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GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES

GPIAA

FINAL INCIDENT INVESTIGATION REPORT

British Midland

Airbus A321-231

G-MIDL

In-flight engine failure

CRZ FL350 LIS FIR

01st AUGUST 2008

REPORT NR 16/INCID/2008

FOREWORD

This report expresses the technical conclusions determined by G.P.I.A.A. Investigator-in-Charge about facts and causes involved in this occurrence.

According to Annex 13 to the International Civil Aviation Organization Convention (Chicago 1944), to the Council Directive nr. 94/56/EC (21st November 1994) and to nr. 3, 11th article of Decree-Law 318/99 (11th August), it is not the object of this report to determine blame or liability but solely to identify causes and deficiencies capable of undermining flight safety and to gather information for preventing further occurrences of similar circumstances.

The original report of this incident has been issued in Portuguese language which is the official version and takes precedence as report of reference. This English translation was published for international readers' information purpose.

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SYNOPSIS

On August 01, 2008, the BMI – British Midland Airbus A321-231, registered G-MIDL, was operating an international passenger flight from EGNX (East Midland Airport – Great Britain) to GCTS (Tenerife South Airport – Canary Islands/Spain), with 199 people on board.

While cruising at FL350, in Lisbon FIR, approximately 105 NM West from Faro VOR (VFL), the flight crew reported an audible abnormal engine noise and noticed airframe vibrations, immediately followed by “ENG2 STALL” message displayed on ECAM .

The appropriate checklist was performed and, when the right engine power was reduced, the stalls and indicator variations disappeared. Trying to increase thrust brought again the abnormal affected engine behaviour.

Thus, the crew decided to perform the engine #2 shutdown and divert the aircraft to Faro International Airport (Portugal) where it landed uneventfully at 09:27 UTC hours.

1. FACTUAL INFORMATION

HISTORY OF THE FLIGHT

On the 1st August, the BMI Airbus A321-231, registered G-MIDL, operating as callsign BMA 7851, departed East Midland Airport (Great Britain) on an international passenger flight to Tenerife South Airport (Canary Islands – Spain), with 2 pilots, 6 cabin flight attendants and 191 passengers on board.

During steady cruise at FL350, in Lisbon FIR, approximately 105 NM West from Faro VOR (VFL), the flight crew reported an audible abnormal engine indication and noticed airframe vibrations, immediately followed by "ENG2 STALL" message displayed on ECAM.

The appropriate checklist was performed and the crew was able to recover the engine, with no indicator variations. Nevertheless, whenever the right engine power was reapplied, the affected engine evidenced abnormal behaviour. Thus, the crew decided to perform the engine #2 shutdown and elected to divert the aircraft to Faro International Airport (Portugal), where the PIC performed an uneventful One Engine INOP landing at 09:27 hours[1]. The weather at Faro Airport was CAVOK, the wind was CALM, QNH 1020 and the temperature was of 18ºC.

The two male pilots, of British nationality, were holding valid ATPL licenses and were qualified to undertake the flight. Limits concerning crew time, flying time and rest time were complied with.

Communications between aircraft and ATM were standard, clear and undoubted.

The operator had fully complied with aircraft maintenance.

There were no personal injuries and damage to the aircraft was confined to its engine #2 internal components.

[1] The time in this report refers to UTC hours.

INVESTIGATION

The Faro AOS (Airport Operational Supervisor) notified by fax the Portuguese AIB (GPIAA) about the incident on 2008, 2nd August. An investigation according to ICAO Annex 13 was opened on the same day.

Background

The aircraft experienced similar abnormality before the flight under analysis:

On 2008, 30th July the G-MIDL, during descent into East Midland Airport, had a message "ENG2 STALL" displayed on ECAM. After stall recovery, the flight continued normally and landed with no other anomaly.

BMI carried out a trouble shooting process, accordingly to the relevant TSM/AMM (section 4A) with no findings. The section 4B required a boroscope inspection to HPC stages 3 and 6 but the task was deferred to a maintenance opportunity or even to an A-check, later on. The related boroscope inspection, performed to stages #3 and 12, took place the day after, following a step change being noted in the parameters of the relevant engine, but nothing was detected on the boroscope inspection.

Engine #2

The engine #2, model IAE V2533-A5 turbofan with the S/N V10391, was manufactured by International Aero Engines and registered the following data:

- Time Since New - 18 574:00 hours
- Cycles Since New - 12 312 cycles
- Time Since Last Shop Visit - 5 011:00 hours
- Cycles Since Last Shop Visit - 4 559 cycles

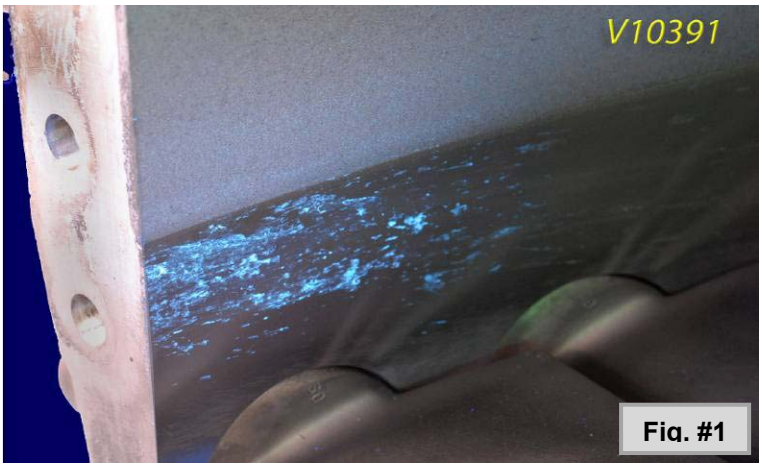
Engine #2 examination

On the 1st August, after landing at Faro Airport, the engine #2 has been subject to a boroscope inspection. Damage to HPC stage 6 rotor blades was discovered with two blades showing missing fragments of airfoil.

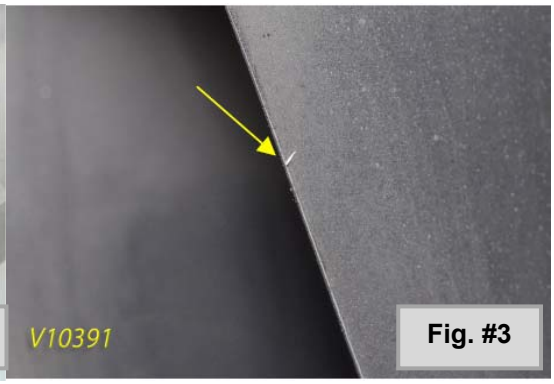
The engine was removed and sent to overhaul.

Overhaul shop strip findings

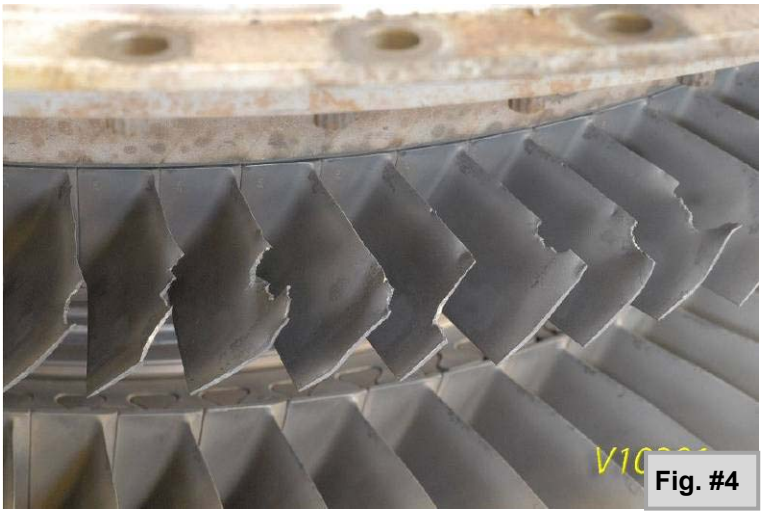
a. During ultra-violet inspection the outer annulus behind the VSVs in front of HPC rotor 3 showed traces of organic material (Figure 1).



b. Impact marks were found on HPC stage 3 and 4 rotor blade airfoils close to the leading edges and also on the tip at the trailing edges (Figure 2 & Figure 3);



c. HPC stage 6 rotor blades showed nicks, dents and broken airfoils at the tip areas and at the trailing edges (Figure 4).



d. One HPC stage 6 rotor blade airfoil was missing 12 mm from the tip (Figure 5);

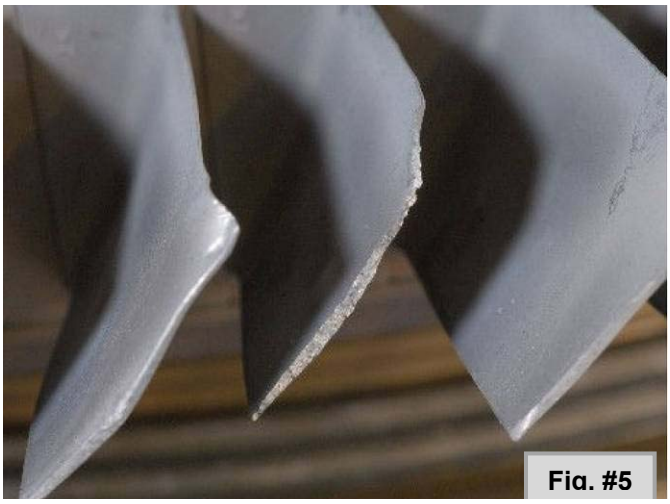


Fig. #5

e. One HPC stage 6 rotor blade airfoil was missing 12 mm from above the platform (Figure 6).

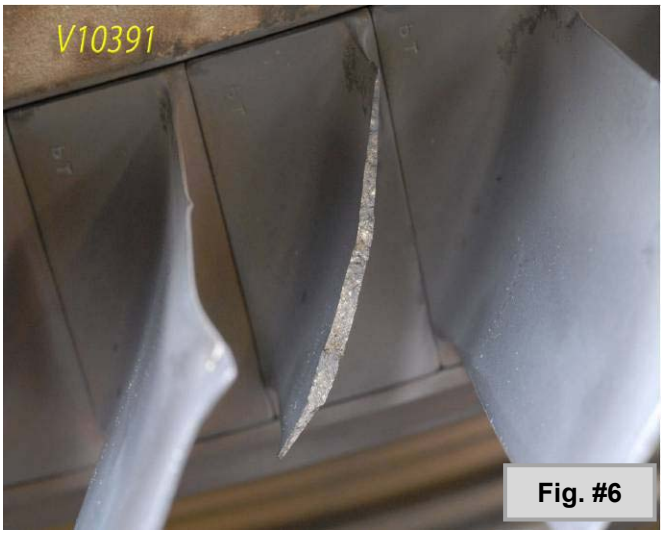


Fig. #6

f. The HPC stage 6 rotor path showed impact marks, gouging and material breakout at several locations (Figure 7).

Fig. #7

g. All stage 6 stator vanes where damaged and showed dents, nicks and loss of material on the trailing edges. One vane was released from above the platform (Figure 8).

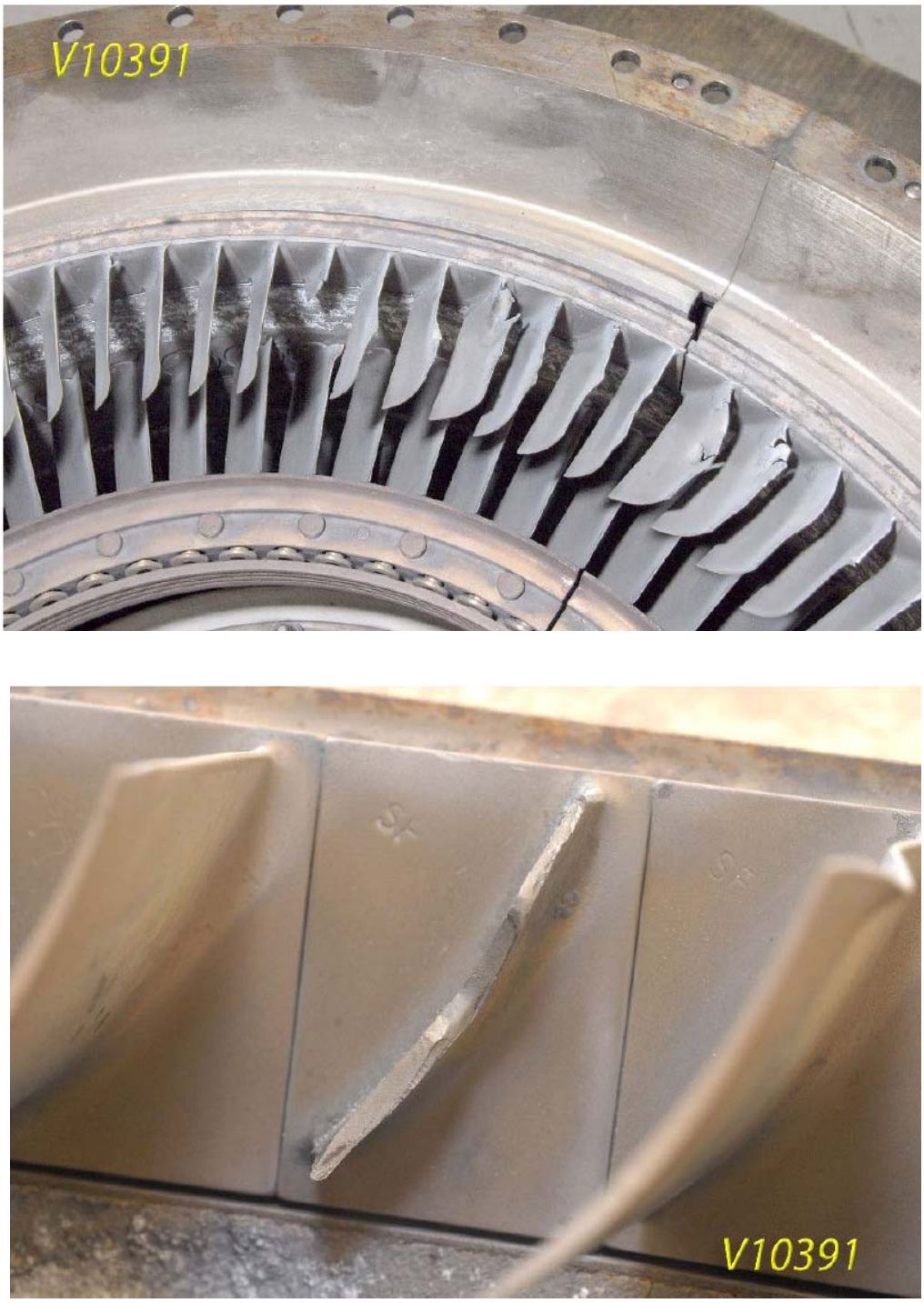


Fig. #8

h. Stage 7 rotor blades and stator vanes also showed minor damage appearing as dents and nicks due to impact;

i. All further downstream stages showed only minor damage.

On shop and laboratory inspection report

The IAE - International Aero Engines AG lab investigation confirmed FOD impact marks to HPC stage 6 rotor blades and soft body impact to the stator vanes. One HPC stage 6 rotor blade and one stator vane were missing. Fractures were initiated, which then propagated through HCF over an unspecified period of cycles. One other HPC stage 6 rotor blade airfoil was missing and showed a fresh crack surface. This airfoil was released as a result of the initial HPC rotor 6 blade airfoil release.

The analyses to the HPC components made possible to determine the sequence of events:

- At some time during a previous aircraft flight FOD in combination with soft body FOD was ingested into the core of the engine impacting the leading and trailing edges of the HPC stage 3 and 4 rotor blades leaving impact marks on the airfoils;
- Further downstream damage was caused by FOD impacting HPC stage 6 rotor blades and soft body impacting stage 6 stator vanes, initiating cracks on one rotor blade and on one stator vane;
- Acrack propagated across the chord width of an HPC stage 6 rotor blade from the trailing to the leading edge;
- On 30th July 2008, the airfoil was released by final fracture;
- After airfoil release the engine stalled during descent but recovered. The performance data showed a step change in engine performance;
- The liberated airfoil initiated a crack on a second HPC stage 6 airfoil close to the tip;
- The initiated crack in one HPC stage 6 stator vane and the second rotor blade propagated to eventual release causing further downstream damage;
- On 1st August 2008, the damaged and deteriorated HPC was responsible for the second stall event during cruise. The engine could not be operated above idle for the remainder of the flight.

2. ANALYSIS

During ultra-violet inspection, traces of organic material have been detected in the outer annulus behind the VSVs in front of HPC rotor 3.

This fact indicates that, somewhere in a previous flight, G-MIDL engine #2 ingested FOD into the core, impacting the leading and trailing edges of the HPC stage 3 and 4 rotor blades, travelled to the HPC stage 6 impacting stator vanes and initiating cracks on one rotor blade and one stator vane.

The initial damage to the HPC is concluded to be from FOD combined with organic impact ingested into the core during engine operation.

FOD traveling down the gas path left impact marks and nicks on HPC stage 3 and 4 airfoils before impacting the stage 6 rotor blades and the stator vanes. Soft body FOD also impacted the leading edges of the stator vanes.

The FOD impact initiated a crack in one stage 6 rotor blade trailing edge and on one stator vane. The crack on the rotor blade propagated from the trailing to the leading edge, whereas the crack in the stator vane propagated from the leading to the trailing edge.

Eventually the cracked HPC stage 6 airfoil was liberated creating a crack in another stage 6 rotor blade and further damaging the stator vanes. This was noticed at the first stall of the engine during descent in 30th July and the flight crew managed to recover the engine.

Two days later, on 1st August (the day of the occurrence) the second HPC stage 6 rotor blade airfoil, together with the stator vane, was released causing further deterioration to the HPC. This led to another stall, which was recovered, but the engine was unable to achieve normal operation during cruise with it being impossible to operate the engine at above idle power settings for the remainder of the flight.

Thus, facing the situation, the flight crew decided to perform an engine #2 shutdown and divert to Faro International Airport (Portugal) to make a precautionary landing.

3. CONCLUSIONS

Findings

- Both pilots were properly licensed with airline transport pilot's ratings, had valid medicals issued by the appropriate authorities and were qualified to undertake the flight;
- Limits concerning crew time, flying time and rest time were complied with;
- The operator had fully complied with aircraft maintenance;
- Aircraft's technical records showed previous entry on engine #2 stall, on 30th July March 2008, but after stall recovery by the crew, the flight continued normally and landed with no other anomaly;
- BMI then carried out a trouble shooting process with no findings. Also a boroscope inspection to HPC stages 3 and 12 was performed the day after this episode but nothing was detected;
- IAE concludes that the event on G-MIDL Engine #2 was caused by hard body FOD and minor organic impact;
- There were no personal injuries to any aircraft occupants.

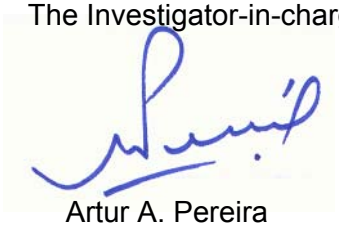
Causes

The investigation concluded that the incident on G-MIDL had its cause in the #2 engine HPC deterioration due to HPC stage 6 rotor airfoils and stator vanes impact damage originated by hard FOD ingestion. These circumstances caused an HPC loss of efficiency with increasing distress resulting in a stall.

4. SAFETY RECOMMENDATIONS

The IIC has no safety recommendation to release.

The Investigator-in-charge



Artur A. Pereira

Lisbon, November 30th, 2009.

ACRONYMS and ABBREVIATIONS

#	Same as “number”
ºC	Centigrade degrees
AIB	Accident Investigation Board
AOS	Airport Operational Supervisor
AMM	Aircraft Maintenance Manual
ATM	Air Traffic Management
ATPL	Airline Transport Pilot Licence
BMI	British Midland
CAVOC	Ceiling And Visibility OK
ECAM	Electronic Centralized Aircraft Monitoring
ENG2	Engine 2
Fig	Figure
FIR	Flight Information Region
FL350	Flight level 350 (35000 feet)
FOD	Foreign Object Damage
GPIAA	*Gabinete de Prevenção e Investigação de Acidentes com Aeronaves* (Portuguese Air Accident Investigation Branch)
IAE	International Aero Engines
H	Hours
HCF	High Cycle Fatigue
HPC	High Pressure Compressor
IIC	Investigator in Charge
ICAO	International Civil Aviation Organization
INOP	Inoperative
INCID	Incident
NM	Nautical Miles
PIC	Pilot In Command
QNH	Altitude above mean sea level based on local station pressure
S/N	Serial Number
TSM	Trouble Shooting Manual
UTC	Universal Time Coordinated
VOR	Very high frequency Omnidirectional Range
VSV	Variable Stator Vanes