

AIRCRAFT SERIOUS INCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/3/2/1395		
Aircraft Registration	ZS-ZWB	Date of Incident	7 March 2022		Time of Incident	0412Z	
Type of Aircraft	Boeing 737-800		Type of Operation		Commercial (Part 121)		
Pilot-in-command Licence Type	Airline Transport Pilot Licence (ATPL)		Age	59	Licence Valid	Yes	
Pilot-in-command Flying Experience	Total Flying Hours		12 865	Hours on Type	3 318		
Last Point of Departure	Lanseria International Airport (FALA), Gauteng Province						
Next Point of Intended Landing	Cape Town International Airport (FACT), Western Cape Province						
Damage to Aircraft	Substantial to number 1 engine						
Location of the incident site with reference to easily defined geographical points (GPS readings if possible)							
At Global Positioning System (GPS) co-ordinates determined to be 26° 41.10' South 027°33.10' East during the climb phase whilst passing FL210 to reach FL217							
Meteorological Information	Wind direction: 94.9°; Wind speed: 05kts; Temperature: 15.9°C; Dew Point: 14°C; Cloud Cover: Nil; Cloud Base: Nil; Visibility: 9 999m; QNH: 849.5hPa						
Number of People On-board	2+4+135	Number of People Injured	0	Number of People Killed	0	Other (On Ground)	0

Synopsis

On Monday morning, 7 March 2022 at approximately 0401Z, a Boeing 737-800 aircraft with registration ZS-ZWB and flight number MN451 took off on a domestic scheduled flight from Lanseria International Airport (FALA) in Gauteng province to Cape Town International Airport (FACT) in the Western Cape province. Two pilots, four cabin crew members and 135 passengers were on-board the aircraft. The flight was conducted in instrument flight rules (IFR) by day and under the provisions of Part 121 of the Civil Aviation Regulations (CAR) 2011 as amended.

Whilst climbing through flight level (FL) 210 to the assigned cruise altitude, the crew heard a loud bang that originated from the No.1 engine. The first officer (FO) who was the pilot monitoring (PM) deduced that the No.1 engine had failed. As a result of the left engine failure, the flight crew conducted an emergency descent and diverted to O.R. Tambo International Airport (FAOR). The aircraft landed safely with a single engine in operation, about 20 minutes after the engine failed. All occupants on-board the aircraft were not injured during this serious incident. The aircraft's left leading edge horizontal stabiliser and the left engine were substantially damaged.

On 14 June 2022, the South Gauteng High Court issued a certificate of appointment (see Appendix A) to liquidators to settle all matters relating to Comair Limited. As a result, the engine was not shipped to the manufacturer for the teardown inspection. On 5 January 2023, the manufacturer wrote to the appointed liquidators and Comair Limited representatives stating that the company position "will remain unchanged. Once there is a new known owner, and once such owner agrees to proceed with the teardown and inspection of the engine, then CFM will provide any requested technical support to the investigation".

The borescope inspection of the engine revealed the internal discolouration and failure of the hot section and its components. Further investigation and testing on the failed engine could not be conducted due to the operator being in the process of liquidation.

Conclusion			
The crew conducted an emergency landing at FAOR due to an in-flight engine failure. The borescope inspection of the engine revealed the internal discolouration and failure of the hot section and its components. The cause of the engine failure could not be determined due to the operator being in the process of liquidation. The investigation will be reopened once the new owner takes over the operation.			
SRP Date	12 September 2023	Publication Date	22 September 2023

Occurrence Details

Reference Number	: CA18/3/2/1395
Occurrence Category	: Category 1
Type of Operation	: Commercial (Part 121)
Name of Operator	: Comair Limited
Aircraft Registration	: ZS-ZWB
Aircraft Make and Model	: Boeing 737-800
Nationality	: South African
Place	: During the climb whilst passing FL210
Date and Time	: 7 March 2022 at 0412Z
Injuries	: None
Damage	: Substantial to number 1 engine

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.

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.

Investigation Process

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was notified of the occurrence involving a B737-800 which occurred in-flight at FL210 near Carletonville, Gauteng province, on 7 March 2022 at 0412Z. The occurrence was classified as a serious incident according to the CAR 2011 Part 12 and ICAO Annex 13 definitions. The AIID appointed an investigator-in-charge to conduct a full investigation. The investigator was dispatched to O.R. Tambo International Airport (FAOR). Notifications were sent to the State of Registry, Operator, Design and Manufacturer in accordance with CAR 2011 Part 12 and ICAO Annex 13 Chapter 4. The State of Design and Manufacturer appointed an accredited representative and advisor. The AIID is leading the investigation as the Republic of South Africa is the State of Occurrence.

Notes:

- Whenever the following words are mentioned in this report, they shall mean the following:
Serious Incident — this investigated serious incident.
Aircraft — the Boeing 737-800 involved in this serious incident.
Investigation — the investigation into the circumstances of this serious incident
Pilot — the pilot involved in this serious incident.
Report — this serious incident report*
- Photos and figures used in this report were taken from different sources and may have been adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report were 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 SACAA, which are reserved.

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Abbreviation	Description
°	Degrees
°C	Degrees Celsius
AIID	Accident and Incident Investigations Division
AMM	Aircraft Maintenance Manual
AMO	Aircraft Maintenance Organisation
ATC	Air Traffic Control
ATPL	Airline Transport Pilot Licence
BSI	Borescope Inspection
CAR	Civil Aviation Regulation
C of A	Certificate of Airworthiness
CRS	Certificate of Release to Service
CVR	Cockpit Voice Recorder
CRMA	Certificate Relating to Maintenance of an Aircraft
EGT	Exhaust Gas Temperature
FACT	Cape Town International Airport
FALA	Lanseria International Airport
FAOR	O.R. Tambo International Airport
FDR	Flight Data Recorder
FT	Feet
FL	Flight Level
GE	General Electric
GPS	Global Positioning System
I.A.W	In Accordance With
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
HPC	Higher Pressure Compressor
Kts	Altitude Above Mean Sea Level
KIAS	Indicated Air Speed
LPC	Low Pressure Compressor
METAR	Meteorological Routine Aerodrome Report
MHz	Megahertz
NTSB	National Transport Safety Board
PF	Pilot Flying
PM	Pilot Monitoring
PN	Part Number
QNH	Query Nautical Height
RWY	Runway
S	South
S/N	Serial Number
SACAA	South African Civil Aviation Authority
SACAR	South African Civil Aviation Authority
SAWS	South African Weather Service
TRACON	Terminal Radar Approach Control
UTC	Co-ordinated Universal Time
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

FACTUAL INFORMATION

1.1. History of Flight

- 1.1.1 On Monday morning, 7 March 2022 at approximately 0404Z, a Boeing 737-800 aircraft with registration ZS-ZWB and flight number MN451 took off on a domestic scheduled flight from Lanseria International Airport (FALA) in Gauteng province to Cape Town International Airport (FACT) in the Western Cape province. Two pilots, four cabin crew members and 135 passengers were on-board the aircraft. The flight was conducted under instrument flight rules (IFR) by day and under the provisions of Part 121 of the Civil Aviation Regulations (CAR) 2011 as amended.
- 1.1.2 Whilst climbing through flight level (FL) 210 to reach FL 217, the crew heard a loud bang that originated from the No.1 engine. The first officer (FO), who was the pilot monitoring (PM), deduced that the No.1 engine had failed. As a result of the left engine failure, the flight crew conducted an emergency descent and diverted to O.R. Tambo International Airport (FAOR). The aircraft landed safely with a single engine in operation at FAOR, about 20 minutes after the engine failure occurred.
- 1.1.3 The captain was the pilot flying (PF) and the first officer (FO) was the pilot monitoring (PM). The captain reported that the aircraft was pushed back from the gate (entrance) at 0401Z and it took off at 0404Z. On the technical logbook 36 (TL 36), the flight data recorder (FDR) (see Graph 2) indicated that taxi and take-off were uneventful. The FAOR air traffic control (ATC) on duty instructed the flight crew to climb to FL217 and maintain that position. The climb to FL217 was uneventful until shortly after the aircraft passed through FL210 when the crew heard a loud bang which originated from the No.1 engine (left side). The PM deduced that the No.1 engine had failed.
- 1.1.4 The FDR data showed that immediately after the loud bang, the No. 1 (left) engine fan and core speeds (N1) decreased from 97.88% to 88.88%; thereafter, to 0%. The left engine low pressure turbine (LPT) vibration parameters increased from 0.40 to 1.83%. The FDR data also showed that the aircraft's altitude at that time was 20 573 feet (ft); and that the left engine failed at 0412:36Z then 12 seconds later at 0412:48Z, the fuel cut off. The crew referenced the emergency checklist procedure and, thereafter, broadcasted a MAYDAY call on frequency 128.30-Megahertz (MHz) stating that they have an engine failure and that they were requesting permission to divert to FAOR. The ATC acknowledged the emergency call and cleared the aircraft to descend and to land at FAOR. The ATC then

activated the alert phase (Alerfa) and advised the control tower that MN451 had an emergency (engine failure). The ATC also alerted the Aerodrome Rescue and Firefighting (ARFF) personnel to be on standby.

1.1.5 The PM advised the cabin crew members and the passengers through the passenger address (PA) system that the engine had failed and that they were diverting to FAOR. The PF asked the senior cabin crew member (SCCM) to check for anything that was unusual in the cabin. Approximately 5 minutes later, the SCCM reported to the pilots that the cabin was secured and that everything was in order. In the cockpit, the pilots went through the checklist to secure the failed engine. Thereafter, they followed the manufacturer's checklist and completed the process. During that time, the crew had to control the aircraft that had lost thrust on the left side and, simultaneously, communicate with the ATC. The aircraft circled overhead FAOR twice whilst the pilots were going through the emergency checklists before they landed on Runway (RWY) 03R.

1.1.6 The aircraft landed at 0432Z. Three emergency vehicles were given clearance to enter the runway behind the aircraft. There was no fluid leak or visible debris from the engine on the runway. The aircraft, followed by emergency vehicles, proceeded to the parking bay where the No.2 engine was shut down. The pilots stated that all indications were reading normal until they heard the loud bang from the No.1 engine. No persons on-board the aircraft were injured. The aircraft sustained damage to the engine, the left-side fuselage skin and the left leading edge of the horizontal stabiliser.

1.1.7. The serious incident occurred during day time at Global Positioning System (GPS) co-ordinates determined to be 26°41.10' South 027°33.10' East, during the climb phase whilst passing FL210.



Figure 1: The flight path taken by the aircraft. (Source: Flight Aware)

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	2	4	135	141	-
Total	2	4	135	141	-

Note: Other means people on the ground.

1.3. Damage to Aircraft

- 1.3.1. The No.1 engine, the left side of the fuselage skin and the left leading edge of the horizontal stabiliser were damaged.



Figure 2: The affected engine.

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

Pilot-in-command (PIC) who was the pilot flying (PF)

Nationality	South African	Gender	Male	Age	59
Licence Type	Airline Transport Pilot Licence (ATPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Night Flight, Grade II Flight Instructor, Safety Pilot, Test Pilot and Tug Pilot				
Medical Expiry Date	31 August 2022				
Restrictions	None				
Previous Incidents	None				

Note: Previous incidents refer to past incidents the pilot was involved in, when relevant to this incident.

Flying Experience:

Total Hours	12 865
Total Past 24 Hours	0
Total Past 7 Days	13
Total Past 90 Days	177
Total on Type Past 90 Days	154
Total on Type	3 318

1.5.1. The PF was initially issued an Airline Transport Pilot Licence (ATPL) on 26 November 1999. His licence was revalidated on 12 March 2021 with an expiry date of 31 March 2022. His last proficiency check was conducted on 15 October 2021.

1.5.2. The PF was issued a Class 1 aviation medical certificate on 16 August 2021 with an expiry date of 31 August 2022 with no medical waiver.

Personnel Information

First Officer (FO) who was the pilot monitoring (PM)

Nationality	South African	Gender	Male	Age	36
Licence Type	Airline Transport Pilot Licence (ATPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument and Night rating				
Medical Expiry Date	30 September 2022				
Restrictions	None				
Previous Incidents	Serious incident on 7 February 2022				

Note: Previous incidents refer to past incidents the pilot was involved in, when relevant to this incident.

Flying Experience:

Total Hours	7 549.37
Total Past 24 Hours	1.09
Total Past 7 Days	20.45
Total Past 90 Days	188:52
Total on Type Past 90 Days	167.38
Total on Type	2 502:58

1.5.3 The PM was initially issued an Airline Transport Pilot Licence (ATPL) on 13 October 2015. His licence was revalidated on 14 June 2021 with an expiry date of 30 June 2022. His last proficiency check was conducted on 5 December 2021.

1.5.4 The pilot was issued a Class 1 aviation medical certificate on 10 September 2021 with an expiry date of 30 September 2022 with no waivers.

1.6. Aircraft Information (Source: Boeing 737 Manual).

1.6.1 *The Boeing 737-800 is a low-wing, narrow body, single-aisle jet transport aircraft powered by two high bypass CFM56-7B26 turbofan engines mounted on pylons beneath the wings. The aircraft is designed to operate with two pilots and six cabin crew on-board. The aircraft is designed to carry a maximum of 189 passengers.*

Airframe:

Manufacturer/Model	Boeing 737-800	
Serial Number	40852	
Year of Manufacture	2012	
Total Airframe Hours (At Time of Serious incident)	24 989.14	
Last Inspection (Date & Hours)	7 December 2021	24 257.17
Hours Since Last Phase Inspection	731.97	
CRS Issue Date	20 February 2022	
C of A (Issue Date & Expiry Date)	5 November 2012	30 November 2022
C of R (Issue Date) (Present Owner)	7 June 2019	
Type of Fuel Used	Jet A1	
Operating Category	Commercial (Part 121)	
Previous Incidents	None	

Note Previous serious incidents refer to past serious incidents the aircraft was involved in, when relevant to this incident.

- 1.6.2. According to available information, the aircraft was first registered to the present owner on 7 June 2019. The Certificate of Release to Service (CRS) was reissued on 20 February 2022 with an expiry date of 29 October 2022 or at 22 679 airframe cycles, whichever occurs first.
- 1.6.3 The aircraft had a valid Certificate of Airworthiness (C of A) that was initially issued by the Regulator on 8 November 2012 with an expiry date of 30 November 2022.
- 1.6.4. Based on the aircraft maintenance records, the last phase inspection (A-Check) was conducted on 7 December 2021 at 24 257.17 airframe hours. The aircraft had accumulated an additional 731.97 airframe hours in operation since the last inspection. An A-Check is conducted every 600 hours.

Engine 1:

Manufacturer/Model	CFM 56-7B
Serial Number	963333
Part Number	CF56-7B26E
Hours Since New	24 989:14
Hours Since Overhaul	Modular assembly

- 1.6.5 The CFM56-7B is a high-bypass, dual-rotor, axial-flow turbofan engine. A single-stage high-pressure turbine (HPT) drives the nine-stage high-pressure compressor (HPC). A four-stage low-pressure turbine (LPT) drives the engine fan and low-pressure compressor (also referred to as the booster). The engine rotates clockwise (aft looking forward).

1.6.6 The engine consists of three major assemblies: the fan, engine core and LPT. General Electric (GE) is responsible for manufacturing the HPC, combustion chamber and HPT (collectively referred to as the engine core). Safran is responsible for manufacturing the engine fan and LPT. Both companies assemble the engines; the engines assembled by GE are identifiable by even number engine serial number (ESN) prefix (for example, 964), and those assembled by Safran are identifiable by an odd ESN prefix (for example, 963). The ESN of the accident engine 963333 showed that Safran assembled the engine.

1.6.7 The fan and booster assembly comprise the front and aft spinner cones, fan disk, fan blades, booster rotor, booster vanes and associated hardware. The fan disk, which is secured to the booster, has 24 fan blade slots. In accordance with (IAW) the instructions in the Boeing 737-600/700/800/900 Aircraft Maintenance Manual (AMF), the fan blades are numbered sequentially (1 through 24) in counterclockwise direction (forward looking aft).

1.6.8 Based on the available information, the No.1 engine full hot section borescope inspection (BSI) was last certified on 9 April 2021; the BSI is conducted at every 1600 airframe hours. The BSI was certified IAW the Boeing 737-800 Maintenance Manual (AMM) Revision 74. The BSI was certified IAW the maintenance planning document (MPD) interval. The following observations were made during the inspection:

- **Fuel Nozzles:** (AMM 72-00-00-200-805-F00) Several deflectors with slight burnt back on the edges; all found to be within the limits.
- **Combustion Chambers:** (AMM 72-00-00-200-805-F00) Inner liner: Nil defects found. Outer liner: Nil defects found.
- **Nozzle Guide Vanes:** (AMM 72-00-00-220-801-F00 & 72-00-00-200-818-F00. Higher pressure (HP) nozzle guide vane (NGV): Several vanes with inner and outer platforms burns and several vanes with thermal barrier coating (TBC) loss on convex side, all were found to be within limits.
- **High Turbine Blades:** (AW AMM 72-00-00-200-807-F00. Two blades were found to have notches. Several blades with leading edge (L/E) thermal barrier coating (TBC) loss; all found to be within limits. All blades had tip rub evidence; all were found to be within limits.

1.6.9 After the BSI was conducted, the engine remained in service with no limitations.

- 1.6.10 Following the serious incident on 7 March 2022, an unscheduled full hot section BSI was performed by the aircraft maintenance organisation (AMO) on 10 March 2022, and the following observations were made during the inspection:

General Inspection Reference AMM 72-00-00

Exterior Inspection

Igniter boxes and leads, electronic control unit (ECU), anti-ice ducts and oil tank are visibly secure, no broken mounts. Starter duct and start valve, hydraulic lines and wire harnesses are all visibly secure with no broken parts.

Accessory Drive Gearbox

Starter, integrated drive generator (IDG), hydraulic pump, fuel pump and fuel control unit (FCU) are visibly secured with no evidence of leaks. No visible damage to the plumbing or tubes.

Compressor Cases.

No visible damage to the lower pressure (LP) compressor bleed valves. No visible bent or broken higher pressure compressor (HPC) variable stator arms. Customer bleed ducts have no visible cracks or evidence of leaking. Fuel nozzles have no visible evidence of leaking. Heat shields for high pressure (HP) turbine cooling manifold have no visible missing material.

Exhaust Cases

LP turbine cooling tubes have no visible dents, cracks or evidence of leaks.

Exhaust Cone

No discrepancies noted at this time. Suggested Action: None. (See Figure 3,4 and 5)

Exhaust Cone

No discrepancies noted at this time.

Suggested Action: None. (See Figures 3,4 and 5).



Figure 3



Figure 4



Figure 5

Low Pressure Compressor (LPC): (Reference AMM Task 72-00-00-200)

LPC 1 Fan blades were smooth to the touch with no recent foreign object debris (FOD). Running seal has no heavy rubs or missing material. (See figure 6)

LPC 2 Blades Initial damage found at HPT, no inspection performed.

LPC 3 Blades Initial damage found at HPT, no inspection performed.

LPC 4 Blades Initial damage found at HPT, no inspection performed.

Exit Guide Vanes No significant discrepancies noted at this time.

Suggested Action: First traces of damage found at Combustor and HPT.



Figure 6

High Pressure Compressor (HPC)(Reference [HPC] AMM task 72-00-00-200)

HPC 1 Blades Initial damage found at HPT; no inspection performed.

HPC 2 Blades Initial damage found at HPT; no inspection performed.

HPC 3 Blades Initial damage found at HPT; no inspection performed.

HPC 4 Blades Initial damage found at HPT; no inspection performed.

HPC 5 Blades Initial damage found at HPT; no inspection performed.

HPC 6 Blades Initial damage found at HPT; no inspection performed.

HPC 7 Blades Initial damage found at HPT; no inspection performed.

HPC 8 Blades No significant discrepancies noted at this time.

The engine was unable to be turned.

HPC 9 Blades No significant discrepancies noted at this time.

The engine was unable to be turned.

Suggested Action: None. LE dents



Figure 7 (top) and Figure 8 (bottom)

Combustor (Reference AMM task 72-00-00-200)

Bulkhead Colour difference visible.

Fuel Nozzles No significant discrepancies noted at the time.

There is no limit on the amount of carbon accumulation.

Inner & Outer Liners First liner normal, other liner colour difference visible. (Figures 9 and 10)





Figure 9 (top) and Figure 10 (bottom)

HPT NGVs LE Discolouration

The engine was unable to be turned. (Figures 11 and 12)



Figure 11



Figure 12

High Pressure Turbine (Reference AMM task 72-00-00-200)

HPT Shrouds Discolouration visible

HPT Blades LE Blades broken off completely.

HPT Blades TE Blades broken off completely. (Figures 13 and 14)



Figure 13 and Figure 14

Low Pressure Turbine (Reference AMM task 72-00-00-200)

LPT 2 Blades - Several blades broken.

LPT 3 Blades - Several blades broken.

LPT 4 Blades - Several blades broken. (Figures 15,16, 17 and 18)



Figure 15 and Figure 16



Figure 17



Figure 18

1.6.11 The engine was removed on 10 March 2022 after the BSI was conducted, and was due to be sent to the manufacturer for the teardown inspection, but the operator was liquidated during the shipping process.

Engine2:

Manufacturer/Model	CFM 56-7B
Serial Number	963334
Part Number	CF56-7B26E
Hours Since New	24989:14
Hours Since Overhaul	Modular assembly

1.7. Meteorological Information

1.7.1 The weather information at FL210 entered in the table below was sourced from the Meteorological Aerodrome Report (METAR) that was issued by the South African Weather Service (SAWS) on 7 March 2022 at 0412Z.

Wind Direction	94.9°	Wind Speed	05kt	Visibility	9999m
Temperature	15.9°C	Cloud Cover	Nil	Cloud Base	Nil
Dew Point	14°C	QNH	849.5 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 navigational equipment was unserviceable prior to the serious incident.

1.9. Communication

1.9.1. The aircraft was equipped with a standard communication system as approved by the Regulator. There were no recorded defects with the communication system prior to the accident. The crew was in communication with FAOR ATC on frequency 128.30 MHz. Due to the liquidation of the operator, the transcript could not be analysed.

1.10. Aerodrome Information

Aerodrome Location	O.R. Tambo International Airport (FAOR)
Aerodrome Status	Licensed
Aerodrome GPS coordinates	26°08'.00" South, 028°14'.05" East
Aerodrome Elevation	5 558ft
Runway Headings	03L/21R, 03R/21L
Dimensions of Runway Used	4 421m x 60m, 3 405m x 60m
Heading of Runway Used	03L/21R,
Surface of Runway Used	Asphalt
Approach Facilities	Runway lights, PAPI, DVOR / DME (JSV), ILS LOC and ILS GP for both runways
Radio Frequency	121.9 MHz, 124.5 MHz, 128.30 MHz, 118.600 MHz

1.11. Flight Recorders

1.11.1 The aircraft was fitted with a flight data recorder (FDR) and a cockpit voice recorder (CVR) as required by Part 121.05 of the CAR 2011 as amended. The FDR and the CVR circuit breakers (CBs) were removed to protect the information. The recorders were removed from the aircraft on 7 March 2022. Both the FDR and the CVR were successfully downloaded on 7 March 2022 at an approved AMO in the presence of the investigator. The transcript from the CVR was not conducted as the investigating team deemed the available information adequate for the report.

FDR information:

- Manufacturer: Honeywell
- Type: Solid-State digital flight recorder
- Part Number: 980-4750-003
- Serial Number: FDR-06151
- Date of Manufacture: November 2018



Graph 1: Blue line shows left engine VN1T and yellow line depicts right engine VN1T.

DATE	TIME	ACID	FLT	AGW	SQAT	PALT	CAS	TAT	N1E1	N1E2	N2E1	N2E2	EGTE1	EGTE2	FFKG1E	FFKG2E	TRAE1	TRAE2	BLDE1	BLDE2	CAIE1	CAIE2	EGTAX1	EGTAX2	EGTRX1	EGTRX2	FAILE1	
70322	4:12:20	AIR	19945	287.00	12.00	97.88	97.75	99.00	98.88	831.00	831.00	2693.00	2627.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:24	AIR	20104	288.00	12.00	97.88	97.88	99.00	98.88	831.00	831.00	2685.00	2620.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:28	AIR	20263	289.00	11.75	97.88	97.88	99.00	99.00	831.00	832.00	2678.00	2620.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:32	AIR	20427	289.00	11.75	97.88	97.88	99.00	99.00	831.00	832.00	2671.00	2613.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:36	AIR	20502	288.00	11.50	47.88	98.00	71.88	99.13	858.00	832.00	973.00	2598.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:40	AIR	20592	286.00	11.25	20.63	98.00	38.25	99.00	839.00	833.00	145.00	2598.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:44	AIR	20648	284.00	10.75	21.13	98.00	13.00	99.00	831.00	834.00	131.00	2598.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:48	AIR	20632	285.00	10.50	21.13	98.00	8.25	99.00	837.00	834.00	131.00	2605.00	71.89	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:52 ZS-ZWB	AIR	20584	286.00	10.75	20.13	98.00	7.13	99.00	840.00	834.00	0.00	2605.00	54.32	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:12:56 ZS-ZWB	AIR	20571	286.00	11.00	20.00	98.00	7.13	99.00	839.00	834.00	0.00	2605.00	44.47	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-
70322	4:13:00 ZS-ZWB	AIR	20559	287.00	11.00	19.88	98.00	7.13	99.00	838.00	834.00	0.00	2605.00	37.79	71.89	ON	ON	OFF	OFF	-	-	-	-	-	-	-	-	-

Graph 2: ZS-ZWB engines parameters.

1.11.2 The FDR data graphs 1 and 2 show that the left engine failed at 0432:36Z at an altitude of 20 573 feet (ft), and at the same time, the fan engine started vibrating between 0.03 and 1.83%. Under normal operation, engine fan vibrations should be approximately 0.40%. The low pressure turbine (LPT) also vibrated from 0.08 to 1.07%, the vibration limits should be approximately 0.40%.

1.11.3 The left engine N1 speed decreased from 97.88% to 0% within seconds, whilst the right engine N1 speed remained constant at 97.88%. The exhaust gas

temperature (EGT) for the left engine increased from 800° to 873°C, under normal operation it should be about 800°C.

1.11.4 The FDR also shows that the aircraft departed (from the gate/parking bay) with both oil tanks full at approximately 14 US quartz. The oil pressure on engine one (left) dropped from 55 pounds per square inch (psi) to 0 psi when the engine failed. The engine failed at 0412:36Z; then 12 seconds later, fuel cut off on the number one engine. At 0432Z, the number two engine (right) was switched off at the gate.

CVR information:

- Manufacturer: Honeywell
- Type: Solid-State Cockpit voice reorder
- Part Number: 980-6032001
- Serial Number: CVR-03221
- Date of manufacture: August 2015

1.12. Wreckage and Impact Information

1.12.1. Post serious incident examination of the aircraft at FAOR showed that the left fuselage, the left-wing inboard flaps lower surfaces, and the left horizontal stabiliser had evidence of impact damage (surface scratching and skin gouging, tears and penetrations).



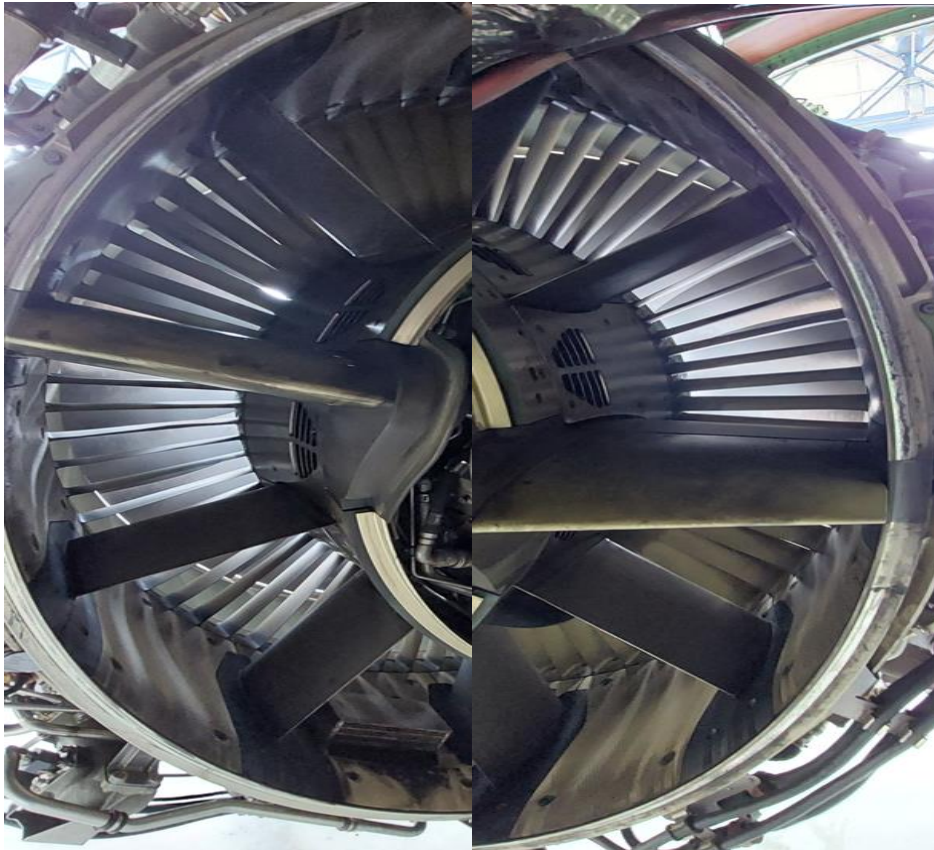
Figure 19: Inboard flaps during repairs.

1.12.2. The operator grounded the aircraft for inspection and repairs after the incident.

1.12.3. Post-incident investigation revealed the following: the fan blades were undamaged but still intact in their respective positions with no evidence of foreign object debris (FOD). The compressor and the stator blades were still intact in their respective positions.



Figure 20: No damage to the fan blades.



Figures 21 and 22: The compressor and the stator blades.

1.12.4. The low pressure turbine (LPT) blades were damaged with cuts almost at the same height all around.

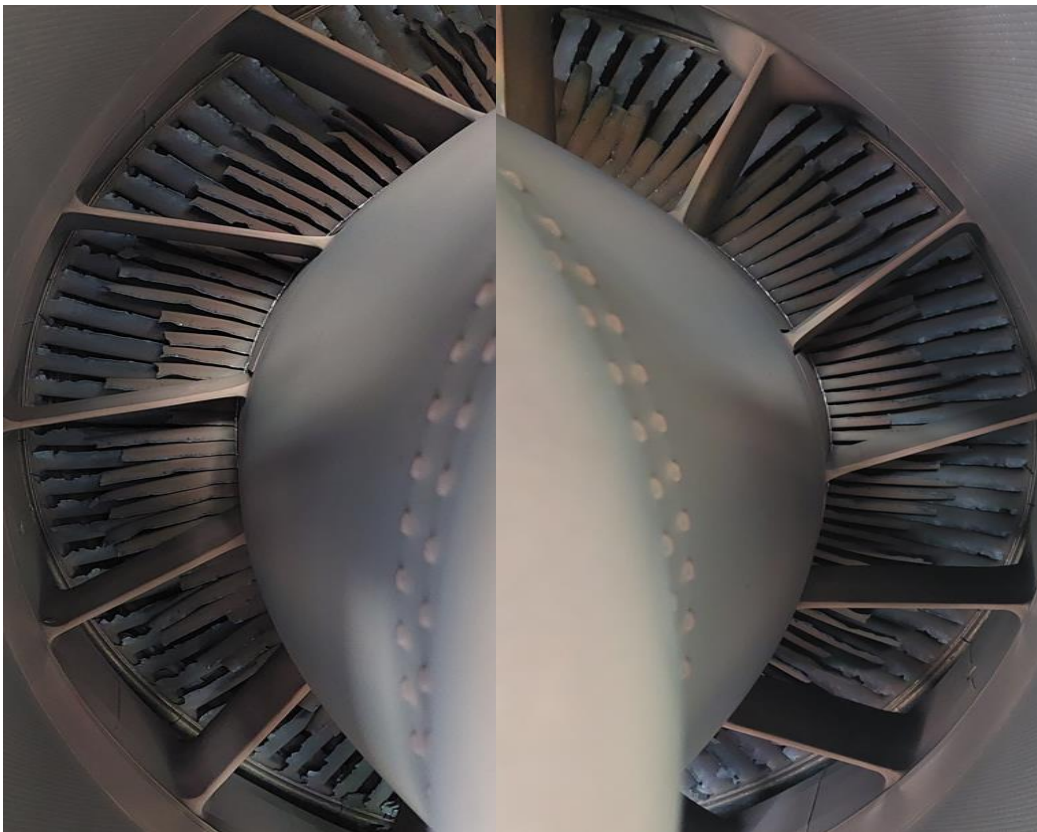


Figure 23: Damaged turbine rotor blades.

1.12.5 The left-side leading edge of the horizontal stabiliser was pierced by debris from the engine.



Figure 24: Damage to the leading edge of the left horizontal stabiliser.

1.12.6 Debris from the engine abraded the left side of the fuselage.



Figure 25: Damage to the skin of the left-side fuselage.

1.12.7 The left-side in-board flap fairing was abraded by debris from the engine.



Figure 26: Damage to the underside of the fuselage aft section.

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 serious incident was considered survivable as no damage was caused to the cockpit and cabin structure of the aircraft.

1.16. Tests and Research

1.16.1. The borescope inspection of the engine revealed the internal discolouration and failure of the hot section and its components. Further investigation and testing on the failed engine could not be conducted due to the operator being liquidated. The investigation will be reopened once the new owner of the engine is identified.

1.17. Organisational and Management Information

1.17.1. According to the operations specifications, Comair operated 23 Boeing 737 series aircraft at the time of the serious incident. All the company's 737 series aircraft were equipped with CFM56-7B engines.

1.17.2. The flight was conducted in accordance with the provisions of Part 121 (Commercial) of the CAR 2011 as amended.

1.17.3. The aircraft maintenance organisation (AMO) which certified the last maintenance inspection (annual inspection) prior to the serious incident flight had an approved AMO certificate that was issued by the Regulator on 9 February 2022 with an expiry date of 28 February 2023.

1.17.4. The operator had an approved Class 1 Air Service Licence No. S066D for domestic schedule, which was issued on 12 August 2015 by the Department of Transport. The licence authorised the carrier to operate under the following categories: Type S1 – transport of passengers between two or more specified points, and Type S2 – transport of cargo or mail between two or more specified points. The aircraft used under this operation should meet category A1 provisions – any aircraft, excluding a helicopter, with a maximum certificated mass exceeding 20 000 kilograms.

1.17.5. The operator had an Air Operating Certificate (AOC) which was issued on 3 May 2021 by the SACAA with an expiry date of 30 April 2022. The aircraft was duly authorised to operate under the AOC.

1.17.6. The last audit was conducted from 23 to 26 March 2021 by the Regulator. The scope of the audit conducted was to determine whether the AOC could be renewed in terms of the requirements stipulated in the Aviation Legislation in South Africa and Part 121 of the CAR 2011 as amended. The Regulator could not find any findings.

1.18. Additional Information

1.18.1 According to Boeing 737 QRH, the Engine Fire or Engine Severe Damage or Separation checklist should be completed if an engine fire warning, airframe vibrations with abnormal engine indications, and/or an engine separation occurs. The four-page checklist has 17 items as shown in Figure 27. The first five items

on the checklist are considered time sensitive as indicated by the black line below the fifth item.

1.18.2 The crew followed the engine severe damage or separation non-normal checklist to avoid confusion.

The following information is an extract from the Boeing 737 Flight Crew Operations Manual:

8.2



737 Flight Crew Operations Manual

**ENGINE FIRE
or
Engine Severe Damage or
Separation**

Condition: One or more of these occur:

- Engine fire warning
- Airframe vibrations with abnormal engine indications
- Engine separation.

- 1 Autothrottle (if engaged) Disengage
- 2 Thrust lever
(affected engine) Confirm Close
- 3 Engine start lever
(affected engine) Confirm CUTOFF
- 4 Engine fire switch
(affected engine) Confirm Pull

To manually unlock the engine fire switch, press the override and pull.
- 5 **If** the engine fire switch or ENG OVERHEAT light is illuminated:

Engine fire switch
(affected engine) Rotate to the stop
and hold for 1 second



▼ Continued on next page ▼

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737 Flight Crew Operations Manual

▼ ENGINE FIRE or Engine Severe Damage or Separation continued ▼

6 Choose one:

◆ On the **ground**:

▶▶ **Go to the Engine Fire on the Ground checklist on page Back Cover.2**



◆ In **flight**:

▶▶ **Go to step 7**

7 **If** after 30 seconds the engine fire switch or ENG OVERHEAT light stays illuminated:

Engine fire switch
(affected engine) Rotate to the other stop and hold for 1 second

▼ Continued on next page ▼

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▼ ENGINE FIRE or Engine Severe Damage or Separation continued ▼

8 Choose one:

◆ High airframe vibration **occurs** and **continues** after the engine is shut down:

Without delay, reduce airspeed and descend to a safe altitude which results in an acceptable vibration level.

Note: If high vibration returns and further airspeed reduction and descent are not practical, increasing airspeed can reduce the vibration.

▶▶ **Go to step 9**

◆ High airframe vibration does **not** occur or does **not** continue after the engine is shut down:

▶▶ **Go to step 9**

9 ISOLATION VALVE switch CLOSE

10 PACK switch (affected side) OFF

This step causes the operating pack to regulate to high flow in flight with the flaps up.

11 APU BLEED air switch OFF

▼ Continued on next page ▼

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▼ ENGINE FIRE or Engine Severe Damage or Separation continued ▼

12 Choose one:

- ◆ APU is **available** for start:
 - APU START
 - When** APU is running:
 - APU GEN switch
(affected side) ON
 - ▶▶ **Go to step 13**
- ◆ APU is **not** available:
 - ▶▶ **Go to step 13**

13 Balance fuel as needed.

YC010 - YD261, YR011 - YS378

14 Transponder mode selector TA

This prevents climb commands which can exceed single engine performance capability.

YK554 - YQ250

15 Transponder mode selector TA ONLY

This prevents climb commands which can exceed single engine performance capability.

16 ISOLATION VALVE switch

(after the fire has been extinguished) AUTO

This step ensures bleed air is available to both wings if wing anti-ice is needed.

17 Plan to land at the nearest suitable airport.

Note: Do not use FMC performance predictions.

▼ Continued on next page ▼


Figure 27. Engine Fire or Engine Severe Damage or Separation checklist

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1.18.3 One Engine Inoperative Landing

Flight crew members were directed after step 17 of the Engine Fire or Engine Severe Damage or Separation checklist to check the One Engine Inoperative Landing checklist.

7.30


737 Flight Crew Operations Manual

One Engine Inoperative Landing

Condition: Landing must be made with one engine inoperative.

- 1 Plan a flaps 15 landing.
- 2 Set VREF 15 or VREF ICE.
Note: 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 5 knots.
- 3 Check the Non-Normal Configuration Landing Distance tables in the Performance Inflight-QRH chapter or other approved source.
- 4 Maintain VREF 15 + wind additive or VREF ICE + wind additive on final approach to assure sufficient maneuver margin and speed for go-around. The minimum wind additive is 5 knots.
- 5 When engine anti-ice is needed, use on the operating engine only.
- 6 **Checklist Complete Except Deferred Items**

▼ Continued on next page ▼

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D6-27370-800-CML September 30, 2022

Figure 28: The first page of One Engine Inoperative Landing checklist.

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▼One Engine Inoperative Landing continued▼

Deferred Items

Descent Checklist

Pressurization LAND ALT ____

Recall Checked

Autobrake ____

Landing data **VREF 15 or VREF ICE** ____,
Minimums ____

Approach briefing Completed

Additional Go-Around Thrust

Choose one:

- ◆ Additional go-around thrust is **needed**:
 - ▶▶ **Go to No Engine Bleed Landing below**
- ◆ Additional go-around thrust is **not** needed:
 - ▶▶ **Go to Go-Around Procedure Review below**

No Engine Bleed Landing

When below 10,000 feet:

WING ANTI-ICE switch OFF

ISOLATION VALVE switch CLOSE

BLEED 1 air switch OFF

▼ Continued on next page ▼

Figure 29: The second page of One Engine Inoperative Landing checklist.

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1.19. Useful or Effective Investigation Techniques

1.19.1. None.

2. ANALYSIS

2.1. General

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

2.2. Analysis

2.2.1. Flight Crew Qualifications

The flight crew was properly licensed and qualified IAW the Regulator's (SACAA) regulations and requirements.

Flight Crew Medical History:

The flight crew had valid and current medical certificates in accordance with the Regulator's (SACAA) regulations and requirements.

2.2.2. Aircraft Mechanical Condition

The aircraft was properly certificated, equipped and maintained by an approved AMO IAW the manufacturer's specifications. There were no recorded defects prior to the serious incident. No evidence was found which indicated structural, engine, or system failures before the left engine failure occurred.

2.2.3. Thus, the investigation concluded that none of the above was a factor in this serious incident.

2.2.4. Operational Factors

At the time of the engine failure (0412Z), the captain was the PF, and the first officer was the PM. Maintaining aircraft control was the most critical demand placed on the flight crew once the emergency situation occurred. Specifically, the crew had to control an aircraft that had lost thrust on its left side. In addition to maintaining control of the aircraft, communication with ATC imposed demand on the flight crew (even though the intent of the communication was to provide assistance to the crew and follow ATC procedures). Following the correct checklists according to the standard operating procedures is a critical part of safe flight operations. However, given the emergency situation, the flight crew's performance of the items on the Engine Severe Damage or Separation non-normal checklist and other relevant non-normal checklists allowed the crew to appropriately balance the procedural requirement of executing the checklist with the high workload associated with maintaining aircraft control and accomplishing timely descent and a safe single engine landing.

2.2.5 The flight crew's decision to land at FAOR was appropriate, given the aircraft's location at the time of the emergency.

2.2.6 Fine weather conditions prevailed at the time of the serious incident; the weather had no bearing to the serious incident flight.

The FDR showed that the aircraft departed (from the parking bay) with both oil tanks full at approximately 14 US quartz. The oil pressure on the number one engine dropped from 55 psi to 0 psi when the engine failed. The engine failed at 0412:36Z; then 12 seconds later, fuel cut off from the number one engine. At 0432Z, the number two engine was shut down at the gate.

3. CONCLUSION

3.1. General

From the available evidence, 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 organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion 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 incident occurring, or would have 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 After completing a comprehensive review of the circumstances that led to this serious incident, the investigation established that the following factors did not contribute to the cause of the serious incident:

- (i) The flight crew's qualifications were in accordance with the South African Civil Aviation Authority (SACAA) regulations.
- (ii) The flight crew's medical history.
- (iii) The airworthiness of the aircraft before the left engine failure occurred.
- (iv) Maintenance of the aircraft by an approved AMO.

3.2.2 The flight was conducted in accordance with the provisions of Part 121 of the CAR 2011 as amended.

- 3.2.3 The aircraft had accumulated an additional 731.97 airframe hours in operation since the last inspection. An A-Check is conducted every 600 hours.
- 3.2.4 The flight crew's decision to land at FAOR was appropriate, given the aircraft's location at the time of the emergency. The aircraft landed safely on RWY 03R.
- 3.2.5 The borescope inspection of the left engine that was signed out on 9 April 2021 revealed that the low-pressure compressor and high-pressure compressor turbine blades sustained minor damage and were all within the limits, according to the manufacturer's maintenance manual, therefore, the engine remained in service with no BSI limitations.
- 3.2.6 During visual inspection on 10 March 2022 after the serious incident, the last stage blades of the left engine low pressure turbine were found damaged.
- 3.2.7 The BSI of the left engine that was conducted on 10 March 2022 revealed internal discolouration and failure of the hot section and its components.
- 3.2.8 Fine weather conditions prevailed at the time of the serious incident; the weather had no bearing to the serious incident.
- 3.2.9 The FDR showed that the aircraft departed the gate with both oil tanks full at approximately 14 US quartz. The oil pressure on the number one engine dropped from 55 psi to 0 psi when the engine failed. The engine failed at 0412:36Z, and 12 seconds later, fuel cut off from the number one engine. At 0432Z, the number two engine was switched off at the parking bay. The transcript from the CVR was not conducted as the investigating team deemed the available information adequate for the report.
- 3.2.10 The left-side fuselage, horizontal stabiliser and inboard flaps lower surface were damaged by debris of the failed engine.

3.3. **Probable Cause/s**

- 3.3.1 The crew conducted an emergency landing at FAOR due to an in-flight engine failure. The borescope inspection of the engine revealed the internal discolouration and failure of the hot section and its components. The cause of the engine failure could not be determined due to the operator being liquidated. The investigation will be reopened once the new owner is identified.

3.4. **Contributory Factor/s**

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 None.

5. **APPENDICES**

5.1. Appendix A: Letter from the High Court appointing the liquidators.

**This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa**

DEPARTEMENT
VAN JUSTISIE



DEPARTMENT
OF JUSTICE

SERTIFIKAAT VAN AANSTELLING VAN * * VOORLOPIGE LIKWIDATEUR(S)
LIKWIDATEUR(S)/VOORLOPIGE-GEREGETELIKE-BESTURDER/
GEREGTELIKE-BESTURDER
[Maatskappywet, No. 61 van 1973 (soos gewysig); Wet op Beslote Korporasies, No. 69 van 1984]

CERTIFICATE OF APPOINTMENT OF * PROVISIONAL LIQUIDATOR(S)
LIQUIDATOR(S) / PROVISIONAL JUDICIAL-MANAGER/
JUDICIAL-MANAGER
[Companies Act, No. 61 of 1973 (as amended); Close Corporations Act, No. 69 of 1984]

Nr. G00613/2022

Hierby word getertifiseer dat
This is to certify that CLOETE MURRAY, KGASHANE CHRISTOPHER MONYELA, AHMED CARIM,

TRACY ANNE CAMERON & BUSHE JEFFREY ERIC BUTHELEZI

SECHABA TRUST

P O BOX 11889

THE TRAMSHED, 6126

is/waard is as * Voorlopige Likwidateur / Voorlopige-Geregetelike-Bestuurder met die magte soos uiteengesit in Artikel
van Wet No. van van

*is/waard appointed * Provisional Liquidator (s) / Provisional Judicial Manager with the powers as set out in Section
286(1)(a)(b)(c)(d)(e) & 4(f) of Act No. 61 of 1973 of

die *Maatskappy / Beslote-Korporasie bekend as
the *Company / Close-Corporation known as COMAIR LIMITED

1907/066783/05

vir onder *Voorlopige Likwidateur / Voorlopige-Geregetelike-Bestuurder geskied is *by Bevel van die Hooggeregshof
which has been placed under *Provisional Liquidation / Provisional Judicial Management *by Order of the

van Suid-Afrika
High Court of South Africa SOUTH GAUTENG HIGH COURT
Division/Magistrate's

Afdeling/Landdroshof

vir die distrik van
Court-for-the-district-of

Maar
by

Spesiale Besluit geregistreer op
Special Resolution registered on 14 JUNE 2022

Oeteken te JOHANNESBURG op
Signed at JOHANNESBURG on



Ass. Meester van die Hooggeregshof
Asst. Master of the High Court

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