMO was in possession of the approved robbing/cannibalisation procedure which it had used for rotable components.

3.2.16 The investigation revealed that whilst levelling off at top of climb, the elevator continued to move in the nose up direction without the stabiliser moving in unison, causing the “stab out of trim” light to illuminate. After the crew had disconnected the autopilot, the elevator moved further to a nose up position (original position) in response to the manual column input. The cause of the stab trim not moving with the elevator could not be determined as all tests conducted on the system came out satisfactory.

3.3 Probable Cause/s

3.3.1 Whilst levelling off at top of climb, the elevator continued to move in the nose up direction without the stabiliser moving in unison, causing the “stab out of trim” light to illuminate. After the crew had disconnected the autopilot, the elevator moved further to a nose up position (original position) in response to the manual column input. The cause of the stab trim not moving with the elevator could not be determined as all tests conducted on the system came out satisfactory.

3.4 Contributory Factors:

3.4.1. None.

4. SAFETY RECOMMENDATIONS

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report; the AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2 Safety Recommendation/s

4.2.1 In the interest of safety, it is recommended that the AMO ensures that its maintenance personnel record all required fields after testing of component/system as required by CAR 2011 Part 43.

4.2.2 Safety action taken by the operator/AMO:

4.2.2.1 The operator had checked all its fleet fitted with STM and had ordered that all STM not modified to status level 9 be removed from the affected aircraft. It was found that aircraft ZS-SJO with STM S/N: 1248, ZS-SJC with STM S/N: 4573 and ZS-SJA

with STM S/N: 3329 had not been modified. The operator ordered the removal of the STMs to be forwarded to the OEM for modification status level 9 embodiment IAW the service letter number 737-SL-27-267.

5. APPENDICES

5.1. Annexure A (Boeing 737-800 QRH - Stabilizer out of trim)
5.2. Annexure B (ATC Transcript)
5.3. Annexure C (FAOR Airport chart)
5.4. Annexure D Service Letter (737-SL-27-267)
5.5. Annexure E Fleet Team Digest (Boeing and Eaton Aerospace)

This Report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

Annexure A

STAB OUT OF TRIM

STABILIZER OUT OF TRIM

Condition: The autopilot does not set the stabilizer trim correctly.

Note: Momentary illumination of the STAB OUT OF TRIM light during large changes in trim requirements is normal.

STABILIZER:

TRIMMING:

Continue normal operation.

(END)

NOT TRIMMING:

Control Column.....HOLD FIRMLY

Autopilot ..... DISENGAGE

Stabilizer trim ..... AS NEEDED

STABILIZER:

RESPONDS to electric trim inputs:

(END)

DOES NOT RESPOND to electric trim inputs:

►►Apply STABILIZER TRIM INOPERATIVE.

(END)

STABILIZER TRIM INOPERATIVE

Condition: The main electric and autopilot stabilizer trim are inoperative.

STAB TRIM CUTOUT switches (both).....CUTOUT

The autopilot is not available.

MANUAL TRIM.....APPLY

Apply steady pressure on the manual trim handles until the needed trim is attained.

If needed:

Use force to cause the disconnect clutch to disengage. Approximately 1/2 turn of the stabilizer trim wheel may be needed.

Note: A maximum two-pilot effort on the trim wheels will not cause a cable or system failure.

The handle(s) should be folded inside the stabilizer trim wheel when manual trim is no longer needed.

If the failure could be due to ice accumulation, descend to a warmer temperature and attempt again.

STABILIZER:

CAN be trimmed manually:

Maintain in-trim airspeed until the start of the approach.

Use an airspeed which results in an in-trim condition. This will reduce the force that is needed to move the stabilizer.

Continue to trim manually for the rest of the flight.

Establish the landing configuration early.

CAN NOT be trimmed manually:

Anticipate higher than normal elevator forces during approach and landing.

The thrust reduction at flare will cause a nose down pitch.

Note: Elevator control is sufficient to safely land the airplane regardless of stabilizer position.

Note: Normal Checklist integrated.

Check Landing Distance.

Plan a flaps 15 landing.

Continued on next page

STABILIZER TRIM INOPERATIVE

Continued from previous page

- APPROACH -

PASSENGER SIGNS ..... ON

FLAP INHIBIT switch ..... FLAP INHIBIT

RECALL ..... CHECK

CABIN CONTROL ..... SET

ENGINE START switches ..... CONT

AUTOBRAKE ..... AS NEEDED

If any of the following conditions apply, set VREF ICE = VREF 15 + 10 knots:

Engine anti–ice will be used during landing

Wing anti–ice has been used any time during the flight

Icing conditions were encountered during the flight and the landing temperature is below 10° C.

Note: When VREF ICE is needed, the wind additive should not exceed 10 knots.

SPEED BUGS ..... SET VREF 15 or VREF ICE,____ B

ALTIMETERS ..... ____,____ B

Go-Around Procedure Review

Do the normal go-around procedure.

Advance thrust to go-around smoothly and slowly to avoid excessive pitch-up.

Positive climb, Gear up.

- FINAL -

SPEED BRAKE ..... ARMED, GREEN LIGHT

GEAR ..... DOWN, 3 GREEN B

FLAPS ..... 15, GREEN LIGHT B

(END)

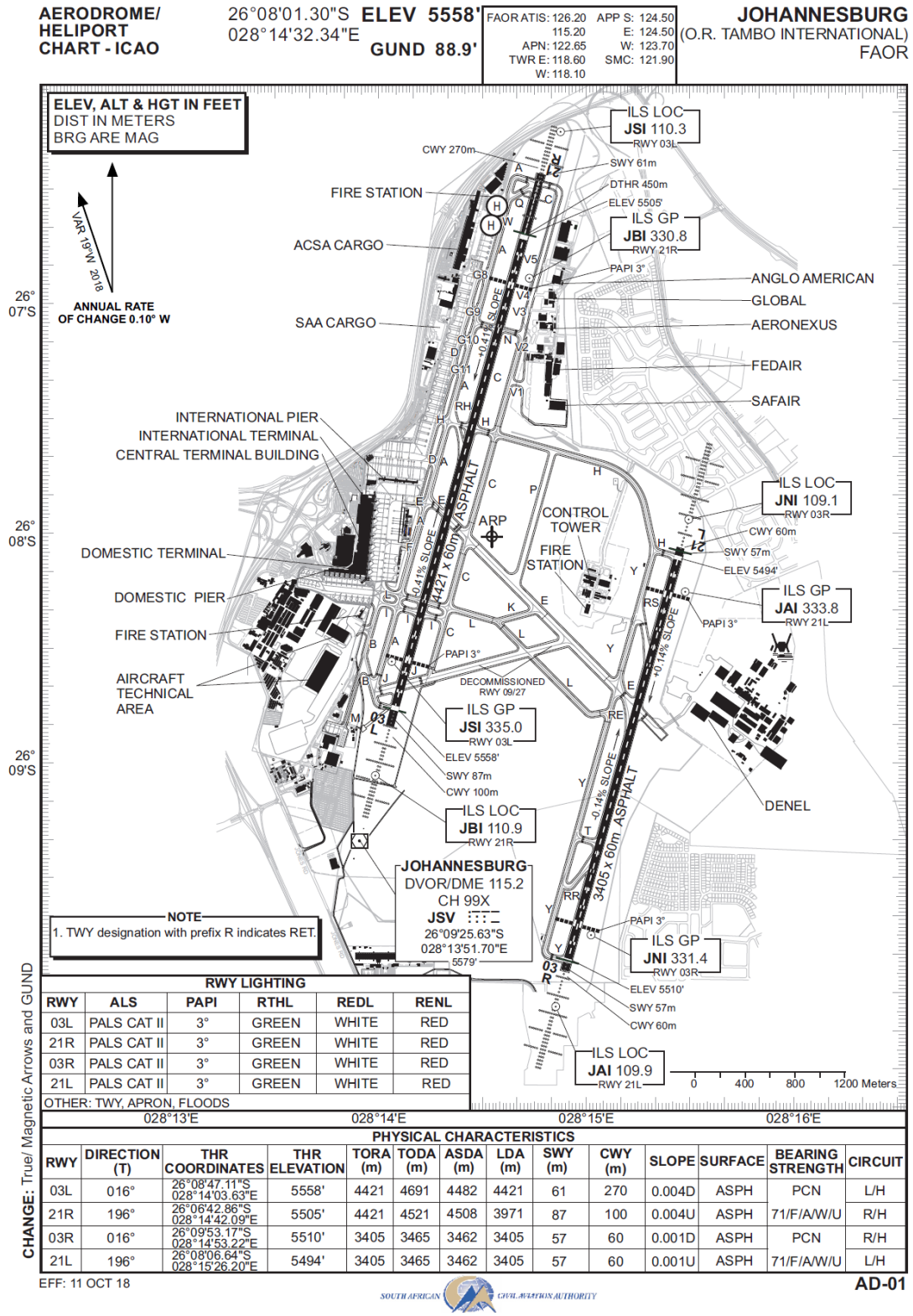
Annexure B

Transcript of the communication between Johannesburg South-west radar and the pilot in command of the aircraft ZS-SJD (Flight MN0129, Boeing 737-800) on 2 September 2019. The frequency in use was 128.3 MHz.

Time	From	To	Message
06:19:13	ZS-SJD	Radar	Johannesburg TULCA 129.
06:19:16	Radar	ZS-SJD	Go ahead.
06:19:18	ZS-SJD	Radar	Sir, we've got an autopilot fail up at flight level 360. We are no longer to comply with RVSM.
06:19:32	Radar	ZS-SJD	TULCA 129 copy. Stand-by for me.
06:19:36	ZS-SJD	Radar	Standing by.
06:19:44	Radar	ZS-SJD	TULCA 129 copy. Unfortunately you will have to descend to level 280 to vacate RVSM.
06:19:47	ZS-SJD	Radar	Ok. We've got our descent now to level 280 and we will advise you on our intentions TULCA 129.
06:19:53	Radar	ZS-SJD	TULCA 129 copy.
06:24:17	ZS-SJD	Radar	Johannesburg TULCA 129.
06:24:19	Radar	ZS-SJD	
06:24:20	ZS-SJD	Radar	Sir, we would like to return back to Johannesburg please. Just for your info we've got a flight control issue. The loss of auto pilot was due to our stabilizer trim and we also got limited manual trim on the aircraft.
06:24:36	Radar	ZS-SJD	TULCA 129 copy. Turn left now. Direct to NEVEX. NEVEX 1 Bravo arrival
06:24:42	ZS-SJD	Radar	Turn left NEVEX to the NEVEX 1 Bravo arrival. and then you still have us at flight level 280. TULCA 129.
06:24:49	Radar	ZS-SJD	TULCA 129. Descend level 290. Report ready for further descend.
06:25:40	Radar	ZS-SJD	TULCA 129. Would you prefer headings for the localizer?
06:25:44	ZS-SJD	Radar	We're routing to NEVEX now. I'll get back to you in a second. TULCA 129.
06:25:49	Radar	ZS-SJD	Copy.
06:25:57	ZS-SJD	Radar	TULCA 129 is the correct "PANPAN-PANPAN-PANPAN"
06:26:00	Radar	ZS-SJD	TULCA 129 Copy. Proceed direct to final approach runway 03L.
06:26:00	ZS-SJD	Radar	Copy. Runway 03L. TULCA 129.
06:26:33	Radar	ZS-SJD	TULCA 129 when you're ready, persons on-board and fuel endurance.
06:26:38	ZS-SJD	Radar	TULCA 129, we're 6 crew, 141 passengers.
06:26:42	Radar	ZS-SJD	Copy. And fuel on-board?
06:26:44	ZS-SJD	Radar	Fuel on-board is about at the moment… stand by. TULCA 129 three hours fuel.
06:26:54	Radar	ZS-SJD	Copy thanks. Do you need emergency services on standby?
06:26:54	ZS-SJD	Radar	Due to a flight control issue – Affirm TULCA 129. We should perform a normal landing, but just have them in the wings there. TULCA 129.
06:27:08	Radar	ZS-SJD	TULCA 129 Copy.
06:28:59	Radar	ZS-SJD	TULCA 129. There are no restrictions. When you're ready descend FL 160.
06:29:04	ZS-SJD	Radar	No speed restrictions. When we're ready descend to FL 160. Should be in the next 29 miles. TULCA 129.
06:30:19	Radar	ZS-SJD	TULCA 129. Just confirm, is it the trim on the vertical

			stabilizer only?
06:30:25	ZS-SJD	Radar	It's the horizontal stabilizer. We've lost the trim there.
06:30:28	Radar	ZS-SJD	It's the horizontal stabilizer. Copy.
06:34:45	Radar	ZS-SJD	TULCA 129. Any other requirements.
06:34:48	ZS-SJD	Radar	At this stage, negative. TULCA 129.Just as requested.
06:34:50	Radar	ZS-SJD	Copy.
06:36:07	Radar	ZS-SJD	TULCA 129. Contact radar now 1245. Bye-bye.
06:36:11	ZS-SJD	Radar	1245. TULCA 129. Bye-bye.

Annexure C


AERODROME/ HELIPORT CHART - ICAO
26°08'01.30"S 028°14'32.34"E
ELEV 5558'
GUND 88.9'
FAOR ATIS: 126.20 115.20
APP S: 124.50
E: 124.50
W: 123.70
SMC: 121.90
APN: 122.65
TWR E: 118.60
W: 118.10
JOHANNESBURG
(O.R. TAMBO INTERNATIONAL)
FAOR
ELEV, ALT & HGT IN FEET
DIST IN METERS
BRG ARE MAG
VAR 19°W 2018
ANNUAL RATE OF CHANGE 0.10° W
ILS LOC JSI 110.3 RWY 03L
CWY 270m
SWY 61m
DTHR 450m
ELEV 5505'
ILS GP JBI 330.8 RWY 21R
PAPI 3°
FIRE STATION
ACSA CARGO
SAA CARGO
ANGLO AMERICAN
GLOBAL
AERONEXUS
FEDAIR
SAFAIR
INTERNATIONAL PIER
INTERNATIONAL TERMINAL
CENTRAL TERMINAL BUILDING
DOMESTIC TERMINAL
DOMESTIC PIER
FIRE STATION
AIRCRAFT TECHNICAL AREA
ARP
CONTROL TOWER
FIRE STATION
4421 x 60m ASPHALT
0.41% SLOPE
ILS LOC JNI 109.1 RWY 03R
CWY 60m
SWY 57m
ELEV 5494'
ILS GP JAI 333.8 RWY 21L
DECOMMISSIONED RWY 09/27
ILS GP JSI 335.0 RWY 03L
ELEV 5558'
SWY 87m
CWY 100m
ILS LOC JBI 110.9 RWY 21R
JOHANNESBURG DVOR/DME 115.2 CH 99X JSV
26°09'25.63"S 028°13'51.70"E
5579'
3405 x 60m ASPHALT
0.14% SLOPE
DENEL
ILS GP JNI 331.4 RWY 03R
ELEV 5510'
SWY 57m
CWY 60m
ILS LOC JAI 109.9 RWY 21L
0 400 800 1200 Meters
NOTE
1. TWY designation with prefix R indicates RET.
RWY LIGHTING
RWY ALS PAPI RTHL REDL RENL
03L PALS CAT II 3° GREEN WHITE RED
21R PALS CAT II 3° GREEN WHITE RED
03R PALS CAT II 3° GREEN WHITE RED
21L PALS CAT II 3° GREEN WHITE RED
OTHER: TWY, APRON, FLOODS
CHANGE: True/ Magnetic Arrows and GUND
26° 07'S
26° 08'S
26° 09'S
028°13'E
028°14'E
028°15'E
028°16'E
PHYSICAL CHARACTERISTICS
RWY DIRECTION (T) THR COORDINATES THR ELEVATION TORA (m) TODA (m) ASDA (m) LDA (m) SWY (m) CWY (m) SLOPE SURFACE BEARING STRENGTH CIRCUIT
03L 016° 26°08'47.11"S 028°14'03.63"E 5558' 4421 4691 4482 4421 61 270 0.004D ASPH PCN L/H
21R 196° 26°06'42.86"S 028°14'42.09"E 5505' 4421 4521 4508 3971 87 100 0.004U ASPH 71/F/A/W/U R/H
03R 016° 26°09'53.17"S 028°14'53.22"E 5510' 3405 3465 3462 3405 57 60 0.001D ASPH PCN R/H
21L 196° 26°08'06.64"S 028°15'26.20"E 5494' 3405 3465 3462 3405 57 60 0.001U ASPH 71/F/A/W/U L/H
EFF: 11 OCT 18
SOUTH AFRICAN CIVIL AVIATION AUTHORITY
AD-01

Annexure D

BOEING

BCA
Customer
Support

SERVICE LETTER

737-SL-27-267
ATA: 2741-00
9 August 2017

SUBJECT: HORIZONTAL STABILIZER TRIM MOTOR UPGRADE

MODEL: 737NG

APPLICABILITY: All 737NG (Aircraft prior to line position 6475, delivered in July 2017)

REFERENCES:

a) Service Letter (SL) 737-SL-27-225-A, "6355C0001-01 Stabilizer Trim Motor – Modification History", dated 30 January 2014

b) Eaton Service Bulletin (SB) 6355C0001-27-02, "Motor, Stabilizer Trim – Rework & Re-Identification of 6355C0001-01 Modification 7 or Modification 8 Units to Modification 9 Units"

c) Eaton SB 6355C0001-27-03 "Motor, Stabilizer Trim- Rework and Re-Identification of 6355C0001-01 to 6355C0001-02"

d) Fleet Team Digest (FTD) Article 737NG-FTD-27-13002 "Stabilizer Trim Motor P/N 6355C0001-01 Experiencing Low Reliability"

e) Service Related Problem (SRP) 737NG-SRP-27-0271, "Stabilizer Trim Motor Low Reliability"

EXPORT COMPLIANCE STATEMENT:

Export of this technology is controlled under the United States Export Administration Regulations (EAR) (15 CFR 730-774). An export license may be required before it is used for development or production, or used by foreign persons from specific countries. The controller of this data has the individual responsibility to abide by all export laws.

ECCN: 9E991

SUMMARY:

The purpose of this service letter is to advise operators of a modification that is now available for the Stabilizer Trim Motor (STM), Part Number (P/N) 6355C0001-01. This service letter provides interchangeability and applicability information for the new P/N 6355C0001-02. See the reference a) SL for additional service history and part interchangeability.

BACKGROUND:

In response to numerous operator reports of early removals of STM P/N 6355C0001-01 and a high No Fault Found (NFF) rate, Boeing and Eaton Aerospace agreed to form a team to investigate these reports.

As a result of this investigation, the team identified several actions that would improve the Mean Time Between Unscheduled Removal (MTBUR) and NFF rates. Eaton released the reference b) Mod. 9 SB as an interim solution and initiated a redesign of the existing Control Printed Wiring Assembly (PWA), P/N 6355-0230-13.

DISCUSSION:

The Boeing and Eaton Working Together Team found that preloading of the Control PWA during assembly and in service thermal cycling could cause premature/intermittent failure of components. As a result Eaton released the reference b) Mod. 9 SB as an interim solution. The first Mod. 9 was installed starting with line position 4773. In reference b) Mod. 9 SB, Eaton developed a shimming procedure to reduce the preload and stress caused by environmental effects. Eaton developed an improved Control PWA, P/N 6355-0230-15, to incorporate the team recommended design changes including component replacement, component footprint optimization, component height spacers, copper balancing, device package changes, clamp circuit removal, reinforcement spacer added (under transistors, etc.) and component replacement for obsolescence. The new Control PWA was subjected to more stringent environmental test criteria intended to better model the installation environment.

Eaton has released the reference c) SB to modify STM P/N 6355C0001-01 to P/N 6355C0001-02 by replacing Control PWA, P/N 6355-0230-13 with PWA, P/N 6355-0230-15.

Boeing will closely monitor the Aircraft Reliability Maintainability System (ARMS) database for reliability improvement trends in the new P/N 6355C0001-02 configuration.

BOEING ACTION:

The STM reliability issues were discussed in the reference d) FTD article. Boeing initiated the reference e) SRP to implement STM design changes needed to improve STM MTBUR and NFF rates. STM P/N 6355C0001-02 was installed in Boeing production concurrent with line position 6475.

SUGGESTED OPERATOR ACTION:

Boeing suggests operators continue using their Mod 9 STMs, P/N 6355C0001-01, until they fail and upgrade to P/N 6355C0001-02 at that time. Boeing recommends operators send their existing STMs, P/N 6355C0001-01s, except Mod 9, to Eaton for upgrade to P/N 6355C0001-02 at the next convenient maintenance opportunity. Contact Eaton Aerospace LLC for upgrade cost and

Export Controlled ECCN: 9E991

schedule information.

ESTIMATED MANHOURS:

Approximately 2 labor hours are necessary to remove, replace, and test the Stab Trim Motor.

WARRANTY INFORMATION:

Boeing warranty remedies are not available for the configuration changes given in this service letter.

INTERCHANGEABILITY:

The STM P/N 6355C0001-02 and 6355C0001-01 are two way interchangeable for 737 NG (-600, -700, -700C, -800, -900, -900ER, BBJ).

While STM P/N 6355C0001-02 is two way interchangeable with P/N 6355C0001-01, P/N 6355C0001-02 is not currently certified for use on 737CL (-300, -400, -500).

PARTS AVAILABILITY:

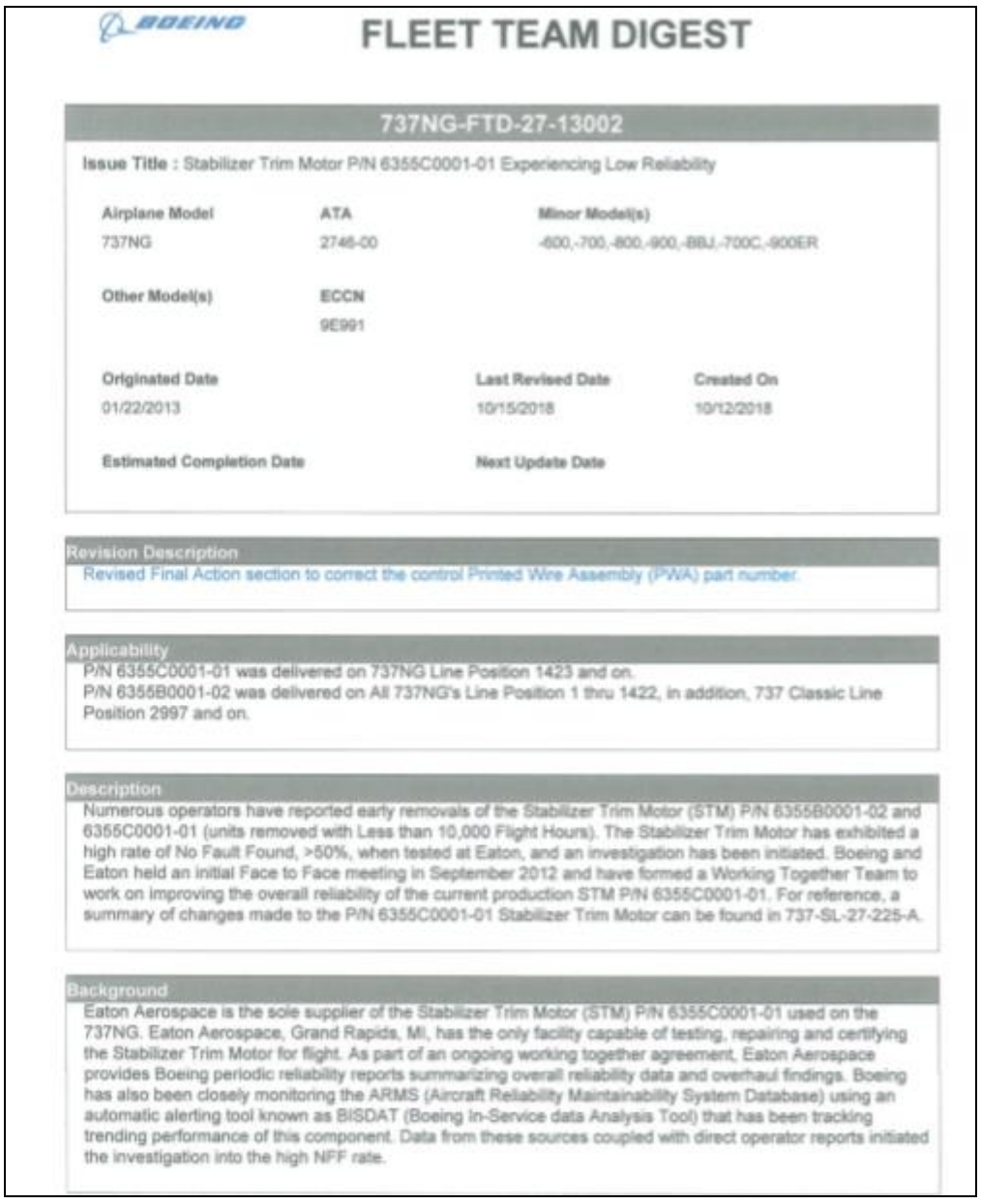
Spare Horizontal Stabilizer Trim Motors (STMs), P/N 6355C0001-02 can be ordered from the Boeing PART Page or through Eaton Aerospace.

SUPPLIER:

Eaton Aerospace LLC
Fuel and Motion Control Systems Division
3675 Patterson Ave SE, Grand Rapids, MI 49512
(616) 949-1090

GRCustomerService@Eaton.com

Annexure E



BOEING

FLEET TEAM DIGEST

737NG-FTD-27-13002

Issue Title : Stabilizer Trim Motor P/N 6355C0001-01 Experiencing Low Reliability

Airplane Model	ATA	Minor Model(s)
737NG	2746-00	-600,-700,-800,-900,-BBJ,-700C,-900ER

Other Model(s)	ECCN
	9E991

Originated Date	Last Revised Date	Created On
01/22/2013	10/15/2018	10/12/2018

Estimated Completion Date	Next Update Date

Revision Description

Revised Final Action section to correct the control Printed Wire Assembly (PWA) part number.

Applicability

P/N 6355C0001-01 was delivered on 737NG Line Position 1423 and on.
P/N 6355B0001-02 was delivered on All 737NG's Line Position 1 thru 1422, in addition, 737 Classic Line Position 2997 and on.

Description

Numerous operators have reported early removals of the Stabilizer Trim Motor (STM) P/N 6355B0001-02 and 6355C0001-01 (units removed with Less than 10,000 Flight Hours). The Stabilizer Trim Motor has exhibited a high rate of No Fault Found, >50%, when tested at Eaton, and an investigation has been initiated. Boeing and Eaton held an initial Face to Face meeting in September 2012 and have formed a Working Together Team to work on improving the overall reliability of the current production STM P/N 6355C0001-01. For reference, a summary of changes made to the P/N 6355C0001-01 Stabilizer Trim Motor can be found in 737-SL-27-225-A.

Background

Eaton Aerospace is the sole supplier of the Stabilizer Trim Motor (STM) P/N 6355C0001-01 used on the 737NG. Eaton Aerospace, Grand Rapids, MI, has the only facility capable of testing, repairing and certifying the Stabilizer Trim Motor for flight. As part of an ongoing working together agreement, Eaton Aerospace provides Boeing periodic reliability reports summarizing overall reliability data and overhaul findings. Boeing has also been closely monitoring the ARMS (Aircraft Reliability Maintainability System Database) using an automatic alerting tool known as BISDAT (Boeing In-Service data Analysis Tool) that has been tracking trending performance of this component. Data from these sources coupled with direct operator reports initiated the investigation into the high NFF rate.

Status

The Boeing/Eaton Working Together Team has identified the root cause of the 6355C0001-01 reliability concern as a potential failure of the 6355-0230-13 Control PWA. The team has identified an issue with the 6355-0230-13 Control Printed Wiring Assembly (PWA) that causes it to stop responding to crew inputs. Eaton discovered fracturing of the solder lead connections between the U8 Non-Volatile Memory (NVM) Integrated Circuit (IC) and the 6355-0230-13 Control Printed Wiring Assembly (PWA). During examination, Eaton found that certain solder leads from the U8 NVM IC and the 6355-0230-13 Control PWA had fractured, causing the STM to stop responding. The STM would remain in an inoperative state until the STM Logic was reset by cycling the power (C849) to the unit. The Boeing/Eaton Working Together Team has verified the STM 6355-0230-13 PWA is failing due to solder lead fracturing caused by both thermal and metal fatigue. The thermal and metal fatigue was caused by exposure to thermal cycling and vibration present in the 737NG empennage.

Eaton has released an interim fix into production and Service Bulletin to upgrade existing Mod 7 or 8 STMs. The Modification Level 9 Change revised the installation procedure for the 6355-0230-13 Control Board PWA into the Housing of the STM. The 6355-0230-13 Control Board is installed into the Main Housing of the STM using fitted shims to control the flatness of the 6355-0230-13 Control PWA. This ensures that the 6355-0230-13 Control PWA remains flat and rigid when installed in the Main Housing. The addition of the new shims prevents the U8 NVM IC and the 6355-0230-13 Control Board from flexing, which can over time cause the fracturing of the solder lead connections.

Qualification of the -02 STM is complete. STM P/N 6355C0001-02 was installed in Boeing production concurrent with line position 6475.

Interim Action

Eaton has released "Eaton Service Bulletin, 6355C0001-27-02, Motor, Stabilizer Trim – Rework & Re-Identification of 6355C0001-01 Mod 7 or Mod 8 Units to Mod 9 Units". This service Bulletin allows Eaton Aerospace to upgrade repaired units to Modification Level 9 prior to return to customers. The Eaton Service Bulletin also provides operators with the option to upgrade their existing pre-Mod 9 units to the current Mod 9 configuration for a set price.

Boeing has performed an in-depth analysis of the Stabilizer Trim System Wiring design to include ships wiring, switches and production breaks and splices. The results of the Boeing Study show that operators may reduce the No Fault Found test results for the STM's by checking the airplane wiring and switching components prior to removal.

Final Action

The STM changes introduced by Modification Level 9 are considered only an interim solution, not the final solution.

The Team completed a design change to the 6355-0230-13 Control PWA. The new Control PWA (P/N 6355-0230-15) has a new U8 NVM IC that is more robust to resist the effects of thermal expansion and fatigue in order to reduce solder lead fracturing. In addition, several manufacturing changes to the 6355-0232 Printed Wiring Board (PWB) were made to improve overall reliability of the PWA. These design changes will result in a new Stabilizer Trim Motor part number, 6355C0001-02. STM P/N 6355C0001-02 was installed in Boeing production starting with line position number 6475.

Milestones

Note: Target dates are based upon currently available status and have risk of future revision.
Root Cause Established: April 2014
Solution Selected: March 2016
Change Committed: December 2017

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Production Incorporation: July 2017 (LN 6475)
Service Bulletin Available: July 2017
Parts Available: August 2017

Part Information

The Stabilizer Trim Motor (STM), P/N 6355C0001-02 is two way interchangeable with the P/N 6355C0001-01. P/N 6355C0001-01 is two way interchangeable with the P/N 6355B0001-02 and P/N 6355B0001-03 STM's.

Affected Documents

Eaton CMM 27-40-10, Stabilizer Trim Motor 6355C0001-01.

Supplier Information

Eaton Aerospace LLC
Fuel and Motion Control Systems Division
3675 Patterson Avenue SE
Grand Rapids, MI 49512-0872 USA
(616) 949-1090
GRCustomerService@Eaton.com

References

Reference Type	Reference Number	Revision Number	Reference Date	Actions
Fleet Team Digest Article (FTD)	737NG-FTD-27-05003			
Fleet Team Economic (FTE)	737NG-FTE-27-10024			
Service Letter (SL)	737-SL-27-225-A		01/30/2014	
Service Related Problem (SRP)	737NG-SRP-27-0271		05/05/2015	
Service Letter (SL)	737-SL-27-267		08/09/2017	
Service Bulletin (SB)	Eaton 6355C0001-27-03		07/01/2017	

Related Categories

- Fleet Team IdeaXchange - Topic of discussion on the Fleet Team IdeaXchange bulletin board