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MINISTÉRIO DAS OBRAS PÚBLICAS, TRANSPORTES E COMUNICAÇÕES
GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES

INCIDENT PRELIMINARY REPORT

TAAG – ANGOLA AIRLINES

BOEING B-777/200

D2-TEF

LISBON

PORTUGAL

December 6th, 2010

PRELIMINARY REPORT Nr. 18/INCID/2010

NOTE

This document has been prepared on the basis of the initial information gathered during the investigation process, without any analysis and based on the description of the circumstances of the accident. Some of the points covered may evolve with time. Nothing in the presentation of this report should be interpreted as an indication of the orientation or conclusions of the investigation, which may evolve according new facts gathered and subsequent analysis.

In accordance with Annex 13 to the Convention on International Civil Aviation Organization, Chicago 1944, with European Parliament & Council Regulation nr 996/2010, from 20/10/2010, and nr 3 of art 11th of Decree Law Nr 318/99, from 11th of August, the investigation, analysis, conclusions and recommendations of this report are not intended to apportion blame or liability but, and only, to determine the causes of such incident and formulate recommendations that may prevent its repetition and to spread the lessons retrieved and capable of prevent futures accidents.

This preliminary report constitutes provisional information, based on finds gathered prior to its publication and it is subject to modifications or corrections if, or when, new evidences are collected during investigation development. The final report will be the official document containing definitive investigation results and will be published on GPIAA web page www.gpiaa.gov.pt

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SYNOPSIS

On the 06th of December, 2010, by 11:15¹, TAAG – Angola Airlines flight DTA-651, operated by a Boeing B-777/200, s/n 34567, registration D2-TEF, suffered an incident, shortly after take-off from Lisbon airport.

Airborne at 11:11, on runway 21, heading Southwest, the aircraft overflew Tagus river, climbing to its cruising altitude, and started a left turn, in order to follow assigned routing. When approaching 5000ft, right hand side engine (#2) showed a N1 speed decrease, together with an EGT increase and high engine & aircraft vibration, which decreased when respective thrust lever was reduced. At same time a message was present on EICAS, announcing an engine #2 abnormal behaviour.

Climb was discontinued and aircraft stabilized at 5000ft. The flight crew performed the appropriated checklists and decided for an approach & landing on departure aerodrome. After ten minutes, engine #2 has been shutdown and, by 11:32, a single engine landing occurred, uneventfully, on same runway of departure, 21mn before.

¹ - All times referred in this report, except other information, are UTC times (Universal Coordinated Time). On that date, local time, in Portugal mainland, was equal to UTC time.

1. ORGANIZATION OF THE INVESTIGATION

1.1 Notification

GPIAA has been notified by Lisbon Airport Operation's Supervisor, at the same time information from Setúbal and Almada Police (PSP) was received, referring the fall of some aircraft parts, which caused several damages on cars and houses, in the city of Almada.

An investigation process was immediately opened, with the appointment of the Investigator In Charge and three more Technical Investigators.

This former Investigation Team went to Lisbon Airport and performed an external inspection of the aircraft, in order to get the necessary clues to qualify the event and organize future actions. Flight Recorders (SSFDR – 980-4700-042, s/n 14062 e CVR – 980-6022-001, s/n 120-09842) were captivated and taken under custody.

Back to the Office, notifications were sent to involved countries' Authorities, as per ICAO Annex 13, chap. 4.1, to European Aeronautical Safety Agency (EASA) and National Civil Aviation Authority (INAC), as per art 8th, nr 1, a) of Regulation Nr. 996/2010, from European Council & European Parliament, inviting them to join the Investigation Commission.

1.2 Investigation Commission

As a consequence of sent notifications and requests received, on the 09th of December, 2010, the Investigation Commission was formed, with three working groups integrating the following personalities:

- a) *Investigator In Charge* - António Alves;
- b) *Group 1 – Flight Operations; Human Factors; Environmental Factors* – chaired by the Investigator Artur Pereira (GPIAA) with the participation of Euclides Oliveira (INAVIC), Paulo Cochat Osório (TAAG) and Mário Coelho (TAAG);
- c) *Group 2 – Flight Recorders* – chaired by the Investigator António Barros (GPIAA) with the participation of Pedro Gonçalves (GPIAA Angola), Eric Kameni (TAAG) and Jorge Sopas (TAAG);
- d) *Group 3 – Material Factors & Maintenance* – chaired by the Investigator Fernando Lourenço (GPIAA) with the participation of Gabriel Júnior (INAVIC), Amaral Lola (TAAG), Amadeu Teca (TAAG) and Pedro Fernandes (GE).

2. INVESTIGATION DEVELOPMENT

After the presentation meeting, the respective working groups met and started the investigation process, gathering the available evidences, as described in subsequent subchapters, which will be subjected to a confirmation & analysis process.

2.1 Group 1

Having the scope of determine the circumstances involving the flight, this group started recovering all the information relating the environmental factors affecting the operation, the composition & qualification of flight crew members and the respect of regulations & procedures established for in-flight & on ground operational services. A preliminary reading of compiled evidence allowed the presentation of following provisional information, shown bellow.

2.1.1 Meteorology

According pre-flight information received, the weather in Lisbon area, at departure time, put no restrictions to the operation.

The situation was characterized by strong winds, specially in altitude, sky partially cloudy and possibility of precipitation, due to a South-westerly circulation, under the influence of a Low pressure situated over the Atlantic, Northwest of Lisbon (*picture nr 1*).

Lisbon airport METAR, covering the period of the flight and shown bellow, registered a light rain at 12:30 only (*one hour after landing*).

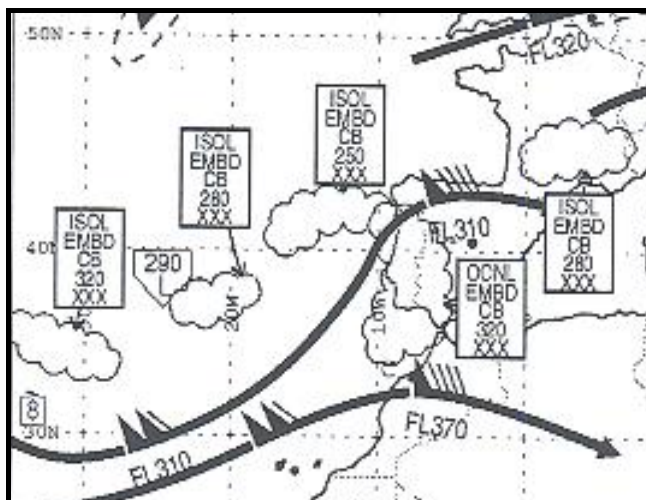


Figura Nº 1

METAR LPPT 061030Z 21008KT 180V240 9999 FEW010 SCT012 BKN020 18/16 Q1004 NOSIG

METAR LPPT 061100Z 21012KT 180V240 9999 FEW009 BKN015 18/17 Q1004 NOSIG

METAR LPPT 061130Z 21011KT 180V260 9999 FEW008 BKN011 BKN015 18/17 Q1004 NOSIG

METAR LPPT 061200Z 21009KT 180V250 9999 FEW009 SCT012 BKN100 18/16 Q1004 NOSIG

METAR LPPT 061230Z 21010KT 180V250 9000 -RA SCT012 SCT060 BKN080 18/16 Q1004 NOSIG

METAR LPPT 061300Z 19009KT 9999 SCT007 BKN020 BKN070 18/17 Q1003 NOSIG

We may notice that, between 11:00 and 11:30, there was a light reduction on lowest cloud base altitude, together with an increasing amount of clouds, which influenced the crew on his decision for an overweight landing.

2.1.2 Flight Crew

The flight crew was composed by two pilots, duly qualified to operate this type of aircraft & route. Their flight experience, at incident time, is shown on table nr 1, below:

References	Commander	F/O
Personal: Sex: Age: Nationality:	Male 51 years Angolan	Male 56 years Swiss / Brazilian
Professional: Type of License: Total Flight Time: Total Flight Time on Type:	ATPL(A) 11 800:00 1 000:00	ATPL(A) 11 300:00 2 800:00

Table Nr. 1

Their Licenses and Medical Certificates were valid and approved training programme had been complied with.

2.1.3 Flight Operations

Required Manuals have been collected and an analysis process is in place to confirm the suitability and fulfilment of operational regulations & procedures, as defined by the operator and competent aeronautical authorities. At this moment there are no evidence of significant deviation from those regulations & procedures.

2.1.4 Ground Operations

At this stage of the investigation nothing points to any strange or inappropriate interference of ground services, which could influence the development of operations.

2.2 Group 2

The aircraft was equipped with a monitoring & control data recording system from which first information data, relating to present event and previous flights, was retrieved, together with historic exceedance registry.

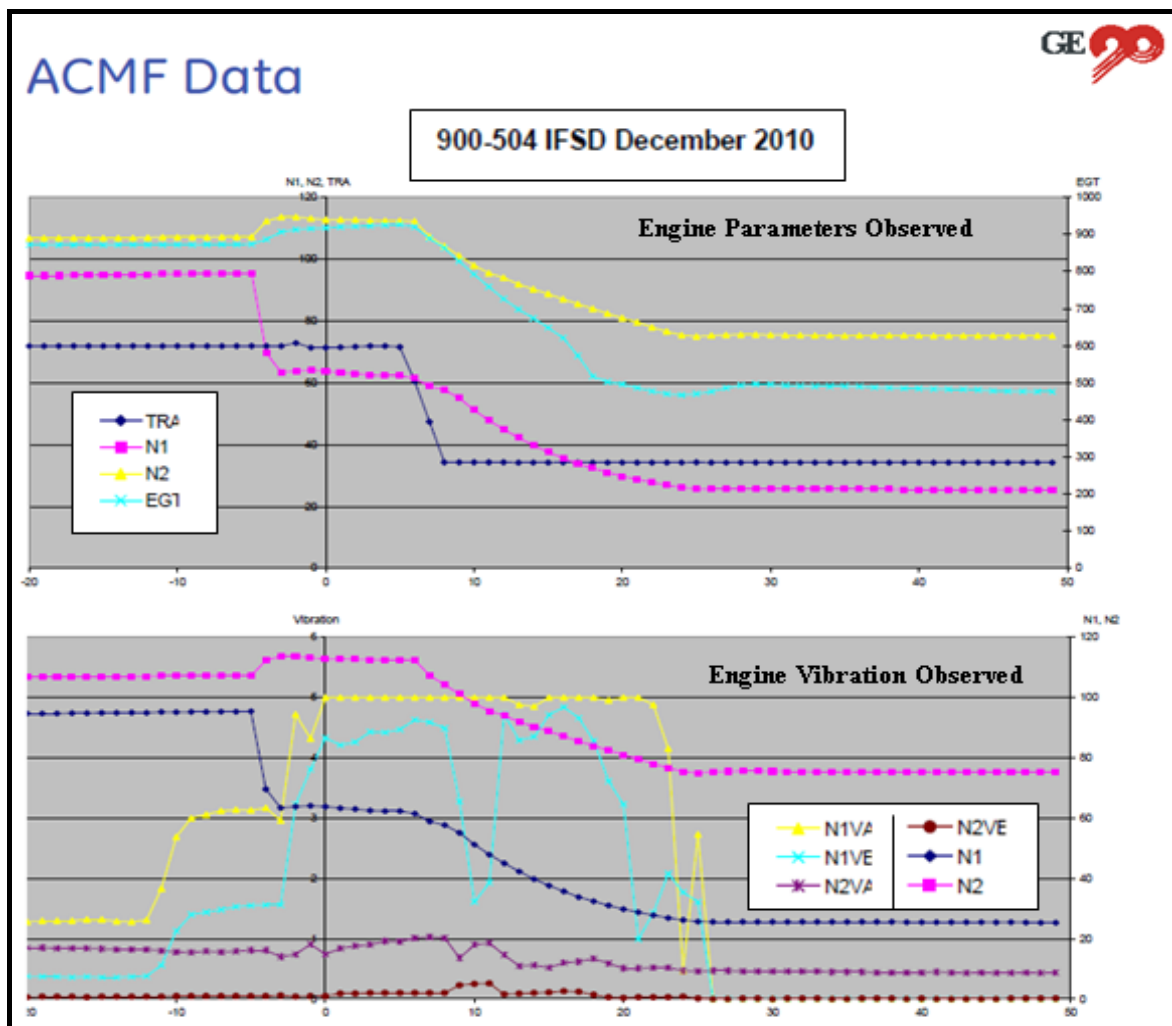
There were, also, one data recording unit (DFDR) and one communications & cockpit voice recording unit (CVR). These recorders, removed from the aircraft, were taken to a data decoding and analysis laboratory, for opening & retrieving of registered information.

Besides, there was a Quick Access Recorder (QAR), which has not been used once data retrieved from DFDR showed to have the right quality and be enough for event analysis.

2.2.1 Aircraft Condition Monitoring (ACMF)

Once access to this unity was gotten, engine # 2 behaviour, during this event and on previous flights, was discharged and sent to GE for study and analysis.

Using ACM information and GE produced graphs (*based on that information*), a presentation of previous 20s till post 50s of the event, can be analysed (*picture nr 2*).



Picture Nr. 2

Looking into these graphs it's possible to confirm that take-off and climb parameters were normal until the event occurred.

Previous flights exceedance registration, in a speedy reading, showed no occurrence directly related with this event. Analysis of discharged data is in progress.

2.2.2 Honeywell SSFDR p/n 980-4700-042, s/n 14062

This unit records all aircraft operational data, including each crew member individual actions and has a storage capacity for 1302 parameters (*raw data*) that, after evaluated and treated, may totalize more than 1900 parameters. This information is recorded continuously and may be presented in graphic or analogical mode.

All data was in good recording and reading condition and, after decoded, it was stored in "Excel" format, in order to ease its access.

A preliminary analysis of this data confirmed the elements retrieved from ACMU. A thorough and selective analysis has to be made, in order to get the maximum pertinent information.

2.2.3 Honeywell CVR p/n 980-6022-001, s/n 120-09842

Destined to record voice communications, either from radio communication systems or cockpit conversations (and other sounds as well), covering the last 120mn of operation, it was in perfect conditions, covered the flight period in study and all four channels recordings were clear and well perceived.

On a first reading, no significant discrepancies with other recordings or operator standard procedures were detected.

2.3 Group 3

Being a group connected with material factors, this team had an activity more close to the equipment, aircraft and engine involved in the incident, counting with the support of engine manufacturer GE detached experts and TAP Portugal Maintenance & Engineering technical services.

Inside this group the first researches, aiming to get the necessary information for investigation orientation and development, were carried out, starting with visual and borescopic inspections and engine & aircraft informatics' and paper supported historic registry consulting (*recorders and technical documentation*).

2.3.1 Aircraft & Engine Identification

The aircraft was a Boeing B-777/200, s/n 34567, Angolan registration D2-TEF, manufactured in 2007 and entered to TAAG service the same year. The engine that suffered the incident was manufactured by General Electric in 2007 and installed on position # 2, right wing, in 26-11-2007, on D2-TEF aircraft, was one GE 90.94B, with s/n 900-504.

When the incident took place it had accumulated 6663 flight hours, with 1203 cycles, like the aircraft.

2.3.2 Exterior Preliminary Inspection

On the 06-12-2010 an exterior inspection was performed to the aircraft and right hand engine, being detected substantial damage to Low Pressure Turbine (LPT) last stage and "stator", with material loss and heavy deformations in all turbine blades and guide vanes (picture nr 3A e 3B).

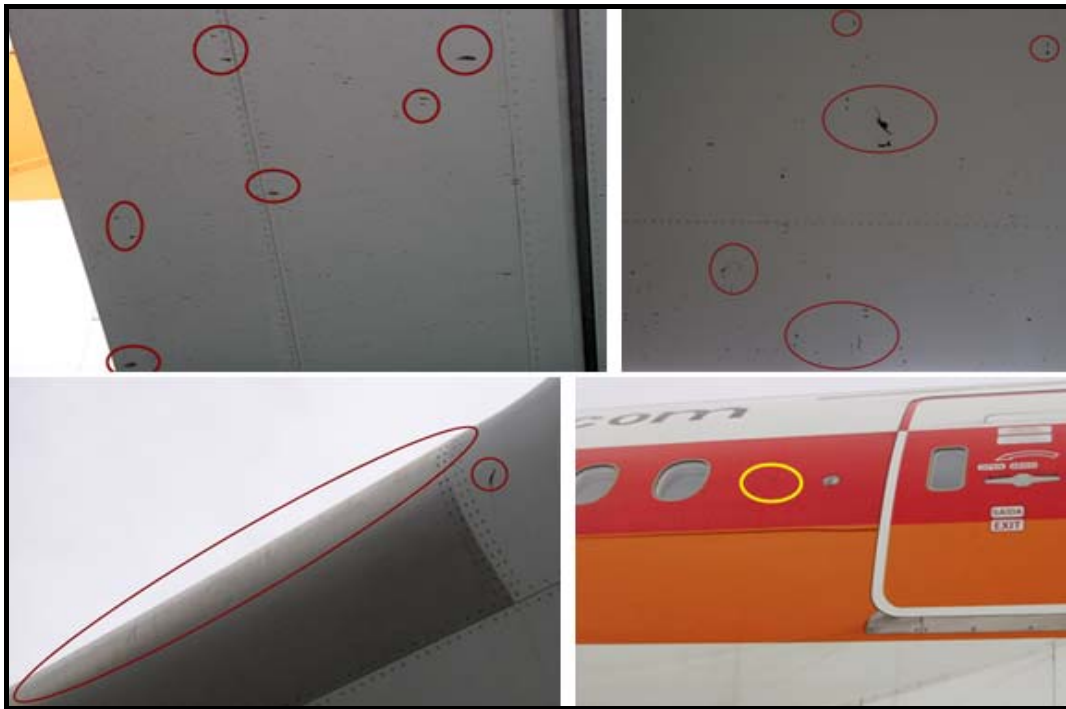


Picture Nr. 3

Engine inlet and "bypass" outflow areas showed no damages or any other FOD ingestion evidences (picture nr 3C e 3D). The same regarding engine cowlings and linings.

On the aircraft surface, some impact marks were detected on "flaperon" lower surface, fuselage right hand side and right horizontal stabilizer leading edge (picture nr 4).

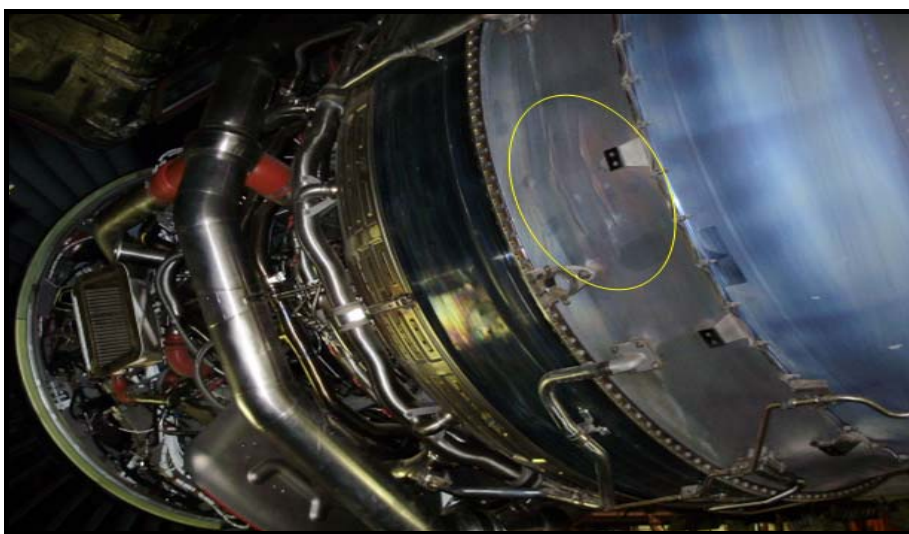
No one of these impacts seemed to have caused skin rupture, except on stabilizer root, where the fairing seemed to be punctured.



Picture Nr. 4

2.3.3 Exterior Engine Inspection

In a subsequent phase, engine cowlings were opened and all compressor, combustion chamber and high pressure turbine (HPT) areas showed to be in perfect conditions. At low pressure turbine (LPT) area, on both sides, some small dents, only detected by touch or contrasting light, were noticed (*picture nr 5*). Cowling's internal side was clean and showed no impact marks.



Picture Nr. 5

2.3.4 Engine Borescopic Inspection

Suspecting the origin of the event was in turbine zone, the investigation continued with a borescopic examination of turbine stages and nozzles. Meanwhile an engine rotation test was performed and confirmed that compressor and high pressure turbine (HPT) were free to rotate, but Fan and low pressure turbine (LPT) were stuck.

Convinced that high pressure turbine (HPT) would be in good shape and only low pressure turbine (LPT) suffered damage, it was decided to start with HPT examination, which should be relatively quick, passing to LPT latter.

HPT examination revealed 1st and 2nd turbine stages, like respective nozzles, showing an apparent good condition and presenting a normal colour (*picture nr 6*).



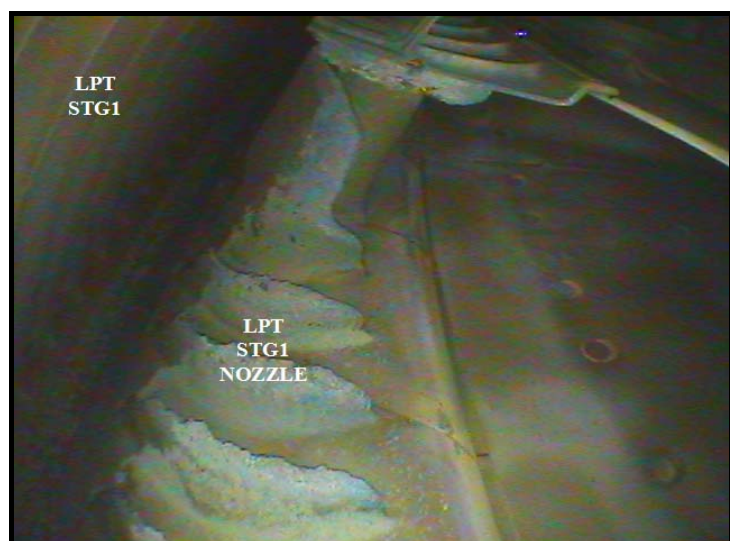
Picture Nr. 6

Moving to low pressure turbine examination (LPT), substantial damage started to be seen.

In LPT 1st stage inlet, several "inlet guide vanes" were chopped off near its roots, and part of LPT stage 1 nozzle external ring was absent.

Its appearance & colour seemed to demonstrate a material failure due excessive heating (*picture nr 7*).

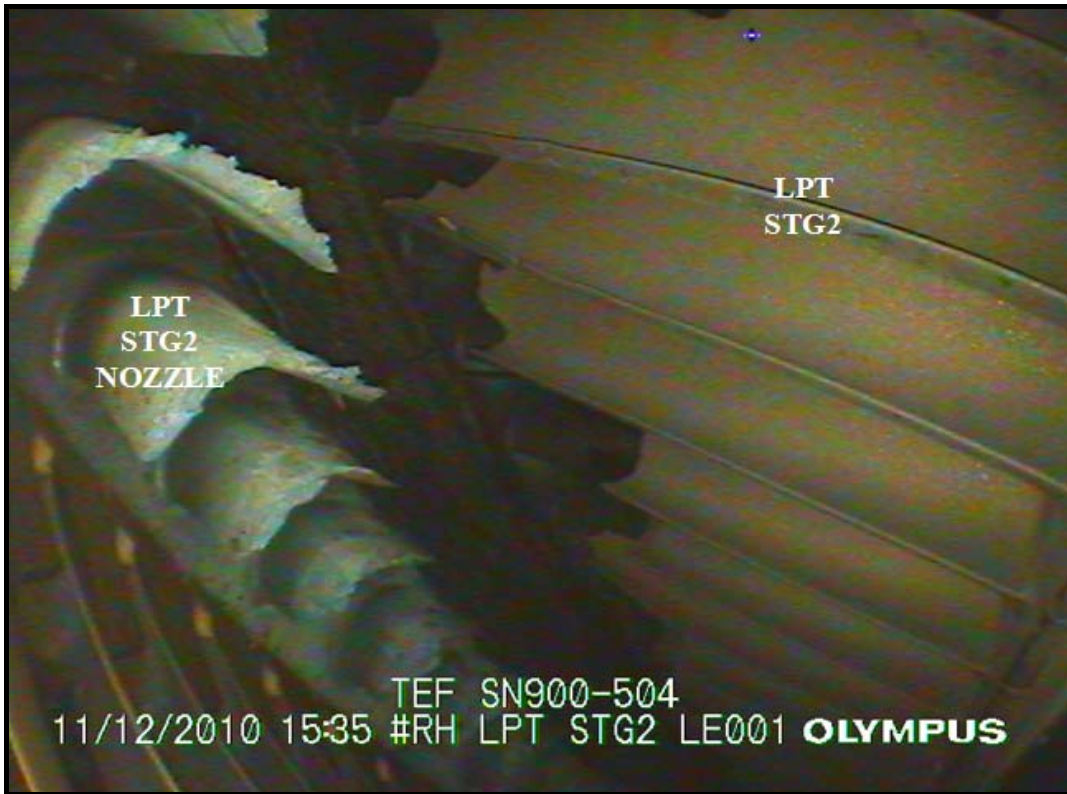
LPT 1st stage blades seemed to be in perfect condition.



Picture Nr. 7

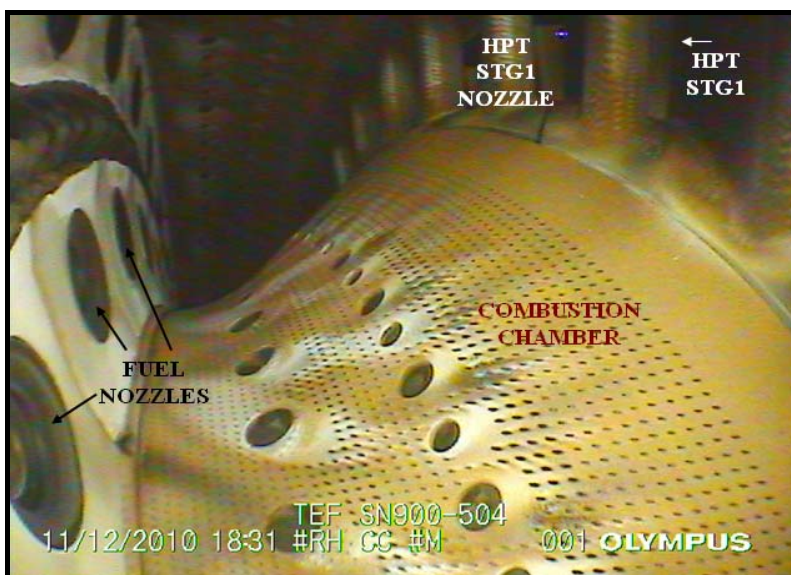
CLH

Progressing to LPT 2nd stage, nozzle vanes continued to show heavy damage and significant parts of turbine blades were missing (*picture nr 8*).



Picture Nr. 8

In the presence of such evidences, considering that LPT couldn't be rotated and a clear view of subsequent stages was not possible, it was decided to examine the combustion chamber, looking for any fuel injectors & fuel nozzles deficiency.



Picture Nr. 9

A complete view of combustion chamber was not possible, being inspected the lower section, from two-o'clock to ten-o'clock position, only.

From what could be seen, the combustion chamber was clean and fuel injector's or fuel nozzle's anomalies couldn't be detected (*picture nr 9*).

2.3.5 Engine Historic Registry

Besides electronic monitoring & control system registrations, Aircraft & Engine Technical Logbook paper registries, were requested.

Those documents started to be checked and will be analysed. At this point there is no sufficient information to be used for investigation orientation. However, previous flight crew remark on Tech-Log stands out, declaring that #2 engine EGT values, in cruise, were 35°/45° higher (picture nr 10).

1. DEFECT REPORT						ATA
IN CRUISE EGT RIGHT ENG 35/45° DEGREES HIGH,						
DESCEND EGT LEFT ENG IN IDLE 718°C						
AFTER LAND ENG LEFT SHUTDOWN DUE TO						
REPORT BY	MNT	CREW	STA	LICENSE		↓
P/N OFF	↓	↓	S/N OFF			↓
R/I	Yes	No	SIGNATURE			DATE
2. DEFECT REPORT						ATA
High EGT, NOTE, REVERSE NOT USED AT LANDING						

Picture Nr. 10

Aircraft Technical Log written information will continued to be checked and analysed and it will be compared with electronic data retrieved from Aircraft Monitoring & Control System Recorder.

2.3.6 Similar Cases History

GE technical services and customer support are developing a follow-up programme on (apparent) similar cases occurred with another operator fleet, which suffered damages on six unities, supposedly due to abnormal operation of fuel injectors.

The knowledge gained with the development of this programme may be applicable to other similar circumstances, like the one behind this investigation.

3. PRELIMINARY CONCLUSIONS

From all groups' activities and research the following **provisional** conclusions were extracted:

1st Aircraft Airworthy Certificate was valid and the approved maintenance programme has been complied with;

2nd Flight Crew Licenses & Medical Certificates were valid and both pilots were entitled to operate the aircraft and the route, without restrictions or limitations;

3rd Environmental factors, like meteorology, were not considered as contributory factors for the event;

4^a Considering that first damages were found after the combustion chamber, suspecting of an excessive temperature build-up in turbine zone, which could cause LPT "guide vanes" material failure, one or more fuel injectors abnormal behaviour could be suspected. LPT 1st stage nozzle vanes failure and parts separation, may have cause the subsequent unities failure, till the exhaust, with consequent damage progressing.

4. FOLLOW-UP ACTIONS

After the evidences found during the initial step of the investigation, once it's impossible to have an efficient view of all engine parts were it's supposed to find the key for event explanation, The Investigation Commission agreed with engine manufacturer (GE) proposed plan, comprising the following steps:

a) Removal of right engine from the aircraft and send it to GE-90 Engine Support Centre in Walles, United Kingdom;

b) Perform a complete borescopic examination to engine hot zone;

c) Dismantle the various engine sections and proceed to its inspection and required material tests to determine event causes;

d) Removal of fuel injectors, from combustion chamber, sending them to the manufacturer (*Parker*), for detailed investigation;

e) Removal of HMU and send it to the provider (*Woodward*), for detailed investigation.

All these actions will be oversighted by an UK AAIB expert, duly registered and photographed, being the final reports sent to the Investigation Commission that will be accompanying the works progress.

Meanwhile, gathered data & evidence's treatment and analysis will continue at different group's level, in order to clarify the event and determine its cause(s).

According with investigation progress and new & relevant facts are uncovered, if considered pertinent, intermediary reports will be published and, if there is the case, safety recommendations issued.

When the process finishes, the final report will be written and publicised in our web page, after GPIAA's Director homologation.

5. SAFETY RECOMMENDATIONS

Immediately after the event, by flight safety department suggestion, the operator ordered a borescopic examination to all engines powering the B-777 fleet.

The engine manufacturer (GE) delivered an information letter to all operators of this type of engine, alerting for the event.

Considering the similitude between this event and the others referred in 2.3.6, we will be waiting for more solid information to determine the relevance of any safety recommendation issuance. Meanwhile we support operator's initiative and call the attention of all other operators of this kind of engine, for the convenience in processing a borescopic examination covering, at least, combustion chamber and turbine zones.

Lisbon, January the 3rd, 2011

The Investigator In Charge,



António A. Alves