AIRCRAFT SERIOUS INCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/3/2/1259		
Aircraft registration	**ZS-SSJ**	**Date of incident**	27 March 2019		**Time of incident**	1330Z	
Type of aircraft	Avro 146-RJ85		**Type of operation**		Air Transport Operations (Part 121)		
Pilot-in-command licence type	Airline Transport		**Age**	55	**Licence valid**	Yes	
Pilot-in-command flying experience	Total flying hours		21 300		Hours on type	2 676	
Last point of departure	O.R. Tambo International Aerodrome (FAOR): Gauteng Province						
Next point of intended landing	Upington Aerodrome (FAUP): Northern Cape Province						
Location of the incident site with reference to easily defined geographical points (GPS readings if possible)							
Radial 030 at 3 DME JSV (GPS position: 26°09'25.63" South 028°13'51.70" East)							
Meteorological information	Wind: 280°V010° at 08kts, Visibility: 9999, Clouds: BKN at 3600ft, Temperature: 23°C, Dew point: 15°C and QNH: 1027						
Number of people on-board	4 + 25	**No. of people injured**	0	**No. of people killed**	0		
Synopsis							

On Wednesday 27 March 2019 at approximately 1330Z, a British Aerospace Avro 146-RJ85 with registration marks ZS-SSJ took off from O.R. Tambo International Aerodrome (FAOR) on a scheduled domestic flight to Upington International Aerodrome (FAUP). On-board the aircraft were two pilots, two crew members and 25 passengers.

The aircraft took off in a north-easterly direction using Runway 03L. The pilots reported that after passing 6 500 feet (ft) above mean sea level (AMSL), the pilots heard a loud “bang” followed by the aircraft yawing to the right. The number 4 engine indicated high vibration levels accompanied by a decreasing low-pressure compressor speed (N1), increased exhaust gas temperature (EGT) and decreased high-pressure compressor (N2) indications. The pilots shut down the engine and secured it according to the Quick Reference Handbook (QRH) procedures. The pilots declared an emergency by broadcasting a “PAN-PAN-PAN”, advising the Air Traffic Control (ATC) that the number 4 engine had failed and that they were requesting an air turn back to FAOR. The aircraft landed safely at 1349Z.

The pilots, crew members and passengers were not injured during the serious incident sequence.

The investigation revealed that the number 4 engine failure was due to the failure of one of the first stage compressor blades which had cracked at the root before it separated. The blade travelled to the rear of the compressor section, damaging the low-pressure (LP/N1) and high-pressure (HP/N2) compressors and some internal engine components. It is likely that the crack on the blade root was due to fatigue.

SRP Date	09 June 2020	Publication Date	31 July 2020

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Abbreviations	Description
AD	Airworthiness Directive
ALERFA	Alert Phase - a situation wherein apprehension exists as to the safety of an aircraft and its occupants.
AGB	Angle Gear Box
AMSL	Above Mean Sea Level
ATC	Air Traffic Control
ATNS	Air Traffic and Navigation Services
ATPL	Airline Transport Pilot Licence
BKN	Broken (cloud layer)
SACATS OPS	South African Civil Aviation Technical Standards Operations
CAT II	Precision instrument approach and landing with a decision height lower than 200 feet (60 metres) but not lower than 100 feet (30 metres).
CAVOK	Ceiling and Visibility OK
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DME	Distance measuring equipment
DVOR	Doppler VHF Omni Directional Range
EGT	Exhaust Gas Temperature
FADEC	Full authority digital engine control
FAOR	O.R. Tambo International Airport
FAUP	Upington International Airport
Ft	Foot/feet
IC	Inspection Check
kN	Kilonewton
kt	Knot
MOR	Mandatory Occurrence Report
N1	Low Pressure Compressor Speed
N2	High Pressure Compressor Speed
PN	Part Number
(Pty) Ltd	Proprietary Limited
QNH	Query Nautical Height
QRH	Quick Reference Handbook
rpm	Revolutions per Minute
SB	Service Bulletin
SN	Serial Number
UK	United Kingdom
VHF	Very High Frequency
Z	Zulu (Term for Universal Coordinated Time - Zero hours Greenwich)

Description of Serious Incident

Reference Number	**:** CA18/3/2/1259
Name of Owner	**:** SA Airlink (Pty) Ltd
Name of the Operator	**:** Airlink
Manufacturer	**:** British Aerospace
Model	**:** Avro 146-RJ85
Nationality	**:** South African
Registration Marks	**:** ZS-SSJ
Place	**:** Radial 030 at 3 DME JSV
Date	**:** 27 March 2019
Time	**:** 1330Z

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****.*

Investigation Process:

The incident was reported to the Accident and Incident Investigations Division (AIID) on 28 March 2019 at about 0723Z. A team of investigators dispatched to the aircraft maintenance organisation (AMO) on 23 April 2019. The investigators co-ordinated with all authorities by initiating the accident investigation process according to CAR Part 12 and investigation procedures. The AIID of the South African Civil Aviation Authority (SACAA) is leading the investigation as the Republic of South Africa is the State of Occurrence. There was no on-site investigation conducted.

Notes:

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

    - *Incident – this investigated serious incident*
    - *Aircraft – the Avro 146-RJ85 involved in this serious incident*
    - *Investigation – the investigation into the circumstances of this serious incident*
    - *Pilot – the pilots involved in this serious incident*
    - *Report – this serious 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 were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows or lines.*

Disclaimer:

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Wednesday 27 March 2019 at approximately 1330Z, a British Aerospace Avro 146-RJ85 aircraft with registration marks ZS-SSJ took off from O.R. Tambo International Aerodrome (FAOR) on a scheduled domestic flight to Upington International Aerodrome (FAUP). On-board the aircraft were two pilots, two crew members and 25 passengers.

1.1.2. The aircraft took off in a north-easterly direction using Runway 03L. The pilots reported that after passing 6 500 feet (ft) above mean sea level (AMSL), they heard a loud "bang" followed by the aircraft yawing to the right. The number 4 engine indicated high vibration levels accompanied by a decrease in low-pressure compressor revolutions per minute (N1 rpm), increased exhaust gas temperature (EGT) and decreasing high-pressure compressor rpm (N2) indications. The pilots then shut down the engine and secured it according to the Quick Reference Handbook (QRH) procedures.

1.1.3. According to the Air Traffic and Navigation Services (ATNS) Mandatory Occurrence Report (MOR), the aircraft levelled off at 8 000ft AMSL. The Air Traffic Control (ATC) stated that the pilots reported airborne and declared an emergency by broadcasting a "PAN-PAN-PAN", advising the ATC that the number 4 engine had failed. The ATC further indicated that the pilots requested an air turn back to FAOR. The ATC acknowledged the emergency and provided the crew with vectors to return to FAOR and declared the alert phase (ALERFA). The aircraft landed safely at 1349Z.

1.1.4. The pilots, crew members and the passengers were not injured during the incident sequence.

Figure 1: An overlay of the incident flight path including a graph simulating the aircraft altitude and speed. (Source: Google Earth)

1.2. Injuries to Persons

Injuries	Pilot	Crew	Passengers	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	2	25	-

1.3. Damage to Aircraft

1.3.1. Damage was limited to the number 4 engine.

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

Pilot-in-command (PIC)

Nationality	South African		Age	55
Licence Number	0720201684	Licence Type	Airline Transport Pilot Licence	
Licence Valid	Yes	Type Endorsed	Yes	
Ratings	Instrument, Flight Instructor, Designated Flight Examiner, Instructor Grade 2.			
Medical Expiry Date	30 November 2019			
Restrictions	Corrective lenses			
Previous Incidents	None			

PIC Flying experience:

Total Hours	21 300
Total Past 90 Days	120.6
Total on Type Past 90 Days	120.6
Total on Type	2 676

1.5.1. The last revalidation check for the PIC was carried out on 25 November 2018 with an expiry date of 30 November 2019.

1.5.2. The PIC had a valid Class 1 aviation medical certificate with an expiry date of 30 November 2019.

First Officer (FO)

Nationality	South African	Gender	Male	Age	52
Licence Number	0270292980	Licence Type	Airline Transport Pilot Licence		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Under sling/Winching				
Medical Expiry Date	30 September 2019				
Restrictions	Corrective lenses				
Previous Incidents	None				

Flying experience:

Total Hours	11 052
Total Past 90 Days	125
Total on Type Past 90 Days	125
Total on Type	1 745.8

1.5.3. The last revalidation check for the FO was carried out on 22 February 2019 with an expiry date of 30 April 2020.

1.5.4. The FO had a valid Class 1 aviation medical certificate with an expiry date of 30 September 2019.

1.6. Aircraft Information

Airframe

Type	Avro 146-RJ85	
Serial Number	E2385	
Manufacturer	British Aerospace	
Year of Manufacture	2001	
Total Airframe Hours (at time of incident)	27 962.17	
Last Maintenance Inspection (hours & date)	27 728.63	21 November 2018
Hours since Last Maintenance Inspection	233.54	
C of A (issue date)	23 December 2010	
C of R (issue date) (Present owner)	25 February 2015	
Operating Categories	Standard Part 121	

1.6.1. The aircraft was issued a certificate of airworthiness on 23 December 2010 with an expiry date of 31 December 2019.

Engine No. 1

Type	Honeywell LF507-1F
Part Number	2-003-040-15
Serial Number	LF07402
Hours Since New	33 799.17
Hours Since Overhaul	Modular assembly

Engine No. 2

Type	Honeywell LF507-1F
Part Number	2-003-040-15
Serial Number	LF07386
Hours Since New	36 826.54
Hours Since Overhaul	Modular assembly

Engine No. 3

Type	Honeywell LF507-1F
Part Number	2-003-040-15
Serial Number	P07654
Hours Since New	27 956.41
Hours Since Overhaul	Modular assembly

Engine No. 4

Type	Honeywell LF507-1F
Part Number	2-003-040-15
Serial Number	P07943
Hours Since New	25 579.28
Hours Since Overhaul	Modular assembly

1.6.2. The aircraft was powered by four Honeywell LF507-1F turbofan engines, each rated at 31.1 kilonewton (kN). Each engine was fitted with a Full Authority Digital Engine Control (FADEC) providing cooler temperature starts and power management with monitoring of the engine speed and temperature to optimise fuel consumption.

1.6.3. All applicable Airworthiness Directives (AD) and Service Bulletins (SB) were reviewed and were found to have been carried out as required.

1.6.4. The last borescope inspection on this engine was carried out in June 2015 and the failed engine had operated for 4443, 28 hours since the last borescope inspection. The borescope inspection limits require that it should be carried out at every 6000 hours initially and, subsequently, at every 3000 hours. The borescope conducted in June 2015 resulted in the replacement of LP compressor blades on the number 4 engine.

1.6.5. The failed number 4 engine with serial number (SN) P07943 was installed in the number four position on 10 December 2018 at a total engine time of 25 349.12 hours and 19 972 engine cycles. At the time of the serious incident, the engine had accumulated a total of 25 579.28 hours and 20 148 cycles. The engine had been in service for 230.16 hours or 176 cycles following the release from an engine overhaul facility on 10 August 2018.

1.6.6. According to the list of Life-Limited Parts (LLP), the blades have a life limit of 50 000 flying hours (FH) and 25 000 cycles. The failed blades had accumulated 4443,28 hours and 2333 cycles, given that the first stage compressor blades had been in operation for 230.16 hours since the last shop visit and 4443.28 hours since they were newly fitted to the engine.

1.6.7. According to the engine condition report, the first stage compressor blades were fitted new when the inspection check 03 (IC-03) on 9 June 2015 at 21 136 hours and 17 815 engine cycles was carried out. The first stage blades accumulated a total of 4443.28 hours and 2333 cycles before they failed.

1.6.8. The last first stage compressor blades inspection in accordance with Honeywell Service Bulletin ALF/LF-72-1105 was accomplished during the last shop visit on 10 August 2018 at 25 349.12 hours and 19 972 engine cycles. No defects were recorded during the inspection. At the time of the serious incident, the engine had accumulated a total of 25 579.28 hours and 20 148 cycles. The engine had been in service for 230.16 hours and 176 cycles following the last first stage compressor blades inspection.

1.7. Meteorological Information

1.7.1. The weather information below was provided by the South African Weather Service on 27 March 2019 at 1330Z for FAOR.

Wind direction	280V010	Wind speed	08 kt	Visibility	CAVOK
Temperature	23°C	Cloud cover	BKN	Cloud base	3 600ft
Dew point	15°C	QNH	1 027		

1.8. Aids to Navigation

1.8.1. The aircraft was fitted with standard navigational equipment as approved by the Regulator (SACAA) for this aircraft type. There were no recorded failures of the navigational equipment prior to this flight.

1.9. Communication

1.9.1. The aircraft was fitted with standard communication equipment as approved by the Regulator for this aircraft type. There were no recorded failures of the communication equipment prior to this flight. The aircraft was equipped with a very high frequency (VHF) radio.

1.10. Aerodrome Information

Aerodrome Location	O.R. Tambo International Aerodrome (FAOR)	
Aerodrome Co-ordinates	26°08'47.11" S 028°14'03.63" E	
Aerodrome Elevation	5558ft	
Runway Designations	03L/21R	03R/21L
Runway Dimensions	4421m x 60m	3405m x 60m
Runway Used	03L	
Runway Surface	Asphalt	
Approach Facilities	DVOR; UHF DME; ILS LOC; ILS GP CAT II; ILS/DME	
Aerodrome Status	Licensed	

1.11. Flight Recorders

1.11.1. The aircraft was fitted with a BAE system cockpit voice recorder (CVR) part number (PN): 299412-0100; serial number (SN): 99SRP149. The CVR records were not downloaded.

1.11.2. The aircraft was fitted with a Honeywell digital flight data recorder (D-FDR) with (PN): 980-4700-003 and SN: SSFDR-07782. The operator sent the D-FDR to an appropriate service provider for downloading of data. The D-FDR downloaded parameters were checked by the service provider and were found to be correct and were also in accordance with the requirements of the South African Civil Aviation Technical Standards (SA-CATS OPS) 121.05.17 (3).

1.11.3. According to Figure 2, the D-FDR recording started at 13:26:00 with all four engines indicating similar N1 speeds (low-pressure compressor rotational speed). All four engines stabilised at 93% N1 after the pilot applied take-off power. At 13:30:00, the number 4 engine N1 suddenly dropped below 40%. The remaining three functional engines experienced a slight drop in N1, but then stabilised at 91%. The N1 speed for number 4 continued to decay until it recorded a zero value. At the time when the number 4 engine experienced the sudden drop in N1 speed, the lateral accelerometer indicated an instantaneous increase in vibration from 0.008 to 0.115 units for a short time. The vertical and longitudinal accelerometers did not record any significant changes in vibration attributed to the engine failure.

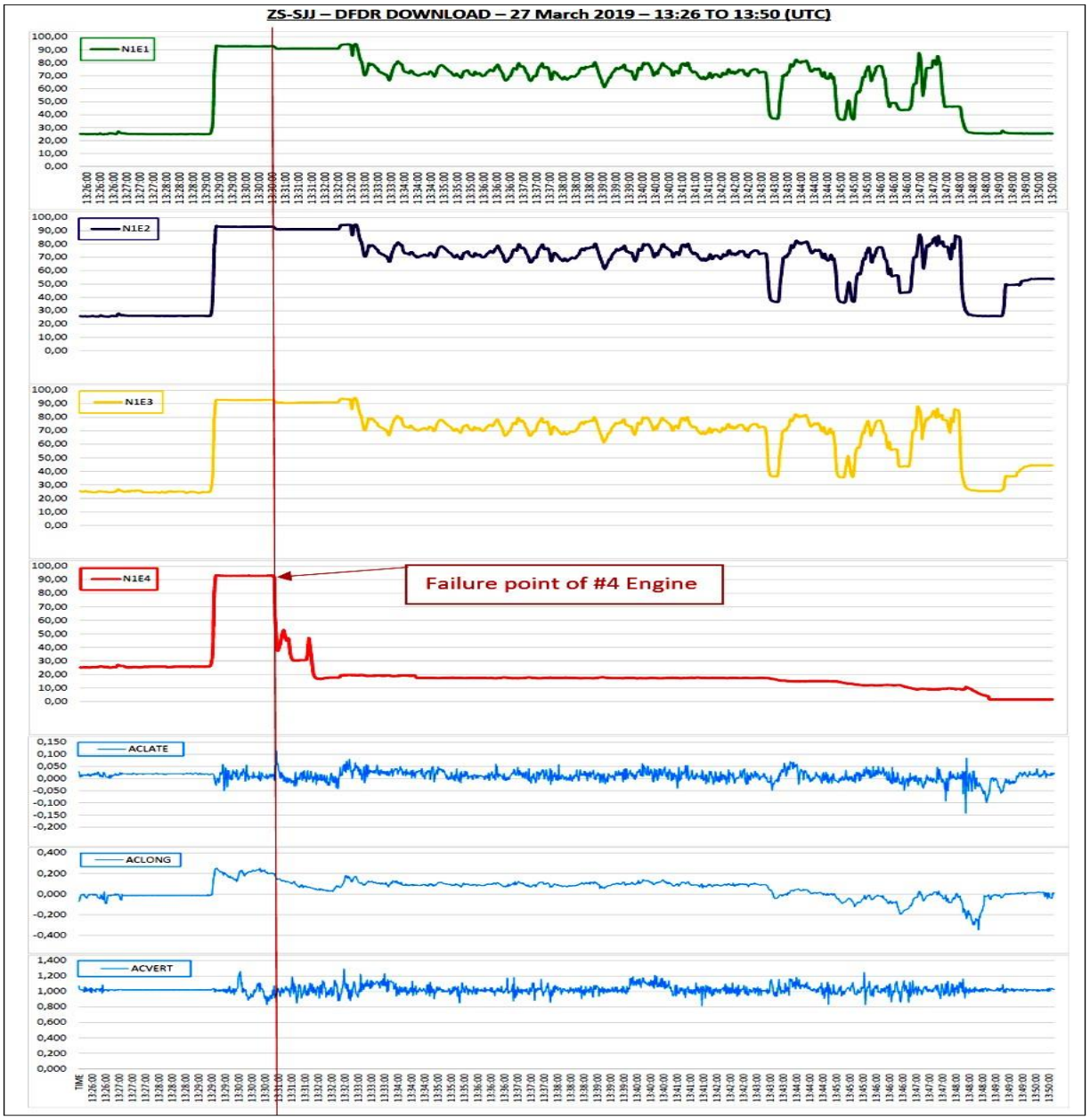

Figure 2: A copy of the DFDR download graph showing engine N1 and accelerometer parameters.

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 there was no damage in the cockpit and cabin areas which could have caused injuries to persons on-board. Damage was limited to the number 4 engine, which had a contained engine failure.

1.16. Tests and Research

1.16.1. Engine number 4 was removed from the aircraft and was shipped to an approved engine overhaul facility, Vector Aerospace, in the United Kingdom (UK) where a teardown inspection was performed. The engine was disassembled for inspection. During the initial inspection, the findings indicated that the damaged engine was in an unacceptable condition for the overhaul facility to carry out an incoming performance test. The engine overhaul facility conducted a borescope inspection of engine number 4.

1.16.2. During the borescope inspection, indications showed that impact damage had occurred to the LP compressor rotor blades, vanes and the compressor rotor. During the initial disassembly of the engine, focus was on the fan module to investigate any potential cause for the failure mode. Inspections revealed that the fan blades did not have any damage or indications to the leading edges or airflow surfaces that could have been attributed to a foreign object being ingested. When LP compressor was disassembled from the fan exit vane assembly, damage was identified on the LP compressor blades and the stator vane assemblies.

1.16.3. Debris of a compressor blade was located within the stator vane assemblies and on the fan frame struts. The fan frame inner shroud and struts had impact damage. The first stage compressor blades showed impact damage and deformation to the blades, along with one blade that had detached from the first stage compressor disc root. The blade inset was still within the disc root. The stub frame inner shroud and vanes had impact damage. The inspection showed that the compressor blade that was released into the compressor core caused impact damage to the compressor blades. Several first stage LPC blades had moved rearwards, causing the front tab of the inset to straighten from the original position. The compressor housing blade was impacted and worn out. Impact damage was evident to the impellor vane along the leading edges.

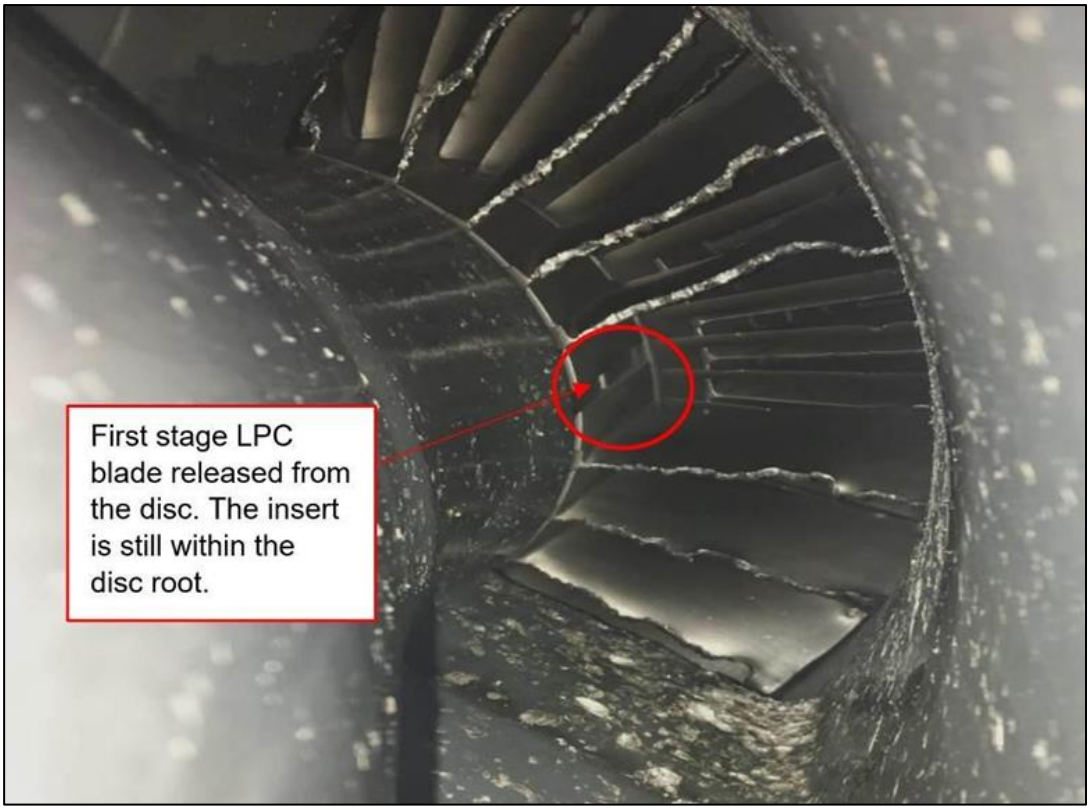

Figure 3: First stage LPC blade released from the disc with inset still within the disc root.
(Source: Standard Aero)

Figure 4: Impact damage to the second stage LPC blades. (Source: Standard Aero)

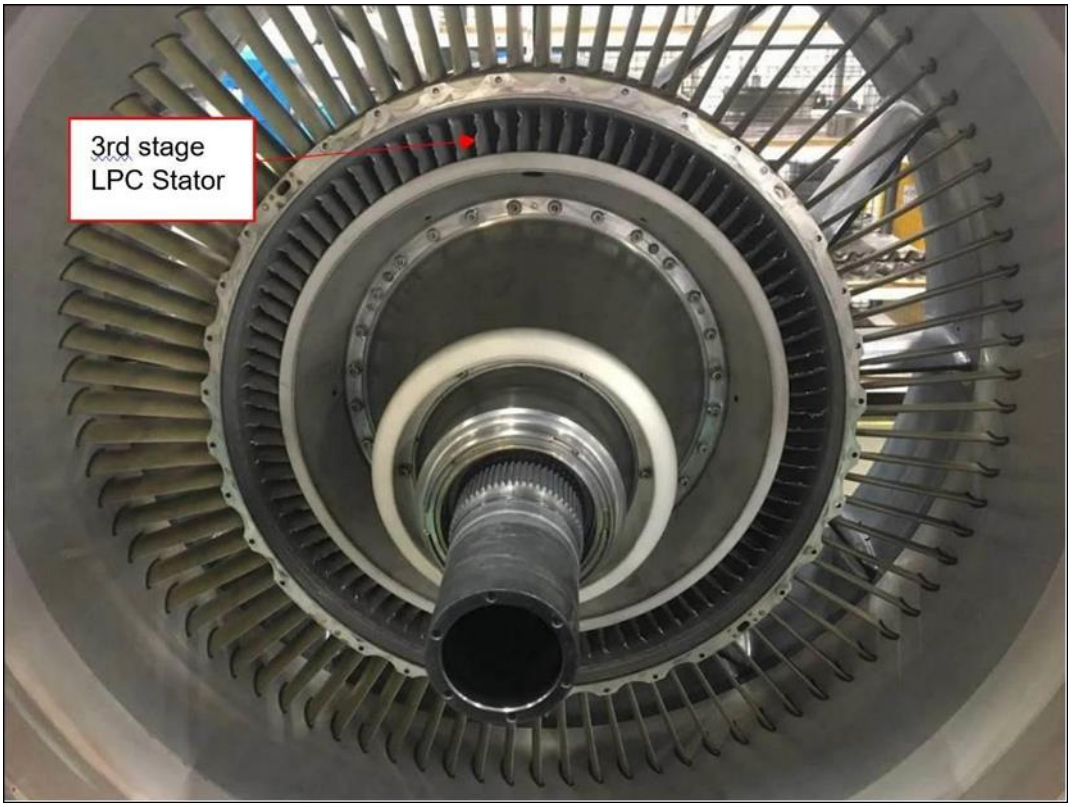

Figure 5: Impact damage to the third stage LPC stator vanes. (Source: Standard Aero)

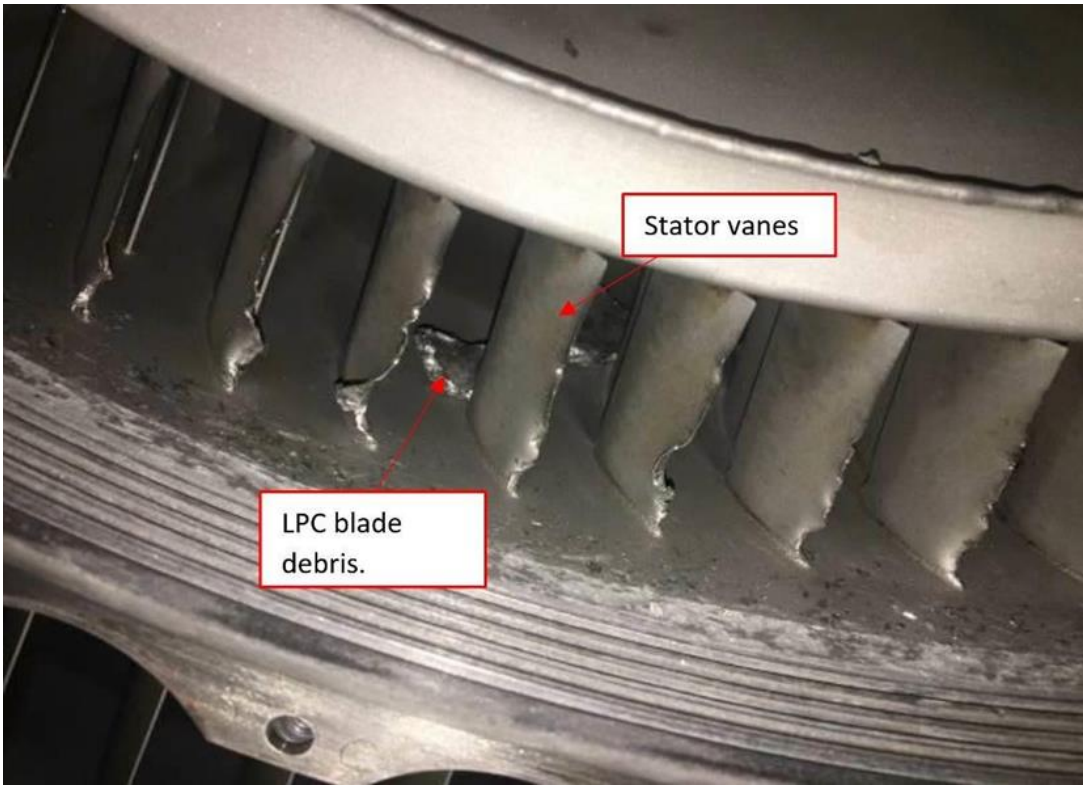

Figure 6: Low-pressure compressor blade debris. (Source: Standard Aero)

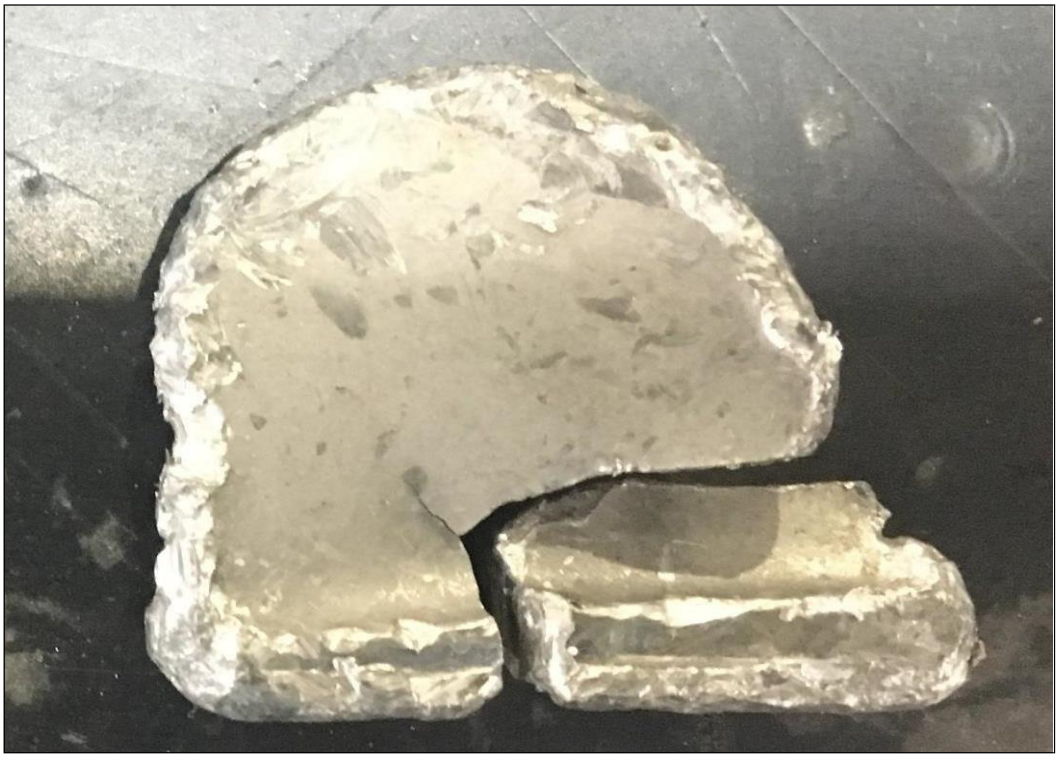

Figure 7: Fragments of the detached compressor blade. (Source: Standard Aero)

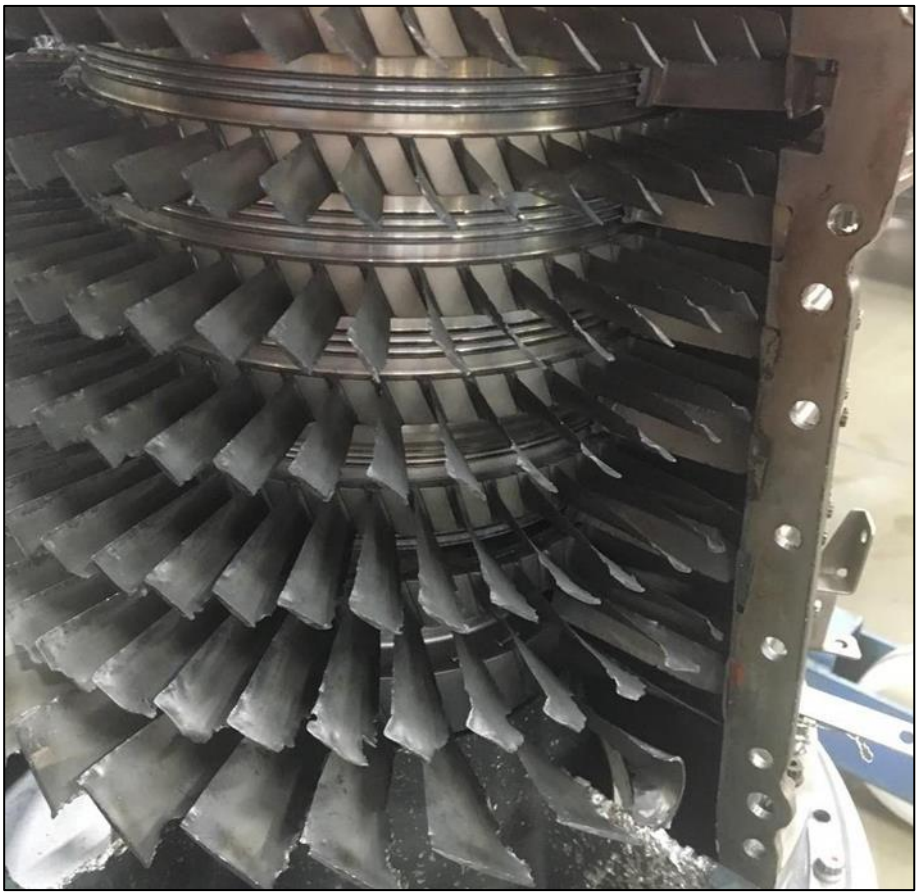

Figure 8: Impact damage to the compressor rotor blades. (Source: Standard Aero)

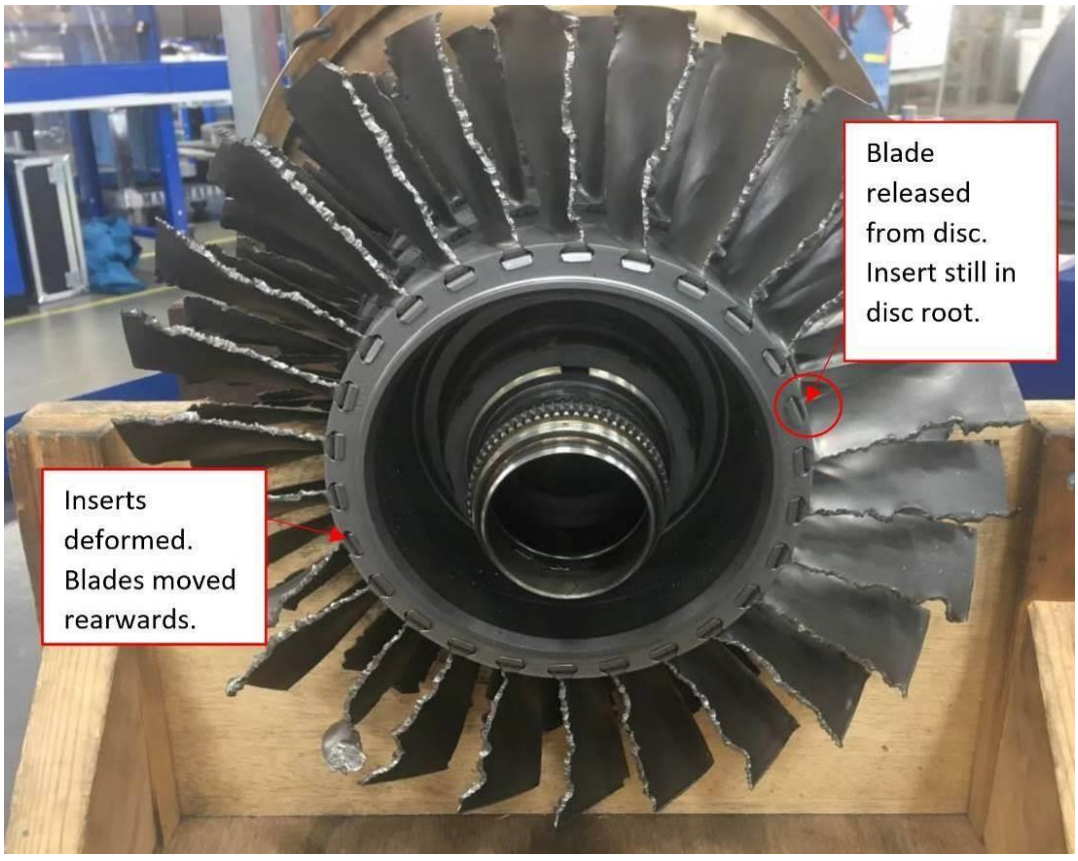

Figure 9: Compressor blade insets deformed as the blades have moved rearwards. (Source: Standard Aero)

1.16.4. During removal of the number 3 bearing package assembly (which supports the forward end of the third turbine rotor shaft assembly) and the accessory drive gear assembly (which provides the rotational mechanical energy to drive the gears in the angle gear box [AGB] module via the tower shaft), it was found that two of the three bolts that position the number 1 bearing housing assembly were loose. The bolts were retained within the bolt holes due to the aft face of the accessory drive gear assembly contacting the stub frame. This prevents the bolts from fully backing out of their positions. The aft face of the number 3 bearing support had worn out, causing a 'lip' on its surface. Spalling to the forward face on the outer race of the number 1 bearing was also identified. The number 1 bearing pump housing (which contains the number 1 bearing and provides the oil feed for the aft side of the bearing) had rotated approximately 45° anticlockwise from the original installation location. The oil transfer tube and the anti-rotation pin had fractured.

Figure 10: Two of the loose bearing house assembly bolts. (Source: Standard Aero)

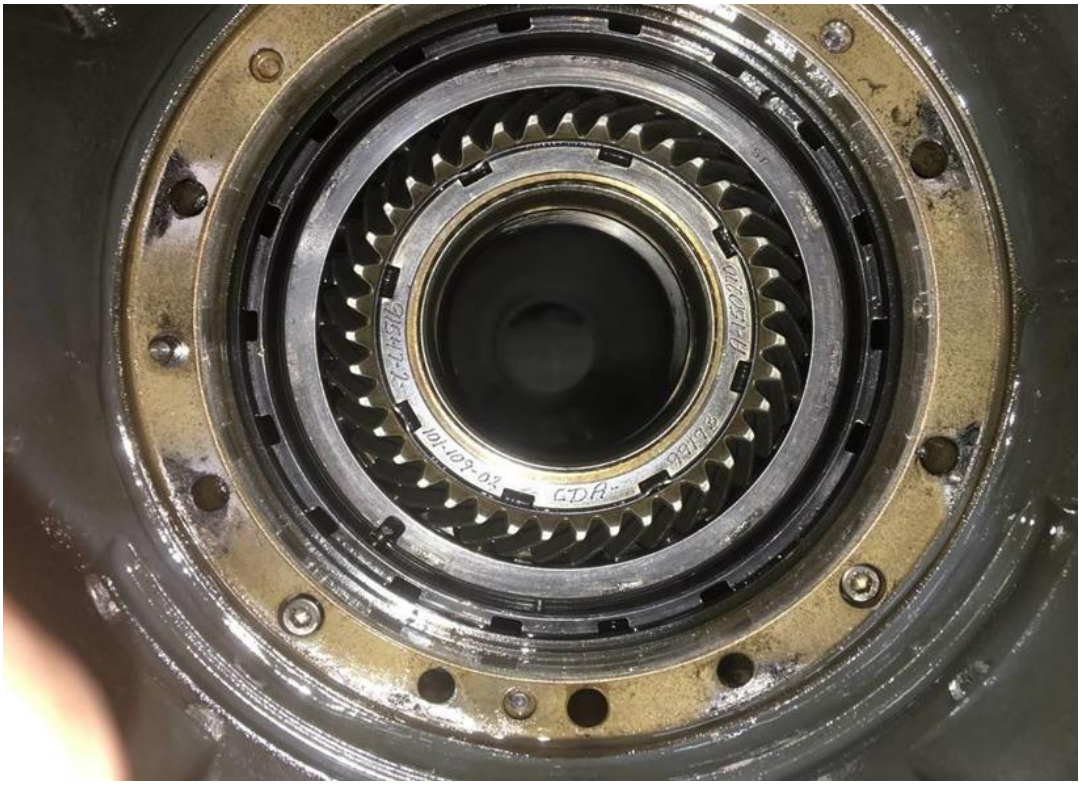

Figure 11. Spalling to the No. 1 bearing race. The pump housing has rotated anticlockwise. Note the location of the oil feed tube. (Source: Standard Aero)

1.16.5. Further inspection of the engine showed that the combustor turning vane assembly (which converts the high energy velocity air from the impellor into high static pressure) had impact damage to the leading edges of the vanes (see Figure 12). The combustor liner had debris within the cooling holes.

Figure 12: Impact damage to the combustor turning vanes. (Source: Standard Aero)

Figure 13: Debris within the cooling holes of the combustor liner. (Source: Standard Aero)

1.16.6. Inspection of the high-pressure turbine (HPT) assembly showed metal splatter on all turbine components. The second stage HPT nozzle assembly had debris within the cooling holes of the outer wall. The first stage HPT nozzle assembly guide vanes indicated impact damage and material loss on the trailing edges. The first stage HPT rotor blades had material loss on the trailing edges.

1.16.7. Inspection of the LPT sub module showed metal splatter on the airflow surfaces of the components. The labyrinth seal of the third stage LPT rotor was worn out from contact with the internal diameter of the compressor shaft.

Figure 14: Metal splatter on the first turbine blades. (Source: Standard Aero)

1.17. Organisational and Management Information

1.17.1. The aircraft was operated in accordance with the Civil Aviation Regulations (CAR) 2011 Part 121. The operator, N061D, was issued an operating certificate on 20 April 2017 with an expiry date of 30 April 2018.

1.17.2. The aircraft was maintained by the aircraft maintenance organisation (AMO) 52. The AMO was issued an AMO certificate on 30 April 2018 with an expiry date of 30 April 2019.

1.18. Additional Information

1.18.1. None.

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. These shall not be read as apportioning blame or liability to any organisation or individual.

2.1.1. The captain had a total of 21 300 flying hours and 2 676 hours were on type. His last revalidation check was carried out on 25 November 2018; he was issued an Air Transport Pilot Licence (ATPL) on the same date with an expiry date of 30 November 2019. The captain was issued a Class 1 aviation medical certificate on 1 November 2018 with an expiry date of 30 November 2019.

2.1.2. The co-pilot had a total of 11 052 flying hours and 1 745.8 hours were on type. His last revalidation check was carried out on 22 February 2019; he was issued an ATPL on the same date with an expiry date of

30 April 2020. The co-pilot was issued a Class 1 aviation medical certificate on 10 September 2018 with an expiry date of 30 September 2019.

2.1.3. The pilots secured the number 4 engine after its failure and returned to FAOR for a safe landing.

2.1.4. The aircraft, a British Aerospace Avro 146-RJ85, was powered by four Honeywell LF507-1F turbofan engines. The number 4 engine was installed in the number 4 position on 10 December 2018 at a total engine time of 25 349.12 hours and 19 972 engine cycles. At the time of the serious incident, the engine had accumulated a total of 25 579.28 hours and 20 148 cycles. The engine had been in service for 230.16 hours and 176 cycles following maintenance intervention from an approved engine overhaul facility on 10 August 2018.

2.1.5. All applicable Airworthiness Directives (AD) and Service Bulletins (SB) were reviewed and were found to have been carried out as required.

2.1.6. The last borescope inspection on this engine was carried out in June 2015 and the failed engine had operated for 4443, 28 hours since the last borescope inspection. The borescope inspection limits require that it should be carried out at every 6000 hours initially, and subsequently, at every 3000 hours. The borescope conducted in June 2015 resulted in the replacement of the LP compressor blades on the number 4 engine. The engine was due for a borescope after an additional 1556. 72 hours, thus, it was still within its limits.

2.1.7. The blades have a life limit of 50 000 flying hours (FH) and 25 000 cycles; and the failed blades had accumulated 4443,28 hours and 2333 cycles, thus, they were not due to be changed yet.

2.1.8. According to the engine condition report, the first stage compressor blades were fitted new at the IC-03 on 9 June 2015 at 21 136 hours and 17 815 engine cycles. The first stage compressor blades accumulated a total of 4443.28 hours and 2333 cycles before one of the blades failed.

2.1.9. The first stage compressor blades were inspected according to Honeywell Service Bulletin ALF/LF-72-1105 during the last shop visit on 10 August 2018 at 25 349.12 hours and 19 972 engine cycles. No defects were recorded during the inspection. The blades had operated for a further 230.16 hours since the last shop visit and 4443.28 hours since their fitment to this engine.

2.1.10. The aircraft was fitted with a Honeywell D-FDR. The unit was downloaded by an approved facility. From the data, the number 4 engine N1 suddenly spooled down at the same time the aircraft lateral accelerometer recorded an instantaneous increase in vibration levels from 0.008 to 0.115 units for a short time.

2.1.11. The investigation revealed that the serious incident occurred because of failure of one of the first stage compressor blades which had cracked at the root before it separated. The blade travelled to the rear of the compressor section, damaging the LP and HP compressors and some internal engine components in the compressor section of the engine.

2.1.12. The first stage compressor blade failed at 230.16 hours following the last shop visit where the compressor section was inspected; no defects were noted during that inspection. It is likely that the crack on the blade root was due to fatigue given that it failed at 230.16 hours after the last shop visit.

3. CONCLUSION

3.1. General

3.2. From the available evidence, the following findings, causes and contributing factors were made with respect to this serious 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 conclusions heading:

- **Findings —** are statements of all significant conditions, events or circumstances in this serious incident. The findings are significant steps in this serious 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 serious 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 serious incident occurring, or mitigated the severity of the consequences of the serious incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.3. Findings

3.3.1. The PIC was issued an ATPL on 25 November 2019 with an expiry date of 30 November 2019. He was issued a Class 1 aviation medical certificate on 1 November 2018 with an expiry date of 30 November 2019.

3.3.2. The FO was issued an ATPL on 22 February 2019 with an expiry date of 30 April 2020. He was issued a Class 1 aviation medical certificate on 10 September 2018 with an expiry date of 30 September 2019.

3.3.3. The aircraft was issued a standard certificate of airworthiness (CoA) on 23 December 2010 with an expiry date of 31 December 2019.

3.3.4. The last phase inspection was carried out on 21 November 2018 at 27 728.63 airframe hours. The aircraft had accumulated an additional 233.54 airframe hours since the inspection was certified.

3.3.5. The engine was installed in the number 4 position on 10 December 2018 at a total engine time of 25 349.12 hours and 19 972 engine cycles. At the time of the serious incident, the engine had accumulated a total of 25 579.28 hours and 20 148 cycles. The engine was in service for 230.16 hours and 176 cycles following its last inspection on 10 August 2018.

3.3.6. One of the first stage compressor blades failed at the root and damaged the other first stage compressor blades and other components in the compressor section.

3.3.7. The first stage compressor blades were inspected according to Honeywell Service Bulletin ALF/LF-72-1105 during the last shop visit on 10 August 2018 at 25 349.12 hours and 19 972 engine cycles. No defects were recorded during the inspection. The blades had operated for a further 230.16 hours since the last shop visit and 4443.28 hours since their fitment to this engine.

3.3.8. The investigation revealed that the number 4 engine failure was due to the failure of the first stage compressor blades which had cracked at the root before they separated. The blades travelled to the rear of the compressor, damaging the LP and HP compressors and some internal engine components in the compressor section of the engine.

3.3.9. It is likely that the crack on the blade root was due to fatigue given that the blade had operated for 230.16 hours since the last shop visit and 4443.28 hours since they were newly fitted to this engine.

3.4. Probable Cause/s

3.4.1. The number 4 engine failure was due to the failure of one of the first stage compressor blades, likely caused by a fatigue crack at the root of the blade.

3.5. Contributory Factors:

3.5.1. 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

4.2.1. None.

5. APPENDICES

5.1. None.

This Report is issued by:

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