FINAL INVESTIGATION REPORT

INVESTIGATION INTO SERIOUS INCIDENT OF M/S SAI FLIGHT NL-736 (SECTOR RUH-LHE) A330 AIRCRAFT, REG NO. AP-BKN EXPERIENCED ENGINE NO. 1 ANOMALY ON 06TH SEPTEMBER 2014

FINAL REPORT

INVESTIGATION INTO SERIOUS INCIDENT OF M/S SAI FLIGHT NL-736 (SECTOR RUH-LHE), A330 AIRCRAFT, REG No. AP-BKN EXPERIENCED ENGINE NO. 1 ANOMALY ON 6TH SEPTEMBER, 2014

Synopsis

The serious incident was reported to Safety Investigation Board (SIB), Pakistan by the operator through Mandatory Occurrence Report (MOR). The incident was notified in accordance with the provision of ICAO Annex-13 to the United States of America (USA), the State of Design and Manufactur. National Transport Safety Board (NTSB), USA appointed Accredited Representative (AccRep). The technical assistance was provided by KLM Engine Services, Netherland and the manufacturer, General Electric (GE), USA.

Authority

Director General Civil Aviation Authority (DG CAA), Pakistan issued Memorandum vide letter No. HQCAA/1901/362/SIB/567 dated 10th September, 2014 and corrigendum dated 31st December, 2015, authorizing SIB to investigate the serious incident.

1. FACTUAL INFORMATION

1.1. **History of the Flight.** M/s SAI aircraft Reg No. AP-BKN was operating a routine revenue flight NL-738 from Riyadh (RUH) to Lahore (LHE) on 6th September, 2014. At around 0941 UTC, during cruise at FL340 the flight crew experienced a thud followed by a decrease in fan (N1) RPM of Engine No.1 (left engine). The flight crew brought **thrust lever to Idle with Auto Thrust "Off".** All other engine parameters were observed to be normal and there was no Electronic Centralized Aircraft Monitor (ECAM) or other warning. Engine Out (EO) page displayed momentarily and then disappeared. Engine No.1 thrust was then reduced to 68% N1 since above this setting vibrations were felt by the flight crew. The flight was continued at FL290 and a safe landing was made at Lahore.

1.2. **Injuries to Persons.** Nil

1.3. **Damage to Aircraft**. There was no damage to the aircraft. The Engine No.1 sustained damage downstream the Low Pressure Turbine (LPT). The details of engine damage are discussed in analysis section of this report.

1.4. **Other Damage.** Nil

1.5. **Personnel Information:**

(a) **Captain**

- Date of Birth : 25 November, 1966
- ATPL No. : 1130
- Medical Validity Date : 31 October, 2014
- Total Flying Experience : 9720:01hrs
- Flying Hrs on Type : 1190:00 hrs

(b) **First Officer**

- Date of Birth : 01 March, 1972
- ATPL No. : 1478

- Medical Validity Date : 31 September, 2014
- Total Flying Experience : 6753:14 hrs
- Flying Hrs on Type : 238:15 hrs

1.6. **Aircraft and Engine Information:**

1.6.1. The aircraft was maintained by the operator in accordance with Pakistan Civil Aviation Authority Regulations. Previously, there was no such reported defect. Prior to the occurrence a borescope Inspection (BSI) of the mishap engine was carried out on 2nd September, 2014 during Check A4, and no abnormality was reported.

1.6.2. **Aircraft**

- Aircraft Make & Model : Airbus A330-300
- Serial No. : 086
- Date of Manufacture : 1994
- Registration Marking : AP-BKN
- Total Aircraft Hours / Cycles : 68954 / 15268

1.6.3. **Engine No.1**

- Make & Model : GE CF6-80 E1A2
- Manufacturer's Serial No. : 810-107
- Year of Manufacture : 1994
- Total Hours/ Cycles : 52764/12817 hrs
- Last Check A4 carried on : 2nd September, 2014
- Last Check A3 carried out : 5th January, 2014
- Last Check A2 carried out : 10th October, 2013
- Last Check A1 carried out : 28th April, 2013
- Last Check C carried out : 19th October, 2012

1.7. **Meteorological Information:** At the time of occurrence the weather was well within limits to undertake the flight.

1.8. **Aids to Navigation:** All the required navigation equipment onboard was serviceable.

1.9. **Aids to Communications.** All the onboard equipment for communication was serviceable.

1.10. **Flight Recorders.** DFDR data was available and utilized for the investigation.

1.11. **Tests and Research.** Metallurgical analysis of Low Pressure Turbine (LPT) Stage 4 nozzles was carried out by GE.

2. ANALYSIS

2.1. Post occurrence BSI and teardown examination of the engine confirmed that there was no damage upstream of Low Pressure Turbine (LPT) stage 4 nozzle.

2.2. The teardown examination of the mishap engine was performed at KLM Royal Dutch Airlines, KLM Engine Services (SPL/TM) 1117 Schipol Airport, Netherland. During this examination no significant damage or abnormality was noted upstream of LPT stage 4 nozzle. Based on the observations and findings of this examination, stage 4 nozzle was submitted for metallurgical analysis.

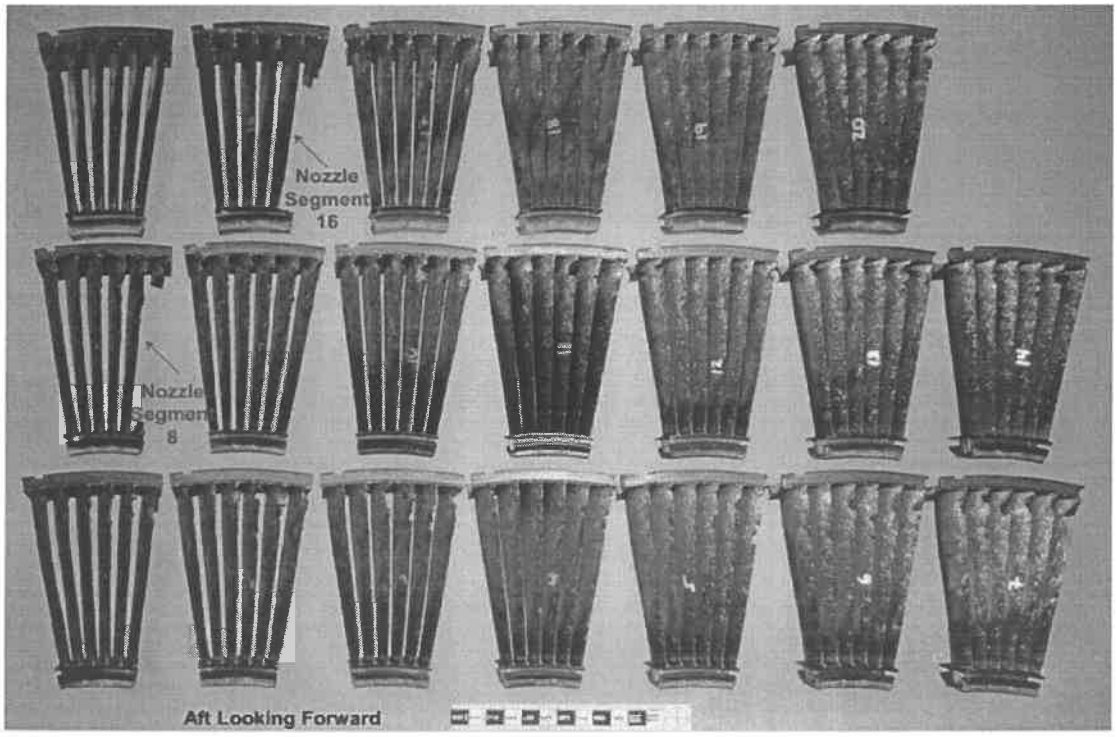
2.3. A set of 20 LPT stage 4 nozzles (P/N 1815M94G03, G11, and G12) was submitted for metallurgical evaluation to GE Aviation in Evendale.

2.4. The salient points of the GE Metallurgical Evaluation Report are summarized below:

2.4.1. The nozzle segments accumulated 52,752 hours / 12,813 cycles since new (TSN/CSN) and 9,664 hours / 1,887 cycles since the last shop visit (TSLSV/CSLSV).

2.4.2. The teardown examination showed that nozzle segments 8 and 16 had fractured airfoils number 6.

2.4.3. Nozzle segment 8 and 16 had fractured the lead airfoils. Remaining airfoils had damage at the trailing edges, near the outboard ends. This damage pattern was consistent with secondary damage.



The set of LPT stage 4 nozzle segments submitted for

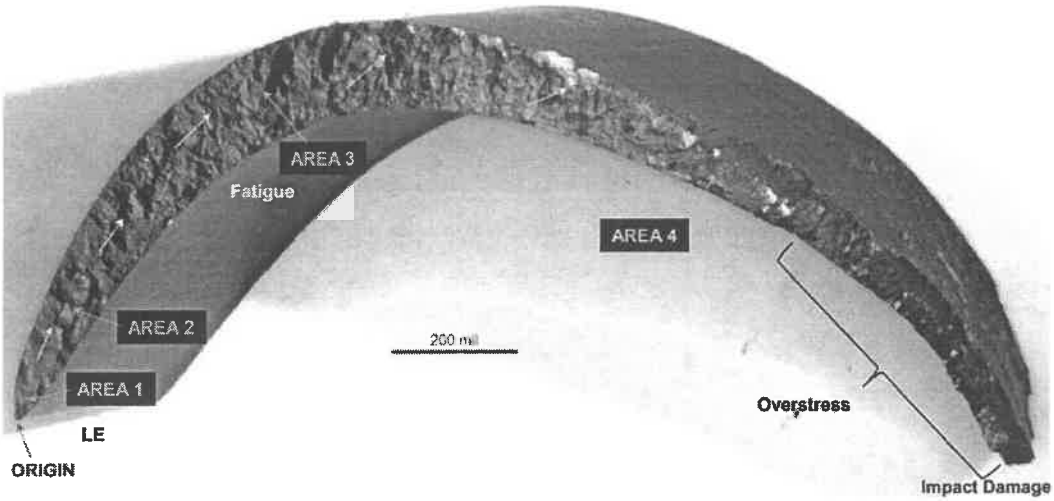
Metallurgical Analysis

2.4.4. The nozzle segments 8 and 16 fractured and liberated airfoils number 6 approximately 0.8 and 1.7 inch inboard of the outer bands, respectively.

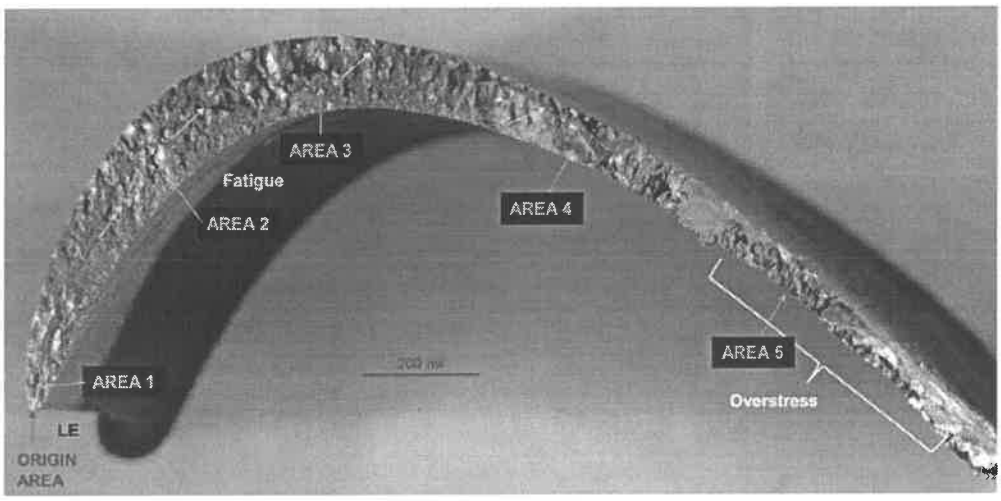
2.4.5. In addition, in nozzle segment 8, adjacent airfoil 5 was also cracked approximately 0.85 inch from the band.

2.4.6. Nozzle segment 16, also cracked adjacent airfoils 5 and 4 approximately 0.6, and 1.25, inch inboard of the outer band. No other nozzle segment airfoils were cracked in the set.

2.4.7. Visual examination showed that both outboard fractures of nozzle segments 8 and 16 were planar, axial, and consistent with fatigue.



High magnification view of airfoil 6 of nozzle segment 8 showing fatigue crack initiation at leading edge and fatigue across the majority of the airfoil. (Indicated areas documented in SEM in GE Metallurgical Report)



High magnification view of airfoil 6 of nozzle segment 16 showing fatigue crack initiation at leading edge and fatigue across the majority of the airfoil. (Indicated areas documented in SEM in GE Metallurgical Report)

2.4.8. The inboard fractures extended at off-angles with rough fracture features, consistent with overstress which was also confirmed by Scanning electron Microscope (SEM).

2.4.9. SEM examination of both outboard fractures showed initiation at the leading edge and propagation with fine, feathery features throughout, consistent with low-alternating stress, high-cycle fatigue (HCF) growth.

2.4.10. No material anomalies were observed at the origin areas.

2.4.11. Energy Dispersive Spectroscopy (EDS) analysis of the fracture surfaces showed base metal elements, with oxygen, consistent with oxidized R80 material, with base metal spectra taken from the metallographic mounts consistent with the requirement of R80 per GE specification C50TF28.

2.4.12. Radial laydown mounts were made into the leading edges of both fatigue fractures showing transgranular growth with a thin alloy depletion layer on the fracture surface (thicker on the part outer surface), and no material / surface anomalies were observed.

2.4.13. Both the radial and cross-sectional mounts showed a base microstructure consistent with properly processed, equiaxed, cast R80 per C50TF28 with no anomalies noted.

2.4.14. Wear was observed on the outer forward hooks that were preferential to the left side (forward looking aft). Axial mounts made through the forward hooks of the fractured nozzles showed that the wear was 4 mils (0.004 inch) and 5 mils (0.005 inch) deep on the left sides and 3 mils (0.003 inch) and none on the right sides of nozzles 8 and 16, respectively.

2.4.15. On nozzle segment 15 axial linear features were observed at the same span of airfoils 1-5. Optical examination and a metallographic mount showed that the features were a result of an offset/step in the surface, consistent with a casting pattern. The features had superimposed axial marks consistent with the surface having been benched during manufacturing.

2.4.16. The average Vickers micro-hardness (500g load) taken from the cross-sectional mounts was HV 460 (HRC 46) for nozzle 8 and HV 456 (HRC 46) for nozzle 16, consistent with expectations for the material (no specified requirement).

3. FINDING

3.1. The post flight inspection of the mishap engine revealed metal pieces in the core exhaust nozzle.

3.2. BSI of the engine was performed by M/s SEAMS and it was reported that LPT stage 4 to 6 had broken blades and NGVs with missing metal beyond AMM limits.

3.3. During the teardown examination of the engine no damage or abnormality was noted upstream of LPT stage 4 nozzle.

3.4. The significant findings of the GE Metallurgical Evaluation Report are summarized below:

3.4.1. The metallurgical examination confirmed that nozzle segments 8 and 16 both had fractured airfoils number 6 with fatigue fractures at the outboard ends (approximately 0.8 and 1.7 inch from the outer band) and overstress fractures on the inboard sides.

3.4.2. The both fatigue fractures initiated from the leading edges where no anomalies were found and propagated with features consistent with low-alternating stress, high-cycle fatigue (HCF).

3.4.3. Additional cracks were found extending from the adjacent airfoil of nozzle segment 8 and next 2 adjacent airfoils of nozzle segment 16.

3.4.4. The material compositional spectra, microstructure, and hardness conformed to the requirements/expectations.

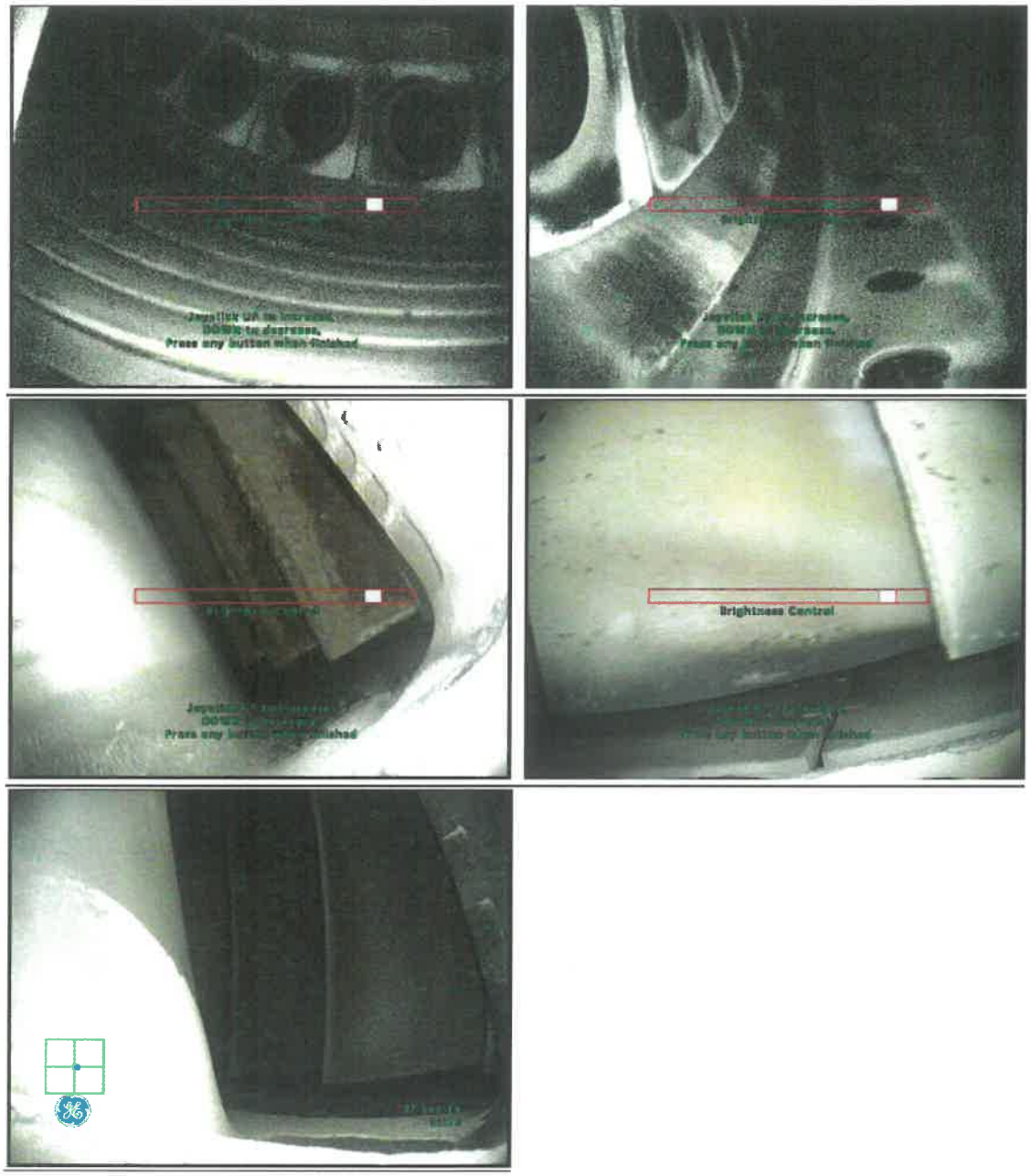
4. CONCLUSION

4.1. The incident took place due to low-alternating stress, high-cycle fatigue fracture of airfoils No. 6 of nozzle segments 8 and 16 of stage 4 of Low Pressure Turbine. The fractured airfoils further damaged the downstream components.

5. SAFETY RECOMMENDATION

5.1 The manufacturer (GE Aviation) is to issue Engine Shop Manual changes to reduce the occurrence of these events by reducing the allowable wear on rail 8 on the LPT case from 0.020" to 0.010" thus requiring the rail to be repaired at engine shop visit.

5.2. As a long term corrective action GE Aviation to release a rail 8 shim. The intent of the shim will be to reduce the wear rate further and reduce the need to repair the case in the future by replacing the shim at Shop Visit (SV) and not repairing the case rail.



General Observations:

vii. Combustion liners in satisfactory condition.

viii. "HP" NGV's in satisfactory condition.

ix. H.PT Blades stages in satisfactory condition.