AIRCRAFT INCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/3/2/1209		
Aircraft Registration	ZS-NBG	**Date of Incident**	11 May 2018		**Time of Incident**	0616Z	
Type of Aircraft	Bombardier CL-600-2C10		**Type of Operation**		Commercial (Part 121)		
Pilot-in-command Licence Type	ATPL		**Age**	60	**Licence Valid**	Yes	
Pilot-in-command Flying Experience	Total Flying Hours		18 417		Hours on Type	8 885	
Last point of Departure	East London Airport (FAEL), Eastern Cape Province						
Next Point of Intended Landing	O.R. Tambo Airport (FAOR), Gauteng Province						
Location of the incident site with reference to easily defined geographical points (GPS readings if possible)							
FAEL at GPS coordinates determined to be S33°02'13.16" E027°49'23.36" at an elevation of about 435ft							
Meteorological Information	Wind direction: 270V300; wind speed: 4 kt; air temperature: 14°C; visibility: CAVOK; dew point: 8°C						
Number of People On Board	4 + 52	**No. of People Injured**	0		**No. of People Killed**	0	
Synopsis							

On 11 May 2018 at approximately 0616Z, the aircraft took off from East London Airport (FAEL) in the Eastern Cape Province on a scheduled commercial flight (flight no. SA1412) to O.R. Tambo International Airport (FAOR) in Gauteng Province. There were four crew members and 52 passengers on-board the aircraft. During take-off and initial climb, all indications were normal. At 600 feet (ft) above ground level (AGL), the captain engaged the autopilot system and selected heading (HDG) mode. At approximately 800ft AGL, the aircraft experienced high vibrations which were followed by a loud "bang" from the back of the aircraft. The flying crew concluded that the number 1 engine had failed, and hence, carried out the number 1 engine severe damage memory items procedure. This was followed by the quick reference handbook (QRH) instructions checks. The captain broadcasted an emergency by stating "PAN-PAN" and communicated the engine failure to the FAEL air traffic control (ATC). The aircraft continued with a single engine climb out and levelled out at about 3 000ft AGL. The ATC provided the flying crew with landing instructions and the aircraft landed safely on Runway 29 at FAEL at approximately 0653Z.

The crew and passengers were not injured during the incident sequence and the aircraft damage was limited to the number 1 engine.

This investigation revealed that the number 1 engine failed because of stage-two high-pressure turbine assembly blade separations due to fatigue. Examination of the fractured surfaces revealed a fatigue region originating at the convex shank surface.

SRP Date	19 July 2019	Publication Date	30 July 2019

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List of abbreviations and descriptions

ABBREVIATION	DESCRIPTION
AD	Airworthiness Directive
AGL	Above ground level
AIID	Accidents and Incident Investigations Division
AMO	Aircraft Maintenance Organisation
AOC	Air Operator Certificate
ATB	Air turn back
ATC	Air traffic control
ATPL	Airline transport pilot's licence
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CAA	Civil Aviation Authority
CAR	Civil Aviation Regulations
FAEL	East London Airport
FAOR	OR Tambo International Airport
FDR	Flight data recorder
ft	Foot/feet
GE	General Electric
HDG	Heading
HPT	High-pressure turbine
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
IIC	Investigator-in-charge
kt	Knot
lb	Pound
LCF	Low-cycle fatigue
LLP	Life limited part
LPT	Low-pressure turbine
MHz	Megahertz
MPI	Mandatory periodic inspection
N1	Low-pressure compressor speed
N2	High-pressure compressor speed
NTSB	National Transportation Safety Board
OEM	Original equipment manufacturer
PF	Pilot flying
P/N	Part number
QRH	Quick Reference Handbook
RMM	Risk management model
SA	South Africa
SACAA	South African Civil Aviation Authority
SB	Service Bulletin
S/N	Serial number
SOP	Standard operating procedure
SSCVR	Solid-state cockpit voice recorder
TSBC	Transportation Safety Board of Canada
USA	United States of America
UTC	Co-ordinated Universal Time
V1	Decision speed for take-off
VHF	Very high frequency
Z	Zulu (representing Universal Co-ordinated Time)

Reference Number	**:**	CA18/3/2/1209
Name of Owner/Operator	**:**	South African Express Airways
Manufacturer	**:**	Bombardier Aerospace
Model	**:**	CL-600-2C10
Nationality	**:**	South African
Registration Marks	**:**	ZS-NBG
Place	**:**	East London Airport (FAEL), Eastern Cape Province
Date	**:**	11 May 2018
Time	**:**	0616Z

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 interests 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 incident was notified to the Accident and Incident Investigation Division (AIID) on 11 May 2018 at about 0800Z. The investigator/s co-ordinated with all authorities on-site by initiating the incident 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.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   - *Incident — this investigated incident*
   - *Aircraft — the Bombardier CL-600-2C10 involved in this incident*
   - *Investigation — the investigation into the circumstances of this incident*
   - *Pilot — the pilot involved in this incident*
   - *Report — this incident report.*

2. *Photos and figures used in this report are 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:

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On Friday morning, 11 May 2018, at approximately 0616Z, the aircraft took off from Runway 29 at East London Airport (FAEL) in the Eastern Cape Province on a scheduled commercial flight (flight no. SA1412) to O.R. Tambo International Airport (FAOR) in Gauteng Province. There were four crew members and 52 passengers on-board the aircraft. The aircraft was flown under instrument flight rules (IFR) by day and the weather conditions were reported to be fine at the time of the incident. This commercial flight was conducted under the provisions of Part 121 of the Civil Aviation Regulations (CAR) of 2011 as amended.

1.1.2 According to the captain who was the pilot flying (PF), the crew started both engines and taxied out to Runway 29 which was the active runway. The captain stated that full power was applied, and all indications were normal. The first officer who was the pilot monitoring (PM), called 80 knots (kt) and confirmed V1 *(V1 is defined as the speed beyond which the take-off should no longer be aborted)*. The captain confirmed that shortly after the call-out of V1, the aircraft took off and all indications were normal. The crew followed normal procedures and a positive climb was confirmed.

At 600 feet (ft) above ground level (AGL), the crew engaged the autopilot and selected heading (HDG) mode. The captain indicated that at about 800ft AGL, the aircraft experienced high vibrations which were followed by a loud “bang” from the back of the aircraft. The flying crew concluded that the number 1 engine had failed and carried out the number 1 engine severe damage memory items procedure. This was followed by the quick reference handbook (QRH) instructions checks. The captain stated that because they had already passed 1 500ft AGL, they only retracted the flaps at an altitude of about 3 000ft AGL. The captain handed control over to the first officer and commenced with the risk management model (RMM). The captain notified FAEL air traffic control (ATC) about the incident and provided them with the number of passengers on-board and the remaining aircraft endurance. The captain informed ATC that he was comfortable to receive vectors whilst the crew were busy sorting out the problem.

The captain stated that even though the N1 and N2 gauges still showed rotation, the crew decided that the engine had not flamed out, but failed, and they did not attempt to relight the engine. The captain informed the passengers about what had happened and confirmed that they would be landing at FAEL. The flying crew confirmed that the runway lengths had been checked and the aircraft was set up for landing with 20° flap according to the QRH. The captain indicated that he took control back and landed the aircraft safely on Runway 29 at FAEL at approximately 0653Z. The aircraft taxied to the bay where the crew shut down the number two engine.

1.1.3 None of the crew or passengers sustained any injuries during the incident. The aircraft had damage limited to the number 1 engine.

1.1.4 The incident occurred during daytime conditions at FAEL at Global Positioning System (GPS) coordinates determined to be S33°02’13.16” E027°49’23.36” at an elevation of about 435ft.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	2	52	-

1.3 Damage to Aircraft

1.3.1 Limited to the number 1 engine.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1 Pilot-in-command/PF:

Nationality	South African	Gender	Male	Age	60
Licence Number	**********	Licence Type	ATPL		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night, instrument				
Medical Expiry Date	31 October 2018				
Restrictions	Corrective lenses				
Previous Accidents	None				

1.5.1.1 Pilot-in-command/PF experience:

Total Hours	18 417
Total Past 90 Days	88
Total on Type Past 90 Days	88
Total on Type	8 885

1.5.1.2 The last validation check for the captain had been carried out on 21 January 2018 and he was found to be competent.

1.5.1.3 The captain was the holder of a class 1 aviation medical certificate which was valid from 16 April 2018 to 31 October 2018.

1.5.2 First Officer/PM:

Nationality	South African	Gender	Male	Age	39
Licence Number	**********	Licence Type	ATPL		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night, instrument, flight instructor				
Medical Expiry Date	30 April 2019				
Restrictions	None				
Previous Accidents	None				

1.5.2.1 First Officer/PM flying experience:

Total Hours	6 560
Total Past 90 Days	167.5
Total on Type Past 90 Days	119.2
Total on Type	2 033.8

1.5.2.2 The last validation check for the first officer had been carried out on 31 January 2018 and he was found to be competent.

1.5.2.3 The first officer was the holder of a valid class 1 aviation medical certificate which was valid from 26 April 2018 to 30 April 2019.

1.6 Aircraft Information

1.6.1 Airframe:

Type	Bombardier CL-600-2C10	
Serial Number	10039	
Manufacturer	Bombardier Aerospace	
Date of Manufacture	2002	
Total Airframe Hours (At time of Incident)	28 164.12	
Last MPI (Date & Hours)	1 May 2018	28 096
Hours Since Last MPI	68.1	
C of A (Issue Date)	3 March 2011	
C of R (Issue Date) (Present owner)	10 February 2011	
Operating Categories	Air Transport Operations (Part 121)	

1.6.1.1 The aircraft had been issued with a certificate of airworthiness (C of A) on 3 March 2011 with an expiry date of 31 March 2019.

1.6.1.2 The aircraft's mass and balance sheet was reviewed and found to be within the prescribed limits. According to the final load sheet, the maximum take-off weight for the aircraft is 32 186 kilograms (kg) and the maximum landing weight is 30 391kg. The aircraft took off with 29 592kg.

1.6.1.3 According to the final load sheet, the aircraft took off with 3 864kg fuel on-board and it required 1 795kg fuel for the flight to FAOR. According to the pilot statement, the aircraft landed back at FAEL with 3 000kg fuel on-board.

1.6.2 Engine 1:

Type	CF34-8C5B1
Serial Number	GEE965272
Total Hours Since New	26 996.1
Hours Since Overhaul	Modular Assembly
Total Cycles Since New	20 962
Cycles Since Overhaul	Modular Assembly

1.6.2.1 The number 1 engine that failed was a General Electric (GE) CF34-8C5B1 turbofan engine with S/N GEE965272. It had been installed in the number 1

position on 9 February 2011 at a total engine time of 11 514 hours and 8 938 engine cycles. At the time of the incident, the engine had accumulated a total of 26 996.1 hours and 20 962 cycles.

The CF34-8C5B1 is a high-bypass turbofan engine that features a single-stage fan, a 10-stage axial, variable geometry compressor, an annular combustor, a two-stage HPT and a four-stage LPT. Two independent rotor systems are supported by five bearings housed in three oil sump cavities. The CF34-8C5B1 is rated at 13 790 lb for sea-level take-off thrust.

The CF34-8C5B1 is a member of the CF34 engine family, certified for Bombardier applications, and is a de-rated version of the CF34-8C5 engine. It powers the 70-passenger Bombardier CRJ700 series airliner and Bombardier Challenger 870 business aircraft.

1.6.2.2 According to the life limited parts (LLP) limitations, the next shop visit of the engine was due at 25 000 cycles. This indicates that the engine had 4 038 cycles remaining before the next shop visit was due.

1.6.2.3 All applicable airworthiness directive (AD) and service bulletin (SB) statuses were reviewed and found to have been signed out in the respective logbook.

1.6.2.4 The two most recent video scope reports for the internal engine inspections were reviewed in this investigation and no defects were reported during those inspections accomplished on 20 April 2015 and 21 December 2016, respectively.

1.6.2.5 The engine was shipped to the GE engine facility in the USA on 3 January 2019 for an engine teardown inspection.

On 8 April 2019, a group of National Transport Safety Board (NTSB) representatives witnessed an analytical teardown inspection of the CF34-8C5B1 engine S/N GEE965272 on behalf of the South African Accident and Incident Investigation Division (AIID) at the GE facility in Strother Field, Kansas, USA. A copy of the NTSB field notes is attached in the appendix of this report.

The NTSB field notes focused on the engine's external inspection and engine disassembly inspection observations. During the disassembly inspection, some observations were made on the high-pressure turbine (HPT) module, the low-pressure turbine (LPT) module and the combustion module.

According to the NTSB field notes, it was observed that the engine had no breaches of case containment or evidence of fire, but that all the HPT stage-two blades were fractured. Five of the blades were separated below the platform and the remaining 63 blade fractures measured ¼ to ½ inch (6.4mm to 12.7mm) above the platform. The report further described severe collateral damage to the LPT module, with a large quantity of liberated aerofoil fragments found loose along the entire flow path. According to the field notes, the combustion module was partially disassembled, and inspection observations indicated that the inspected parts were in typical condition of a combustor with the time in service.

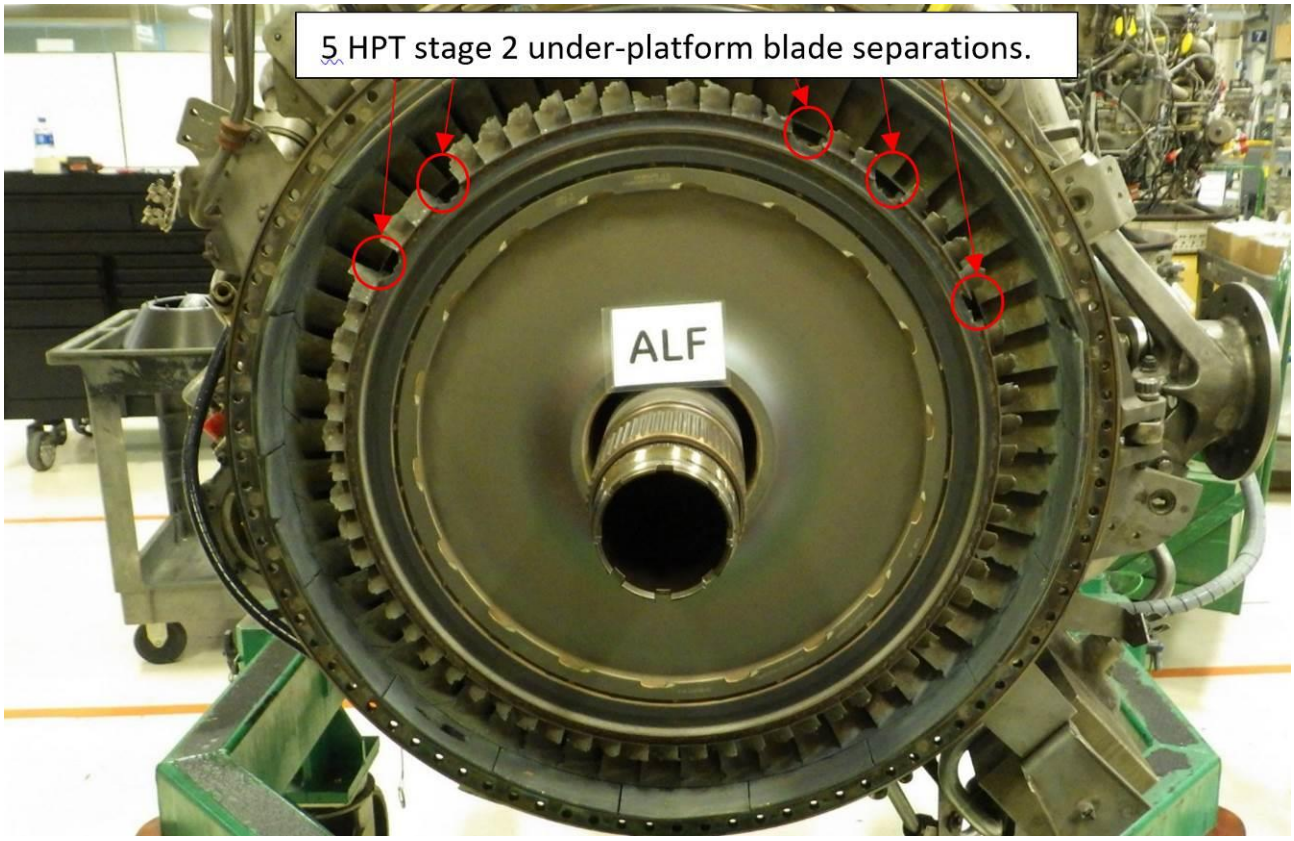

Figure 1: Five HPT stage-two blade separations

1.6.3 Engine 2:

Type	CF34-8C5B1
Serial Number	GEE965234
Hours Since New	25 420
Hours Since Overhaul	Modular Assembly
Cycles Since New	20 008
Cycles Since Overhaul	Modular Assembly

1.6.3.1 According to the LLP limitations, the next shop visit of the engine was due at 25 000 cycles. This indicates that the engine had 4 992 cycles remaining before the next shop visit was due.

1.7 Meteorological Information

1.7.1 The following weather information was provided in the pilot questionnaire.

Wind direction	270V300	Wind speed	4kt	Visibility	CAVOK
Temperature	14°C	Cloud cover	Nil	Cloud base	Nil
Dew point	8°C				

1.8. Aids to Navigation

1.8.1 The aircraft had standard navigational equipment installed. There was no evidence found of any defect or malfunction experienced with the navigation equipment during the flight.

1.9 Communications

1.9.1 The aircraft was equipped with standard communication equipment as required by the Regulator. There were no recorded defects to communication equipment prior to the flight. The crew communicated with ATC on very high frequency (VHF) 118.3 Megahertz (MHz) and 120.1 MHz.

1.10 Aerodrome Information

Aerodrome Location	FAEL, Eastern Cape	
Aerodrome Coordinates	S33°02’13.16” E027°49’23.36”	
Aerodrome Elevation	435ft	
Runway Designations	09/24	11/29
Runway Dimensions	1 584m x 4 5m	1 939m x 45m
Runway Used	29	
Runway Surface	Asphalt	
Approach Facilities	ILS, VOR, DME	

1.11 Flight Recorders

1.11.1 On 4 July 2018, flight data recorder (FDR) model FA2100 with P/N FA2100-2042-00 and S/N 000375111 was downloaded by the Transport Safety Board-Canada (TSBC) and the analysed data was presented to the AIID. The data retrieved from the recording unit indicated that the engine was operating normally during take-off and initial climb, until the engine had a sudden failure.

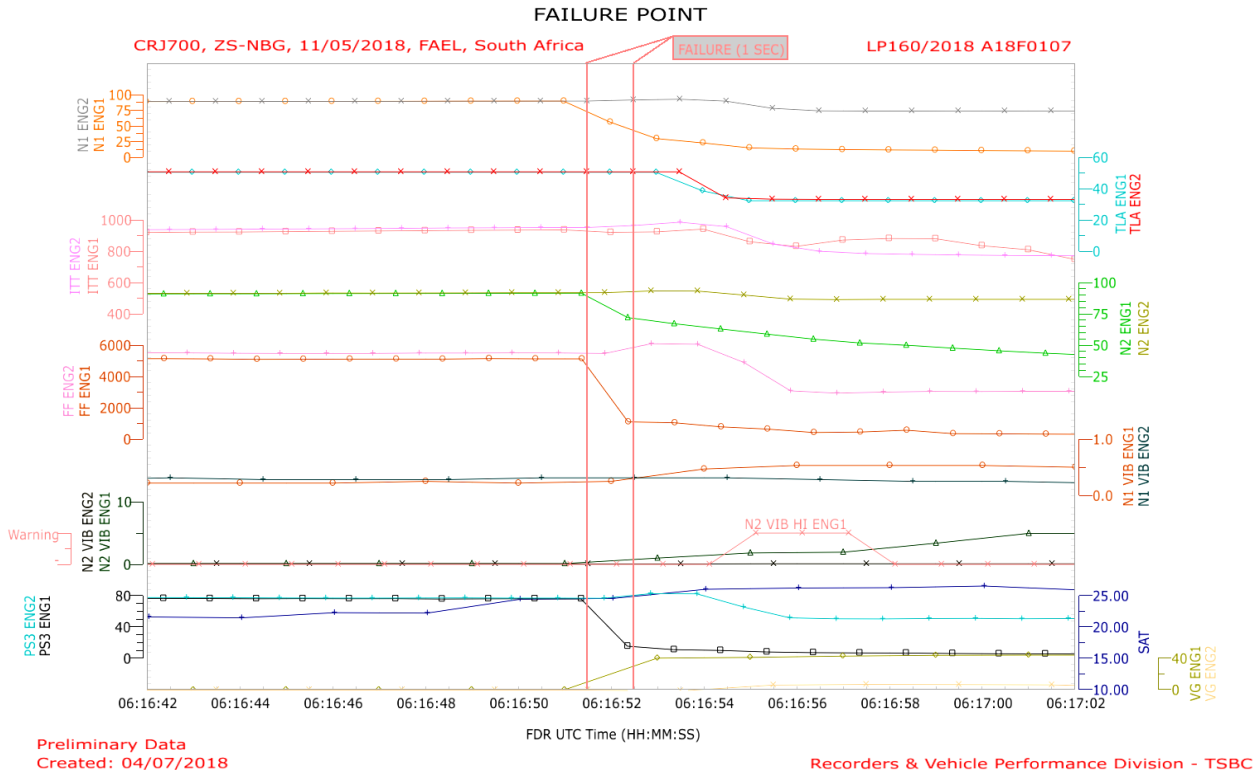

Figure 2: FDR download highlighting the number 1 engine failure point

1.11.2 The FDR download and analysis revealed that all parameters were normal and that engine number 1 encountered a sudden catastrophic failure. In Figure 2, it is evident that when engine number 1 failed at 06:16:52, the N1 decreased, N2 decreased, fuel flow decreased, and the vibration increased. The FDR download also showed a warning of N2 high vibration for engine number 1 after the engine failure between 06:16:54 and 06:16:58.

1.11.3 The aircraft was equipped with a solid-state cockpit voice recorder (SSCVR) P/N 2100-1020-00 and S/N 000185568. The cockpit voice recorder (CVR) recordings indicated that the crew focused on the situation and followed procedures as prescribed in the company's standard operating procedures (SOPs) when the engine failure occurred.

1.12 Wreckage and Impact Information

1.12.1 The aircraft took off from Runway 29 at FAEL and encountered a contained engine failure during the initial climb. The aircraft made an air turn back (ATB) to land back at FAEL. The aircraft made a safe landing on Runway 29 and taxied to the parking bay. The aircraft remained intact and the damage was limited to the number 1 engine.

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 aircraft which could have caused injury to the occupants.

1.16 Tests and Research

1.16.1 The engine was shipped to the original equipment manufacturer (OEM) for a teardown inspection. The NTSB witnessed an analytical teardown inspection of the CF34-8C5B1 engine with S/N 965272 on behalf of the AIID at GE Strother, Strother Field, Kansas, 8–10 April 2019.

Metallurgical evaluation of previous stage two turbine blade revealed a fatigue region originating at the convex shank surface. The fatigue features were consistent with corrosion-assisted fatigue having significant discolouration with smooth, indistinct topography. GE introduced an improved stage two blade with P/N 4125T65G01 in 2010, adding an under-platform corrosion coating along with geometry changes to reduce shank stresses to meet the requirements of the coated LCF life. GE SB 72-0228 was originally issued in April 2010, introducing the modification at customer convenience. The SB was revised in February 2013 to change the compliance to recommended at next shop visit due to the number of blade failure events recorded. SB 72-0228 was not embodied on the CF34-8C5B1 engine with S/N 965272 which failed.

1.17 Organisational and Management Information

1.17.1 South African Express Airways SOC Ltd, known as South African Express or simply SA Express, is a state-owned airline based in South Africa that started operations on 24 April 1994.

1.17.2 The organisation holds an Operating Certificate approved by the Regulator, which was issued on 27 September 2017.

1.17.3 The aircraft was maintained by an AMO which held an approval certificate issued by the Regulator on 9 September 2017 and which expired on 30 September 2018.

1.18 Additional Information

1.18.1 None.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

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

2.1 The captain held an ATPL with the correct aircraft type endorsed. The last validation check for the captain was carried out on 21 January 2018 with an expiry date of 31 January 2019. The captain was the holder of a class 1 aviation medical certificate with restrictions to wear corrective lenses, which was valid from 16 April 2018 to 31 October 2018. The captain had logged 18 417 total flying hours and 8 885 total flying hours on type. The investigation established that the pilot had sufficient experience to fly the aircraft.

2.2 The first officer held an ATPL with the correct aircraft type endorsed. The last validation check for the first officer was carried out on 31 January 2018 with an expiry date of 31 January 2019. The first officer was the holder of a class 1 aviation medical certificate, which was valid from 26 April 2018 to 30 April 2019. The investigation established that the first officer had sufficient experience to fly the aircraft.

2.3 The flying crew concluded that the number 1 engine had failed and carried out the number 1 engine severe damage memory items procedure. This was followed by the quick reference handbook (QRH) instructions checks. The captain informed ATC that he was comfortable to receive vectors whilst the crew were busy sorting out the problem. The captain informed the passengers about what had happened and confirmed that they would be landing at FAEL. The crew acted professionally and according to company procedures when they were faced with an emergency.

2.4 The aircraft had been issued with a C of A on 3 March 2011, which expired on 31 March 2019.

2.5 The aircraft was issued with a C of R on 10 February 2011.

2.6 The last maintenance was an A check which had been carried out on 1 May 2018 at 28 096 hours. The aircraft had flown a total of 68.1 hours since the last A check.

2.7 Engine number 1 failed during a climb out after taking off from FAEL. The aircraft made an ATB and landed safely at FAEL. Engine number 1 was removed and shipped to GE.

2.8 On 8 April 2019, the NTSB representatives witnessed an analytical teardown inspection of the CF34-8C5B1 engine, S/N 965272, on behalf of the investigator-in-charge (IIC) at the GE Strother facility in Strother Field, Kansas, USA.

The NTSB findings were that engine number 1 failure was because of the second stage high-pressure turbine (HPT) blades failure, which caused the failure of the low-pressure turbine. Five of the blades were separated below the platform and the remaining 63 blades measured ¼ to ½ inch (6.4mm to 12.7mm) above the platform. The fractured surfaces revealed a fatigue region originating at the convex shank surface. The fatigue features were consistent with corrosion-assisted fatigue, having significant discolouration with a smooth, indistinct topography. The failure was recognised as a significant in-flight shut-down (IFSD) condition, with 28 previous occurrences known to the manufacturer. In addition to this failed engine,

the events have involved high-cycle HPT stage-two blades on 15 of the CF34-8C series engines and 14 of the CF34-8E series engines, at between 7 554 and 16 200 cycles. This failed engine had been installed in the number 1 position on ZS-NBG on 16 May 2010 at 11 514 hours and 8 938 engine cycles. The engine had accumulated a total of 26 996.1 hours and 20 962 cycles. It should be noted that the engine accumulated 4 762 cycles more than any previous case of blade separation below the platform that had been reported to the manufacturer.

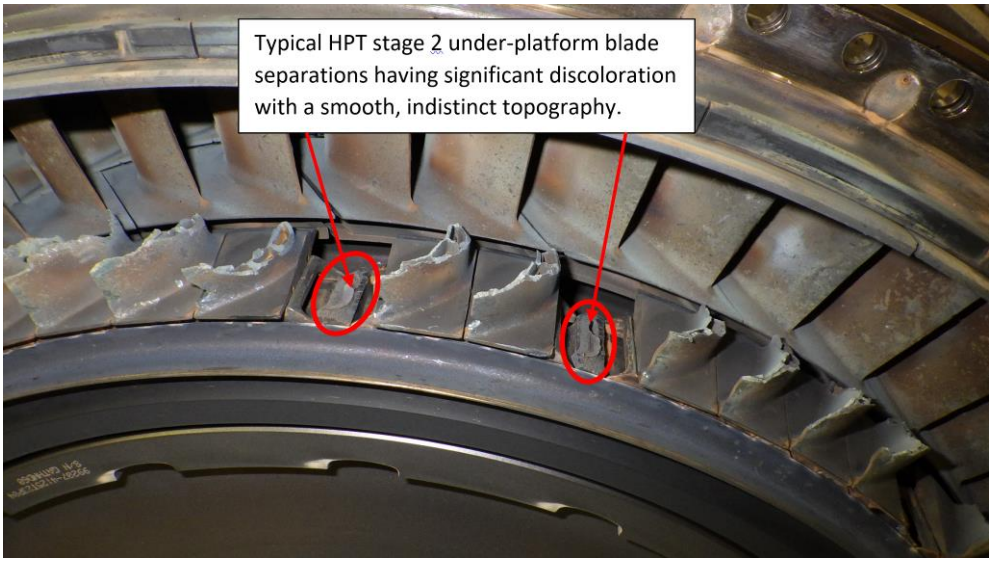

Figure 3: Typical HPT stage-two under-platform blade separations having significant discolouration with a smooth, indistinct topography

A corrective action is in place. GE introduced an improved stage-two turbine blade with P/N 4125T65G01 in 2010, adding under-platform corrosion coating along with geometry changes to reduce the shank stresses to meet the coated LCF life. The improved blade is introduced through a GE field plan whereby operators must accomplish the GE SBs 72-0228 R1 for CF34-8C series engines or 72-0119 R1 for CF34-8E series engines. The SBs are rated CAT 3 at GE, which means fulfilment of the SB is recommended at the next shop visit. The last shop visit of the engine was on 7 May 2010 just after the initial release of the SB in April 2010 which was to be embodied at customer convenience. At the time of the engine failure, the GE database showed that 71.2% CF34-8C series engines and 92.2% CF34-8E series engines have complied with the recommended modification.

3. CONCLUSION

3.1 General

From the available evidence, the following findings, causes and contributing factors were made with respect to this incident. These points 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 conclusion heading:

- **Findings:** 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 indicative of deficiencies
- **Causes:** actions, omissions, events, conditions or a combination thereof, which led to this incident
- **Contributing factors:** 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 captain was issued with an ATPL on 21 January 2018 with an expiry date of 31 January 2019 and the correct aircraft type rating was endorsed.

3.2.2 The captain was the holder of a class 1 aviation medical certificate, which was valid from 16 April 2018 to 31 October 2018 with restrictions to wear corrective lenses and follow hypertension protocol.

3.2.3 The first officer was issued with an ATPL on 31 January 2018 with an expiry date of 31 January 2019 and the correct aircraft type rating was endorsed.

3.2.4 The first officer was the holder of a valid class 1 unrestricted aviation medical certificate, which was valid from 26 April 2018 to 30 April 2019.

3.2.5 The last maintenance was an A check which had been carried out on 1 May 2018 at 28 096 hours. The aircraft had flown a total of 68.1 hours since the last A check.

3.2.6 The engine had been installed in the number 1 position on 16 May 2010 at a total engine time of 11 514 hours and 8 938 engine cycles. At the time of the incident, the engine had accumulated a total of 26 996.1 hours and 20 962 cycles.

3.2.7 The aircraft was issued with a C of R on 10 February 2011.

3.2.8 The aircraft had been issued with a C of A on 3 March 2011with an expiry date of 31 March 2019.

3.2.9 The aircraft had sufficient fuel on-board at the time of the incident. The aircraft took-off with 3 864kg fuel on-board and landed back at FAEL with 3 000kg fuel on-board.

3.2.10 The aircraft weight and balance was found to be within limits. The maximum take-off weight for the aircraft is 32 186kg and the maximum landing weight is 30 391kg. The aircraft took off with 29 592kg.

3.2.11 The operator was issued with an air operator certificate (AOC) on 27 September 2017 with an expiry date of 30 September 2018.

3.2.12 The AMO was issued with an approval certificate on 9 November 2017 with an expiry date of 30 September 2018.

3.2.13 Weather conditions on the day of the incident were not a factor.

3.2.14 The FDR download and analysis indicated that all parameters were normal and that the number 1 engine had failed.

3.2.15 The engine teardown revealed that the HPT stage-two assembly had experienced five blades under-platform separations. Examination of the fractured surfaces by the manufacturer revealed a fatigue region originating at the convex shank surface. The fatigue features were consistent with corrosion-assisted fatigue having significant discolouration with a smooth, indistinct topography.

3.2.16 The corrective action in place, SB 72-0228, was not embodied on the CF34-8C5B1 engine with S/N 965272 which failed. The SB is rated CAT 3 at GE, which means fulfilment of the SB is recommended at the next shop visit. The last shop visit of the engine was on 7 May 2010 just after the initial release of the SB in April 2010, which was to be embodied at customer convenience at the time.

3.3 Probable Cause/s

3.3.1 The number 1 engine failure because of the HPT turbine stage-two assembly blade separations. Examination of the fractured blades revealed a fatigue region originating at the convex shank surface which was caused by corrosion.

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 section 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 Safety intervention: The manufacturer had issued the SB 72-0228: The installation of the improved stage-two turbine blade with P/N 4125T65G01 in accordance with GE service bulletin SB 72-0228 should be mandatory at the next shop visit for unmodified engines due to the number of significant IFSD events recorded thus far. From 2010 to present, there have been 29 confirmed significant events on CF34-8C and CF34-8E series engines at between 7 554 and 20 962 cycles at the time of failure. At the time of the incident, the engine had accumulated a total of 20 962 cycles.

5. APPENDICES

5.1 Appendix 1: NTSB field notes

Appendix 1

NTSB Field Notes

NTSB Engine Investigation in support of South Africa CAA Investigation of the May 11, 2018, SAX CRJ700, ZS-NBG, Air Turnback Event at East London Airport, South Africa

Strother Field, KS
April 10, 2019

FIELD NOTES

The NTSB and other parties witnessed an analytical teardown inspection of CF34-8C5 engine serial number (S/N) 965272 on behalf of the South Africa CAA at GE Strother, Strother Field, Kansas, April 8-10, 2019. The work was performed ESN 965272 was removed from the No. 1 position of South African Express CRJ700 Reg, No. ZS-NBG following a May 11, 2018 in flight shutdown that led to an air turnback and successful single engine landing at East London Airport, South Africa.

1.0 Engine description

The CF34-8C5B1 is a high bypass turbofan engine that features a single-stage fan, a 10-stage axial, variable geometry compressor, an annular combustor, a two-stage high pressure turbine (HPT), and a four-stage low pressure turbine (LPT). Two independent rotor systems are supported by five bearings housed in three oil sump cavities. The CF34-8C5B1 is sea level takeoff thrust rated at 13,790 lb.

2 0 Engine data

component	S/N	TSN	CSN	TSSV	CSSV
Engine	965272	26,970	20,990	15,474	12,021
HPT S2 blades	----	15,474	12,021	new	new

3.0 Engine external inspection

The engine data plate confirmed the engine as Model CF34-8C5 engine S/N 965272.

The engine had no case uncontainments or evidence of fire. The low pressure (N1) rotor could not be rotated at the fan. Following LPT removal from the engine, the N1 could rotate freely. The accessory drive train/high pressure (N2) rotor was rotated at the accessory gearbox (AGB) starter pad and drive train continuity was verified at the drive shaft and at the at the compressor rotor.

The fuel filter element and bowl were clean.

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The oil was drained from the engine; the odor of the oil was normal. The oil filter housing was clean; the oil filter was not received with the engine. The magnetic chip detector at the AGB oil delivery port was clean. The A-, B-, and C-sump scavenge oil screens were clean.[1]

General visual inspection (GVI)[2] of the external components found them in serviceable condition. The centerbody and exhaust nozzle displayed some small, randomly distributed impact dents consistent with debris striking the inner gas path surfaces. A considerable amount of metal debris was lying in the LPT exhaust at 6 o'clock.

GVI of the compressor variable geometry system found no loose, damaged or missing parts. The fan containment case abradable material (rub strip) exhibited two areas of concentrated erosion at 8 and 10 o'clock[3]; a small area of case parent material was visible at 10 o'clock. The other fan components were in typical serviceable condition.[4]

The general condition of the compressor was assessed by a borescope inspection (BSI) of stages 1, 3, 5, 7, and 9. No unserviceable conditions were found.[5] The N1 speed pickup was removed and appeared to be in serviceable condition. The compressor was not disassembled.

4.0 Engine disassembly observations

4.1 High pressure turbine

A fragment of combustor baffle material was found lying between two nozzle airfoils at 6 o'clock. The S1 shrouds were heavily coated with molten metal material (splatter), 360°. There was no evidence of material loss. One segment (Segment 1) was distorted. The S1 blade airfoils were missing ~20% of the outer span. The remaining stubs were uniformly worn, consistent with blade path contact. Several S2 nozzle airfoils exhibited holes in the leading edge (LE) consistent with impact. All of the S2 nozzle airfoil trailing edges (TEs) were cracked, with many exhibiting inner platform scoring, distortion and tearing. The nozzle airfoils were uniformly coated with heavy splatter. The honeycomb air seals exhibited wide axial and deep radial grooves consistent with the N2 spool movement associated with heavy unbalance vibration. The S2 shrouds exhibited a thin coating of metal splatter, 360° impact damage; shrouds 4 and 11 exhibited impact damage through to the parent material. All of the S2 blades were fractured. Five were separated below the platform; the remaining 63 blade airfoils measured ¼ to ½ inch above the platform.

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[1] The fuel filter and the oil system screens and chip detector were previously inspected and then reinstalled.

[2] The engine shop receiving GVI records are submitted with these notes.

[3] O'clock refers to approximate circumferential locations in a clockwise direction, viewed from the rear of the engine looking forward.

[4] Typical in-service condition refers to a part assessed by general visual inspection that appears to be in serviceable condition, with no dimensional inspections performed.

[5] Shop QC Record No. 8C-01-100-02, Borescope Discrepancy Report, and BSI video are submitted with these notes.

4.2 Low pressure turbine

The LPT shaft exhibited heavy wear to all seal knife edges, consistent with operation with an out of balance rotor.[6]

LPT stages 3 through 5 showed extensive damage and missing material. Metal splatter was deposited throughout the gas path. The S6 nozzle airfoils showed hard body damage to the outer ~15% span. The S6 blade airfoils were intact and displayed extensive, light, impact damage and small-particle metal splatter over the entire span. A large quantity of liberated airfoil fragments were found loose along the entire flow path.

The LPT case exhibited two ~4 inch circumferential bulges and several smaller dents along the high- to low-pressure turbine transition zone. The largest bulge was ~4 inches by 1½ inch x 0.18 inch deep. The nozzle segment hooks were extremely worn, with rounded corners. The S3 hooks had the most wear, with 30 – 40% material loss.

The inner transition liner displayed 360° impact damage and metal splatter. All of the seal knife edges were rounded.

The outer transition liners were severely damaged. The EGT probe tips were sheared.

4.3 Combustor

The combustion module was partially disassembled and inspected. The condition of the swirlers, outer liner, inner liner, baffles and TBC were in typical condition for the time in service.

[6] Recorded data indicated that the engine core experienced vibration in excess of 10 mils during the failure event.