NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 26, 2016

Maintenance Factual

DCA15FA185

A. ACCIDENT

Operator:	British Airways
Location:	Las Vegas, NV
Date:	September 8, 2015
Time:	1613 Pacific Daylight Time[1]
Airplane:	Boeing B777-236ER, Registration Number: G-VIIO, Serial Number: 29320

B. MAINTENANCE FACTUAL

Group Chairman: Gregory Borsari
National Transportation Safety Board
Washington, DC

Member: Robert Smedley
Federal Aviation Administration
Daly City, CA

[1] All times are Pacific Daylight Time (PDT) based on a 24-hour clock, unless otherwise noted. Actual time of incident is approximate.

Member: Sukhdev Rai
British Airways
London, Heathrow

Member: Richard Anderson
Boeing Commercial Airplanes
Seattle, WA

Member: Justin Doxey
Air Accidents Investigation Branch
Aldershot, Hampshire

Member: David Brown
GE Aviation
Nantgarw, Cardiff

C. SUMMARY

On September 8, 2015, at about 1613 Pacific daylight time (PDT), a British Airways flight 2276, a Boeing 777-236ER, registration number G-VIIO, powered by two General Electric GE90-85BG11 turbofan engines experienced a No. 1 engine (left) uncontained failure and subsequent fire during the takeoff ground roll on runway 07L at McCarran International Airport (LAS), Las Vegas, Nevada. The flightcrew aborted the takeoff, stopped the aircraft on runway 07L, and evacuated the airplane. The No. 1 engine, the inboard left wing, and a portion of the left and right fuselage experienced fire damage. The fire was extinguished by airport rescue and firefighting (ARFF) after the evacuation started. The 157 passengers, including 1 lap child, and 13 crew members evacuated via emergency slides on the runway. There were 19 minor injuries and 1 serious injury reported. The airplane was substantially damaged. The flight was operating under the provisions of 14 Code of Federal Regulations (CFR) Part 129 flight from LAS to London-Gatwick International Airport (LGW) Horley, England.

D. DETAILS OF THE INVESTIGATION

1.0 Air Operator Certificate

On October 28, 2014, the United Kingdom (UK) Civil Aviation Authority (CAA) issued (issue 17) an Air Operator Certificate (AOC) to British Airways PLC located at Waterside, PO Box 365, Harmondsworth, Middlesex, UB7 0GB, United Kingdom.

See Attachment 1

2.0 Repair Station Certificates

The CAA issued an approved Maintenance Organization Approval Certificate (Reference UK 145.00021) to British Airways PLC, Heathrow Airport, Hounslow, Middlesex and Gatwick

Airport, Gatwick, West Sussex. The original issue date was July 6, 1992 and revised August 20, 2015.

The CAA issued a Continuous Airworthiness Management Organization Approval Certificate (Reference UK.MG.0037) to British Airways PLC, Heathrow Airport. Hounslow, Middlesex. Original issue date was September 29, 2005 and revised August 20, 2015.

The Federal Aviation Administration, Certificate Management Office issued an approved Repair Station Certificate (Certificate Number BRAY010F, dated October 5, 1977) to British Airways PLC, Heathrow Airport, Hounslow, Middlesex with the following ratings: Limited Power Plant, Limited Airframe (February 16, 1995), Limited Accessories (September 28, 2010), Limited Non Destructive Testing Inspection, Testing and Processing (September 28, 2010), Limited Radio (April 12, 2013) and Limited Instrument (April 12, 2013). Certificate in effect until May 31, 2016.

See Attachment 2

3.0 Foreign Operations Specifications (OpSpecs)[2]

The FAA issued British Airways PLC Foreign OpSpecs approval based on the State of the Operator's (UK Civil Aviation Authority) Air Operator Certificate (AOC) number GB 0441. The Foreign OpSpecs grants approval for commercial operations in the United States.

a) In accordance with Foreign OpSpecs Part A001.b (1) British Airways PLC can conduct foreign air carrier operations in common carriage in the United States pursuant to the applicable requirements.

b) As per Foreign OpSpecs Part A003 British Airways is authorized to operate the following aircraft fleets to the United States:

Table 1 – Aircraft

Aircraft Type	Number of A/C
Airbus A380-800	9
Airbus A318-112	2
Boeing B747-400	43
Boeing B767-300	17
Boeing B777-200/300	58
Boeing B787-8	8

[2] Operations Specifications contain the authorizations, limitations, and certain procedures under which each kind of operation, if applicable, is to be conducted by the certificate holder.

c) The CAA Operations Specifications (GB0441), grants the following specific approvals to British Airways PLC:

- Dangerous Goods
- Low visibility operations specifically for Approach & Landing and Take-off
- RVSM
- ETOPS
- Navigation specifications for PBN Operations
- Minimum Navigation Performance Specification
- Cabin Crew Training
- Issue of Cabin Crew attestations
- Continuing Airworthiness Management in accordance with approval UK.MG.0037

d) British Airways PLC has been granted Operations Approval (EASA-OPS) under AOC number GB 0441, in accordance with Commission Regulation EU no. 965/2012 (Air Operations), which includes specific requirements for the Minimum Equipment List (MEL), Flight Crew Operating Manual (FCOM) and Weight & Centre of Gravity schedules.

e) Continuing Airworthiness Management is governed by Commission Regulation EU no. 1321/2014 (Continuing Airworthiness) Annex I (EASA Part M).

Subpart C of EASA Part M includes the following requirements:

- M.A.301 Continuing Airworthiness Tasks
- M.A.302 Aircraft Maintenance Program
- M.A.303 Airworthiness Directives
- M.A.304 Data for modifications and repairs
- M.A.305 Aircraft continuing airworthiness record system
- M.A.306 Operator's technical log system

f) Subpart G of EASA Part M.A.708 (Continuing Airworthiness Management) stipulates that for commercial air transport purposes the operator must either be EASA Part 145 approved or contract suitability approved Organizations to carry out maintenance activities per the AMP/CAM.

g) British Airways PLC is approved in accordance with Commission Regulation EU no. 1321/2014 (Continuing Airworthiness) Annex II (EASA Part 145) under approval no. UK.145.00021. In addition, British Airways PLC contracts other EASA Part 145 Maintenance Repair Organization, see vendor table in section 16.0.

4.0 Type Certificate Data Sheet

The Type Certificate Data Sheet (EASA.IM.A.003 derived from FAA Type Certification Data Sheet No. T00001SE) prescribes conditions and limitations under which the product for which the Type Certificate (TC) was issued meets the airworthiness requirements of the EASA Regulations. According to the document, The Boeing Company is the holder of the TC.

5.0 Aircraft Information

The Boeing Company manufactured the airplane (registration G-VIIO, serial number 29320) on November 5, 1998. The Export Certificate of Airworthiness (FAA form 8130-4) was issued on January 26, 1999. The airplane had 85,442 total hours with 12,835 total cycles at the time of the accident.

The airplane was equipped with two General Electric (GE) engines and a Honeywell Auxiliary Power Unit (APU). The engines and APU had accumulated the following operating times at the time of the accident:

Table 2 - Engine and APU Information

	No.1 Engine	No.2 Engine	APU
Manufacturer	GE	GE	Honeywell
Part Number	GE90-85BG11	GE90-85BG11	GTCP331-500B
Manufacture Date	June 28, 1999	February 17, 1999	March 25, 1999
Date Installed	January 10, 2015	June 11, 2013	April 22, 2015
Serial Number	900-294	900-277	P1275
Location of Engine/APU Installation	British Airways Gatwick	British Airways Gatwick	British Airways Gatwick
Time Since Overhaul (hours)	3,645	12,000	519
Cycles Since Overhaul	503	1,645	510
Days Since Overhaul	251	881	166
Engine Total Time Hours	66,801	72,001	22,956
Engine Total Cycles	9,992	10,637	18,578
Total Time of Airframe during engine/APU installation (hours)	81,797	73,433	83,246
Total Cycles of Airframe during engine/APU installation	12,332	11,190	12,514

6.0 Aircraft Maintenance Program

British Airways Aircraft Maintenance Program (AMP) controls and manages the continuing airworthiness of the aircraft to ensure that the inherent design levels of safety and reliability are maintained throughout the operational life of the airframe.

The British Airways AMP is developed in accordance with EASA Part.M.A.302 regulations for continuing airworthiness, reliability management and an ongoing review of the effectiveness of the maintenance program. This is also known, by the Air Transport Industry, as the Reliability, Control & Maintenance Program.

The Maintenance Program is derived from the Boeing 777 Maintenance Review Board (MRB) report document (reference D622W001-MRBR), and is based on the maintenance recommendations and mandatory requirements of the Original Equipment Manufacturers (OEM) for the airframe, powerplant and associated equipment.

The ongoing management of the program is in accordance with the processes outlined in EASA regulations.

Table 3-Type Certificate holder's maintenance recommendations

Manufacturers Manual ref	Issue Number	Date
Boeing Airframe Maintenance Planning Document (MPD)	N/A	May 2014
Rolls Royce Engine Time Limits Manual Ref T-Trent-2RR	50	March 2015
General Electric Engine GE90 Engine Manual Ref: GEK100700	65	March 2015
General Electric Engine GE90-100 Engine Manual Ref: GEK109993	30	November 2014
Boeing APU MPD	N/A	May 2014
Honeywell APU Engine Manual Ref: 49-26-57 life limits	19	October 14
Certification Maintenance Requirements (CMR) Boeing MPD	N/A	May 2014
Airworthiness Limitation Items (AWL) Boeing MPD	N/A	May 2014

The UK CAA have approved the British Airways AMP for the B777 aircraft and associated Contract Administration Manuals (CAM), which cover the associated engine and APU maintenance programs.

Table 4- Aircraft and Engine Maintenance Program for B777

Fleet	Aircraft Maintenance Program	Engine Maintenance Program	APU Maintenance Program
Boeing B777-200/300 Series	MP/Boeing777/1000/GB0441 AMP no. L3114	TRENT 895-17 EMP no. 10187952 CAM: 10090285	GTCP331-500B EMP no. 10151167 CAM: 10033329
		GE90-76/85 EMP no. 10095956 CAM: 10090502	
		GE90-115B EMP no. 10153648 CAM: 10090502	

Table 5- Maintenance Check Intervals

Check	Time Limit
Pre-Departure	Each Departure
ETOPs Transit Check	To be completed prior to each sector,
Daily Check	To be completed before the first flight of the day from main base a maximum of once in any calendar day or stopover.
Weekly Check	130 Flying Hours
Monthly Check	350 Flying Hours
A Check	600 Flying Hours
2A Check	105 days/400 cycles*
4A Check[3]	210 days/800 cycles*
B Check	400 days/2000 cycles/6000 hours*
C Check	750 days/4000 cycles/12000 hours*
2C Check	1500 days/8000 cycles/24000 hours*
D Check	3000 days/16000 cycles/48000 hours*
2D Check	6000 days/32000 cycles/96000 hours*
Fatigue Inspection	20000 cycles evaluation of fatigue related inspection program.
Standalone Items	Individual intervals as required
Life Limited Parts	Individual intervals as required

* Whichever comes first

The Aging Aircraft Maintenance Inspection Program for G-VIIO showed the following:

The airplane is part of the Supplemental Structural Inspection Document (SSID) program with an initial inspection threshold of 20,000 flight cycles.

[3] The maintenance program for the British Airways B777 does not contain a 3A check

In accordance with EASA Part M, sub-part I, British Airways PLC is approved to carry out Airworthiness Review Certificate (ARC) revalidations and extensions. The ARC validates the aircraft's non-expiring Certificate of Airworthiness. The ARC was last revalidated on November 25, 2013 and extended in accordance with M.A.901 on November 17, 2014 for a further 12 months.

The following is a listing of the previous inspections accomplished on Airplane G-VIIO. This information was retrieved from the airplane maintenance records:

Table 6 - Maintenance Checks

Check	Last Check Date	Location	Total Time	Total Cycles
Pre-Departure	September 8, 2015	Las Vegas, Nevada	85,442.36	12,835
ETOPS Transit Check	September 8, 2015	Las Vegas, Nevada	85,442.36	12,835
Daily Check	September 8, 2015	London Gatwick	85,432.48	12,834
Weekly Check	September 2, 2015	London Gatwick	85,326.33	12,822
Monthly Check	September 8, 2015	London Gatwick	85,432.48	12,834
A Check	September 3, 2015	London Gatwick	85,346.14	12,824
2A Check	July 29, 2015	London Gatwick	84,748.91	12,740
4A Check	April 22, 2015	London Gatwick	83,246.19	12,514
B Check	April 8, 2015	London Gatwick	83,044.78	12,488
C Check	April 13, 2014	Cardiff, Wales	77,928.46	11,812
2C Check	April 13, 2014	Cardiff, Wales	77,928.46	11,812
D Check	April 13, 2014	Cardiff, Wales	77,928.46	11,812
2D check	April 13, 2014	Cardiff, Wales	77,928.46	11,812

7.0 Reliability Program

The efficiency of the maintenance program is reviewed through the following committees:

- Fleet Technical Review Meeting (FTRM)
- Component Technical Review Meeting (CTRM)
- Maintenance Task Control Meeting (MTCM)

The basis for the effective analysis of the British Airways Maintenance Program is through the continuous monitoring of the aircraft, engines, components and equipment during their normal operational service as recommended by the guidance material in UK CAA Publication CAP 562 leaflet 5-60 (Condition Monitored Maintenance).

Reliability Monitoring forms part of the “Continued Surveillance” Maintenance Program agreed upon by British Airways. The program covers the production and circulation of reliability reports and the investigation of highlighted shortfalls with recommendations / actions.

The monitoring of aircraft technical performance is achieved through a regular report issued for each main fleet aircraft type, titled Reliability, Evaluation and Control Technique (REACT).

The reliability of components is monitored through a report called Component Performance Report (CPR), which is prepared from data centered on unscheduled removals.

Identification of significant fleet technical issues by monthly and yearly fleet statistical performance analysis based on EASA Acceptable Means of Compliance to M.A.302 Appendix 1 is necessary for corrective actions developed, agreed upon and implemented.

The statistical reports utilized in the Reliability Program are a bi-product of the 'day-to-day' technical records data input to the maintenance computer system. The reports cover both Systems and Component Reliability based on Flight Crew Technical Log entries / Maintenance Entries / Hangar Entries and unscheduled component removal data respectively. Reports are produced monthly from Flight Crew Technical Log entries and Delay Reports and 3 monthly for components. This process is conducted for each aircraft type separately.

Identification of significant fleet technical issues by weekly, monthly and yearly fleet statistical performance analysis is necessary for corrective actions developed, agreed and implemented. The respective Fleet Chief convenes a Fleet Technical Review Meeting (FTRM) to discuss technical issues arising from the performance analysis.

The FTRM is attended by representatives from Engineering's Technical, Production, Planning and Materials departments. Optional attendees include Quality and Flight Operations Flight Technical Managers. In addition an open invite is extended to the UK CAA.

8.0 Minimum Equipment List (MEL)

British Airways was authorized to use an approved MEL on its airplanes per its UK CAA OpSpecs. At the time of the accident, there were seven open MEL items in the Aircraft Technical Log, three of which were cabin defects.

Table 7 – Open MEL Items

BA Ref	Description
AK0083803	No 2 engine forward and aft heatshield gap strip trimmed iaw SRM 54-53-70
AK2110942	No 1 engine IDG still shows service on EICAS after servicing carried out
AK2233283	Captain's Side Display unserviceable
AK2441772	Fuselage insulation above Satcom SDU in poor condition
NF5056772	Forward galley upper panel damaged
NF5441601	IFE Media Loader unserviceable
NF5441682	Passenger Control Unit at seat 30C inoperative

9.0 Supplemental Type Certificates (STC)[4]

Supplemental Type Certificates (STCs), supplied by British Airways, were reviewed. A total of 15 STCs were documented and installed by the operator. There were no STCs that were applicable to the engines.

10.0 Airworthiness Directives (AD)[5] and Service Bulletins (SB)

British Airways provided an AD summary. Service Bulletins were included as part of this summary. A review of Airworthiness Directive status lists for the airplane, powerplants and appliances were conducted. All ADs applicable to this airplane were either implemented or accounted for future embodiment within the mandated compliance period for each AD. No discrepancies were found during the review of the listing.

- Of the 154 airframe related ADs applicable to G-VIIO, 84 were related to Boeing SBs, of which 68 had been incorporated.
- Of the 429 non engine core related SBs (including AD related), applicable to G-VIIO, 168 had been incorporated.

British Airways had reviewed the following mandatory documents at the noted dates:

Table 8 – AD Review

Mandatory Document	Issue	Dated
FAA Airworthiness Directives	Bi-Weekly: 2015-18	September 6, 2015
CAA Mandatory Requirements for Airworthiness (CAP747)	Issue: 3 Amdt: 02	November 25, 2014
EASA Airworthiness Directives	Bi-Weekly: 18-2015	August 31, 2015

11.0 Aircraft Technical Logs

A review of Aircraft Technical and Cabin Logs was carried out from January 11, 2015 (engine Serial no. 900294 installation on date G-VIIO) to the date of the accident. Particular attention was given to ATA chapters 26, 28, 29, 31 and all engine ATA related items by the maintenance record group. There were 3,752 entries of which 99 were associated with the relevant ATA chapters.

A review of the aircraft health monitoring (AHM) messages for the above referenced ATA chapters was accomplished for the period of six months prior to the accident.

[4] The FAA issues Supplemental Type Certificates, which authorize a major change or alteration to an aircraft, engine or component that has been built under an approved Type Certificate.
[5] Airworthiness Directive (AD) is a regulatory notice sent out by the FAA and EASA informing the operator of an action that must be taken for the aircraft to maintain its airworthiness status.

12.0 Weight and Balance

As per EASA-Ops CAT.POL.MAB.100 paragraph b, G-VIIO is weighed every four years and was last accomplished on November 20, 2012 at the British Airways Gatwick maintenance facility. The figures for the last weight and balance are shown below:

Basic Operating Weight:	141621	Kg
Arm	1237.24	inches
Moment	175218795	Kg/Inches

See Attachment 3

13.0 Mandatory Occurrence Reporting (MOR)

All incidents and occurrences that fall within the EASA reporting criteria of EASA Part M sub-part B and the UK Air Navigation Order are reported to the UK CAA within 72 hours. Reports are also sent to the organization responsible for the type design or supplemental type design as appropriate. Full details of the type of incident / occurrence to be reported are contained within CAA publication CAP 382, EASA AMC 20-8, EASA Part 145.A.60 and Part M.A.202.

A review of Ground Occurrence and Air Safety Reports related to G-VIIO between January 2015 and the accident date identified 15 reports, five of which were reported as MORs. One of the 15 reports was on the number one engine oil vent tube union leaking oil, dated June 26, 2015. Maintenance found the union loose at the 12 o-clock position, tightened the union and ran the engine for 15 minutes with no oil leaks noted.

14.0 Major Repairs and Alterations

A review was carried out on G-VIIO records. There were 13 major alterations on the airframe. No major alterations to the engines, nacelles or pylons were observed. There were a total of 46 major repairs to the fuselage, empennage and nacelles. Two affected the number one engine nose cowl and one repair affected the number one engine fan cowl.

15.0 Life Limited Parts

Life Limited Parts status report for the airplane, the two installed powerplants and the APU were reviewed. No expired life limited parts were identified.

16.0 Vendors

Prior to contracting an EASA Part 145 MRO, British Airways accomplishes audits in accordance with EASA Part M.A.201(h). Post contracting oversight of the MRO is accomplished per the requirements of Part M.A.712(b).

Line stations supported by approved EASA Part 145 accredited organization are audited initially at start-up and thereafter yearly using the Line Station Desktop review process. British Airways

Continuing Airworthiness Maintenance Exposition (CAME) part 5.10 refers to the listing of British Airways approved Line Maintenance providers.

Tables 9 through 12 list of principle vendors and related approval numbers:

Table 9 - Base Maintenance

Company	Approval Reference
British Airways Maintenance Cardiff (BAMC)	UK.145.0048

Table 10 – Engine and APU Maintenance

Company	Approval Reference
GE Aircraft Engine Services	UK.145.00073
GE Aviation – On Wing Support	UK.145.01276
Honeywell Aerospace GmbH (APU)	DE.145.0022

Table 11 – Component Maintenance

Company	Approval Reference
Airbase Interiors Limited	UK.145.01092
British Airways Avionic Engineering (BAAE)	UK.145.00142
British Airways Interiors Engineering (BAIE)	UK.145.00507
British Airways Component Engineering (BACE)	UK.145.00736

Table 12 – Line Maintenance

Nevada Airline Services LLC	EASA.145.6635

17.0 Method of Record Keeping

In accordance with EASA Part M.A.305 records for British Airways aircraft are maintained for the life of the aircraft plus a further 36 months.
Records include, but are not limited to:

- Routine aircraft workcards and defect cards
- Modification embodiment record
- Technical log pages
- Component EASA form 1 or equivalent

Aircraft Maintenance and Engine Log Books are maintained electronically, these are controlled by the British Airways airworthiness control system, as accepted by the UK CAA.

18.0 Manuals

British Airways uses the following manuals to maintain the airworthiness of its fleet and management of the airline:

Continuing Airworthiness Management Exposition (CAME) – outlines British Airways continuing airworthiness management procedures used to comply with EASA Part M regulatory requirements.

Maintenance Organization Exposition (MOE) – outlines British Airways' maintenance procedures used to comply with EASA Part 145 regulatory requirements.

Minimum Equipment List (MEL) – List of equipment and instruments that may be inoperative on a specific British Airways aircraft.

Weight and Balance Manual – Weight and balance procedures to be followed by maintenance and flight operations personnel on all aircraft operated by British Airways.

British Airways Quality Standards Manual – defines the quality standards for British Airways, including the operator's definitions for AMP/MPD inspections.

British Airways Engineering Standards Manual – defines the standards that conform to technical policies as developed for British Airways Engineering.

British Airways ETOPS Manual – section 6 of the Engineering Standards Manual which defines British Airways' requirements for personnel involved in Extended-range Twin-engine Operational Performance Standards (ETOPS).

British Airways Aircraft Tires and Wheels Manual – defines British Airways' requirements for tires and wheels.

Manufacture Supplied and British Airways customized Manuals - Aircraft/Engine Maintenance Manuals, Structural Repair Manuals, Overhaul Manuals, Wiring Manuals, Fault Isolation Manuals, Illustrated Parts Catalog, Corrosion Program Manual, NDT Manual, and Service Bulletins.

19.0 No.1 Engine History

The Maintenance Group reviewed the records associated with the No.1 engine. Table 13 provides the most recent on-wing tasks performed on No.1 Engine, including the task description and record of completion. This review focused on ATA chapters for the No.1 Engine; both routine and non-routine items were reviewed.

In addition, a summary of the last shop visit for No.1 engine is provided in section 20.0. Review of the Engine Health Monitoring data was also carried out and summarized in section 21.0.

Table 13 – Recent on-wing tasks performed on No.1 Engine

ATA	Type of Task	Task Description	Frequency	Last C/W
72-06	Aircraft Maintenance Item (AMI)	Detailed Inspection of combuster dome and liner and stage 1 nozzle leading edge (with flexi boroscope).	250 FC	July 29, 2015
72-06	AMI	Detailed Inspection of HPT 1st and 2nd stage blades and 2nd stage nozzle leading edge on Left and Right Engines (with boroscope).	500 FC	July 29, 2015
72-30	AMI	Torque check of No.1 Engine PS3 & P3B Connectors.	Aligned to 4A Chk	July 29, 2015
74-21	AMI	Replace Engine Igniter Plugs	600 FC	July 29, 2015
79-01	AMI	Engine Oil Filter replacement	Aligned to B Chk	April 22, 2015
80-11	AMI	Engine Starter Chip Detector Inspection	2000 FH	July 29, 2015
72-00	AMI	GE90 Engine Compressor Wash	500 FC	August 28, 2015
73-11	AMI	Main fuel pump strainer assembly inspection	3000 FH	April 22, 2015
72-02	AMI	DMS Sensor Contamination Inspection	2500 FH	July 29, 2015
72-00	AMI	GE90 HPC Stg1 Rotor Blade Boroscope for tip curl	500 FC	July 29, 2015

20.0 No.1 Engine Last Shop Visit History

The GE90 engine series is configured in a modular format. This allows all airworthiness data to be tracked at engine, module and where applicable, piece part level. Dependent upon operator policy, commercial practices and maintenance requirements this modular format allows assemblies and piece parts to be transferred between engine serial numbers. Modules that have been installed at new manufacture to a particular engine serial number will carry the same engine serial number pre-fixed with a module identifier. As an example the High Pressure Compressor module (HPC) is pre-fixed with the letter X.

Engine serial number (ESN) 900294 most recent shop visit was at General Electric (GE) Aviation Wales in July 2014, with the engine being released to service December 2014. At that time the engine life details were as follows:

- Time Since New (TSN) 63156 hours Cycles Since New (CSN) 9489
- Time Since Overhaul (TSO) 23026 hours Cycles Since Overhaul (CSO) 3440

The engine was removed from service in order to rectify High Pressure Turbine (HPT) nozzle guide vane cracking. During the shop visit the following noteworthy items were also addressed:

- High Pressure Turbine Stage 1 shrouds replaced
- Low Pressure Turbine Stage 6 blades replaced
- High Pressure Turbine Forward Seal replaced due to approaching life limit

The High Pressure Compressor (HPC) module installed during the 2014 shop visit was original to the engine and as such carries the serial number X900294. Additionally the life details of the module match those of the engine. The work scope for the HPC was Level 2 which equates to a Light Repair. Items of note during this shop visit were as follows:

- HPC Stage 1 Blades replaced
- Variable Stator Vane lever arms Fluorescent Penetrant Inspection (FPI) I.A.W SB72-0833
- HPC Forward Cases repaired due to Skydrol contamination
- HPC 8-10 Spool P/N 1694M80G04 S/N GWNHA236 remained fully assembled

At the time of the shop visit there were 16 ADs applicable to the GE90-85B model, all of which were complied with. The following two ADs apply to HPC 8-10 Spool hardware (dependent on part number).

Table 14 – Engine Airworthiness Directives at Shop Visit

Airworthiness Directive	Applicability	Task	Frequency
AD 2002-04-11	General Electric Company (GE) GE90-76B/ -77B/ -85B/ -90B/ -94B series turbofan engines	Fluorescent Penetrant Inspection and Eddy Current Inspection of the stage 8-9 inertia weld of the high pressure compressor rotor (HPCR) 8-10 stage spool for cracks	Perform inspections of the following parts at each piece part opportunity
AD 2011-15-06	GE GE90-76B/ -77B/ -85B/ -90B/ -94B series turbofan engines with a HPCR 8-10 stage spool, part number (P/N) 1844M90G01 or P/N 1844M900G02 installed	Fluorescent Penetrant Inspection and Eddy Current Inspection of the stage 9-10 inertia weld of the HPCR 8-10 stage spool for cracks	Perform inspections of the following parts at each piece part opportunity

FAA AD 2002-04-11 (which is applicable to 1694M80G04) was not accomplished during the 2014 shop visit because the inspection is only required if the HPC 8-10 spool is exposed to piece part level.

At the time of the shop visit there were 883 Service Bulletins as defined by the British Airways workscope, recorded in the maintenance record. All service bulletins were found to be in compliance based on the embodiment category. The following service bulletins relate specifically to the HPC 8-10 spool.

Table 15 – HPC 8-10 Spool Applicable SB

Service Bulletin Number	Intent	Status
G90_GE90_047 (AD 2002-04-11)	Mandatory Inspection of 8 - 10 spool (local modification used to track embodiment of AD 2002-04-11)	Not Applicable - Mandatory inspection not performed. Module components not exposed to piece part level this shop visit
GE90_72_460	Spare Parts Release - Introduces 8-10 Spool P/N 1844M90G01 & P/N 1844M90G02	Not Required this shop visit
G90_72_815	Spare Parts Release - Release of GE90-76B, GE90-85B and GE90-90B parts for use on GE90-94B models (includes P/N 1694M80G04)	Not Required this shop visit

HPC module X900294 was last subject to a heavy repair workscope during the preceding shop visit in 2009. The HPC module was contracted to Snecma Services in France. At that time the engine/module life details were as follows:

- TSN 40130 hours CSN 6049
- TSO 40130 hours CSO 6049

During the shop visit the following noteworthy items were addressed:

- 8-10 Spool P/N 1844M90G01 S/N GWNBS501 removed due to life expiration
- 8-10 Spool P/N 1694M80G04 S/N GWNHA236 installed in overhauled condition

HPC 8-10 spool S/N GWNHA236 was originally installed to HPC module X900121 and remained installed in that module until being exchanged to X900294 during shop visit at Snecma in 2009. This was the first time the subject spool had been disassembled to piece part level since original installation in 1995. The subject spool was removed from X900121 at Snecma and subsequently contracted to GE Aviation Wales for Overhaul. At that time the component life details were as follows:

- TSN 47499 hours CSN 7516
- TSO 47499 hours CSO 7516

Initial inspection package accomplished included an FPI inspection of interior and exterior surfaces and Stage 8-9 Inertia weld Eddy Current Inspection (ECI). These FPI & ECI inspections satisfy the intent of AD 2002-04-11. Following a detailed inspection the subject spool was deemed to be in an unserviceable condition as a result of shop findings that may be rectified using repairs outlined in the engine shop manual. There were two findings not covered by the Engine Shop Manual (ESM). GE Wales provided the repair process and inspection requirements for these two items.

A Departure Record (DR) 17-08-0706 was submitted and approved which provided an approved repair processes in order to address the two conditions.

- Repair of minor nicks IAW Standards Practice Manual (SPM) TASK 70-42-00-350-002
- Repair of corrosion pitting IAW SPM Task 70-21-00-110-051

GE Wales produced a locally approved repair document, substantiated by DR, as a means of providing a repair that is unique to a specific component. In this case Development Office Instruction (DOI) DOI 60064 & DOI 60065 was compiled using DR 17-08-0706 as substantiation.

The subject spool was repaired using a combination of ESM repair procedures & DOI repair procedures and on completion declared to be in an Overhauled condition. The certificate of release to service was issued in March 2009 and the component returned to Snecma Services to be installed into X900294.

Table 16 details back to birth shop visit history of spool S/N GWNHA236:

Table 16 – HPC 8-10 Spool Shop Visit History

		TSN	CSN	Spool Status	Module Workscope
1997	**900121**	30	37		
1694M80G04	GWNHA236	30	37	Not Dismantled	Repair
1999	**900121**	10097	2279		
1694M80G04	GWNHA236	10097	2279	Not Dismantled	Repair/Modified
2002	**900121**	17210	3489		
1694M80G04	GWNHA236	17210	3489	Not Dismantled	Tested
2004	**900121**	25021	4711		
1694M80G04	GWNHA236	25021	4711	Not Dismantled	Repair
2008	**900121**	47499	7516		
1694M80G04	GWNHA236	47499	7516	Removed	Overhauled
2009	**900294**	40130	6049		
1694M80G04	GWNHA236	47499	7516	Installed	Overhauled
2014	**900294**	63156	9489		
1694M80G04	GWNHA236	70526	10956	Not Dismantled	Repair

21.0 No.1 Engine Health Monitoring Data

Engine Health Monitoring (EHM) data for two periods were reviewed. The first period was approximately 1 month of data that ran from May 2014 until June 2014 when the engine was removed for shop visit. The 2nd period ran from post shop visit engine installation in January 2015 until September 2015. The following parameters were reviewed:

- Indicated Fan Speed – Take Off & Cruise
- Fan Vibration Forward Pick Up –Take Off
- Core Vibration Rear Pick Up – Take Off &Cruise
- Core Speed – Take Off & Cruise
- EGT – Take Off
- Delta EGT – Cruise
- EGT (Hot Day) Margin – Take Off
- Fuel Flow – Take Off &Cruise

The data allows for an analysis of both individual data points and data trend. There were no anomalies noted in the parameters reviewed.

22.0 Flight Recorder Parameter Verification

The flight recorder parameter verification is an Annual task (350 days) as part of the AMP on the Boeing 777 fleet. The review process verifies that each parameter is being recorded correctly and if not, corrective action is taken. The parameter verification reviews the EASA/FAA mandatory parameters. In addition, while accomplishing the parameter verification if an issue is observed with a non-required parameter then technician corrective action is required. The maintenance group reviewed the flight recorder parameter verification checklist for G-VIIO. The last check was completed January 21, 2015 as part of a 2A check maintenance visit. The flight recorder was removed and sent to British Airways Quality and Technical FDR group for the parameter verification. All parameters passed the verification check.

23.0 Door Slides

The maintenance record group reviewed the door emergency slide maintenance program. Table 17 shows the door slide overhaul and installation dates for G-VIIO. No discrepancies were found.

Table 17 – Door Emergency Slide Fitted

Position	Door 1 LH
Part No	62771-119
Serial No	0446
Date of Manufacture (DOM) (inflatable)	06.1998
Date of last Overhaul	04.04.15
Location of last overhaul	BAIE (UK.145.00507)
Installation	21-04-15

Position	Door 1 RH
Part No	62771-120
Serial No	0740
DOM (inflatable)	11.1999
Date of last Overhaul	14.11.15
Location of last overhaul	BAIE (UK.145.00507)
Installation	19.01.15

Position	Door 2 LH
Part No	62772-203MOD2
Serial No	0055
DOM (inflatable)	08.1995
Date of last Overhaul	10.07.15
Location of last overhaul	BAIE (UK.145.00507)
Installation	27.07.15

Position	Door 2 RH
Part No	62772-216
Serial No	0758
DOM (inflatable)	03.2001
Date of last Overhaul	29.08.2012
Location of last overhaul	BAIE (UK.145.00507)
Installation	01.09.2012

Position	Door 3 LH
Part No	62773-319
Serial No	0476
DOM (inflatable)	02.1999
Date of last Overhaul	16.07.15
Location of last overhaul	BAIE (UK.145.00507)
Installation	28.07.15

Position	Door 3 RH
Part No	62773-304M0D2
Serial No	0122
DOM (inflatable)	07.1996
Date of last Overhaul	13.07.15
Location of last overhaul	BAIE (UK.145.00507)
Installation	28.07.15

Position	Door 4 LH
Part No	62774-415
Serial No	0667
DOM (inflatable)	11.1999
Date of last Overhaul	20.07.15
Location of last overhaul	BAIE (UK.145.00507)
Installation	28.07.15

Position	Door 4 RH
Part No	62774-416
Serial No	0541
DOM (inflatable)	02.1999
Date of last Overhaul	17.04.15
Location of last overhaul	BAIE (UK.145.00507)
Installation	21.04.15

Submitted by: Gregory Borsari
Aviation Accident Investigator
Maintenance

Attachment 1

British Airways, PLC.
Air Operator Certificate

AIR OPERATOR CERTIFICATE

(Approval schedule for air transport operators)

UNITED KINGDOM

CIVIL AVIATION AUTHORITY

Civil Aviation Authority

Types of operation:
Commercial Air Transport (CAT): Passengers / Cargo

AOC number:

GB 0441

Valid until suspended or revoked

Issue No. 17

BRITISH AIRWAYS PLC

Operator address: Waterside (HFB1)
PO Box 365
Harmondsworth
Middlesex
UB7 0GB

Telephone: [redacted]

Fax: [redacted]

E-mail: [redacted]

Operational points of contact:

Contact details at which operational management can be contacted without undue delay are listed in Operations Manual Part A, Section 1, 1.2.

This certificate certifies that BRITISH AIRWAYS PLC is authorised to perform commercial air transport operations, as defined in the attached operations specifications, in accordance with the Operations Manual, Annex IV to Regulation (EC) No 216/2008 and its Implementing Rules.

Date of issue:

28 October 2014

[redacted]
FLIGHT OPERATIONS

[redacted]
Signature

Name: Captain D Russell

Title: Flight Operations Manager

Attachment 2

British Airways, PLC.
Repair Organization & Station Certificates

Civil Aviation Authority

of the

United Kingdom

A Member of the European Union

MAINTENANCE ORGANISATION APPROVAL CERTIFICATE

REFERENCE: UK.145.00021

Pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council and to Commission Regulation (EC) No 2042/2003 for the time being in force and subject to the conditions specified below, the Civil Aviation Authority of the United Kingdom hereby certifies:

BRITISH AIRWAYS PLC

HEATHROW AIRPORT
HOUNSLOW
MIDDLESEX
TW6 2JA

GATWICK AIRPORT
GATWICK
WEST SUSSEX
RH6 0LS

Registered Company Number: 01777777

as a maintenance organisation in compliance with Section A of Annex II (Part-145) of Regulation (EC) No 2042/2003, approved to maintain products, parts and appliances listed in the attached approval schedule and issue related certificates of release to service using the above references.

CONDITIONS

1. This approval is limited to that specified in the scope of work section of the approved maintenance organisation exposition as referred to in Section A of Annex II (Part-145), and

2. This approval requires compliance with the procedures specified in the approved maintenance organisation exposition, and

3. This approval is valid whilst the approved maintenance organisation remains in compliance with Annex II (Part-145) of Regulation (EC) No 2042/2003.

4. Subject to compliance with the foregoing conditions, this approval shall remain valid for an unlimited duration unless the approval has previously been surrendered, superseded, suspended or revoked.

Date of original issue: 06 JULY 1992

Date of this revision: 20 AUGUST 2015

Revision No: 08/15

Signed: [redacted]

For the Civil Aviation Authority

MAINTENANCE ORGANISATION

APPROVAL SCHEDULE

REFERENCE: UK.145.00021

ORGANISATION: BRITISH AIRWAYS PLC
HEATHROW AIRPORT, HOUNSLOW, MIDDLESEX, TW6 2JA.
GATWICK AIRPORT, GATWICK, WEST SUSSEX, RH6 0LS.

CLASS	RATING	LIMITATION	BASE	LINE
AIRCRAFT	A1 Aeroplanes above 5700 kg	AIRBUS A300 B4/C4/F4 600 SERIES		X
		AIRBUS A318-100 SERIES	X	X
		AIRBUS A319-100 SERIES	X	X
		AIRBUS A320-100/200 SERIES	X	X
		AIRBUS A321-100/200 SERIES	X	X
		AIRBUS A330-200/300 SERIES		X
		AIRBUS A340-200/300/500/600 SERIES		X
		AIRBUS A380-800 SERIES	X	X
		BOEING 737-300/400/500 SERIES	X	X
		BOEING 737-600/700/800/900 SERIES		X
		BOEING 747-200/300/400 SERIES	X	X
		BOEING 757-200/300 SERIES	X	X
		BOEING 767-200/300 SERIES	X	X
		BOEING 767-400 SERIES		X
		BOEING 777-200/300 SERIES	X	X
		BOEING 777-300 ER SERIES	X	X
		BOEING 787-8	X	X
		BOEING 787-9 SERIES	X	X

Date of original issue: 06 JULY 1992

Date of last revision approved: 20 AUGUST 2015

Revision No: 08/15

Signed: [redacted]

For the Civil Aviation Authority

MAINTENANCE ORGANISATION

APPROVAL SCHEDULE

REFERENCE: UK.145.00021

ORGANISATION: BRITISH AIRWAYS PLC
HEATHROW AIRPORT, HOUNSLOW, MIDDLESEX, TW6 2JA.
GATWICK AIRPORT, GATWICK, WEST SUSSEX, RH6 0LS.

ENGINES	B1 Turbine	CFM-56 SERIES GENERAL ELECTRIC GE90 SERIES Q.E.C. Strip & Build, minor modifications, defect rectification, component changes and workshop checks in accordance with approved data, excluding module changes and overhaul. IAE V2500 SERIES Q.E.C. Strip & Build, minor modifications, defect rectification, component changes and workshop checks in accordance with approved data, excluding module changes and overhaul. ROLLS ROYCE RB211-524 ROLLS ROYCE RB211-535 ROLLS ROYCE RB211 TRENT 700/800 SERIES Minor modifications, defect rectification, component changes and workshop maintenance inspections in accordance with approved data, excluding module changes and overhaul.
	B3 APU	GTC P331-200 GTCP 331-500B as fitted to the B777 aircraft. Q.E.C. Strip & Build, minor modifications, defect rectification, component changes and workshop checks in accordance with approved data, excluding module changes and overhaul. GTC P36-280 SERIES GTC P36-300 GTC P85-129 GTC 131-9 SERIES PRATT & WHITNEY 901A as fitted to the B747-400 aircraft. Q.E.C. Strip & Build, minor modifications, defect rectification, component changes and workshop checks in accordance with approved data, excluding module changes and overhaul.

Date of original issue: 06 JULY 1992

Date of last revision approved: 20 AUGUST 2015

Revision No: 08/15

Signed: [redacted]

For the Civil Aviation Authority

MAINTENANCE ORGANISATION

APPROVAL SCHEDULE

REFERENCE: UK.145.00021

ORGANISATION: BRITISH AIRWAYS PLC
HEATHROW AIRPORT, HOUNSLOW, MIDDLESEX, TW6 2JA.
GATWICK AIRPORT, GATWICK, WEST SUSSEX, RH6 0LS.

COMPONENTS OTHER THAN COMPLETE ENGINES OR APU's	C3 Comms and Nav C4 Doors - Hatches C6 Equipment C7 Engine - APU C8 Flight Controls C12 Hydraulic Power C13 Indicating/ Recording Systems C20 Structural	Components in accordance with the Capability List defined in the Company MOE.
SPECIALISED SERVICES	D1 Non Destructive Testing	EDDY CURRENT LIQUID PENETRANT MAGNETIC PARTICLE RADIOGRAPHIC ULTRASONIC THERMOGRAPHY

This approval schedule is limited to those products, parts and appliances and to the activities specified in the scope of work section of the approved maintenance organisation exposition.

Maintenance Organisation Exposition reference: ATP E10863

Date of original issue: 06 JULY 1992

Date of last revision approved: 14 AUGUST 2015

Revision No: ISSUE 68

Signed: [redacted]

For the Civil Aviation Authority

Civil Aviation Authority

of the

United Kingdom

A Member of the European Union

CONTINUING AIRWORTHINESS MANAGEMENT ORGANISATION

APPROVAL CERTIFICATE

REFERENCE: UK.MG.0037 (ref. AOC GB0441)

Pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council and to Commission Regulation (EC) No 2042/2003 for the time being in force and subject to the condition specified below, the Civil Aviation Authority hereby certifies:

BRITISH AIRWAYS PLC
HEATHROW AIRPORT, HOUNSLOW, MIDDLESEX, TW6 2JA

Registered Company Number: 1777777

as a continuing airworthiness management organisation in compliance with Section A, Subpart G of Annex I (Part M) of Regulation (EC) No 2042/2003, approved to manage the continuing airworthiness of the aircraft listed in the attached schedule of approval and, when stipulated, to issue recommendations and airworthiness review certificates after an airworthiness review as specified in point M.A.710 of Annex I (Part M), and, when stipulated, to issue permits to fly as specified in point M.A.711(c) of Annex I (Part M) of the same regulation.

CONDITIONS

1. This approval is limited to that specified in the scope of approval section of the approved continuing airworthiness management exposition as referred to in Section A, Subpart G of Annex I (Part M) of Regulation (EC) No 2042/2003.

2. This approval requires compliance with the procedures specified in the Annex I (Part M) to Regulation (EC) No 2042/2003 approved continuing airworthiness management exposition.

3. This approval is valid whilst the approved continuing airworthiness management organisation remains in compliance with Annex I (Part M) to Regulation (EC) No 2042/2003.

4. Where the continuing airworthiness management organisation contracts under its Quality System the service of an/several organisation(s), this approval remains valid subject to such organisation(s) fulfilling applicable contractual obligations.

5. Subject to compliance with the conditions 1 to 4 above, this approval shall remain valid for an unlimited duration unless the approval has previously been surrendered, superceeded, suspended or revoked.

   If this form is also used for AOC holders, the AOC number shall be added to the reference in addition to the standard number and the condition 5 shall be replaced by the following extra conditions:

6. This approval does not constitute an authorisation to operate the types of aircraft referred in paragraph 1. The authorisation to operate the aircraft is the Air Operator Certificate (AOC).

7. Termination, suspension or revocation of the AOC automatically invalidates the present approval in relation to the aircraft registrations specified in the AOC, unless otherwise explicitly stated by the competent authority.

8. Subject to compliance with the previous conditions, this approval shall remain valid for an unlimited duration unless the approval has previously been surrendered, superseded, suspended or revoked.

Date of original issue: 29 SEPTEMBER 2005

Signed: [redacted]

Date of this revision: 20 AUGUST 2015

Revision No: 08/15

For the Civil Aviation Authority

CONTINUING AIRWORTHINESS MANAGEMENT ORGANISATION

APPROVAL SCHEDULE

REFERENCE: UK.MG.0037 (ref. AOC GB0441)

ORGANISATION: BRITISH AIRWAYS PLC
HEATHROW AIRPORT, HOUNSLOW, MIDDLESEX, TW6 2JA

AIRCRAFT TYPE/SERIES/GROUP	AIRWORTHINESS REVIEW AUTHORISED	PERMITS TO FLY AUTHORISED	ORGANISATION(S) WORKING UNDER THE QUALITY SYSTEM
AIRBUS A318-100 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
AIRBUS A319-100 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
AIRBUS A320-100/200 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
AIRBUS A321-200 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
AIRBUS A380-800 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 737-300/400/500 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 747-400 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 757-200 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 767-300 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 777-200 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 777-300 ER SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 787-8	YES	NO	AS LISTED IN CAME NO. DIR 10056920
BOEING 787-9 SERIES	YES	NO	AS LISTED IN CAME NO. DIR 10056920

This approval Schedule is limited to that specified in the scope of approval contained in the approved Continuing Airworthiness Management Exposition section **0.2.5**

Continuing Airworthiness Management Exposition Reference: DIR 10056920

Date of original issue: 29 SEPTEMBER 2005

Date of last revision approved: 18 AUGUST 2015

Revision No: 23

Signed: [redacted]

For the Civil Aviation Authority

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number **BRAY010F**

This certificate is issued to

BRITISH AIRWAYS PLC

whose business address is
EAST BASE, HEATHROW AIRPORT
HOUNSLOW, MIDDLESEX TW6 2JA
UNITED KINGDOM

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved **REPAIR STATION**

with the following ratings:
LIMITED POWERPLANT
LIMITED AIRFRAME (FEB. 16, 1995)
LIMITED ACCESSORY (SEP. 28, 2010)
LIMITED NON-DESTRUCTIVE INSPECTION, TESTING & PROCESSING (SEP. 28, 2010)
LIMITED RADIO (APR. 12, 2013)
LIMITED INSTRUMENT (APR. 12, 2013)

This certificate, unless canceled, suspended, or revoked, shall continue in effect **UNTIL MAY 31, 2016.**

By direction of the Administrator

[redacted]

Date issued:

OCTOBER 05, 1977

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Attachment 3

Weight & Balance

Weight & Centre of Gravity Schedule Extract

AIRCRAFT DESIGNATION **BOEING 777-200**

REGISTRATION **G-VIIO**

LAYOUT **283 SEATER**

The Basic Weight is Calculated from Weighing Report dated 20.11.2012
It includes the total quantity of engine oil,
unusable fuel and items on the Basic Equipment List Ref No. REV00419858

BASIC WEIGHT KG	**141621**
BASIC INDEX	**274**

The centre of gravity in this condition
at this weight with landing gear extended is 1237.24 INS AFT of the datum

The datum as defined in the Flight Manual is STN 0 -92.5 IN FWD OF THE NOSE

The schedule was prepared on 20.11.2012 and supersedes all previous issues

Max. Take Off Weight 275000 Kg

[redacted]

Signed
for General Manager
Flight Operations, BA

Reason for issue:
AIRCRAFT WEIGHED