AIRCRAFT ACCIDENT REPORT

GITTO/2009/10/21/F

Accident Investigation Bureau

Report on the Accident involving Gitto Construczioni Generali Nigeria Limited Bell 407 Helicopter Registered 5N-BIC at Uyo Airport, Akwa Ibom State, Nigeria On 21st October, 2009

This report was produced by the Accident Investigation Bureau, Murtala Muhammed International Airport, Ikeja, Lagos.

The report is based upon the investigation carried out by the Bureau, in accordance with Annex 13 to the Convention on International Civil Aviation, Nigerian Civil Aviation Act 2006, and Civil Aviation (Investigation of Air Accidents and Incidents) Regulations.

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of aircraft accident/serious incident investigations to apportion blame or liability.

Readers are advised that Accident Investigation Bureau investigates for the sole purpose of enhancing aviation safety. Consequently, Accident Investigation Bureau reports are confined to matters of safety significance and should not be used for any other purpose.

As the Bureau believes that safety information is of great value if it is passed on for use of others, readers are encouraged to copy or reprint for further distribution, acknowledging Accident Investigation Bureau as the source.

Recommendations in this Report are addressed to the Regulatory Authority of the State (NCAA).

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GLOSSARY OF ABBREVIATION USED IN THIS REPORT

AIB	Accident Investigation Bureau
AEP	Airport Emergency Plan
AME	Aircraft Maintenance Engineer
AMEL	Aircraft Maintenance Engineer's Licence
AMM	Aircraft Maintenance Manual
ATL	Air Transport License
AOC	Air Operators Certificate
AOP	Airline Operating Permit
CAAs	Civil Aviation Authorities
CG	Centre of Gravity
CHIP DET	Chip Detector
CO2	Carbon Dioxide
C of A	Certificate of Airworthiness
CT	Compressor Turbine
DC	Direct Current
EECU	Electronic Engine Control Unit
FAAN	Federal Airport Authority of Nigeria
FADEC	Fuel Authority Digital Electronics Control

FMA	Federal Ministry of Aviation
H & S	Hants and Sussex
HMU	Health Monitoring Unit
ICAO	International Civil Aviation Organisation
LCD	Liquid Crystal Display
NCAA	Nigerian Civil Aviation Authority
NCAR	Nigerian Civil Aviation Regulations
PMA	Primary Magnetic Alternator
PNCF	Permit for Non-Commercial Flight
PT	Power Turbine
RFM	Rotorcraft Flight Manual
SARPs	Standard And Recommended Practices
SPDC	Shell Petroleum Development Company
TBO	Time Between Overhaul
UK	United Kingdom
VFR	Visual Flight Rules
XEDA	X-ray Energy Dispersive Analysis
XMSN CHIP	Transmission Chip

Aircraft Accident Report No.:	GITTO/2009/10/21/F
Registered Owner and Operator:	Gitto Construczioni Generali Nigeria Limited
Aircraft Type and Model:	Bell 407 Helicopter
Manufacturer:	Bell Helicopter Textron, Canada
Date of Manufacture:	January, 1999
Registration Number:	5N–BIC
Serial No.:	53340
Location:	Gitto Construczioni site located within Uyo Airport.
Date and Time:	21st October, 2009 at 1330hrs *All times in this report are local time (equivalent to UTC+1) unless otherwise stated.*

SYNOPSIS

The Accident Investigation Bureau (AIB) was notified by the Nigerian Civil Aviation Authority (NCAA) of the accident on 22nd October, 2009 at about 1200hrs. The Bureau investigators were dispatched to the site same day. All other stakeholders were notified accordingly.

The Bell 407 helicopter registered 5N-BIC operated from Abuja to Calabar on the 20th of October 2009. On the 21st of October 2009, 5N-BIC departed Calabar to Port Harcourt at about 1230hrs on a Visual Flight Rules (VFR) positioning flight with the Pilot and an Engineer on board. According to the Pilot, a few minutes after departing Calabar for

Port Harcourt, the transmission chip detector indication was noticed at a location close to Gitto Uyo Site. The pilot made a radio call to Eket of the intention to divert to Uyo due technical[1]. On landing at Gitto site, Uyo, the Maintenance Engineer reported that maintenance inspection was carried out on the transmission oil system; the three chip detector plugs on the transmission were checked and found satisfactory. Furthermore, an engine ground run was carried out and all indications were found normal.

The Pilot decided to continue the flight from Uyo to Port Harcourt. Less than five minutes after take-off, the engine chip detector indication came on and about thirty seconds after, the engine oil pressure showed zero. The Pilot decided to make an air return but could not make it to the Helipad as there was a 'bang' from the engine and the aircraft dropped uncontrolled to the ground and crashed. There was post-crash fire.

The Engineer sustained minor injury and was treated and discharged from the same hospital in Port Harcourt.

The investigation identified the following causal and contributory factors:

Causal Factors

i. Improper maintenance of the oil system which led to oil starvation resulting in the failure of the No. 6, 7, and 8 bearings in the power turbine section of the engine, leading to power loss.

ii. Improper identification by the pilot of the transmission chip light illumination during flight instead of the engine chip light.

[1] Due to technical reasons

Contributory Factors

i. The decision of the pilot to continue with the flight from Uyo to Port Harcourt International Airport without identifying the cause of the transmission chip detector indication.

ii. The non-replacement of the stage 1 & 2 turbine wheels due to limited life remaining.

One Safety Recommendation was made.

1.0 FACTUAL INFORMATION

1.1 History of the flight

The Bell 407 helicopter registered 5N-BIC operated from Abuja to Calabar on the 20th of October 2009. On the 21st of October 2009, 5N-BIC departed Calabar for Port Harcourt on a Visual Flight Rules (VFR) positioning flight at about 1230hrs with the Pilot and an Engineer on board. A few minutes into the flight, the Pilot reported noticing chip detector indication of the transmission system in the cockpit. The pilot reported that a radio call was made to Eket ATC of the intention to divert to Uyo due technical. On landing at Gitto construction site, Uyo; the Maintenance Engineer reported that a check was carried out on three chip detector plugs on the transmission but no metal chips were discovered. The plugs were inspected, cleaned, reinstalled and followed with ground run.

The Pilot stated that the transmission was checked, checked round and everything was found normal. At 1310hrs, the Pilot started the aircraft and there was no abnormal indication on the instrument panel. 5N-BIC took-off at about 1315hrs and called Eket ATC indicating departure from Gitto construction site to Port Harcourt International Airport. During the flight from Uyo to Port Harcourt, the engine chip detector light indication came on less than five minutes after take-off, at an altitude of about 800ft. The pilot then contacted Eket and informed them of his intention to return to Uyo Airstrip. Barely thirty seconds after the call, the engine oil pressure dropped to zero on the LCD indicator. According to the Pilot, this does not show on the instrument panel and the engine oil temperature still remains in green and normal.

The Pilot stated that a loud explosion was heard from the engine accompanied by a swift turn to the left and all instrument lights came ON. While all this was happening, they were above a jungle. This compelled pilot to stretch the flight over to get a place to land. The pilot further stated that as the helicopter was flared, there was insufficient rotor rpm. This caused the helicopter to land hard, short of the helipad at the Gitto construction site. The aircraft crashed within the vicinity of the helipad. The accident occurred at 1330hrs within the Gitto construction site on the 21st of October, 2009. There was fire outbreak which engulfed the aircraft. The occupants were however rescued and taken to Shell Petroleum Development Company (SPDC) of Nigeria Exploration & Production, Eastern Division Hospital, Port Harcourt for medical treatment with various degrees of injuries.

1.2 Injuries to Persons

Injuries	**Crew**	**Passengers**	**Others**
Fatal	Nil	Nil	Nil
Serious	1	Nil	Nil
Minor/None	1	Nil	Nil
Total	2	Nil	Nil

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 The Pilot

Nationality:	Nigerian
Age:	53 years
Gender:	Male
Licence No.:	CPL 3592(H)
Licence Validity:	24th February, 2010
Aircraft Ratings:	Bell 406, 407
Medical Validity:	28th February, 2010
Simulator Validity:	24th February, 2010
Total Flying Experience:	18,000hrs
On Type:	11,000hrs
Last 90 hours:	Not available
Last 30 days:	Not available
Last 24 hours:	Not available

He is the Chief Pilot of the Company.

1.5.2 Aircraft Engineer

Nationality:	Nigerian
Age:	53 years
Gender:	Male
Licence No.:	1093

Licence Validity:	19th February, 2009
Aircraft Ratings:	Bell 206, 406, 407, 412 and C-172

The Engineer's licence expired eight months before the crash.

1.6 Aircraft Information

1.6.1 General Information

Type:	Bell 407
Serial No.:	53340
Operator:	Gitto Construczioni Generali Nigeria Limited
Manufacturer:	Bell Helicopter Textron, Canada
Year of Manufacture:	1999
Airframe Time as at 18/10/09:	1866hrs
Total landings/cycles:	Not Available
Certificate of Insurance:	29th July, 2010
Certificate of Airworthiness:	21st November, 2009

1.6.2 Power Plant

Manufacturer:	Rolls – Royce (Allison)
Year of Manufacture:	1999
Hours:	1787.8
Engine Model:	250-C47B
Cycles as at 18/10/09:	3247

Serial No.:	CAE–847353
Fuel used:	Jet-A1

1.6.2.1 Last Engine Overhaul before the Accident

The aircraft engine was sent to H&S Aviation on the 8th of April, 2009 for overhaul at the total time of 1787.8 hours as against the mandatory 2000 hours because of persistent oil leakages from the gearbox input seal. The cost estimate for the repair/overhaul of the engine was submitted to Gitto Construczioni Generali Nigeria Limited on the 19th of May, 2009 by Hants & Sussex Aviation U.K. via Cost Estimate No. E6358396-01. With the submission of this estimate, reference was made on the rejection of some high value parts.

> *The following high value parts have been rejected that were not part of the original quote: stage 1 nozzle, stage 2 nozzle, stage 1 nozzle shield, PT outer shaft, gear shaft and bearing.*

On receipt of the engine at H&S Aviation Ltd., the engine was disassembled into modules. See Appendix VI.

It is pertinent to note that the AMO facilty (H&S Aviation Limited) is not on the list of NCAA approved AMO.

1.6.3 Weight and Balance Data

The aircraft was within the permissible weight and balance limits.

1.6.4 Parts and/or Systems which had bearing on the accident:

i. Transmission Chip Detector Warning Light (transmission chip detector)

The transmission chip detector system consists of chip detectors on the top case of the transmission, the main case, the sump and finally, the freewheeling unit.

The chip detectors carry magnets which attract ferrous particles at any of the detector locations.

The XMSN CHIP caution light illuminates when the gap is closed on the chip detector switch. The pilot or maintenance personnel must check for caution/advisories before shutting down, to determine the location of the chip.

ii. The transmission has an oil pressure monitoring system which consists of a transmission oil pressure switch sensor, indicator, and caution light. The main transmission oil pressure switch controls the transmission oil pressure caution light and the main transmission oil pressure indicator. This switch causes the caution light to illuminate if the oil pressure drops to a minimum of 14±2psi. The transmission system also has a temperature indicating system.

iii. FADEC

Full Authority Digital Engine Control is a system consisting of a digital computer called an "Electronic Engine Control" (EEC) or Electronic Engine Control Unit (EECU) and its related accessories that control all aspects of aircraft engine performance. The FADEC (EECU) could have assisted in this investigation but it was destroyed by post-crash fire.

1.7 Meteorological Information

Calabar Aerodrome:

1100 UTC

Wind (QAN):	190/04KT
Visibility (QBA):	12km
Cloud (QBB):	BKN 420M
Weather (QNY):	NIL
Pressure (QNH):	1012

1200 UTC

Wind (QAN):	180/06KT
Visibility (QBA):	15km
Cloud (QBB):	BKN 420 M
Weather (QNY):	NIL
Pressure:	1012
Temperature (QAM):	29°/22°C

1.8 Aids to Navigation

Not Applicable to VFR flights.

1.9 Communications

There was good communication between the pilot and Eket ATC, and the onboard communication radios were all serviceable when the accident occurred.

1.10 Aerodrome Information

The Aerodrome was under construction as at the time of the accident.

1.11 Flight Recorders

The aircraft was not fitted with a Flight Data Recorder or Cockpit Voice Recorder. Neither recorder was required by Nig.CARs.

1.12 Wreckage and Impact Information

The helicopter crashed short of Gitto helipad at Uyo. The crash site is a flat land covered by corn stalks and surrounded by palm trees. However, the main wreckage was largely in one piece with the engine severely burnt.

The tail rotor drive shaft, tail boom and tail rotor gear box were found about 10 meters away from the main wreckage.

The wreckage was heavily contaminated with sand which was used to fight the fire as the available fire extinguishers were not adequate.

Figure 1: A Section of turbine area of the engine that was ripped open exposing the turbine wheels

Figure 2: Section of the burnt aircraft wreckage

Figure 3: Picture showing the rear view of main wreckage of 5N-BIC after the crash

1.13 Medical and Pathological Information

The Bureau received medical reports of the Pilot, detailing injuries sustained as a result of the accident from various medical facilities in Port Harcourt where the pilot was first diagnosed as having spinal cord injury, and other reports from hospitals in Italy and Germany respectively. The Pilot was incapacitated from the injuries.

1.14 Fire

There was post-crash fire.

Figure 4: Picture showing heaps of sand that was used to extinguish the fire on 5N-BIC accident at Uyo Aerodrome

1.15 Survival Aspect

The accident was survivable because there was a liveable volume of space available to the Pilot and the Engineer on board.

According to the Pilot, on the flight leg from Gitto site, Uyo to Port Harcourt International Airport, not up to 5mins at 800ft, the engine chip lights came ON in flight as they were over the jungle, but he managed to stretch the flight to an available clear ground for landing. As the helicopter flared, with insufficient rotor rpm, they managed to land but very hard.

The Engineer came out first from the aircraft. The Pilot could not move his body but was able to close the throttle to cut off the fuel supply. Then the pilot called for help from the Engineer, before staff of Gitto company came for rescue.

1.16 Test and Research

1.16.1 Engine Teardown/Examination

The engine was shipped to the Rolls-Royce facility in Indianapolis, Indiana, USA for teardown/examination. The engine was delivered to the secure Rolls-Royce Accident Investigation Facility. The examination of the engine commenced on 8th September, 2011 under the supervision of the Federal Aviation Administration (FAA). Upon opening of the shipping container, the engine was found to be heavily damaged by an apparent magnesium fire. The engine also exhibited extensive corrosion.

The engine was hoisted from its shipping container using a nylon sling. As a result of extensive damage to the auxiliary gearbox, the engine could not be mounted on a rollover stand, and the engine had to be disassembled while resting on an examination bench. See Appendix X for the full report.

1.16.1.1 Extract from the Teardown report

<u>Turbine Wheel Assembly Stage 1 & 2</u>

The turbine splined adapter was deformed outwards when it was examined which would cause the splined adapter to become decoupled from the second stage turbine wheel. This deformation and smearing observed on the turbine splined adapter was indicative of rapid heating. The 1st stage turbine nozzle airfoil exhibited impact damage on the trailing edges. The nozzle diaphragm also exhibited radial impact marks and punctures. The 1st stage turbine stub shaft was retained for failure analysis in the laboratory.

Also, from the teardown report, the 2nd stage turbine and turbine nozzle assembly were found to be missing. However, the aft face of the power turbine support exhibited evidence of contact by the 2nd stage turbine wheel, which confirms forward movement of the 2nd stage turbine during engine operation.

1.17 Organisational and Management Information

1.17.1 Gitto Construczioni Generali Nigeria Limited

The company was founded in 2002 by a civil engineering company, based in Italy which has been in existence since 1957.

1.17.1.1 Permit for Non-Commercial Flight (PNCF) granted to Gitto Construczioni Generali Nigeria Limited by the Federal Ministry of Aviation (FMA)

A PNCF was granted to the company on the 22nd of June, 2005 by the FMA vide a letter ref.: FMA/ATMD/502/S/802/1/68 in accordance with Regulations 14(I) of the Civil Aviation Air Transport (Licensing) Regulation 1965. The PNCF has a validity period of three years.

However, Gitto Construczioni Generali Nigeria Limited applied for renewal of their PNCF on 28th August, 2008.

NCAA wrote a letter dated 21st August 2009, reminding the company to submit the following documents:

i. Personal History Statement (PHS) forms duly completed by the company Directors;
ii. Duly completed NCAA PNCF processing form.

The company responded on the 5th of October 2009 with the requested documents.

The investigation revealed that as at the time of the accident, the renewal was still being processed.

1.17.2 H&S Aviation

H&S Aviation is a company based in U.K with utilization of aftermarket service under its parent company; BBA Aviation Plc. U.K. The company's aftermarket services include repairing and overhauling of gas turbine and turbo fan engines, and their components.

H&S Aviation is split into five autonomous business units focused on a specific product range and there is also a separate component repair facility and R-R model 250 training school.

This facility carried out overhaul on the helicopter engine on 8th April 2009, due to Gearbox Input Seal Leakage and Overhaul of the Turbine. See Appendix VII.

1.17.3 Nigerian Civil Aviation Authority (NCAA)

The Nigerian Civil Aviation Authority (NCAA) is the apex regulatory body overseeing the activities of all airline operators, crew, engineers, airports, airstrips and heliports, navigation aids and air traffic service providers. NCAA functions include safety oversight on all the above.

1.17.3.1 Air Transport Economic Regulations (Nig.CARs 18.2.4)

18.2.4. This section shall apply to flight operations undertaken for non-commercial or private purposes:

18.2.4.1. No person shall use any aircraft for non-commercial purposes between two or more places in Nigeria, unless such a person holds a Permit for Non-Commercial Flights (PNCF) issued by the Authority.

18.2.4.2. Application for the grant or renewal of a PNCF shall be made in writing to the Authority and shall meet the requirements as specified in IS:18.2.4(A) and IS:18.2.4(B) or such other information as may be published by the Authority from time to time.

IS:18.2.4(A)—(1) General

(i) Application for grant of Permit for Non-Commercial Flights (PNCF) shall be made in writing to the Director-General, Nigerian Civil Aviation Authority (NCAA).

(ii) The application shall be signed by a person duly authorized by the applicant.

(iii) The application for renewal of PNCF must be submitted to the Director-General, Nigerian Civil Aviation Authority on or before a date not less than six (6) months to the expiration of the existing PNCF.

18.2.4.3. The Authority if satisfied that the applicant has complied with the requirements for the grant or renewal of the PNCF, shall grant or renew the PNCF.

18.2.4.4. A PNCF shall be valid for a period of three (3) years and subject to renewal every three years on such terms and conditions as may be specified by the Authority from time to time.

1.17.3.2 Duration of AME licence

Nig.CARs 2.6.2.9. Duration of AME Licence

(a) Validity.—The duration of the AME licence is five years.

(b) Renewal.—An AME licence that has not expired may be renewed for an additional 5 years if the holder presents evidence to the Authority that he/she has within the past 24 months, exercised the privileges of the licence and complied with the recent experience requirements as contained in 2.6.2.10.

(c) Reissue.—If the AME licence has expired, the applicant shall have received refresher training acceptable to the Authority and passed a skill test on the areas of operation contained in IS: 2.6.2.7 for the AME general and any associated ratings.

1.18 Additional Information

1.18.1 Engine Chip

Ferrous particles in engine oil when present, the flight manual recommends that the crew should land as soon as possible.

1.18.2 Oil Chip Plug or Detectors

Chip detectors consist of small plugs which can be installed in an engine oil filter or oil sump. Over a period of time engine wear and tear cause small metal chips to break loose from engine parts and circulate in engine oil. This signals early warning of an impending engine failure. The magnetic plugs are found in the chip detectors. You can easily remove the plugs from the chip detectors for oil inspection without losing oil.

1.18.3 Summary of the Work performed at H&S Aviation Ltd.

Unit Type CA47B, Serial Number: CAE847353, PROJECT NUMBER: 6358396, on 08/04/2009 are as follows:

1- Turbine module fully disassembled to carry out a full overhaul of the turbine, including replacement of stage1 and 2 wheels due to limited life remaining.

2- Compressor assembly - fully disassembled to carry out a time continued repair to ensure optimum compressor efficiency to maintain engine performance.

3- Gear box assembly - fully disassembled but leaving the oil pump assembled to investigate and rectify the leaking input seal.

4- Main build component including the combustion assembly were disassembled to carry out time-continued repair.

5-The following accessories were offloaded.

** Fuel nozzle for clean and rig check-passed test*
** Bleed valve for rig check-note: required overhaul due to failing rig check.*
** HMU – Currently under investigation.*

1.18.4 Autorotation

Autorotation is a state of flight in which the main rotor system of a helicopter or similar aircraft turns by the action of air moving up through the rotor, as with an autogyro, rather than engine power driving the rotor. Autorotation was achieved in this aircraft by the proper operation of the freewheeling unit.

1.18.5 Bell 407 Model Rotorcraft Flight Manual (RFM) (BHT-407-FM-1)

Section 3 Emergency/Malfunction Proceedures from the TC Approved Bell 407 Rotorcraft Flight Manual

The following terms are defined as:

LAND AS SOON AS POSSIBLE	*Land without delay at nearest suitable area (i.e., open field) at which a safe approach and landing is reasonably assured.*
LAND AS SOON AS PRACTICABLE	*Landing site and duration of flight are at discretion of pilot. Extended flight beyond nearest approved landing area is not recommended.*

While the following are the Proceedures to be adhered to during Emergencies as prescribed in RFM.

3-3-A-2 ENGINE FAILURE – INFLIGHT

- ***INDICATIONS:***
  1. *Left yaw.*
  2. *ENGINE OUT and RPM warning lights illuminated.*
  3. *Engine instrument indicate power loss.*
  4. *Engine out audio activated when NG drops below 55%.*
  5. *NR decreasing with RPM warning light and audio on when NR drops below 95%.*

- ***PROCEDURE:***

1. *Maintain heading and attitude control.*
2. *Collective – Adjust as required to maintain 85 to 107% NR.*

NOTE

Maintaining NR at high end of the operating range will provide maximum rotor energy to accomplish landing, but will cause an increased rate of descent.

3. *Cyclic – Adjust to obtain desired autorotative AIRSPEED.*

NOTE

Maximum AIRSPEED fro steady state autorotation is 100 KIAS. Minimum rate of descent airspeed is 55 KIAS. Maximum glide distance airspeed is 80 KIAS.

4. *Attempt engine restart if ample altitude remains. (Refer to ENGINE RESTART, paragraph 3-3-B).*
5. *FUEL VALVE switch – OFF.*
6. *At low altitude:*
   a. *Throttle – Closed.*
   b. *Flare to lose airspeed.*

7. *Apply collective as flare effect decrease to further reduce froward speed and cushion landing. Upon ground contact, collective shall be reduced smoothly while maintaining cyclic in neutral or centered position.*
8. *Complete helicopter shutdown.*
   See Appendix: XI (B)

3-3-G. ENGINE OIL PRESSURE LOW OR FLUCTUATING

- ***INDICATIONS:***

1. *Engine oil pressure below minimum.*
2. *Engine oil pressue fluctuating abnormally.*

- ***PROCEDURE:***

1. *Engine oil pressure and temperature – Monitor*
2. *Land as soon as practicable.*

3-3-H. ENGINE OIL TEMPERATURE HIGH

- ***INDICATIONS:***

1. *Engine oil temperature increasing above normal.*
2. *Engine oil temperature above maximum.*

- ***PROCEDURE:***

Land as soon as practicable.

2.0 ANALYSIS

2.1 The Flight

5N-BIC was cleared by Eket ATC to depart from Gitto construction site, Uyo to Port Harcourt International Airport. At 800ft and less than 5 minutes after departure, the engine chip detector light came on. This type of Emergency/Malfunction according to Section 3 of the RFM, recommends the pilot to land as soon as possible. The pilot then turned the aircraft back towards the departure point. Barely thirty seconds after the turn, the engine oil pressure showed ZERO on the LCD indicator. However, the engine oil temperature still remained in the green band. See Appendix VIII. Thereafter, the pilot heard a loud bang from the engine followed by a left yaw indicating an engine failure.

At 800ft AGL with the worst case scenerio, the helicopter in hover and Maximum Gross Weight, a successful autorotation can be accomplished in accordance with the Bell 407 RFM Height versus Velocity Performance Chart. See Appendix X. This can only be achieved by applying the recommended procedures.

According to the pilot, he went into autorotation immediately and with the prevailing conditions, it was possible to safely land. The RFM recommends a speed of 80KIAS for maximum glide distance. Since the helicopter was over a jungle at the time of the engine power loss, the pilot elected to stretch the glide so that he could land in a clear area. As a result, the main rotor rpm decreased, which resulted in the helicopter landing hard. See Appendix IX (B).

2.2 Transmission system Magnetic Chip indication

The aircraft departed Calabar for Port Harcourt on the 21st of October 2009 at 1230hrs. On that flight leg, the crew observed the transmission magnetic chip indicator light came up at a location close to Gitto construction site, Uyo.

Magnetic chip detectors consist of small plugs which are installed on the top and main cases of the transmission, the oil sump and the freewheeling unit. Over a period of time transmission wear and tear causes small metal chips to break loose from transmission parts and circulate in transmission oil. This signals early warning of an impending transmission failure.

The crew landed at Gitto construction site in Uyo due technical. The Engineer reported carrying out inspection of the three transmission chip detector plugs. Upon the examination, no metal chips were reported to have been found. The plugs were cleaned and reinstalled, after which the pilot checked the transmission and walked round the aircraft in a bid to detect any abnormal situation.

On 21st October, 2009 at 1310hrs, the pilot reported that no indication came ON when the engine was started. A five-minute ground run was carried out before the aircraft took off.

The Rolls Royce procedure for evaluating an engine chip situation recommends that after the first chip light indication, the chip detector should be cleaned and replaced. This is to be followed by a thirty minute ground-run. If the chip detector light illuminates again during the initial thirty minute ground-run, it is required of the engineer to drain the oil, clean or replace the filters and perform a second thirty minute ground-run.

If the chip light illuminates during the second thirty minute ground-run, the engine should be removed from service.

From the above, it can be seen that the maintenance operations carried out by the Engineer were inadequate in that:

- A thirty minute ground-run was not performed.
- The maintenance procedure was inconclusive as prescribed by the AMM.

2.3 Low Engine Oil Pressure indications in flight from Uyo to Port Harcourt

At 1315hrs on the same day, the crew departed Uyo for Port Harcourt. The pilot reported that less than five minutes into the flight at an altitude of 800ft, the engine chip light illuminated and barely thirty seconds later, engine oil pressure dropped to zero.

Loss of oil pressure is an emergency. Most oil starvation engine events are caused by the loss of oil from the engine. It is the low oil level that then causes the low oil pressure. Sometimes, as the quantity of oil remaining in the sump gets very low, a slight increase in oil temperature might be observed.

The first indication of a low oil level problem is an abnormal reduction in oil pressure. Once the oil level in the sump has dropped to a level whereby the oil pump-pickup is not completely submerged, and starts to draw in air as well as oil, critical parts of the engine will no longer receive vital lubrication.

It is pertinent to note that this engine had persistent issues of oil leakage, which prompted the engine overhaul at 1787.8hrs before its due time of 2000hrs.

From the H&S report, the Bureau could not determine whether the oil input/labyrinth seal was replaced in the engine accessory gearbox. The cumulative snags noticed in this accident are suggestive of oil leakage due to lack of labyrinth seal replacement, and which can invariably, lead to engine seizure.

2.4 Engine power loss

Barely five minutes after take-off from Uyo to Port Harcourt, the engine chip detector indication illuminated, which prompted an air-return. About thirty seconds after, the engine oil pressure dropped to ZERO. A loud "bang" was heard from the engine with loss of power.

The teardown report on the accident engine revealed that the root cause of loss of power was an improper oil system maintenance which led to oil starvation, resulting in failure of No. 6, No. 7 and No. 8 bearings. As the No. 6 and No. 7 bearings deteriorated and lost ability to centre the Power Turbine and Gas Producer rotors, the Power Turbine Inner Shaft began rubbing on the outside diameter of the Turbine Splined Adaptor.

The resulting frictional heating of the Turbine Splined Adaptor weakened it and allowed the aft splined end to mushroom outward under the tangential stress impacted by torque from the Second Stage Turbine Wheel. This disconnected the turbine and compressor, resulting in a turbine overspeed. The subsequent overspeed of the Gas Producer rotor resulted in burst of the First Stage Turbine Wheel, and subsequent burst or release of the Second Stage Turbine Wheel.

2.5 Last Engine Overhaul Carried out by Hants & Sussex Aviation U.K on the 8th April 2009, due to Gearbox Input Seal Leakage and Overhaul of the Turbine

From the inspection report available to the Bureau from Hants & Sussex, there is no evidence to show that the stage 1 & 2 turbine wheels were replaced due to the limited life remaining. It should be noted that the manufacturer recommends that the stages 1 & 2 wheel of the power turbine should be replaced at 3000 cycles. Non replacement could lead to engine failure and multiple engine related issues. Also, from the report of the finding on disassembly and detailed inspection of the turbine, the 1st and 2nd stage turbine wheels with part numbers 23053299 and 23032280 respectively, were confirmed to be unserviceable and must be replaced during the overhaul.

From the available records, there was no indication that these components were replaced during the overhaul. However, the request for complete overhaul of the engine includes disassembly of the turbine module sufficiently to allow the replacement of the stage 1 and 2 wheels.

Consequently, from the engine teardown report, the 2nd stage turbine and turbine nozzle assembly were found to be missing, the aft face of the power turbine support exhibited evidence of contact by the 2nd stage turbine wheel which confirms forward movement of the 2nd stage turbine during engine operation.

Also, AIB discovered that the facility at H & S Aviation was not in the list of NCAA approved AMOs at the time of the accident.

2.6 Personnel

2.6.1 The Pilot

The pilot was the Chief Pilot of the company and carries out daily management of the company's aircraft operations. He was medically fit with a valid licence, therefore, qualified to operate the flight.

2.6.2 The Engineer

The Engineer had a Bell 407 rating on his licence. The verification action on the reported chip light indication on the flight leg from Calabar to Uyo on 21st October, 2009 was carried out by the Engineer whose licence had expired eight months before the accident. This is not in accordance with the Regulations (Nig.CARs 2.6.2.9); he was therefore not authorised to release the aircraft to service.

2.7 NCAA Oversight

In the course of this investigation, the Bureau discovered that the PNCF granted to the company had expired on 21st June, 2008. The Regulations stipulate that renewal process should be initiated six months prior to expiration (Nig.CARs IS:18.2.4(A)—(1)(iii)). But the company applied for renewal on the 28th of August 2008, which was two months after the licence had expired. From the records available to the Bureau, NCAA wrote a letter dated 21st August 2009, reminding the company to submit certain documents with regards to the application. Apparently, NCAA was aware that the company was flying without a valid PNCF. This is not in accordance with Nig.CARs 18.2.4. The investigation revealed that as at the time of the accident, the renewal was still being processed.

3.0 CONCLUSIONS

3.1 Findings

1. The pilot was seriously injured while the Engineer sustained minor injuries.
2. The Engineer's licence had expired eight months before the crash (19th February 2009) and hence was not authorized to release the helicopter for flight.
3. Fire fighting exercise on the wreckage was carried out with fire extinguishers and sand.
4. Vital evidences were destroyed and disturbed by the mode of fire fighting.
5. H&S Aviation was not an NCAA approved AMO at the time of the accident.
6. NCAA oversight on the company aircraft was inadequate.
7. Gitto Construczioni Generali Nigeria Limited applied for renewal of their PNCF on 28th August, 2008, more than two months after its expiration.
8. As at the time of the accident, Gitto Construczioni Generali Nigeria Limited did not have a valid PNCF.
9. The Nig.CARs stipulates that applications for PNCF renewal should be made six months before expiration of the current one.
10. The aircraft was completely destroyed by impact forces and fire.
11. The aircraft was not fitted with a Flight Data Recorder or Cockpit Voice Recorder. Neither recorder was required by Nig.CARs.
12. The engine had persistent oil leakages which fast-tracked its overhaul before 2000 hours.
13. The helicopter had engine chip light indication and engine oil pressure drop on the Uyo to Port Harcourt trip.
14. The company rescheduled the TBO of the engine from 2000hrs to 1787.8hrs due to persistent oil leakage.
15. The company has poor recordkeeping of aircraft documents.

16. The FADEC unit installed on the aircraft was severely burnt, so its parameters could not be retrieved or decoded.

The investigation identified the following causal and contributory factors:

3.2 Causal Factor

i. Improper maintenance of the oil system which led to oil starvation resulting in the failure of the No. 6, 7 and 8 bearings in the power turbine section of the engine, leading to power loss.

ii. Improper identification by the pilot of the transmission chip light illumination during flight instead of the engine chip light.

3.3 Contributory Factors

i. The decision of the pilot to continue with the flight from Uyo to Port Harcourt International Airport without identifying the cause of the transmission chip detector indication.

ii. The non-replacement of the stage 1 & 2 turbine wheels due to limited life remaining.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendation 2017-004

NCAA should intensify its surveillance and monitoring on all privately-owned aircraft to ensure that operational and maintenance procedures are strictly adhered to in accordance with the relevant sections of the Nigerian Civil Aviation Regulations (Nig. CARs).

RESPONSES TO SAFETY RECOMMENDATIONS

NCAA Response on AIB Safety Recommendations

<u>The NCAA responded to Safety Recommendation 4.1 (2017-004) as follows:</u>

"The NCAA exercises oversight on all Nigerian and foreign registered aircraft operating in the private categories in Nigeria. These aircraft and the Approved Maintenance Organizations (AMO)/personnel that release them to service are subject to continuous surveillance and oversight as required by the Nig. CARs and detailed in the approved Technical Guidance Materials;"

APPENDICES

Appendix I: Conditions of hardware as submitted for failure analyses

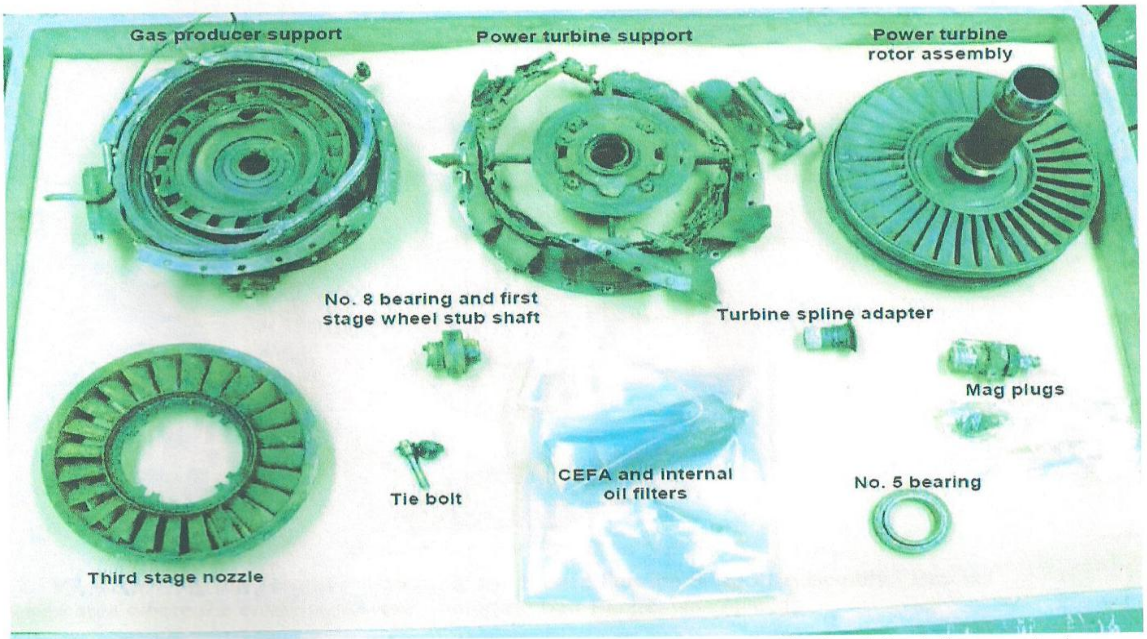

Figure 1. Photograph showing the as-received condition of hardware submitted for failure analysis.

Appendix

The general condition of the Power Turbine Support Assembly is shown in Figure 2. The aft bolt flange portion of the power turbine support assembly exhibited metal which appeared to have peeled outward. This damage was consistent with damage caused by high energy fragments exiting the engine. However, the fact that the major part of this damage appears to be concentrated in one arc sector of the structure is not consistent with a classic wheel burst, which typically exhibits a three-lobed damage pattern. Approximately 80 degrees of the support circumference was absent from the top portion of the support, including the outboard portion of the oil inlet strut and the Power Turbine Pressure Oil Nozzle, which supplies oil to the No. 6 and No. 7 Bearings. The oil scavenge strut at the bottom of the assembly was sectioned and no blockage was detected. A section through the power turbine support close to the scavenge strut revealed blockage of the scavenge hole leading to the strut area. The material in this scavenge hole was analyzed using semi-quantitative x-ray energy dispersive analysis (XEDA) which determined that the material contained elements consistent with AMS 5383 (Inconel 718), and AMS 6490 (M-50), which is consistent with the engineering requirements for the Power Turbine Support Assembly and No. 6 Bearing, respectively. It could not be determined if this blockage was present before the event or occurred as a result of the event.

Appendix II: Showing the general condition of power support assembly

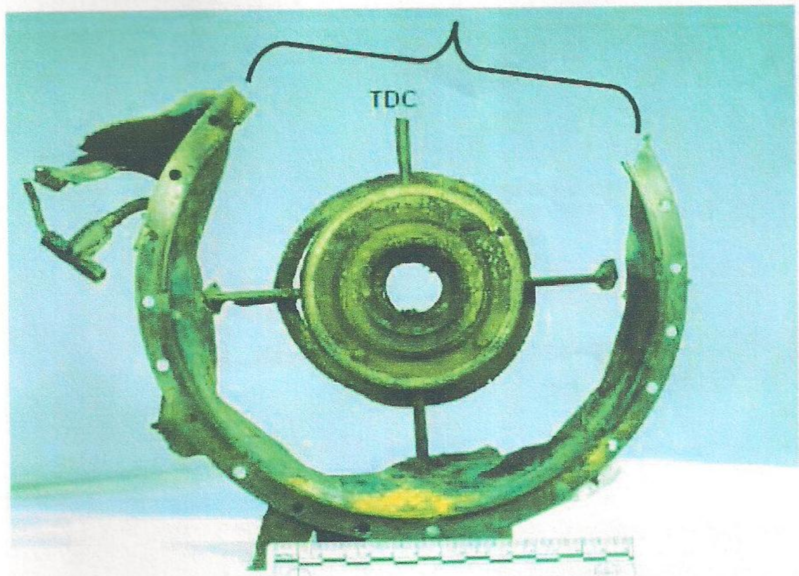

Figure 2. View showing the general condition of the Power Turbine Support Assembly. Bracket indicates an area where the entire outer case, including bolt flange, was missing.

A cross-section through the sump area, shown in Figure 3, revealed that the No. 6 Bearing was severely damaged and melted and the No. 7 Bearing outer ring was shifted forward from its typical position. The aft portion of the static seal was separated from the sump but still present during the engine disassembly. An axial cross-section through the No. 7 Bearing outer ring and adhered debris was polished for evaluation and is shown in Figure 4. Semi-quantitative XEDA determined that the No. 7 Bearing outer ring, as well as material deposits in the raceway, was an AMS 6491 (M-50) type material which is consistent with the engineering drawing requirements for the bearing outer ring, inner ring and rollers. One additional piece of metal debris adhered to the ring as indicated in Figure 4 was determined to be AMS 6415 (SAE 4340) which is consistent with the engineering drawing requirement for the bearing separator. Incipient melting was observed near the forward shoulder portion of the outer ring. Grain structure appeared heat affected throughout the outer ring as shown in Figure 5.

Appendix III: Showing the cross section through the power turbine support

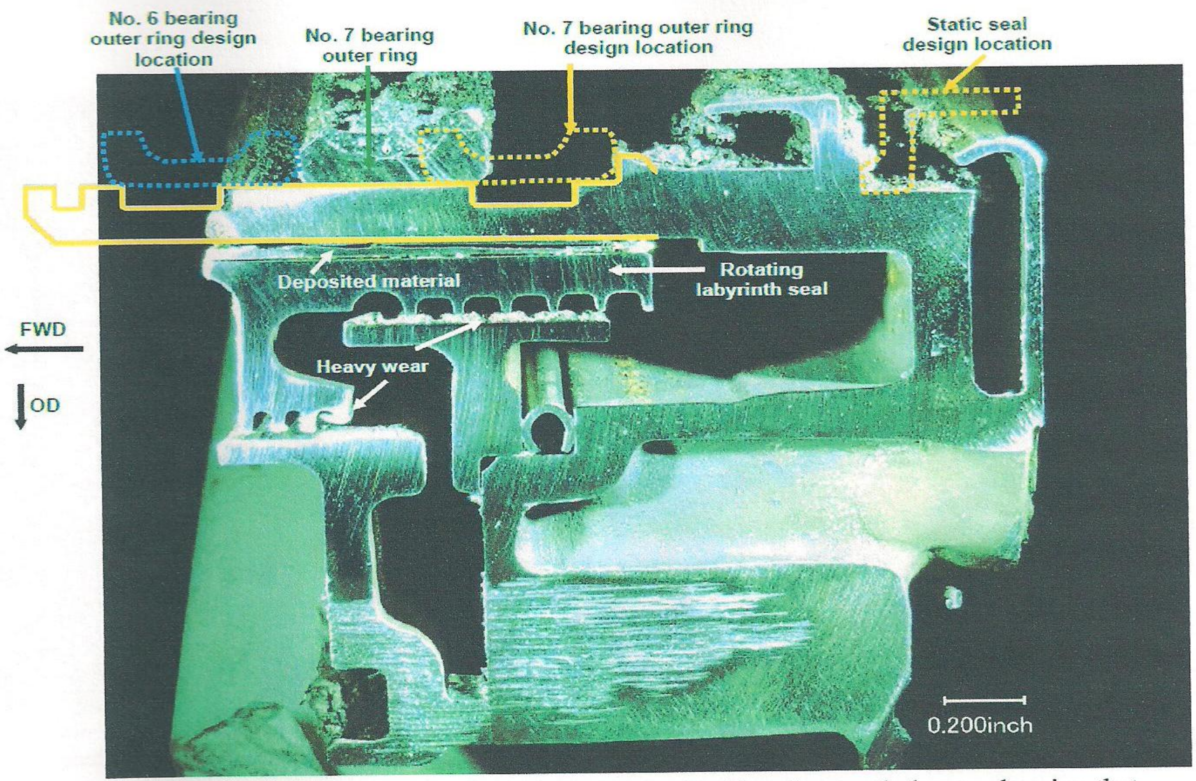

Figure 3. Detailed view of cross-section through the Power Turbine Support hub area showing that material is missing from the forward side of the sump, including the No. 6 Bearing and separator. The separator was found separate from this sump area during disassembly.

Appendix IV: Showing the full view of the #5 Bearing

#5 Bearing

Appendix V: Cross section of No. 7 bearing

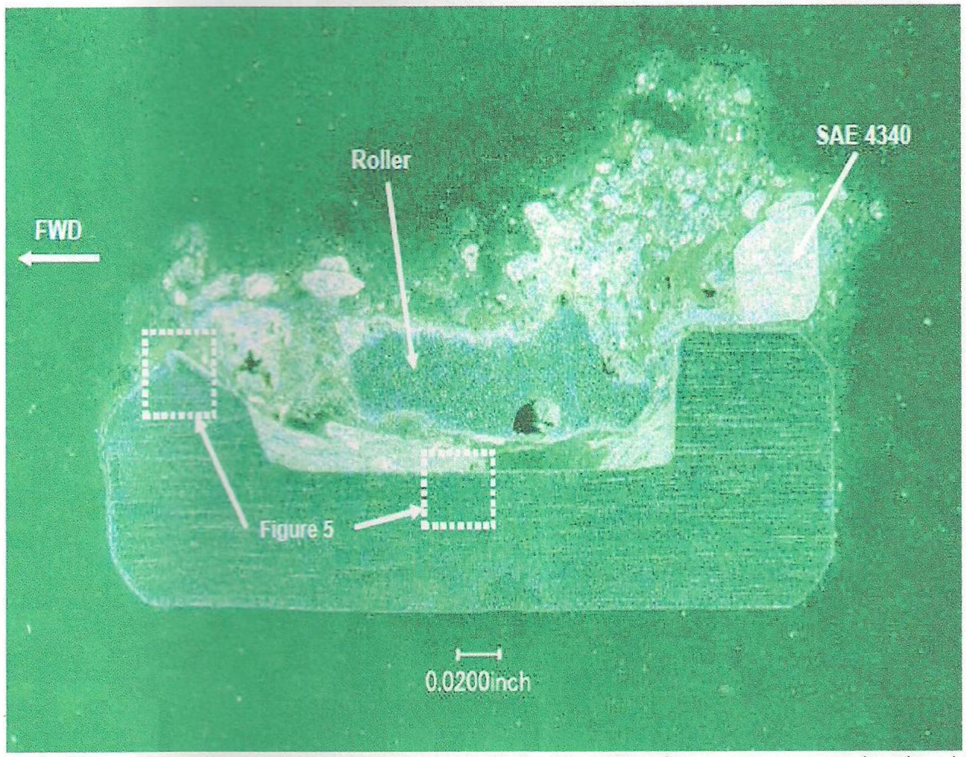

Figure 4. View of metallurgical cross-section through the No. 7 Bearing outer raceway showing debris which was consistent with bearing roller material.

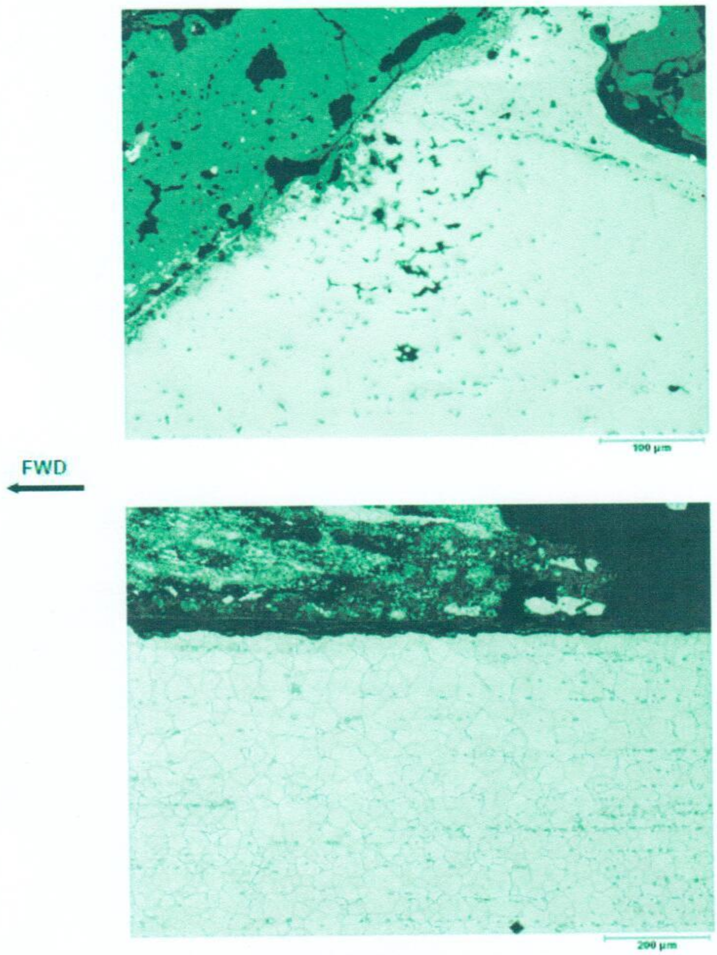

Figure 5. Detailed views of the metallurgical cross-sections through the No. 7 Bearing outer raceway at locations shown in Figure 4. The upper image shows evidence of incipient melting; the lower image shows heat affected grain structure near the middle of the raceway.

A layer of deposited material was observed between the inner diameter of the rotating Labyrinth Seal and the Power Turbine Support hub, as indicated by the arrow in Figure 3. This material was analyzed using semi-quantitative XEDA and determined to contain elements found in AMS 5662 (IN 718) and AMS 6490 (M-50) which is consistent with the engineering requirement for the Power Turbine Support Assembly and No. 6 Bearing, respectively. Deposited material which contained elements consistent with the No. 6 Bearing materials was found on the Turbine Splined Adapter, Third Stage Turbine Nozzle and Power Turbine rotating Labyrinth Seal. This level of damage to the No. 6 Bearing is indicative of significant heat generation in this area of the bearing sump. The following paragraph describes the effects of this heat on the Turbine Splined Adapter, which is located just inside the No. 6 Bearing.

The general condition of the Turbine Splined Adapter in the as-received condition is shown in Figure 6. The internal splines at the aft end of the component were splayed outward and deformed in the direction of engine rotation. The Turbine Splined Adapter showed evidence of smearing on the aft internal splines consistent with damage generated as the adapter began to splay outward and decouple from the splines on the Second Stage Turbine Wheel stub shaft. The component was bulged outward between the forward splines and flange as shown in Figure 7. The forward spline portion of the component was unremarkable, which is consistent with evidence on disassembly that the spline joint with the Turbine to Compressor Coupling remained intact.

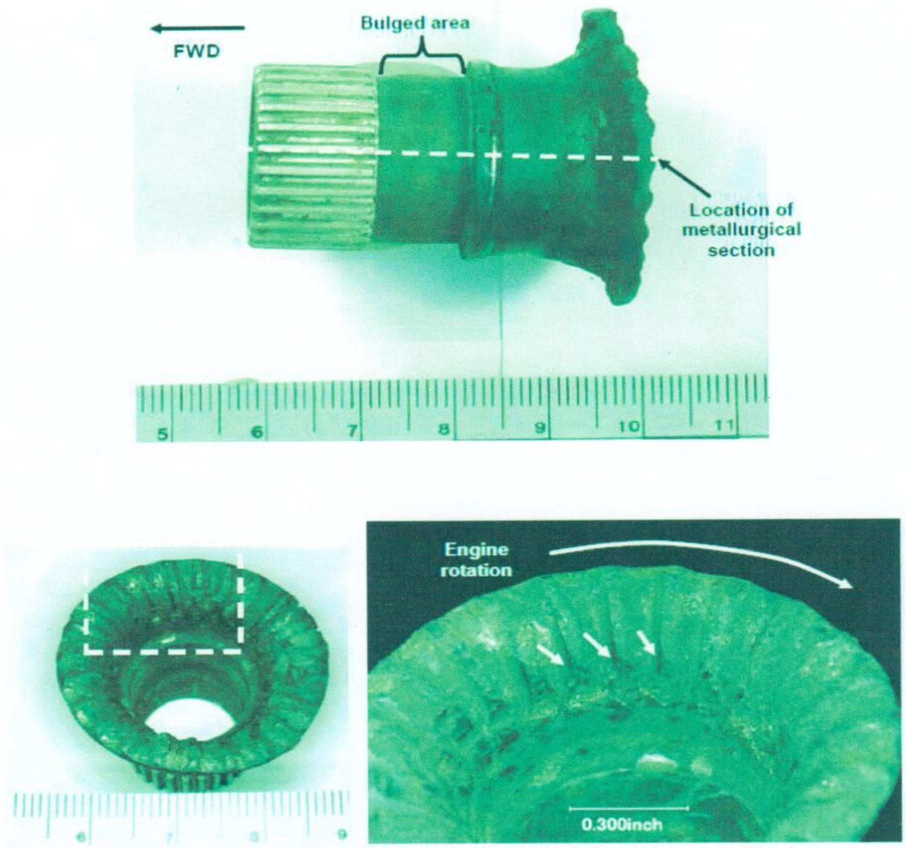

Figure 6. Views showing the general condition of the Turbine Splined Adapter. The lower images are detailed views of the component, aft looking forward. The small arrows indicated locations of smearing in the direction of rotation during decoupling from the second stage turbine wheel.

An axial cross-section was taken along the Turbine Splined Adapter at the location indicated in the upper image of Figure 6. This cross-section, shown in Figure 7, was polished and etched for metallurgical evaluation revealing thermal distress along the entire length of the component. The microstructure at locations B through E was consistent with thermal distress. Deposited material on the component at location C was analyzed using semi-quantitative XEDA and determined to contain elements found in AMS 6490 (M-50) which is consistent with the engineering requirement for the No. 6 Bearing. In cross-section, the Turbine Splined Adapter measured 2.1 inches long which is greater than the engineering drawing requirement of 1.9 inches, indicating a significant amount of plastic deformation. Semi-quantitative XEDA determined that the Turbine Splined Adapter was an AMS 6470 (135 Mod) type material as required by the engineering drawing.

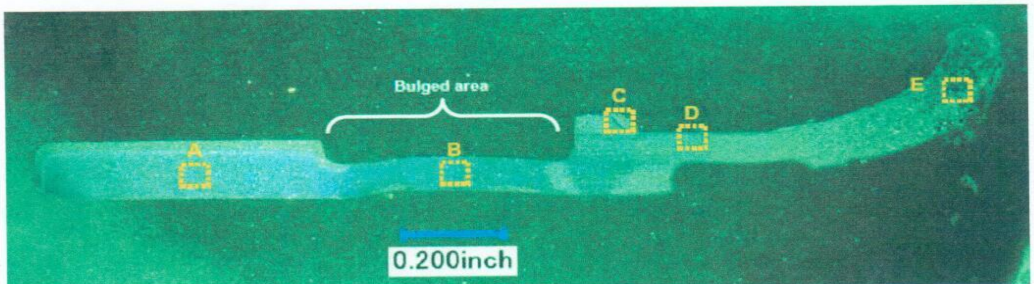

Figure 7. View of metallurgical cross-section through the Turbine Splined Adapter showing microstructural condition.

The general condition of the Gas Producer Turbine Support assembly and First Stage Turbine Nozzle is shown in Figure 8. The internal Energy Absorbing Ring was plastically deformed with three areas of significant deformation as shown by the arrows in Figure 8. The forward portion of the support assembly exhibited areas of metal which appeared to have peeled outward. This three-lobed damage is consistent with damage caused by a First Stage Turbine Wheel burst. Damage to the First Stage Turbine Nozzle Assembly was consistent with secondary damage generated by impact from First Stage Turbine Wheel fragments. The Second Stage Turbine Nozzle was not included with the engine when it was received at Rolls-Royce.

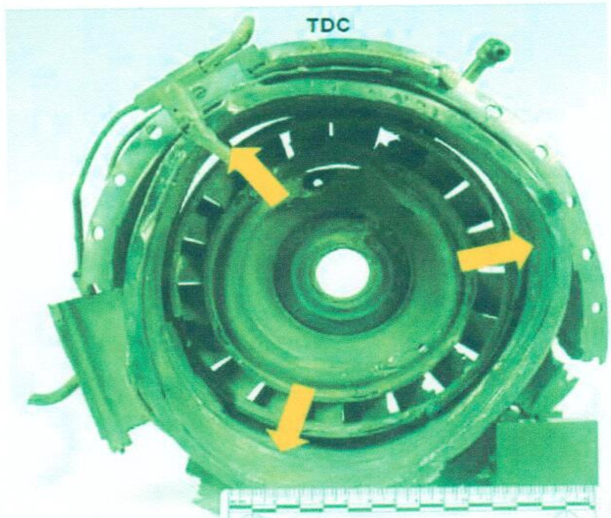

Figure 8. Forward looking aft view showing general condition of the Gas Producer Turbine Support assembly. Arrows indicate areas of the most deformation in a three-lobed pattern indicative of First Stage Turbine Wheel burst.

There is little evidence available to determine the cause of loss of lubrication to the No. 6 and No. 7 Bearings. Rolls-Royce was unable to obtain the Engine Log Book, and little was communicated to Rolls-Royce about the service history of this engine. The Power Turbine Pressure Oil Nozzle, which supplies oil to the No. 6 and No. 7 Bearings, was not included with the engine hardware received for investigation. There was very little oil left in the engine as-received. The External Scavenge Oil Sump was found dry. The oil scavenge strut at the bottom of the assembly was sectioned and no blockage was detected. A section through the Power Turbine Support close to the scavenge strut revealed blockage of the scavenge hole leading to the strut area. The material in this scavenge hole was analyzed using semi-quantitative x-ray energy dispersive analysis (XEDA) which determined that the material contained elements consistent with AMS 5383 (Inconel 718), and AMS 6490 (M-50), which was consistent with the engineering requirement for the Power Turbine Support assembly and No. 6 Bearing, respectively. It could not be determined if this blockage was present before the event or occurred as a result of the event.

The engine oil pressure fluctuation reported just before the event was likely caused by low oil quantity, as stated in the troubleshooting section of the M250 Operation and Maintenance Manual (O&M manual). The O&M manual requires a Pressure Oil Nozzle flow check to measure the oil flow from the nozzle every 150 hours, or earlier if carbon is found in the oil system. This check assures that the No. 6 and No. 7 Bearings are receiving adequate lubrication and cooling. The O&M manual also requires the No. 6 and No. 7 Bearing scavenge oil strut, Pressure Oil Nozzle, screen and External Scavenge Oil Sump be cleaned every 300 hours, or when the oil flow check does not meet requirements. In addition, a daily oil level check within 15 minutes of shutdown is required together with an inspection of the impeding oil bypass indicator. When followed, these requirements have proven reliable to detect and prevent a lubrication problem before it becomes an operational issue.

Appendix VI: Engine Examination Report

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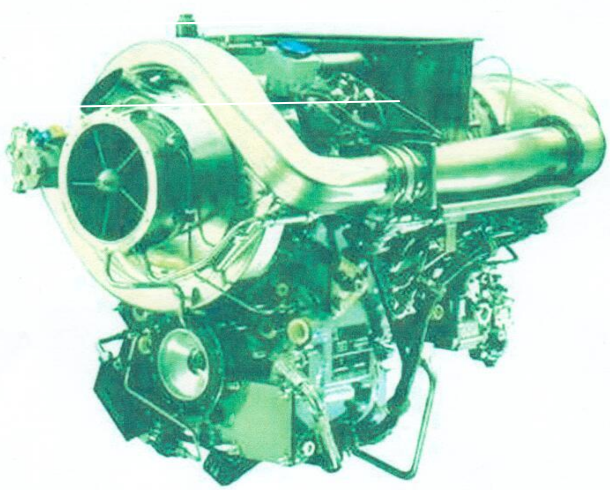
Rolls-Royce

Engine Examination Report

Rolls-Royce Corporation
Model 250-C47B
Engine CAE 847353



Jack Johnson
Air Safety Investigations

Accident date: 21 October 2009
Investigation date: 8 October 2011
Report date: 10 April 2012

Gitto Construzioni Generali
Uyo, Nigeria

Gitto Construzioni - S/N CAE 847353 21 October 2009

Background and Accident Information

On 21 October 2009, a Bell 407, registration 5N-BIC, was destroyed after a hard landing and post-crash fire. The pilot and mechanic/crew member, were seriously injured.

The aircraft was enroute from Calabar to Port Harcourt, with a stop at Uyo, when the accident occurred. According to statements taken by the NTSB, the crew noticed low transmission oil level, low transmission oil pressure and a transmission chip detector warning light during the flight to Uyo. After landing at Uyo, the airport maintenance engineer carried out an inspection of the aircraft's transmission oil system and transmission chip detector. No anomalies were reported. The engineer then conducted a ground run, and found no unusual indications. The aircraft was returned to service.

The helicopter then departed Uyo for Port Harcourt. An estimated 5-10 minutes after takeoff, the engine oil pressure indication dropped to zero and the engine chip detector warning light illuminated. The crew attempted to return to Uyo, but landed hard, short of the helipad. An intense post-crash fire consumed the helicopter.

On 22 October 2009, local authorities investigated the accident site and then moved the wreckage to an unspecified location.

In July of 2011, Rolls-Royce Air Safety received contact from Nigerian authorities, who asked for a detailed examination of the engine by Rolls-Royce. The engine was shipped to Rolls-Royce's examination facility in Indianapolis for disassembly and analysis under the auspices of the Federal Aviation Administration.

This report presents the observations made during the investigation.

Aircraft Information

Model	Bell 407
Serial Number	53340
Registration Number	5N-BIC
Airframe Total Time	UNK

Engine Information

Engine Model	Rolls-Royce 250-C47B
Rating:	650 HP
Serial Number	CAE-847353
Engine Total Hours	UNK
Last Inspection	UNK

Wreckage and Impact Information

The accident site was not visited by Rolls-Royce personnel for security reasons. No information or photographs regarding the accident site was received by Rolls-Royce.

Engine Control Unit Data

The Engine Control Unit (ECU) is presumed to have been consumed by an intense post-crash fire. No additional information is available.

Engine Maintenance and Records

No engine records or logbooks were provided. Due to the intensity of the post-crash fire, only limited information was available from the various data plates. Fragments of the turbine dataplate indicate that the turbine was overhauled in June 2009 by H&S with 1787.8 hours of operation recorded on the data plate.

Turbine Module Data Plate

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE-847353	23063392	UNK	UNK
Gearbox	CAG-47365	23063393	UNK	UNK
Compressor	CAC-44713	23065593	UNK	UNK
Turbine	UNK	23063354	UNK	>1787.8 Hours
FMU	UNK	UNK	UNK	UNK
Fuel Pump	JGALP0935	UNK	UNK	UNK
Fuel Spray Nozzle	UNK	UNK	UNK	UNK
Bleed Valve	UNK	UNK	UNK	UNK

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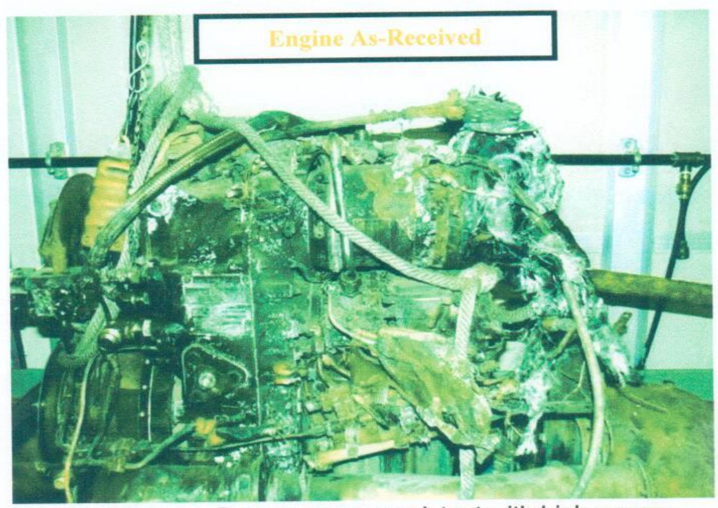
Detailed Engine Examination

The engine was shipped to the Rolls-Royce facility in Indianapolis, Indiana for disassembly and detailed examination. The engine was delivered to the secure Rolls-Royce accident investigation facility and remained in its unopened shipping container until 8 September 2011, when the engine was examined under the auspices of the Federal Aviation Administration. Upon opening of the shipping container, the engine was found to be heavily damaged by an apparent magnesium fire. The engine also exhibited extensive corrosion.

The engine was hoisted from its shipping container using a nylon sling. Because of extensive damage to the auxiliary gearbox housing, the engine could not be mounted in a rollover stand, and the engine had to be disassembled while resting on an examination bench.



Disassembly and detailed examination of the engine revealed the following:

The engine exhibited evidence of post-crash magnesium fire, and also was heavily contaminated with sand, which was reportedly used in an attempt to extinguish the fire. The engine exhibited extensive corrosion, consistent with prolonged exposure to a moist environment.

The engine had been severed immediately aft of the 3rd stage turbine nozzle. The compressor discharge tubes, oil lines, pneumatic lines and thermocouple lines exhibited evidence of high-energy debris impacts. Damage was consistent with high energy impact from liberated turbine disc debris.

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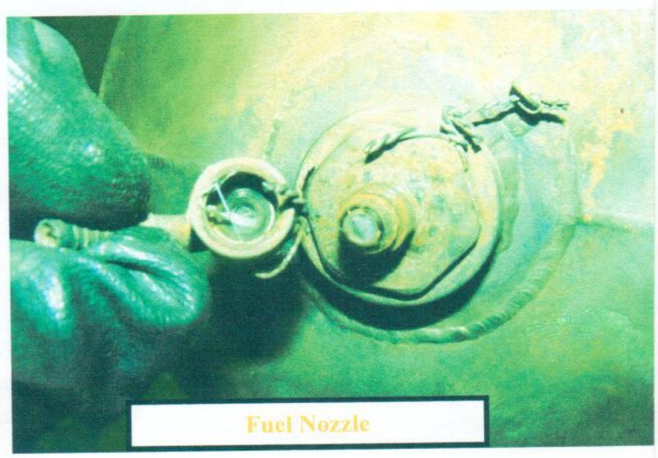
The gas generator turbine module, combustion section and compressor discharge tubes were removed from the engine as a single unit, and then examined separately.

Remains of Gas Generator Turbine and Combustor

The combustor outer case and inner liner were removed and examined. Both were contaminated by sand and corrosion. The liner exhibited no evidence of streaking or abnormal combustion. All damage to the outer case is attributable to either the turbine disc burst or crash damage.

The fuel nozzle exhibited surface corrosion which obliterated the engraved serial number and part number. The fuel nozzle inlet fitting was clogged with what appeared to be spider's web. The fuel nozzle could not be disassembled due to heavy corrosion.



Fuel Nozzle

The first stage nozzle shield was removed and examined. It exhibited no evidence of metal splatter or abnormal combustion (streaking). Removal of the nozzle shield exposed the #8 bearing oil sump cover. No evidence of oil leakage from this cover was present. The oil sump cover was then removed, exposing the #8 bearing.

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The #8 bearing chamber exhibited patches of corrosion throughout. The #8 bearing retainer snap ring had partially dislodged. No oil residue was present in the bearing chamber. The #8 bearing was removed and found to be dry, corroded and exhibiting operational damage. Although corroded, the #8 bearing oil jet was properly secured and was confirmed to flow a normal stream when flow checked with alcohol. The bearing and associated hardware was retained for detailed examination by the failure analysis laboratory.

#8 Bearing Chamber

The aft end of the fractured turbine tie bolt was located in its normal position, within the 1st stage turbine stub shaft. The tie bolt nut appeared to be in good condition, and examination of the threads revealed no evidence that the nut had loosened during operation. The fracture surface on the stub shaft was smeared, and the shaft itself was slightly deformed. The tie bolt section was retained for detailed examination by the failure analysis laboratory.

Aft End of Turbine Tie Bolt

The 1st stage turbine nozzle airfoils exhibited impact damage on the trailing edges. The nozzle diaphragm also exhibited radial impact marks and punctures. The first stage turbine energy absorption ring exhibited impact and deformation damage consistent with a 1st stage turbine overspeed burst. The 1st stage turbine stub shaft was retained for detailed examination by the failure analysis laboratory. No other pieces of the 1st stage turbine wheel were found.

The 2nd stage turbine and turbine nozzle assembly were also missing. There was insufficient evidence to determine if the 2nd stage turbine wheel had burst or had been liberated as a whole. The aft face of the power turbine support exhibited evidence of contact by the 2nd stage turbine wheel, which confirms forward movement of the 2nd stage turbine during engine operation.

The power turbine support was extensively damaged by liberated turbine debris and corrosion.

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The turbine splined adapter was spread radially (bell-mouthed) on the aft end and bulged in the middle. Witness marks on the aft internal splines are consistent with turbine rotation as the splined adapter became excessively hot and subsequently opened up under centrifugal load. The opening up of the aft end of the splined adapter would allow the gas generator turbine to disengage from the compressor.

Turbine Splined Adapter

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Compressor Removal

The compressor module was inspected and then removed from the auxiliary gearbox.

Compressor, showing #2 bearing and Spur Adapter Gearshaft

The compressor had been damaged by fire and had corroded extensively. Sand was present throughout the compressor gas paths. There was no evidence of foreign object ingestion or operational failure of the compressor. The bleed valve had been mostly consumed by fire.

Removal of the compressor module allowed inspection of the spur adapter gearshaft and #2 bearing. Both were heavily corroded, devoid of oil, and appeared to have suffered no operational damage or failure. The compressor was not disassembled further.

Auxiliary Gearbox Examination

The auxiliary gearbox had been partially consumed by fire. The exterior of the gearbox housing was blackened and had begun to corrode.

The engine auxiliary components were removed. The starter generator was damaged by fire and could not be rotated by hand. The drive shaft was intact. The HMU was partially consumed by fire. The control arm could be moved by hand and various internal components also moved when the control arm was manipulated. The drive shaft was intact and could not be rotated by hand. The fuel pump was fire damaged, but the drive shaft could be rotated by hand.

When the gearbox was opened, revealing the interior of the gearbox, all major components were found in the correct locations. There was no evidence of operational failure or malfunction of the gearbox. The gearbox was mostly dry, although small traces of oil trickled from several undetermined locations.

Internals of Auxiliary Gearbox

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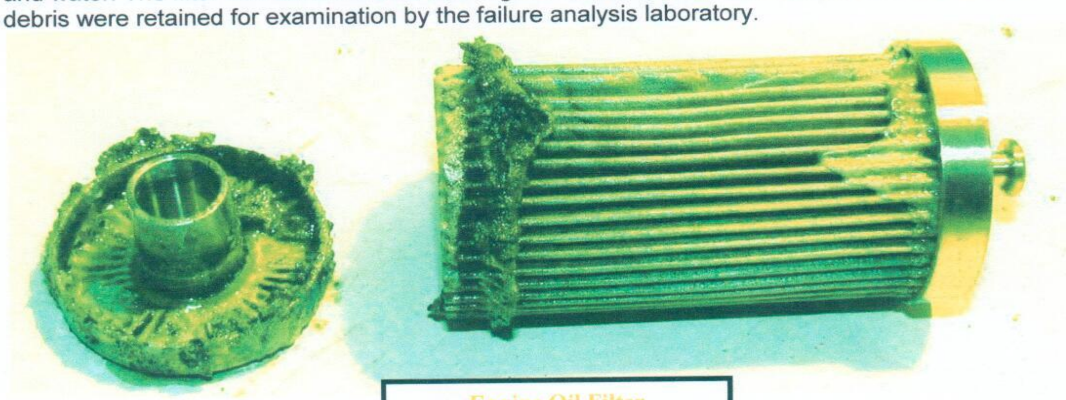
The upper and lower magnetic chip detectors were removed and inspected. Both had captured a small amount of ferrous debris. The upper magnetic chip detector had captured what appeared to be a bearing roller pin. Both detectors and their debris were retained for examination by the failure analysis laboratory.

Upper Magnetic Chip Detector

The engine's fuel filter was opened and examined, and found to contain no debris.

The engine's internal oil filter was removed and examined. The filter chamber contained both oil and water. The filter was contaminated with organic matter and metallic debris. The filter and its debris were retained for examination by the failure analysis laboratory.

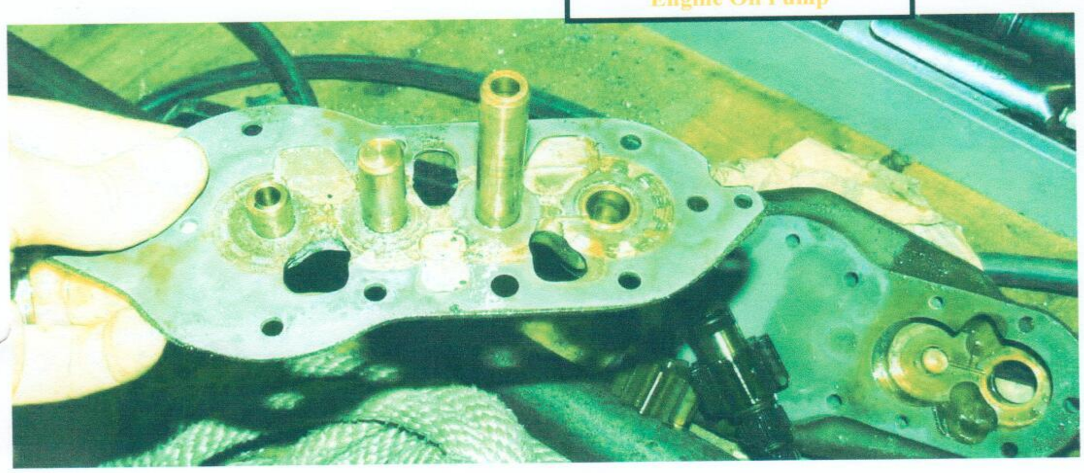


Engine Oil Filter

Gitto Construzioni - S/N CAE 847353 **21** October 2009

The engine oil pump was then disassembled. When opened, the interior of the pump was oil-wetted. All gear-rotors were intact and appeared undamaged. The oil pump drive shaft was intact and could be rotated easily by hand. A small amount of metallic debris was present within the pump, and the pump exhibited evidence of having operated with contaminated oil, with light gouging being noted along the rotational paths of the gear-rotors. There was no evidence of operational failure or malfunction of the pump.

Engine Oil Pump



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Summary of Findings

The 1st stage turbine wheel suffered an overspeed burst.

There was insufficient evidence to determine the disposition of the #2 turbine wheel.

Analysis of the #5, #6, #7 and #8 bearings indicate indicates thermal damage.

Damage to the #6 and #7 bearings is consistent with a lack or loss of lubrication.

Ductile deformation and expansion of the turbine spline adapter are consistent with extremely high temperatures being reached in the #6/7 bearing chamber.

The aft end of the turbine splined adapter expanded well beyond the splines on the gas generator turbine, allowing the turbine to decouple.

Witness marks on the inner splines of the turbine splined adapter are consistent with a decoupling of the gas generator turbine from the compressor at the turbine splined adapter.

A sudden decoupling of the gas generator turbine from the compressor during engine operation can result in an overspeed of the gas generator turbine.

Rolls-Royce

Rolls-Royce Corporation
P.O. Box 420
Indianapolis, Indiana
46206-0420 USA

Tel: 317-230-8907
Fax: 317-230-3381
Speed code: P-38
CNA0759-SLE-04-2012

27 April 2012

To: NTSB Investigator, Accredited Representative

Subject: Rolls-Royce M250-C47B Loss of Power on Aircraft Operated by Gitto Construction

Dear

The purpose of this memo is to document the findings of an investigation into the 21 October, 2009 incident involving a Bell 407 aircraft wherein a M250-C47B engine (Serial Number CAE 847353) experienced a loss of power.

Incident Description
On the flight leg from Calabar to Uyo airport, the crew (pilot and maintenance engineer) noticed low oil pressure and a chip detector indication on the transmission system. After landing at Uyo airport the maintenance engineer reported that he carried out maintenance inspection on the transmission oil system and checked the transmission chip detector and was satisfied. He then carried out an engine ground run and determined that all indicating systems were normal.

The crew then decided to continue the flight from Uyo to Port Harcourt. Within 5 to 9 minutes after takeoff, engine oil pressure dropped to zero and an engine chip detector indication was observed. The crew decided to make an air return to the helipad, but was unsuccessful as a "loud bang" was heard from the engine, with loss of power. The aircraft descended uncontrolled to the ground crashing as a result with post crash fire. An effort was made to fight the fire with hand-held fire extinguishers and sand. This left the wreckage partially covered with sand, and significant evidence disturbed.

Investigation
It should be noted that the engine wreckage from this event was not received by Rolls-Royce until August 2011, some 22 months after the event. Information given to Rolls-Royce by the NTSB accredited representative indicated that during the interim period, the wreckage was not retained in a secured location. Hence, it cannot be determined whether all of the engine hardware that was present at the accident scene was sent to Rolls-Royce. This, together with inability to obtain maintenance records or the Engine Logbook, resulted in some uncertainty as to root cause and primary failure mode.

The subject engine was disassembled at Rolls-Royce Corporation on 8 September 2011, and the damaged parts were submitted to the Rolls-Royce Materials Laboratory for metallurgical examination. Results of teardown inspection and the metallurgical investigation are as follows:

- The specific cause of the in-flight loss of power could not be conclusively determined, but general damage to the engine was indicative of an overspeed burst of the First Stage Turbine Wheel.
- Damage found on the No.5, No. 6, No. 7 and No. 8 Bearings was consistent with operating with insufficient lubrication. The No. 6 Bearing was severely damaged and melted producing molten spatter deposits on adjacent components.
- The Turbine Splined Adapter was deformed outward which would cause the splined adapter to become decoupled from the Second Stage Turbine Wheel. This deformation and smearing observed on the Turbine Splined Adapter was indicative of rapid heating.
- A groove was worn into the aft face of the Power Turbine Support at the radial location which corresponds to the Second Stage Turbine Wheel forward seal arm suggesting a forward shift of the Gas Producer Turbine rotor. Damage to the No. 8 Bearing and its adjacent labyrinth seal is consistent with loss of axial location on the gas producer rotor.
- Damage to the Power Turbine Support and Power Turbine Rotor Assembly was consistent with secondary damage caused when the No. 6 Bearing lost its ability to radially locate the power turbine rotor.
- Damage to the Gas Producer Turbine Support and Energy Absorbing Ring was indicative of a First Stage Turbine Wheel burst.

The engine was found to be severed just forward of the Gas Producer Turbine Support. A significant amount of sand, which was used to attempt to fight the post-crash fire, was found throughout the engine.

The collection of hardware that was submitted to the Failure Analysis Laboratory for investigation is shown in Figure 1.

Since the Engine Log Book for the subject engine was not made available, it could not be determined whether these requirements were being met.

Conclusion

The conclusion of this investigation is that the root cause of loss of power was improper oil system maintenance which led to oil starvation, resulting in failure of the No. 6, No. 7 and No. 8 Bearings. As the No. 6 and No. 7 Bearings deteriorated and lost ability to center the Power Turbine and Gas Producer rotors, the Power Turbine Inner Shaft began rubbing on the outside diameter of the Turbine Splined Adapter. The resulting frictional heating of the Turbine Splined Adaptor weakened it and allowed the aft splined end to mushroom outward under the tangential stress imparted by torque from the Second Stage Turbine Wheel. This disconnected the turbine and compressor, resulting in a turbine overspeed. The subsequent overspeed of the Gas Producer rotor resulted in burst of the First Stage Turbine Wheel, and subsequent burst or release of the Second Stage Turbine Wheel. It cannot be determined if release of the Second Stage Turbine Wheel was due to a burst, or whether the wheel remained intact with the wreckage after the accident. No major portions of the Second Stage Turbine Wheel were included with the wreckage as shipped to Rolls-Royce.

Recommendations

It is important to follow the O&M manual instructions regarding oil system maintenance, as outlined above. With over 29.5 million hours of operation on M250 Series IV engines, these procedures have proven reliable to detect and prevent lubrication problems before they affect engine operation.

Regards,

Appendix VII

Last Engine Overhaul Carried out by Hants & Sussex Aviation U.K on the 8th April 2009, due to Gearbox Input Seal Leakage and Overhaul of the Turbine

HS Team 250 — AVIATION — LEADERS IN TURBINE SERVICE

Model 250 Summary Report

Unit Type: C47B	**Cust Ref:** 08458
Serial No: CAE 847353	**Receipt Date:** 08/04/2009
Project No: 6358396	**RR 250 Report A S/N:**

Introduction

Engine removed and shipped to H+S Aviation for a time continued repair due to a gearbox input seal leak and overhaul of the turbine as detailed in quotation Q3182.

Summary

On receipt at H+S Aviation Ltd, the engine was disassembled into modules to carry out the following work scope:

1. Turbine module fully disassembled to carry out a full overhaul of the turbine, including replacemen of the Stage 1 & 2 Wheels due to limited life remaining.

2. Compressor Assembly - Fully disassembled to carry out a time continued repair to ensure optimun compressor efficiency to maintain engine performance.

3. Gearbox Assembly - fully disassembled but leaving the oil pump assembled to investigate and rectify the leaking input seal.

4. Main build component including the combustion assembly were disassembled to carry out time continued repair.

5. The following accessoried were off loaded:

* Fuel Nozzle for clean and rig check - Passed test.

* Bleed Valve for rig check - note: required overhaul due to failing rig check.

* HMU - Currently under investigation.

Inspection findings:

On the completion of the Gearbox disassembly/inspection it was found that the Gearshaft assy, Spur, Power Train Tacho & PMA P/N 6889157 was found to have fretting on the seal running surface which affected the Teflon coated area of the seal from preventing the oil leak. There was also a highl polished area on the shaft under this contamination, which will have contributed to the leak. Please see photos previously supplied.

HMU P/N 23078031 S/N JGALM0636: On receipt it was found to be in a dirty condition and the throttle max stop was broken off. (Seperated). The HMU has been cleaned/rig tested and found that i would not go into manual mode, therefore it is currently under investigation for repair.

During inspection of the Compressor Assembly it was found that the Compressor Scroll Assembly P/N 23074076 S/N FU40321 plug had seperated at the turning vane area. There is currently no repai

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available but a request for a one off repair has been submitted to Rolls-Royce.

Please note: At the request of the customer a cost estimate and condition report have processed and will be submitted for approval prior to the engines complete findings i.e results of the HMU and Compressor Scroll Assembly and therefore may effect the final invoice costing.

See Inspection report for full details of replacement and repairable components.

CEB Embodiments:

72-6019 Rev 3: Engine accessory gearbox oil filter housing add bronze bushing to 'oil in' 'oil out' & bypass ports.

72-6023 Rev 1: Engine Turbine Assy - Recoating of inner power turbine shaft.

72-6037 Rev 6: Engine, turbine assy - Inspection and replacement of 1st Stage Nozzle Heat Shield.

72-6043 Rev 0: Engine, main accessory gearbox - release of rework and reidentified lip seals.

72-6051 Rev 0: Engine turbine assy release of new 2nd Stage turbine splined adapter and splined lock nut.

72-6052 Rev 0: Engine gearbox assy - replacement of breather gear seal.

72-6053 Rev 0: release of new centrifugal beather gearshaft with molybdenum coating.

72-6055 Rev 2: Compressor rear support - inspect no.2 bearing lock key slot radii.

Date: 14/05/2009

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For and on behalf of H+S Aviation Ltd

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Appendix VIII: Engine and Transmission Oil Pressure Indicators

ENGINE OIL PRESSURE

50 PSI	Minimum
50 to 90 PSI	Operation below 79% NG RPM
90 to 115 PSI	Continuous operation below 94% NG RPM
115 to 130 PSI	Continuous operation
130 PSI	Maximum for continuous operation
200 PSI	Maximum for cold start

ENGINE OIL TEMPERATURE

0 to 107 C	Continuous operation
107 C	Maximum

TRANSMISSION OIL PRESSURE

30 PSI	Minimum
40 to 70 PSI	Continuous operation
70 PSI	Maximum

TRANSMISSION OIL TEMPERATURE

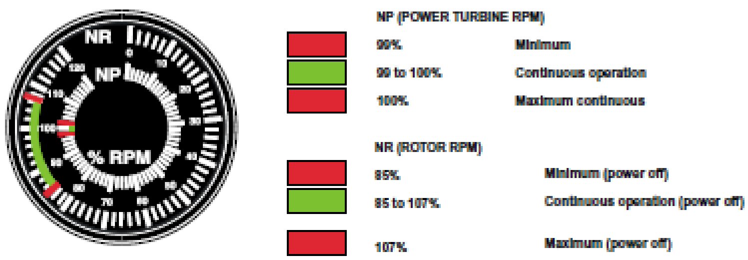
15 to 110 C	Continuous operation
110 C	Maximum

NG (GAS PRODUCER RPM)

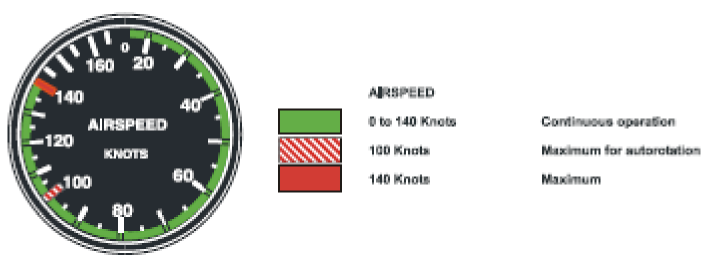
63 to 105%	Continuous operation
105%	Maximum continuous operation
106%	Maximum transient, 10 seconds

Appendix IX

A) POWER TURBINE (NP) AND ROTOR (NR) RPM INDICATOR

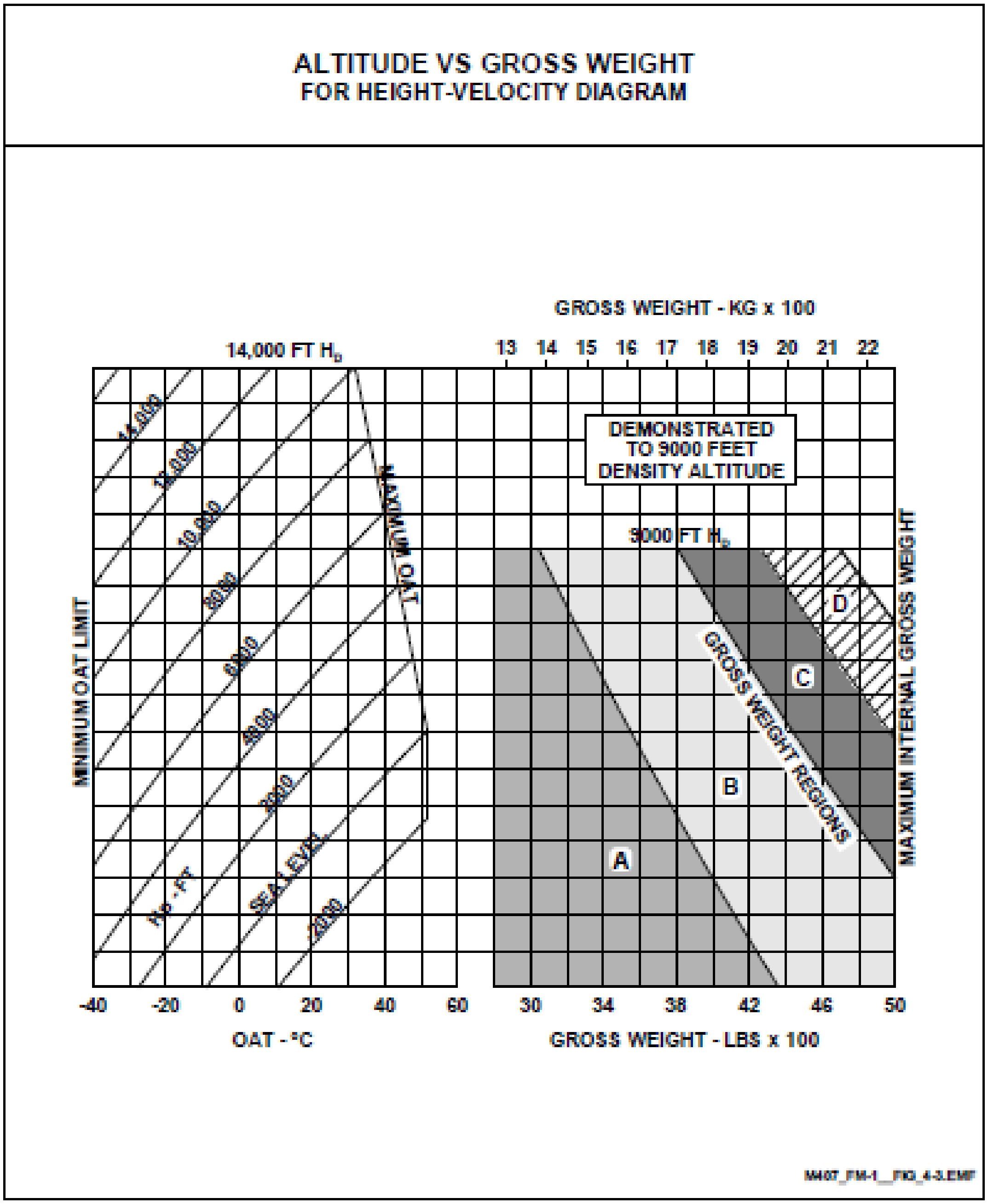


B) AIRSPEED INDICATOR



Appendix X

A) ALTITUDE VS GROSS WEIGHT



B) HEIGHT VS VELOCITY

HEIGHT-VELOCITY DIAGRAM
FOR GROSS WEIGHT REGIONS A TO D