AIR ACCIDENTS INVESTIGATION INSTITUTE

of the Czech Republic

Ref. No. CZ 08/359

FINAL REPORT

Investigation of Serious Incident A/C Airbus A 310, Registration OK-WAB, on 31st July 2008 on KJFK

Prague
June 2009

The report's information, findings and conclusions concerning the aircraft accident or system failures endangering operational safety are solely of informative nature and can only be used as recommendations to prevent similar accidents due to similar causes. The author of the Final report states explicitly that it cannot be used to lay the blame or responsibility for the accident on anyone or to file insurance claims.

Used abreviations:

AAII	*Air Accident Investigation Institute of Czech Republic*
AMM	*Aircraft Maintenance Manual*
ATC	*Air Traffic Control*
ATPL	*Airline Transport Pilot Licence*
ATIS	*Automatic terminal information service*
BA	*Barometric Altitude*
BKN	*Broken*
BSI	*Boroscope Inspection*
CAS	*Calibrated Airspeed*
CAVOK	*Clouds and Visibility OK*
CC	*Cabin crew*
C/L	*Check list*
CPT	*Captain*
CSN	*Cycles since new*
CTC	*Centralized Traffic Control*
CSA	*Czech Airlines*
ECAM	*Electronic Centralized Aircraft Monitoring*
FCOM	*Flight Crew Operating Manual*
FEW	*Few (cloud descriptor)*
FC	*Flight crew*
FOD	*Foreign Object Damage*
EGT	*Exhaustion gas temperature*
FO	*First Officer*
EDX	*Energy Dispersive X-ray*
ft	*Feet*
HPa	*Hectopascal*
HPC	*High Pressure Compressor*
ILS	*Instrument landing system*
KJFK	*John F. Kennedy International Airport*
KT (kt)	*Knots (1,852 kmh^{-1})*
LPC	*Low Pressure Compressor*
LPT	*Low Pressure Turbine*
LKPR	*Praha - Ruzyně International Airport*
MLW/LW	*Maximum Landing Weight/ Landing Weight*
MPD	*Maintenance Plan Documentation*
MRB	*Maintenance Review Board*
MS	*Maintenance Schedule*
MTOW/TOW	*Maximum takeoff mass/takeoff mass*
N_{12}	*Rotation speed in RPM or %*
PAX	*Passengers*
R	*Right*
RWY	*Runway*
QAR	*Quick Access Recorder*
QRH	*Quick Reference Handbook*
SIM	*Simulator*
T	*Temperature (°C)*
TSN	*Time Since New (also TTSN)*
TWR	*Aerodrome control tower*
UTC	*Coordinated Universal Time*

A) Introduction

Operator:	CSA a.s., Czech Republic
Aircraft manufacturer and model:	Airbus Industries, A310 -304
Registration Mark:	OK - WAB
Planning destination:	LKPR, Czech Republic
Place of incident:	KJFK, USA
Date and time:	31/07/2008, 21:01 (all times are UTC)

B) Synopsis

On August 1st 2008, AAII was notified by CSA of a serious incident involving an Airbus A310, registration mark OK-WAB, flying from New York to Prague. On July 31st 2008 shortly after take-off the engine No. 2 lost suddenly much of its power and so the crew decided to return back to the airport. In response to the notification an investigation into this serious incident was launched.

The final report on the incident issued AAII based :
Beranových 130, 199 01 Prague 99, Czech Republic
fax: +420 266 199 234
web site: www.uzpln.cz

The cause of the incident was investigated by an Air Accident Investigation Institute commission comprising:

Commission chairman:	Mr. Ing Lubomír Stříhavka, AAII
Commission member:	Mr. Ing. Josef Procházka, AAII
	Mr. Ladislav Musil, deputy of operator
	Mr. Ing. Jindřich Kocáb, deputy of operator

C) The report includes the following main parts:

1) Factual information
2) Analysis
3) Conclusions
4) Safety recommendation

Annexes : Annex no. 1 - Investigation Report Engine 695365 of 10 Sept. 2008
Annex no. 2 - HAM TQ/M Report 2008 529 of 22 December 2008

1 Factual information

1.1 History of the flight

The take-off from KJFK´s RWY 22R got started at 21:00. After taking off approximately at an altitude of BA=900 ft the crew noticed some vibration of the plane and a difference in engines´ thrust. Checking the engines´ flight instruments the crew found out that engine no. 2 low pressure turbine speed was down at N_{12} = 73 % and the exhaustion gas temperature exceeded 900^0 C. The indicated values of engine no.1 corresponded to the regime set and were at normal. No warning appeared on ECAM. The pilot in command was the flying pilot at the moment the critical situation occurred. The flight crew reduced the power of engine no. 2 to the idling speed and reported the problem to ATC at KJFK airport. Because the vibration still continued after the slowing down of engine no. 2 and EGT continued to go up, the crew decided to shut off the engine.

In stabilizing the plane flight at the one-engine regime at the moment of retracting the flaps, a signal arrived indicating that the air speed limit for speed with the flaps up was exceeded. This situation lasted for seven seconds.

After accomplishing procedures according to QRH-Engine Over Limit C/L, Single Engine Operation C/L, Overweight Landing C/L and Approach C/L the air crew asked for radar vectoring and ILS approach onto RWY 31.

The landing took place without further failures at a landing weight of 147 t (MLW is 124 t). After landing the crew asked for technical assistance because of high temperature at the right undercarriage leg. The airport service group made a visual check and released the plane to taxi to the stand.

1.1.1 Collaboration between flight and cabin crews

The captain told the chief of cabin that the airplane was flying back to the KJFK airport due to a technical defect on engine no 2. The chief of cabin then informed passengers. The captain then told the passengers that everything was under control and a normal landing was supposed to take place.

After talking to the chief of cabin the captain decided, due to a short time left before landing, that CC would not take emergency procedures and only would check and crosscheck chutes preparation, check on passengers having safety belts fastened properly and check on luggage being properly stored in overhead bins. CC was ready to help in case the flight deck ordered emergency evacuation. The time to landing was about 7 to 10 minutes. The chief of cabin told the captain the cabin was prepared for landing. The crew gave no more emergency command. After landing, the chief of cabin said that all the passengers stayed in their places and told them to leave the plane when it had stopped and the information lights had been out.

1.2 Injuries to persons

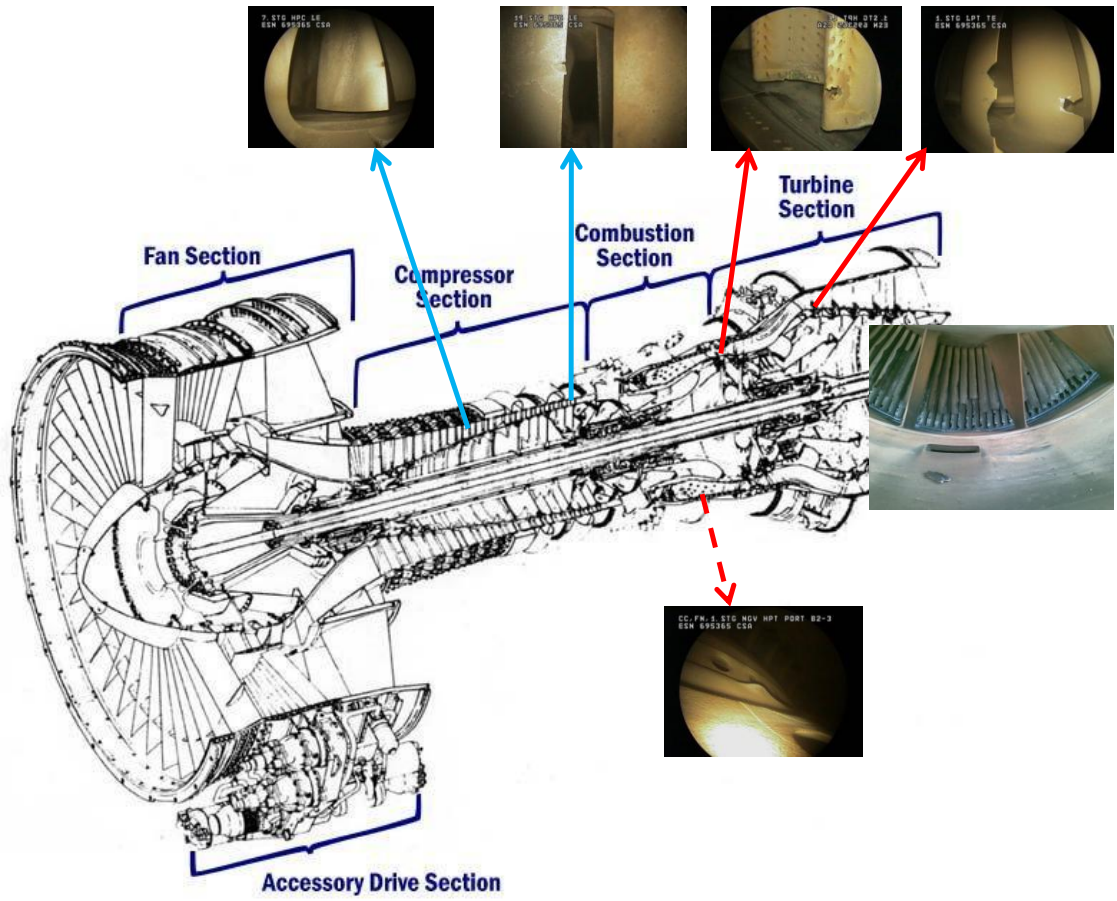
Injuries	Crew	Passengers	Others (inhabitants, etc)
Fatal	0	0	0
Serious	0	0	0
Light/no injury	0/9	0/211	0

1.3 Damage to Aircraft

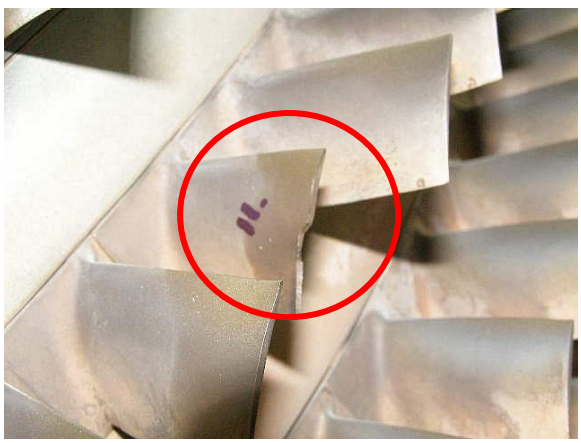
The loosening of the engine no. 2 metallic parts did not cause damage to aircraft surface or to the primary structure of the plane. Landing gear was not damaged by the fact that the maximum landing weight was exceeded. An external inspection by the crew of the engine no. 2 outlet revealed that the low pressure turbine last stage blades were damaged. A contract technician of SR Technik Company confirmed the damage. The damaged engine was not usable for further operation of the airplane.

1.3.1 Damage to engine

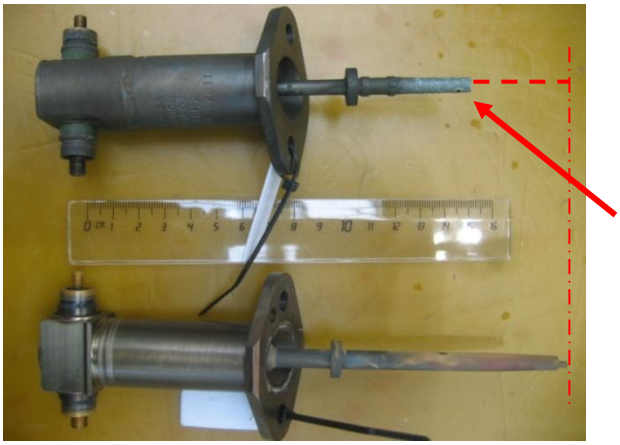
Engine damage was assessed and described by a foreign maintenance and repair service after the engine had been transported to Europe. A complete BSI of the main engine´s parts was carried out before dismounting the engine. The inspection indicated that a foreign object could have been sucked in (FOD). On September 9 and 10 as the engine was completely taken apart other damaged parts were revealed. In the compressor section, one blade in the HPC 11th stage had one third of its working part broken off. On one measuring probe EGT, 1/3 of the probe body was missing. 1/5 of the working part of a blade of LPT´s first stage was broken off. The first two damages carried marks of older damage. It is very likely that after a part of the LPT first stage´ s blade was separated causing the engine vibration, the 2nd to 4th LPT stages blades were damaged too along with other parts of the engine. At the rear part of the engine there was a rib broken through accompanied by a hole in the outer mantle of the LPT rear box. Taking into account the above damage and conforming to Annex L-13 Supplement C the damage as found out corresponds to the class of serious incident.



BSI showed the damaged engine

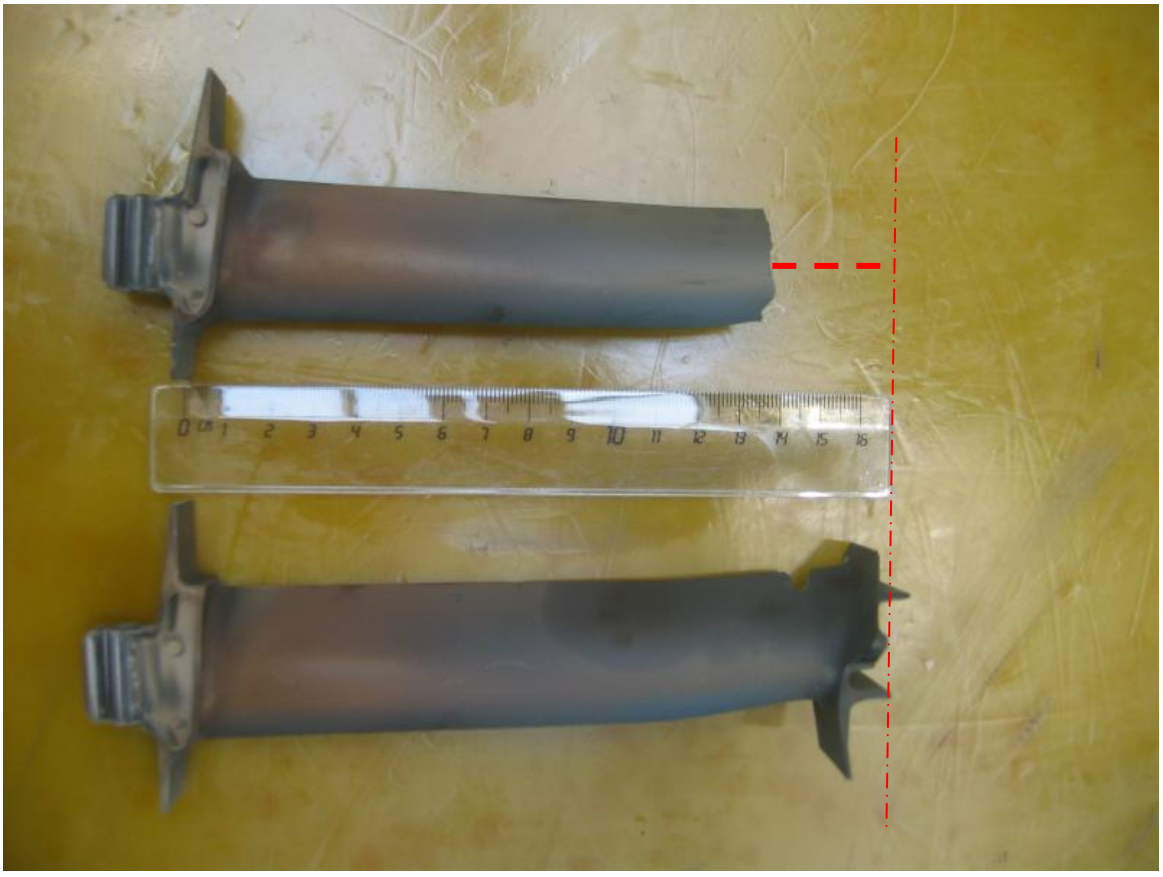


one blade in the HPC 11th stage had one third of its working part broken off

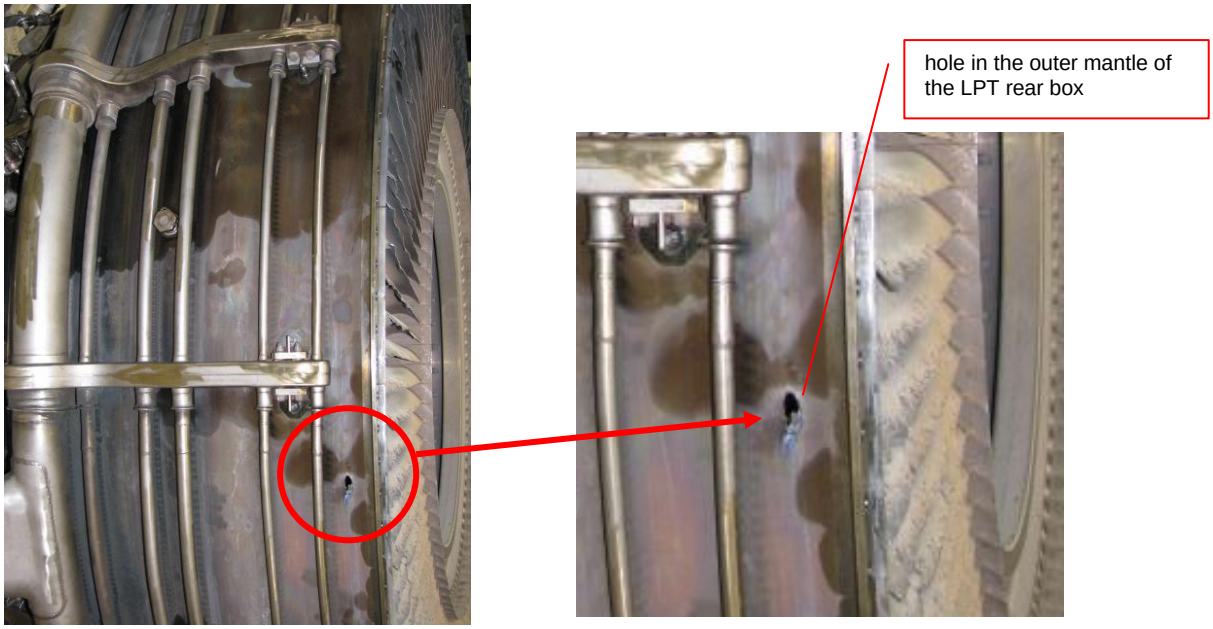


measuring probe EGT, 1/3 of the probe body was missing

the 2nd to 4th LPT stages blades were damaged too



1/5 of the working part of a blade of LPT´s first stage was broken off



All the damage is given in Annex no. 1 - Investigation Report Engine 695365 of 10 Sept. 2008

1.4 Other damage

NIL

1.5 Personnel information

1.5.1 Captain (CPT)
Male, aged 53 years, ATPL(A) licence valid till 30-th Apr. 2013, rating CP/Exam A310, medical valid till 20-th Dec. 2008

Flying experience	*Flight time in last 24 hrs*	*Flight time in last 90 day*	*Total hrs*
Total	**1:46**	**65:35**	**13,310**
as PIC	**1:46**	**65:35**	**8,226**
on A310	**1:46**	**65:35**	**6,678**

Time off duty prior to the flight: 30-th Jul 2008.
CPT passed the latest exam "Line Check" on 2-nd Dec. 2007 and SIM on 12-nd Mar. 2008.

1.5.2 First officer (FO)
Male, aged 48 years, ATPL(A) licence valid till 19-th Feb. 2013, rating FO A310, medical valid till 2-nd Jan. 2009.

Flying experience	*Flight time in last 24 hrs*	*Flight time in last 90 day*	*Total hrs*
Total	**1:46**	**108:39**	**5,050**
as FO	**1:46**	**108:39**	**1,812**
on A310	**1:46**	**108:39**	**1,812**

Time off duty prior to the flight: 30-th Jul. 2008.
FO passed the latest exam "Line Check "on 27-rd Jun. 2008 and SIM exam. 11-rd Jul. 2008.

1.6 Aircraft information

Type:	Airbus A310-304
Year of manufacture:	1991
Total FH/FC to 31-st Jul. 2008:	73 825 FH/ 12 412 FC
MTOW/TOW:	157 000 kg/150 637 kg
MLW/LW:	124 000 kg/146 637 kg
Engine No.1:	
Type:	CF6 80C2A2
Year of manufacture:	1991
Serial number:	695418
TSN:	50 767 hrs
Engine No.2:	
Type:	CF6 80C2A2
Year of manufacture:	1991
Serial number:	695365
TSN:	67 249 hrs
CSN:	11 731 cycle

Note: Engine No.2 was exchanged for another one at KJFK Airport by operator´s service.

The airplane had a valid airworthiness certificate. The latest check, an S-check, was made on July 30, 2008. During operation of the plane with the engines as stated above no cases were reported pointing to collision with a foreign object or sucking it into engine. The plane was used mostly for long-range flights to South-East Asia, Canada, and the U.S.A.

The previous crew recorded no abnormal functioning of aircraft systems or engines during the flight on July 30, 2008. The crew did not notice any sucking-in of a foreign object or bird strike. The speed limit for using engine reverse run at the previous landing had not been exceeded.

1.7 Meteorological information

ATIS KJFK on 31-rd Jul 2008, 20:00 UTC: 200°/15 kt, CAVOK, FEW 5000, BKN 25000, T 29/19.

1.8 Aids to navigation

NIL

1.9 Communications

In collaboration with NTSB, radio communications were ensured between the aircrew and KJFK airport ATC station on frequency KENNEDY TWR. The record was comprehensible and legible.

1.10 Aerodrome information

KJFK Airport is an international aerodrome in the U.S.A.
Responding to the inquiry about whether there was any tire defect or some components lost on RWY 22R prior to A 310 takeoff on July 31, 2008, KJFK officials answered such an event had not been recorded.

1.11 Flight recorders

The flight history was evaluated from QAR onboard equipment. The data record was easy to read.
The CVR record at the critical situation was not examined any more, because of equipment technical parameters was re-written by another record.
It followed from the QAR record that both the engines were showing normal parameters during the take-off.

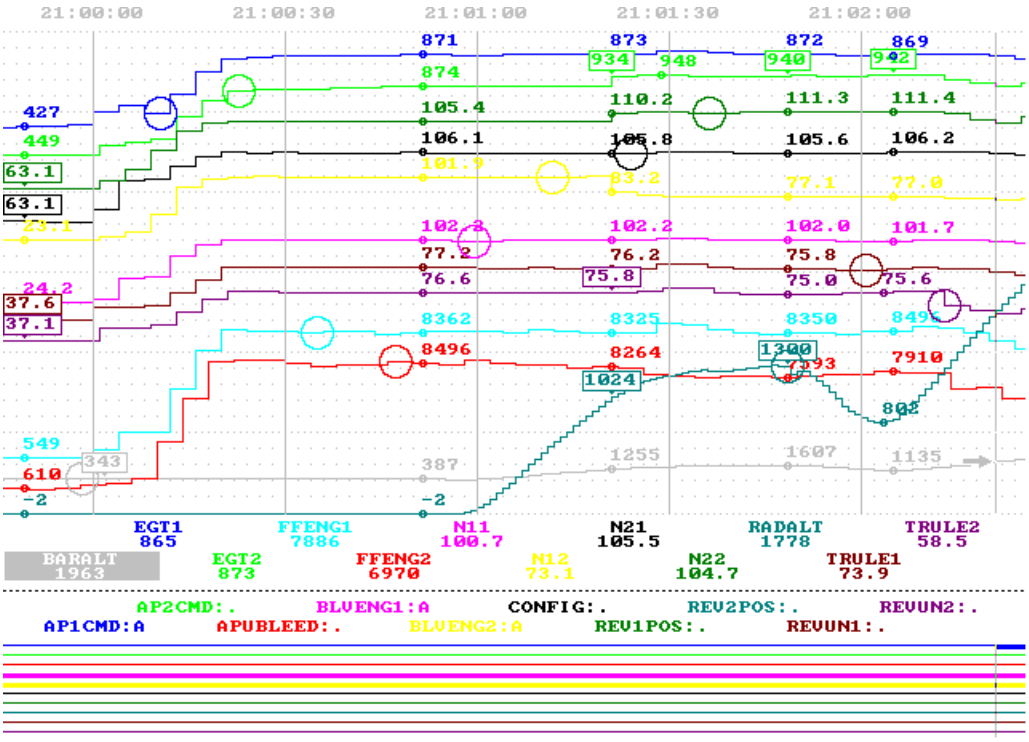
Progress of engines´ parameters and their stabilization at take-off:

Regime:	IDLE				TRULE 1,2
Time:	20:59:59	21:00:04	21:00:08	21:00:13	21:00:21
N_{11} (%)	24,2	54,1	57,9	57,6	102,4
N_{12} (%)	23,1	26,2	32,5	60,5	101,8

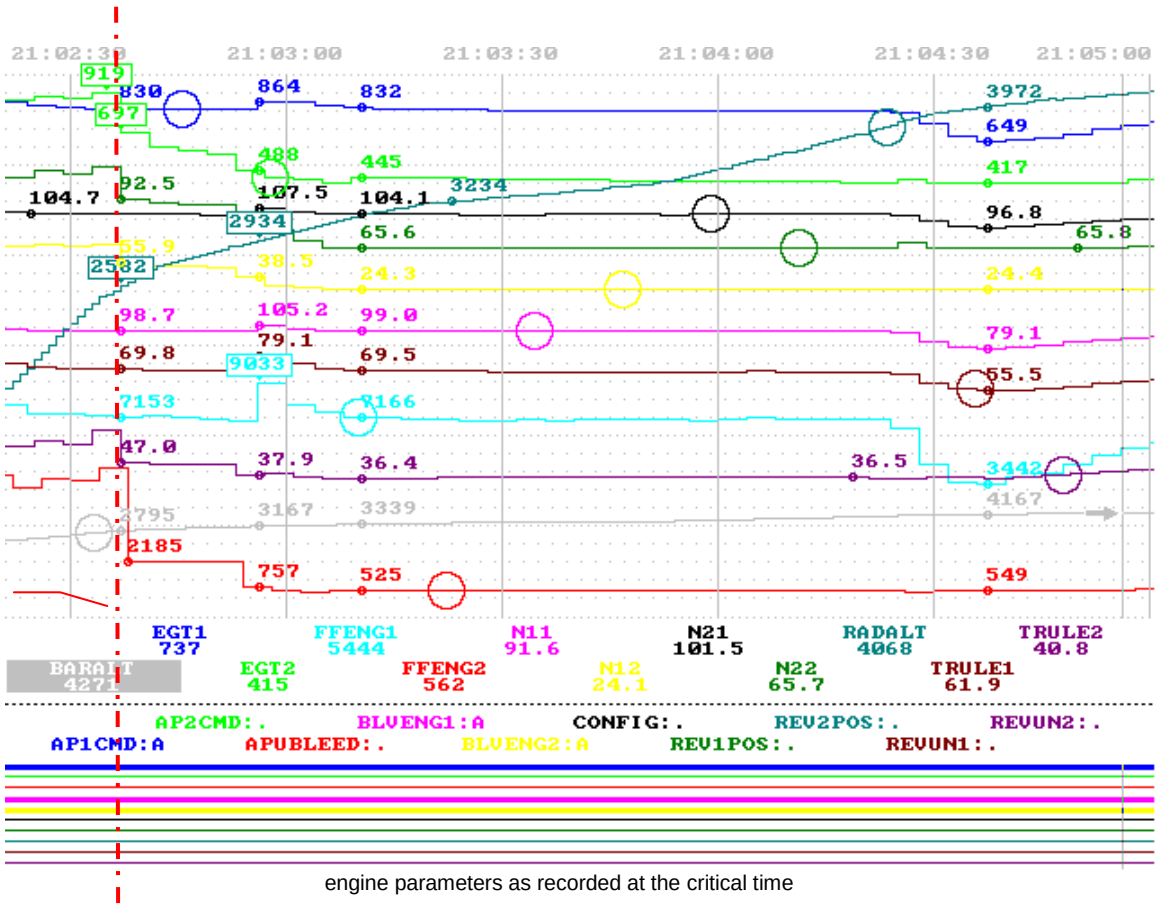
Comments on other flight parameters as recorded:

- at BA 1,411 ft left turn began;
- at BA 1,255 ft first indications of engine no. 2 failure occurred (jump drop of N_{12} from 102.1% to 83.2%);

- engine no. 2 vibration increased from 0.2 to 4.77 (max. vibration value 5.07);
- engine no.2 EGT increased from 877°C to 934 °C without ECAM activation;
- in turning to the heading of 125° the bank was increasing up to 39.8° ;
- at BA 1,527 ft the plane began to descend at an average descent rate of 2,780 ft/min;
- minimum BA reached 1,135 ft;
- simultaneously the CAS speed increased from 236 kts to 271.5 kts;
- during the speed increase the maximum allowable speed with flaps extended (230 kts) was exceeded for 7 sec. ;
- at a speed of 253 kts flaps retraction began
- flaps were retracted at a speed of 271 kts. Limit speed is 245 kts;
- the plane began to ascend from minimum BA 1,135 ft. The average rate of climb was 3,240 ft/min;
- maximum overload in climb transition 1.69 g;
- at 21:02:13 TRULE 2 gradual slow down began;
- AP1 was connected at 21:02:21 at BA 1,963 ft and speed was stabilized to 240 kts;
- engine no.2 slowed down to idle at 21:02:53;
- the plane was stabilized at BA 4,295 ft and “ENGINE OVER LIMIT C/L” started;
- engine no.2 was turned off at 21:06:10 and “LANDING C/L started;
- one-engine flight, radar vectoring, ILS approach executed in a standard way;
- AP shutoff at BA 463 ft, the crew finished the approach and landing manually;
- the plane´s landing weight was 146,637 kg;



engine parameters as recorded at the Take off



engine parameters as recorded at the critical time

1.12 Description of incident site

CTC Kennedy and KJFK international airport.

1.13 Medical and pathological information

NIL

1.14 Fire

NIL

1.15 Survival aspects

NIL

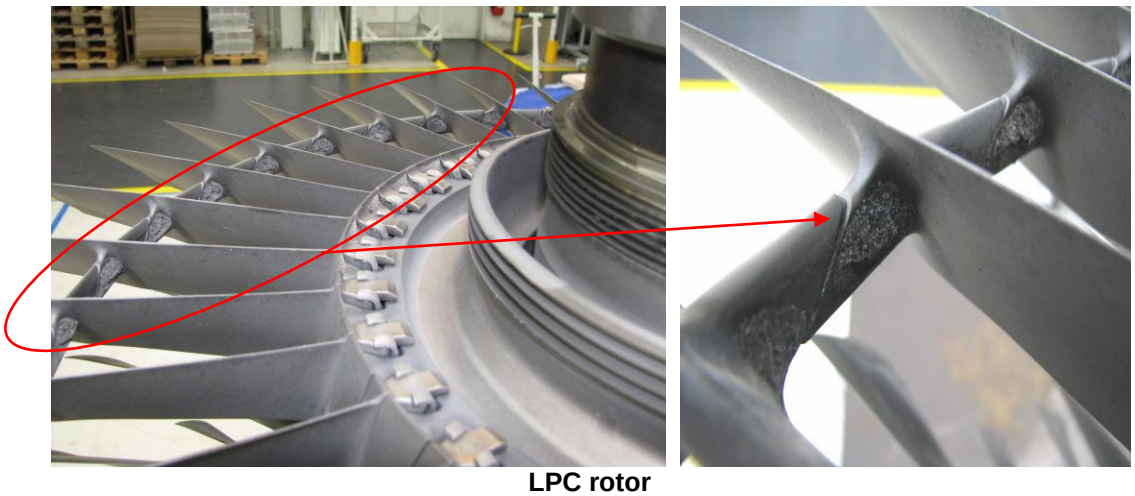
1.16 Tests and research

On the basis of the engine damage found, the commission decided to carry out an expertise examination of material composition and investigation into fracture surface nature of the engine parts in question in collaboration with maintenance service abroad.

LPC Stator: In the trough of 3rd stage blades there were rests of black stuff. The stuff was sent to the lab to know the material composition.

LPC Rotor: On the bottom of mid span shroud there were big deposits of an unknown matter. The matter was sent to the lab to know the material composition.

LPC stator

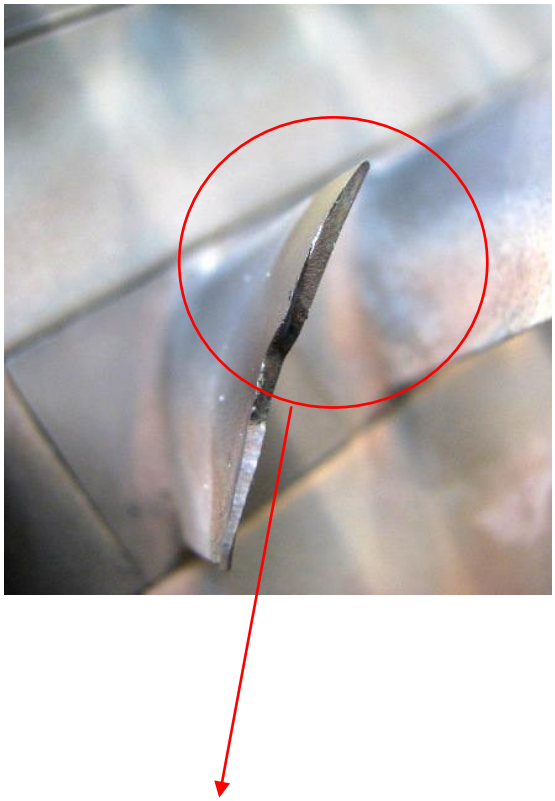


LPC rotor

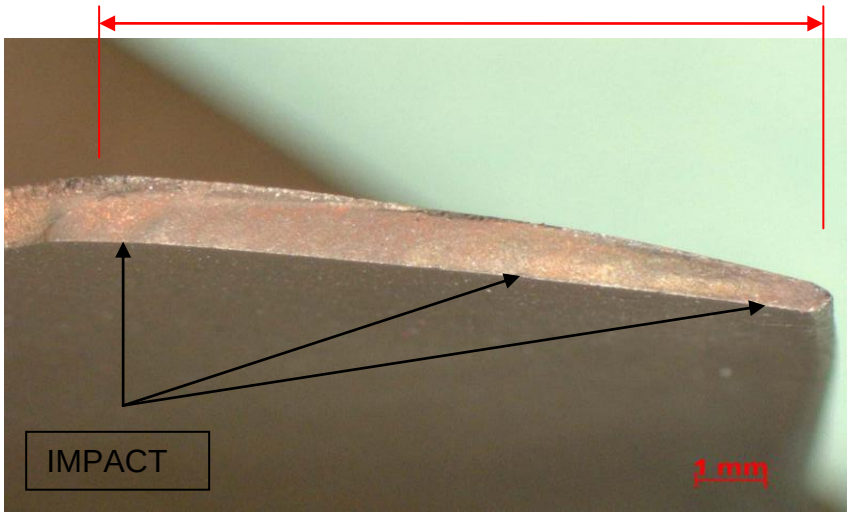
Foreign object:
- EDX analysis was done. The composition of rubber-like contamination on the 3rd stage LPC stator blades proved the main elements to be carbon, oxygen and silicon. Consistence of the black colored samples goes from soft and malleable to hard and brittle. These contaminations are very likely to be organic compounds. The material deposited on the reinforced shroud at the mid span of the 1st stage HPC rotor blades contains these organic compounds too. Moreover, this material deposited on the mid span shroud contains a lot of sand grains.

HPC 11th stage blade: The blade is broken off at about 1/3 height from the end. The stub of the blade was sent to the lab for metallurgical examination of the fracture surface.

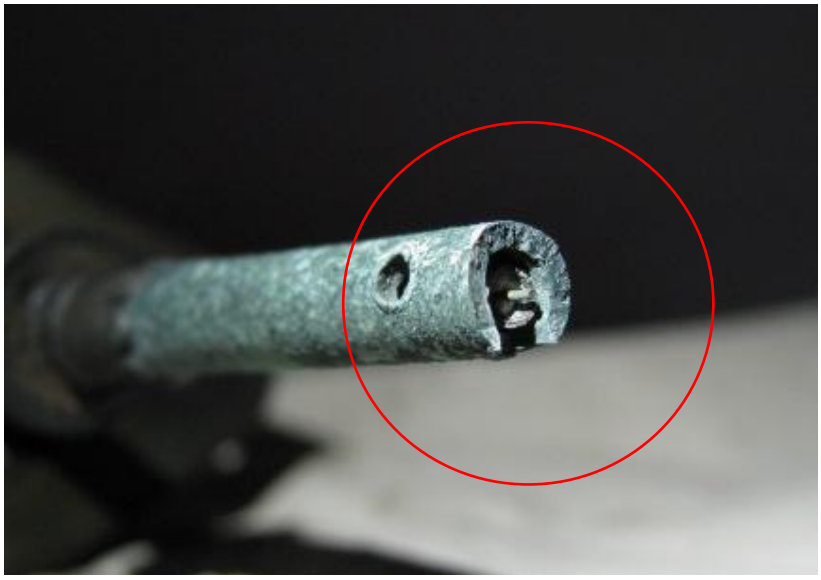
Macroscopic examination of the blade´s fracture surface revealed a zone of fatigue fracture near the leading edge taking up around 40 percent of fracture surface.
Crack´s front shape, as seen on the crack fracture surface after it has stopped, and typical marks of fracture surface indicate that the fracture originated just on the leading edge. The other blades of this stage show some traces of foreign object impact at leading edges at the same locations (further referred to as impact). A few small impacts are visible on the concave surface of the damaged blade along its full length. They are located at a place where the fracture surface runs through the blade profile. The mutual position of impacts after the crack stopped and the impact traces show that these small impacts took place only after the fatigue crack got initiated. Examination using an electron scanning microscope revealed that the fracture fatigue surface and the surface of the final break present different structures. EDX analysis did not reveal any organic matter on the profile surfaces.
The fracture nature corresponds to a high cycle fatigue mode.



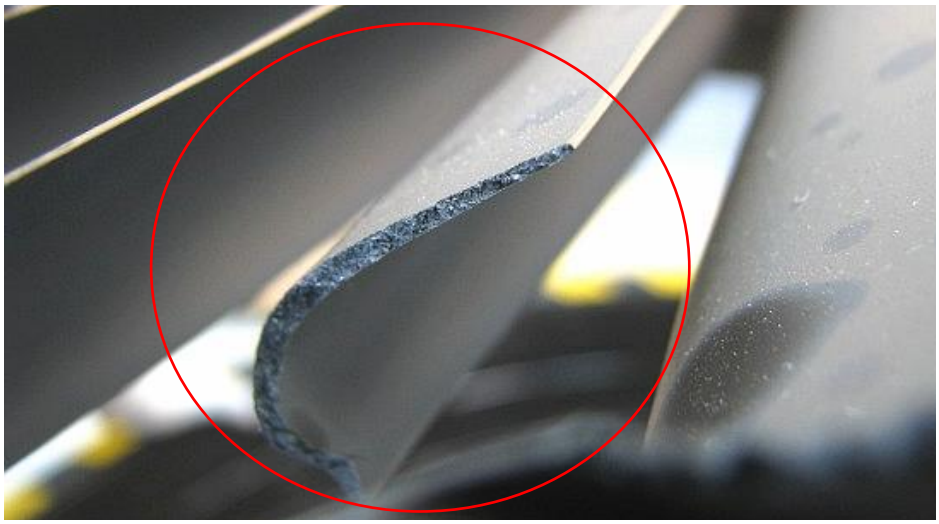
Fatique area (40%)



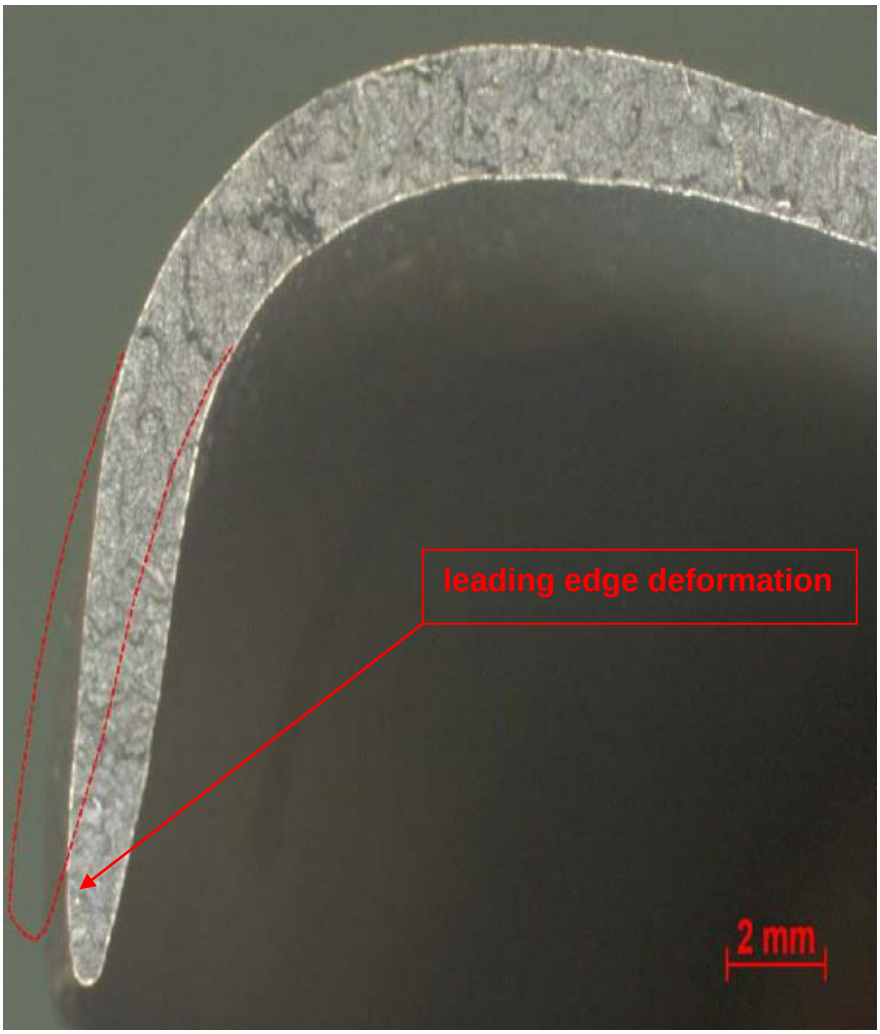
EGT probe: the EGT probe showed an oxidation crack area with a fatigue fracture, orientate from both a ventilating hole. The metalografic analysis of the crosscut from crack area in source disturbances disclose extensive an oxidation in this area probe EGT. The probe´s fracture surface was sent to the metallurgical lab for examination.

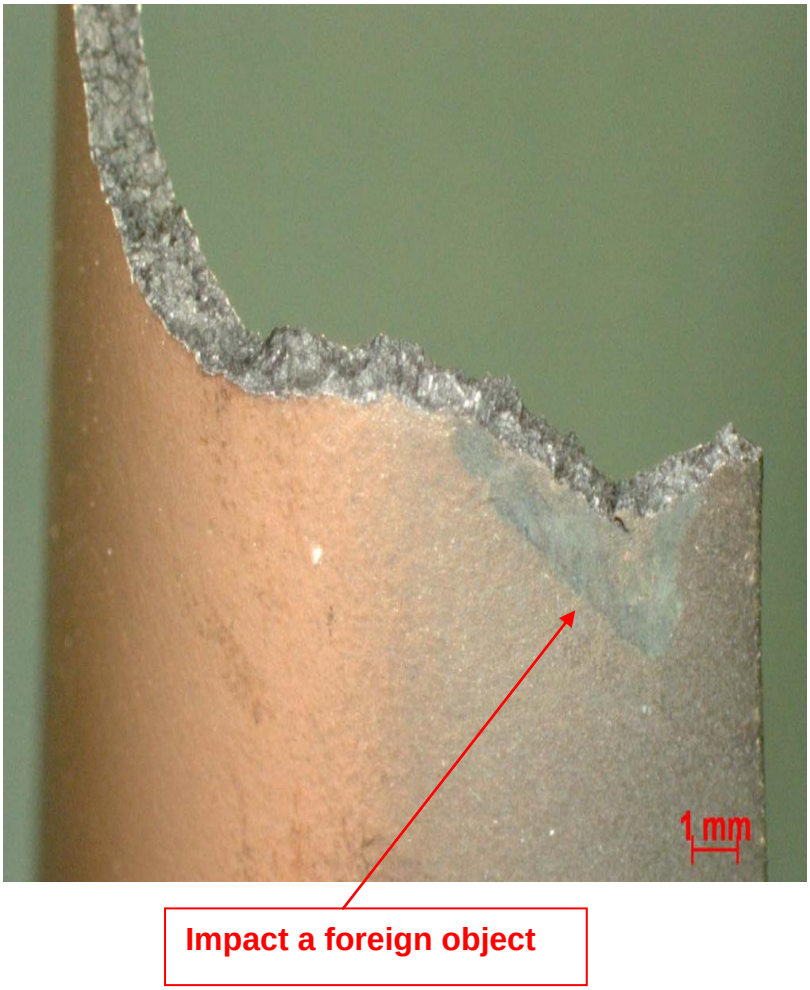


LPT rotor: on one blade of the first stage, the blading cover came off approximately at 1/5 of the blade length. The blade stub was sent to a metallurgical lab for fracture surface examination.



The profile of the damaged blade features slight deformation in the fracture zone and a trace of big impact on the profile convex surface near the leading edge. There are visible star-shaped cracks on the profile concave side under the fracture surface.
Examination using an electron scanning microscope revealed a dendritic, transcrystalline damaged surface, a sign of an accelerated fracture mode.
This blade was primarily damaged by an unknown object that hit the profile on the concave surface near the leading edge.
EDX analysis of impact zone revealed no other material. In addition, metallurgical investigation revealed a lot of cracks caused by oxidation mainly on the profile convex side.
This bad status of the blade could have contributed to its accelerated fracture. The blade was not overheated.


leading edge deformation
2 mm



A report on the fracture surfaces´ laboratory examination is to be found in Annex no. 2 HAM TQ/M Report 2008 529 of 22 December, 2008.

1.17 Organizational and management information

NIL

1.18 Additional information

The A310 aircraft registered OK-WAB is not operated by the operator any longer. The last business flight on the operator´s lines took place on 19 August, 2008.

1.19 Useful or effective investigation techniques

The incident has been investigated according to L-13 National Regulation (Investigation into Air Accidents and Incidents of the Czech Republic as per recommendation of ICAO - Annex 13).

2 Analysis

2.1 Analysis of factual information

- the crew was properly qualified and trained for the flight and medically fit
- the plane had a valid airworthy certificate
- during the flight to New York the previous crew noticed no abnormal functions of aircraft systems or signs of FOD;
- the engine no.2 presented a failure immediately on taking off from New York;

2.2 Handling the engine failure by aircrew

The captain´s decision was in accordance with FCOM procedures “Non-Normal Procedures” by the operator. As the crew tried to identify the engine failure and the plane was controlled manually, the flight got unstable with the plane exceeding its operational limit. This was caused by the flying pilot´s effort to identify the failure, which was not indicated by ECAM. The crew shut off the engine after assessing the circumstances. CC, PAX and ATC station were informed about the situation. Emergency or urgent correspondence was not used during communications with ATC KJFK. The flight attendants worked in accordance with operator´s procedures and fully ensured the passengers´ safety in applying emergencies.

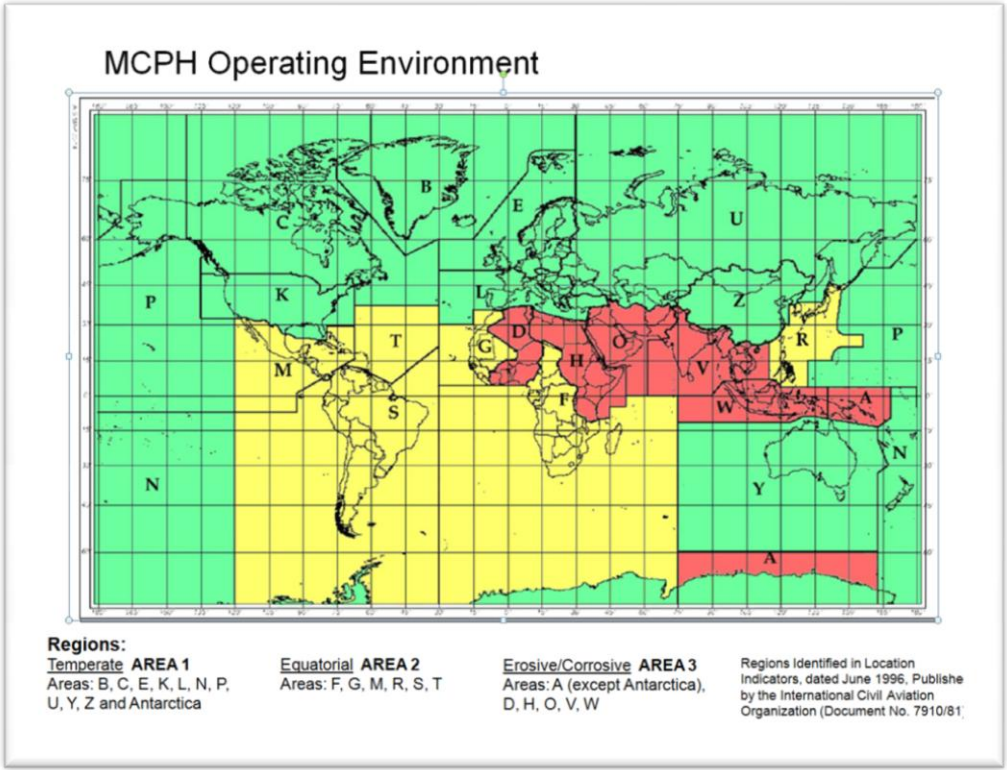
2.3 Probable cause of engine failure

The engine speed dropped abruptly likely due to the braking off of one blade of LPT first stage during the plane taking off, the time the engine was under an utmost strain. However, the impact print, leading edge deformation and oxidization traces in the fracture surface of the blade of LPT first stage show the failure could have been also caused by a foreign object intrusion, or by a shock from separated parts of blade of the HPC 11^{th} stage or by some parts of EGT probe. Macroscopic and metallurgical findings on the blade´s fracture surface do not allow to precisely fix the time of the failure. Mechanical deformation provoked stress concentration in the LPT first stage blade material in the radial direction. The thing got worse gradually till the blade integrity failed. Breaking off the blade of LPT first stage caused more extensive damage to engine parts aft of the rotor of LPT first stage. The damage found on the HPT eleventh stage blade and on the EGT probe was older. The propagating fatigue crack, which was probably caused by a previous impact, gradually reached the critical size before the failure of LPT first stage blade occurred. The traces of organic material found in an LPC part and small impacts on HPC blades point to the intake of foreign objects during engine operation. The soft consistence matter is very likely to be tiny pieces of rubber or tar sucked in as the plane moved on the ground or at takeoffs and landings, which were not indicated by the crew in operation.

According to MS A310 rev. 37 Dec 11/07 worked by Lufthansa Technik AG, based on MPD rev. 24 and MRB rev. 3, the only borescope inspection of high pressure compressor of CF6-80C2A2 engine is the “First stage HPC blade borescope inspection” to point 72300100000 carried out at an interval of 400 FC (under AMM 72-31-00) from which it follows that no more borescope inspections on further HPC stages are carried out. A complex BSI is carried out in case some

damage to the engine inlet or damage to the low pressure compressor following a bird strike or other FOD are found out or reported by the crew.

Long-term operation on routes across continents and oceans may cause hardened atmospheric pollutants to deposit on “mid span shrouds” (see ICAO Document 7910/81).



3 Conclusion

The serious incident was caused by an engine no. 2 failure in the phase of initial climb after take-off. The failure is likely to have been brought about by one blade of LPT fist stage braking off.
The crew was not able to prevent the engine failure and reacted to the critical situation in accordance with the operator´s procedures.
The event is classified as serious incident for technical reasons according to L-13 Regulation, Supplement C article 2 (Investigation into Air Accidents and Incidents of the Czech Republic as per recommendation of ICAO - Annex 13).

4 Safety recommendations

a/ The domestic operator of A310 aircraft shall inform aircrews and technical staff about the commission conclusions.

b/ The manufacturer and service organization of CF6 80C2A2 engines shall inform operators of these engines about this Final report.

Approved by Prague, June 17, 2009

5. Annexes

No.	title of Annex	pages
1.	Investigation Report Engine 695365 of 10 Sept. 2008	50
2.	HAM TQ/M Report 2008 529 of 22 December, 2008.	11