



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 4, 2022

POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT

NTSB No.: ENG20LA046

A. INCIDENT

Location: Donalsonville, Georgia, USA

Date: September 28, 2020

Time: 1630 Eastern Daylight Time (GMT-4)

Aircraft: Thrush S2R-H80, Registration N6216K

Operator: Spring Creek Aviation (doing business as Custom Ag and Air Incorporated)

B. POWERPLANT GROUP

Powerplant Group Chairman: Stephen J. Yee
Powerplant Engineer
National Transportation Safety Board
Washington D.C.

Accredited Representative (Czech Republic): Stanislav Suchý
Accident Investigator
Air Accidents Investigation Institute
Prague, Czech Republic

Technical Advisor: Sam Farmiga
Flight Safety Investigator
General Electric Aviation
Cincinnati, Ohio

Technical Advisor (Czech Republic): Zuzana Sekerešová
Flight Safety Leader
General Electric Aviation Czech
Prague, Czech Republic

C. SUMMARY

On September 28, 2020, about 1630 eastern daylight time (EDT) a Thrush S2R-H80, N6216K, powered by one General Electric Aviation Czech (GEAC, formerly Walter Aircraft Engines a.s.) H80-100 turboshaft engine, was involved in an incident approximately seven miles northwest of Donalsonville Municipal Airport (17J), Donalsonville, Georgia. According to the pilot, he departed 17J at 1600 EDT with 350 gallons of pesticide to spray peanut fields. While maneuvering to re-enter a field, he reported that the “engine came apart” and he force landed the airplane in the peanut field. During landing, the landing gear sunk into the wet field and the airplane nosed over. The pilot reported that there was no damage to the airframe, but he observed a hole in the turbine engine case and nacelle consistent with an uncontained engine failure as well as propeller blade damage. The pilot was not injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 137 aerial application flight.

The airplane was recovered, and the engine was removed and shipped to the manufacturer GEAC, Prague, Czech Republic for examination and disassembly.

Visual examination of the engine revealed the power turbine (PT) disk was separated from the reduction gear box (RGB) but remained in the engine. The PT disk tie bolts connecting the PT shaft to the disk had all been fractured. When the RGB was disassembled the stages 1 and 2 planetary gear sets had several damaged and fractured gear teeth. The sun gear was found with all its gear teeth fractured and missing. Two of the six nuts used to secure the torque meter support to the countershaft casing were missing.

Several components from the RGB and PT were sent to the General Electric (GE) Aviation Materials Lab for further examination and failure analysis. Imprint marks found on the teeth of one stage 1 planetary gear were inconsistent with the expected witness marks created during engagement with the crown wheel. The metal debris found lodged in the crown wheel was determined to be consistent with the material used for the nuts of the torque meter support. Fractography conducted on the RGB sun and planetary gears revealed high contact stress conditions leading to teeth fracture initiating near the root land due to overload.

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E. ACRONYM TABLE

ACRONYM	DEFINITION	ACRONYM	DEFINITION
AD	Airworthiness Directive	GEAC	General Electric Aviation Czech
ALF	Aft Looking Forward	GMT	Greenwich Mean Time
ASB	Alert Service Bulletin	ICAO	International Civil Aviation Organization
CSN	Cycles Since New	NTSB	National Transportation Safety Board
EASA	European Aviation Safety Agency	p/n	Part Number
EDT	Eastern Daylight Time	PT	Power Turbine
ESN	Engine Serial Number	RGB	Reduction Gearbox
FAA	Federal Aviation Administration	SB	Service Bulletin
FLA	Forward Looking Aft	s/n	Serial Number
GE	General Electric	TSN	Time Since New

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H. DETAILS OF THE INVESTIGATION

1.0 Engine and Airplane Information

1.1 Engine Description

The incident airplane was powered by a GEAC (formerly Walter Aircraft Engines a.s.) H80-100 turboshaft engine (**Figure 1**). The H80-100 series engine is based on the Walter M601E-11 series engine design and is a free turbine turboshaft engine that features two independent parts: the gas generator and the propulsor. The gas generator contains two axial compressor stages, one centrifugal compressor stage driven by a single-stage axial turbine, an annular combustor with fuel spray ring, and a power section with single-stage axial turbine. The propulsor consists of a two-stage countershaft RGB designed to operate with a dual acting propeller and water injection. A torquemeter provides shaft power evaluation.

The Federal Aviation Administration (FAA) Type Certificate Data Sheet E00048EN, Revision 16, dated March 9, 2020, states the H80-100 engine produces 800 shaft horsepower at sea level at maximum continuous and at takeoff rating (five minutes). Takeoff rating is flat rated to 105.8°F (41°C) at sea level static and maximum continuous rating is flat rated to 87.8°F (31°C) at sea level static¹.

All directional references (front, rear, right, left, top, bottom, clockwise, counterclockwise) are made aft-looking-forward (ALF) unless otherwise specified. All numbering is in the circumferential direction starting with no. 1 at or immediately clockwise from the 12 o'clock position and progressing sequentially clockwise ALF.

1: Engine rating is based on International Civil Aviation Organization (ICAO) International Standard Atmosphere sea level, static conditions with no installation losses, compressor intake screen installed, no external accessory loads, and no air bleed.

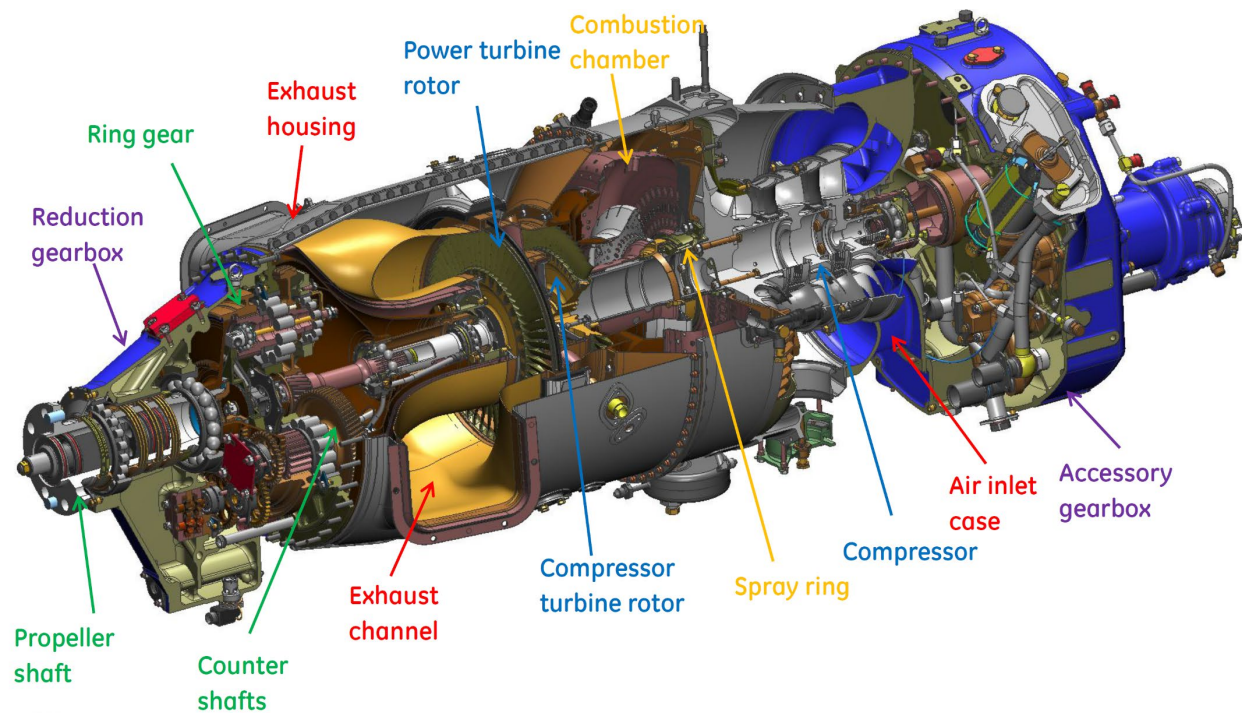


Figure 1: Cross-Section View of a GE H80 Turboprop Engine

(Figure Courtesy of GEAC)

1.2 Engine History and Maintenance

The incident engine, engine serial number (ESN) 143016, passed an initial acceptance test at GE Prague on October 23, 2014.

Long metallic chips found during a periodic inspection prompted a RGB replacement which was performed at Prime Turbines in Dallas, Texas, USA on February 8, 2019 in accordance with GEAC Service Bulletin SB-H80-72-00-00-0044 Revision 3. Prime Turbines stated the nuts and lock washers that secured the torque meter support to the roller bearing housing were not touched during the RGB replacement. The engine had accumulated 1,854 hours time since new (TSN) and 3,346 cycles since new (CSN) at the time of the gearbox removal.

GEAC released Service Bulletin SB-H80-72-00-00-0044 Revision 01 on September 14, 2018 to identify engines with potential risk of long, hair-like metallic chips on the RGB oil screen and increased axial play in the propeller. The current service bulletin Revision 03 was released on April 27, 2020.

GEAC released Alert Service Bulletin ASB-H80-72-00-00-0025 Revision 03 on July 24, 2018 to install a modified engine outlet system designed to prevent uncontainment of power turbine components during an overspeed event. The European Aviation Safety Agency (EASA) issued Airworthiness Directive (AD) 2017-0151R1 on December 5, 2018 and the FAA issued AD 2020-15-04 effective August 31, 2020 mandating the GEAC ASB. The incident engine was within the 10-year compliance time requirement defined by the AD and had not yet complied with the AD at the time of the event.

According to GEAC maintenance records, the incident engine had accumulated 2,762 hours TSN and 4,955 CSN at the time of the incident.

2.0 Airplane Examination

The airplane landed in a peanut field (**Photo 1**) and it was revealed the engine had a hole at approximately the 7 o'clock position (**Photo 2**).



Photo 1: Aircraft Forced-Landing in a Field Post-Incident

(Photo Courtesy of GEAC)



Photo 2: Hole Seen in Left-Hand Side of Engine after Engine Cowl Removal

(Photo Courtesy of GEAC)

3.0 Engine Examination

The incident engine was disassembled by technicians at the GEAC facility in Prague, Czech Republic between October 20-22, 2020. Representatives from the Czech Air Accidents Investigation Institute and GEAC were in attendance. The NTSB did not travel for this examination. **Photo 3**, **Photo 4**, and **Photo 5** show the engine data plate and the as-received engine condition. All details of the examination were provided by GEAC and **Figure 2** below highlights the components requiring further metallurgical examination.



Photo 3: ESN 143016 Data Plate

(Photo Courtesy of GEAC)

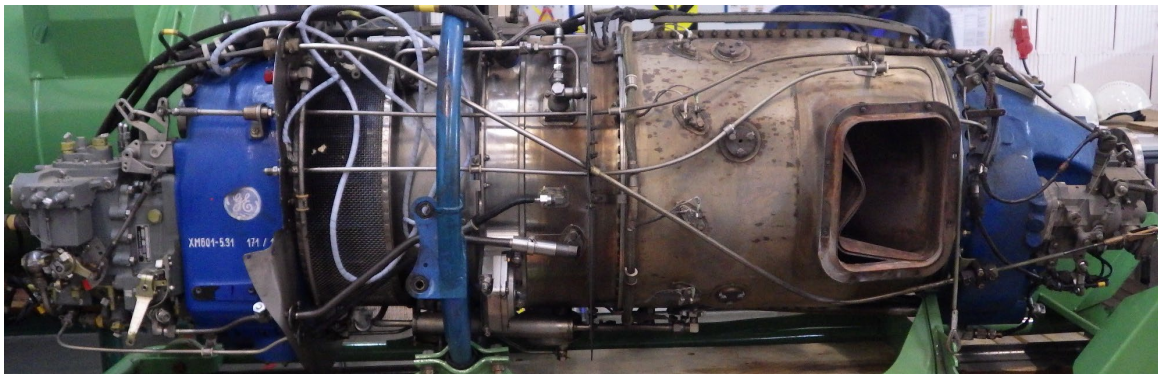


Photo 4: Engine Right-Side As-Received

(Photo Courtesy of GEAC)



Photo 5: Engine Left-Side As-Received

(Photo Courtesy of GEAC)

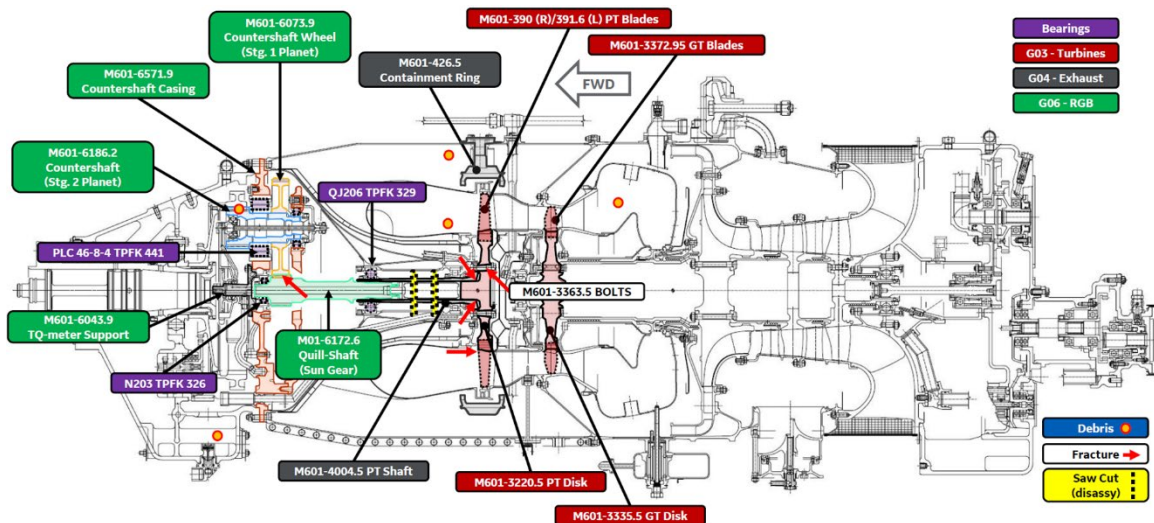


Figure 2: Engine Cross-Section Identifying Components Included in Examination

(Figure Courtesy of GEAC)

The PT disk (**Photo 6**) was found separated from the PT shaft with a fractured forward pin and all eight PT disk coupling bolts fractured. Five blade root attachments were found still installed in the disk. Additionally, nine blade attachments and remnants from several PT blades were found inside the engine. All of the recovered blade attachments were found with transverse airfoil fractures near the air-foil-to-platform transition area.

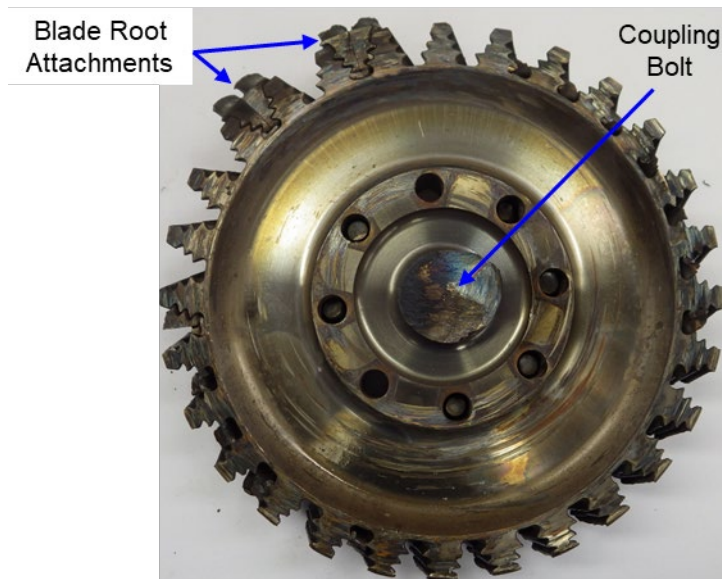


Photo 6: Separated PT Disk, Damaged Blade Attachments and Fractured Coupling Bolt

(Photo Courtesy of GEAC)

The roller bearing housing was exposed when the RGB was removed from the engine. The torque meter support was secured to the roller bearing housing by nuts and lock washers that are threaded onto six studs. Two of the six studs located at the 3 and 11 o'clock positions forward looking aft (FLA) were found with the nuts and lock washers missing. The lock washers at the 1 and 9 o'clock positions were found with the large tabs broken off (**Photo 7**). One nut was found crushed within the crown wheel gear teeth while another was found fragmented within the RGB.

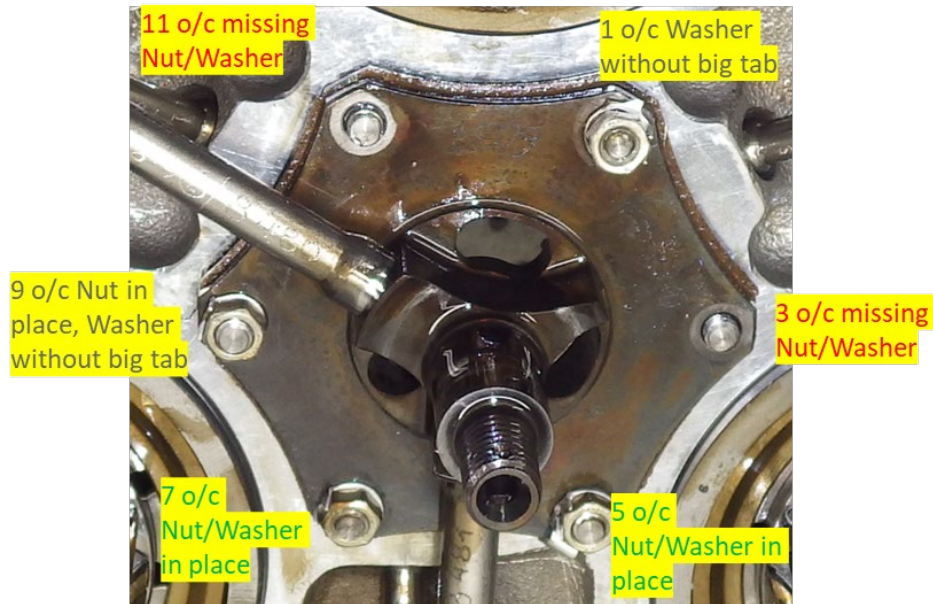


Photo 7: FLA View of Torque Meter Support within RGB

(Photo Courtesy of GEAC)

Five of the six threaded studs exhibited deformation (bent), damaged threads, or both (**Photo 8**). Only the 3 o'clock position threaded stud appeared undamaged. The countershaft casing had radial cracks located at the 1, 5, and 9 o'clock stud positions (**Photo 9**).

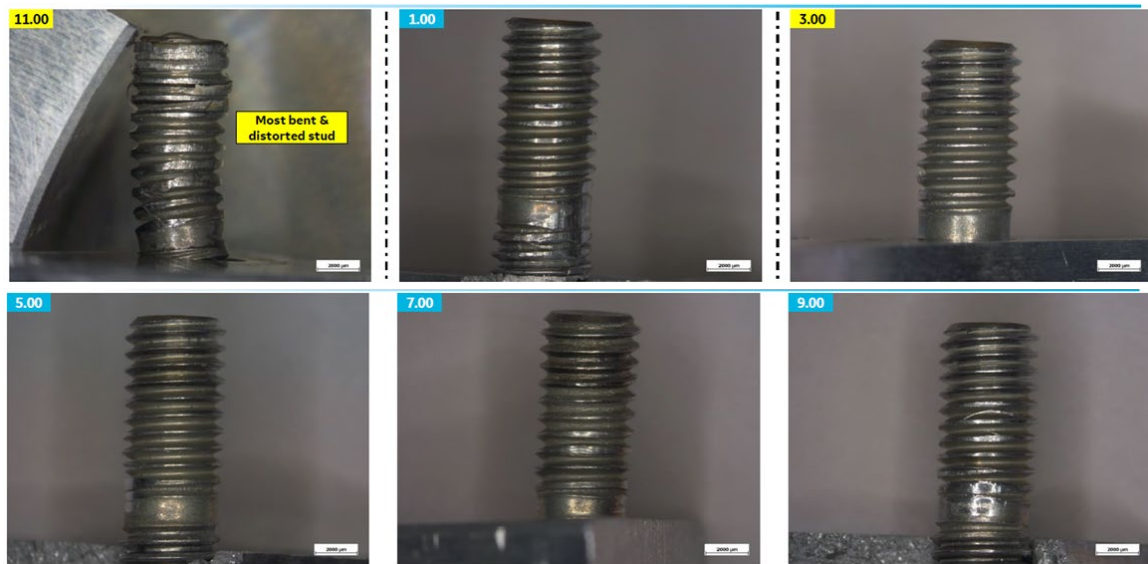


Photo 8: Condition of Threaded Studs With The 3 o'clock Stud Relatively Undamaged

(Photo Courtesy of GEAC)

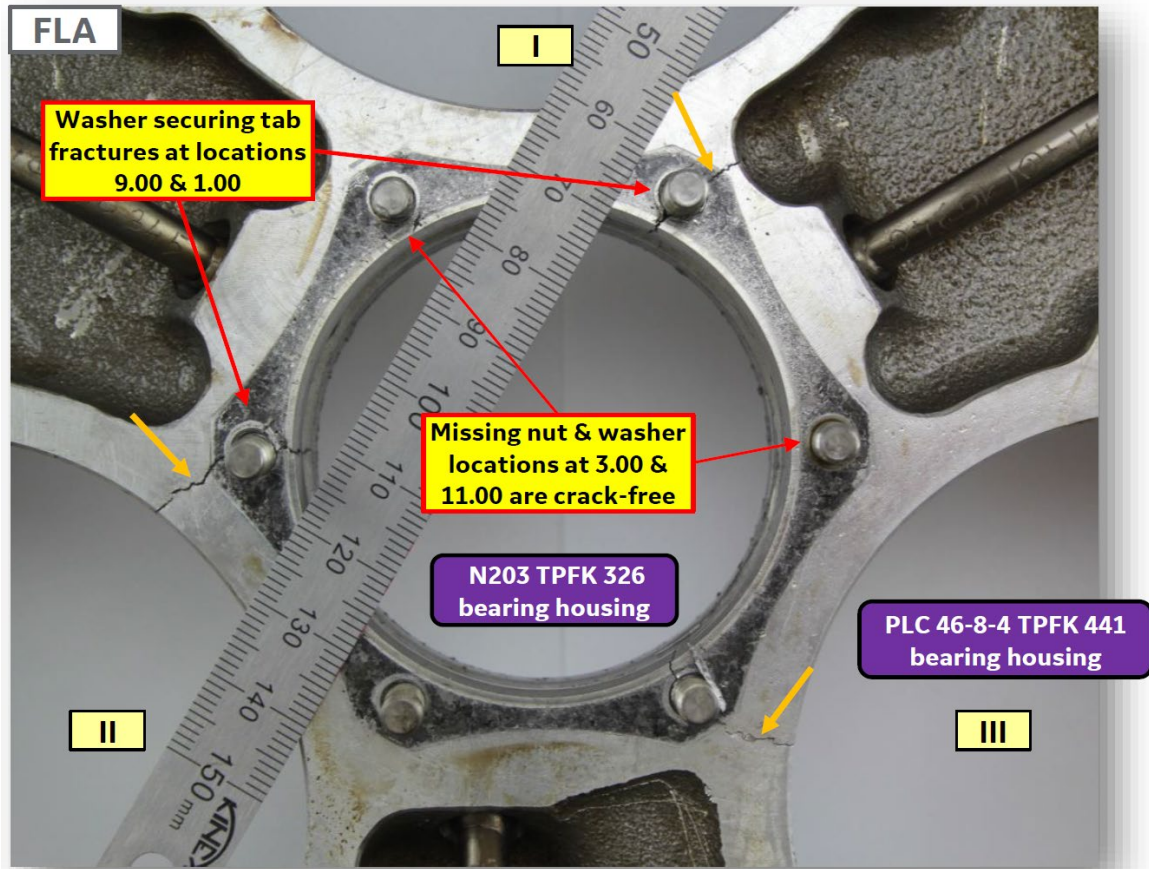


Photo 9: Orange Arrows Indicate Radial Crack Locations in the Countershaft Casing
(Photo Courtesy of GEAC)

A diagram of how the countershaft gears, quill shaft, and crown wheel mesh together within the RGB is shown in **Figure 3** below. Three countershaft gears, referred to as stage 1 planetary gears, exhibited sections of consecutive teeth around the disk with various levels of damage (**Photo 10**).

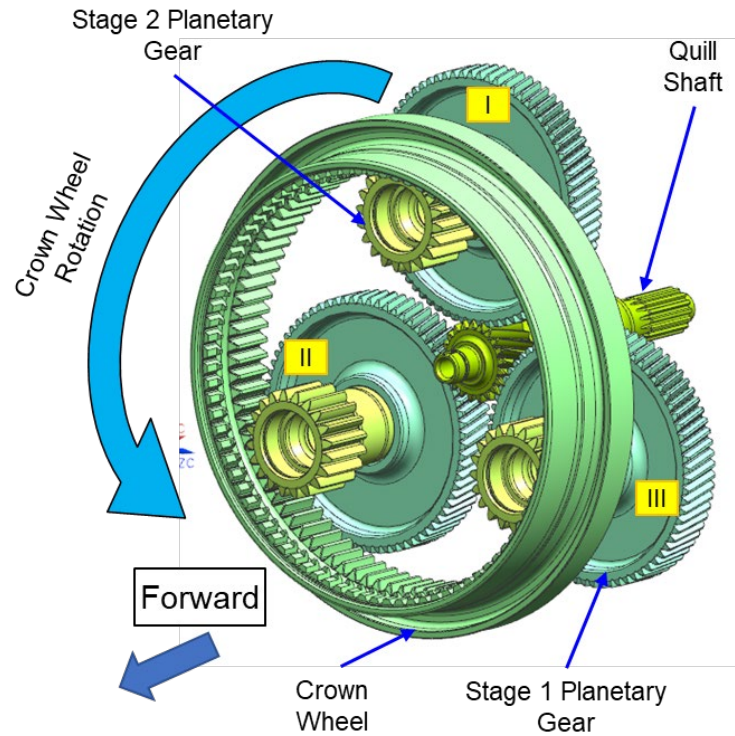


Figure 3: Gear Assembly Within the RGB

(Figure Courtesy of GEAC)

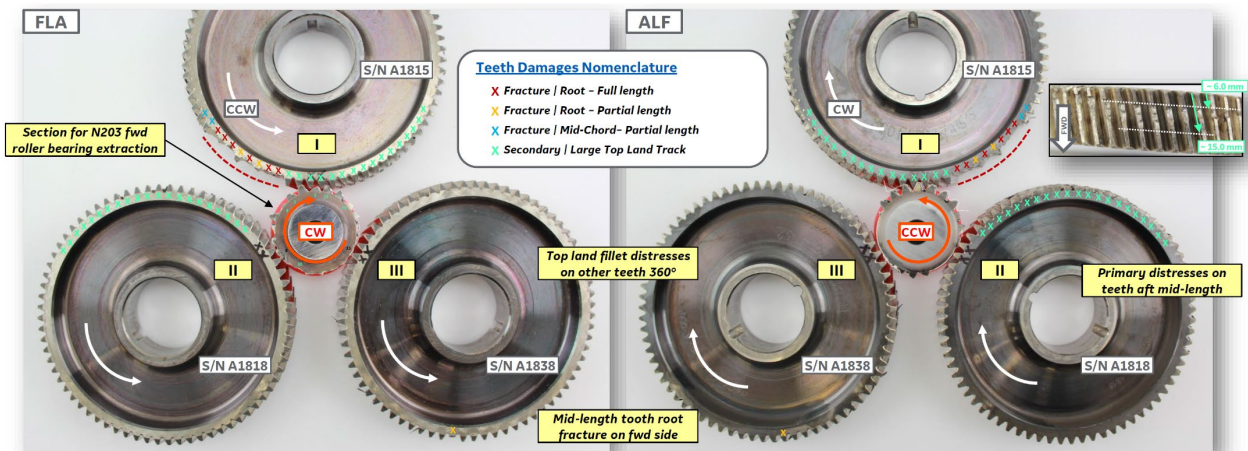


Photo 10: Damage Mapping of Stage 1 Planetary Gears

(Photo Courtesy of GEAC)

All three countershafts, referred to as stage 2 planetary gears, were intact. One gear (**Photo 11**) had imprint marks transverse to both the loaded and unloaded faces of multiple gear teeth.

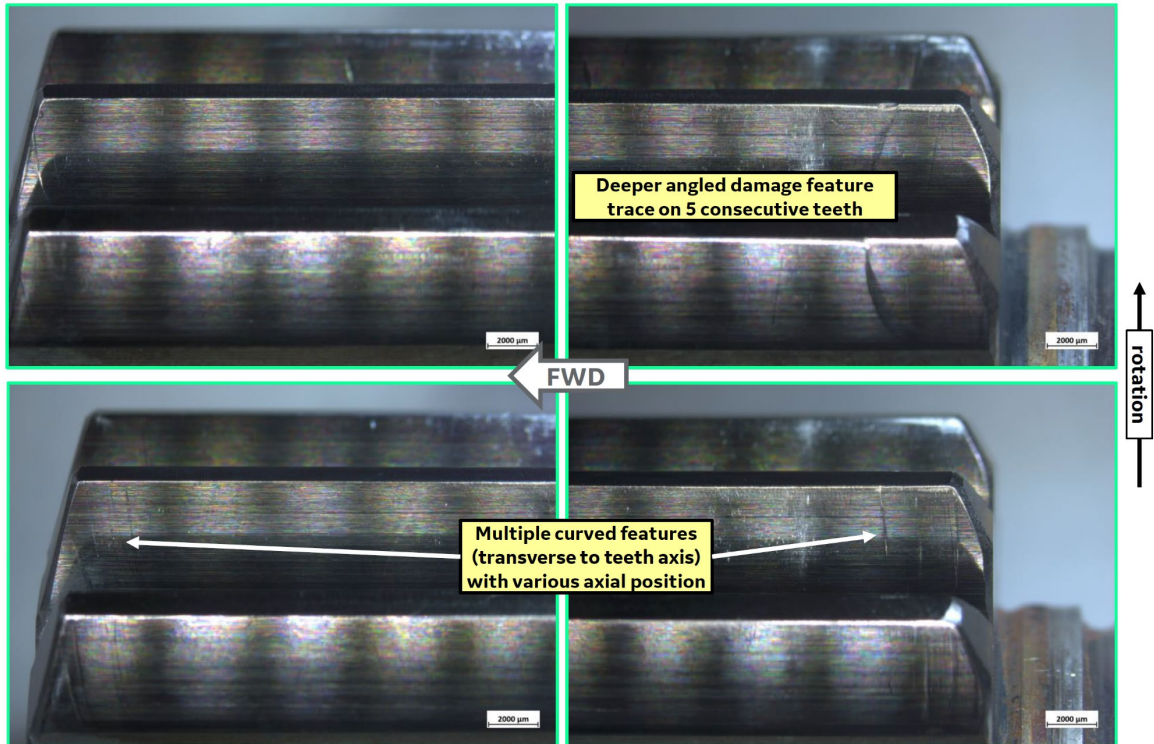


Photo 11: Imprint Marks Seen on Stage 2 Planetary Gear s/n H1515

(Photo Courtesy of GEAC)

The aft end of the quill shaft (**Photo 12**) was visibly bent and displayed torsional deformation immediately forward of the aft splines. All the forward roller bearings were flattened and had material displacement. The forward spline gear teeth were missing apart from the apparent remains of the forward and aft spline regions. The aft end of the shaft had a semicircular region of discoloration.



Photo 12: Quill Shaft As-Received

(Photo Courtesy of GEAC)

4.0 Metallurgical Examination

The stages 1 and 2 planetary gears, quill shaft, countershaft casing, crown wheel, and PT shaft/disk coupling were sent to GE Aviation Material Laboratory in Evandale, Ohio, USA for analysis. The GE metallurgy report **Attachment 1** is available in the docket.

Visual inspection of the stage 1 planetary gear located in position one (**Photo 10**) showed eight consecutive gear teeth (numbered N_0 to N_7) with macro-fractographic features (**Photo 13**). Smooth initiation regions can be seen transitioning to greater topographical changes suggesting the fractured teeth had fatigue initiation from the root fillet area of the loaded tooth faces that propagated across the tooth in the circumferential direction toward the unloaded faces. Tooth N_0 had a noticeably larger flat fracture surface than the adjacent fractured teeth.

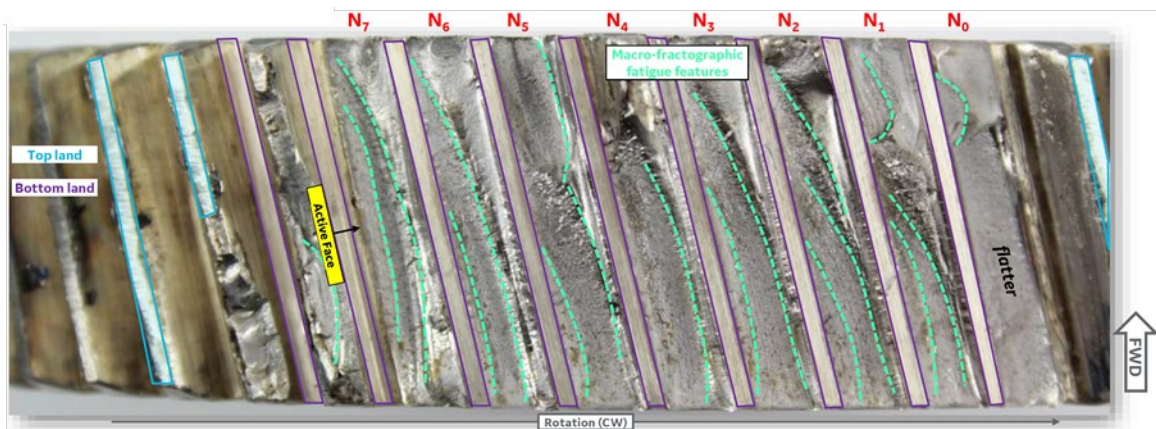
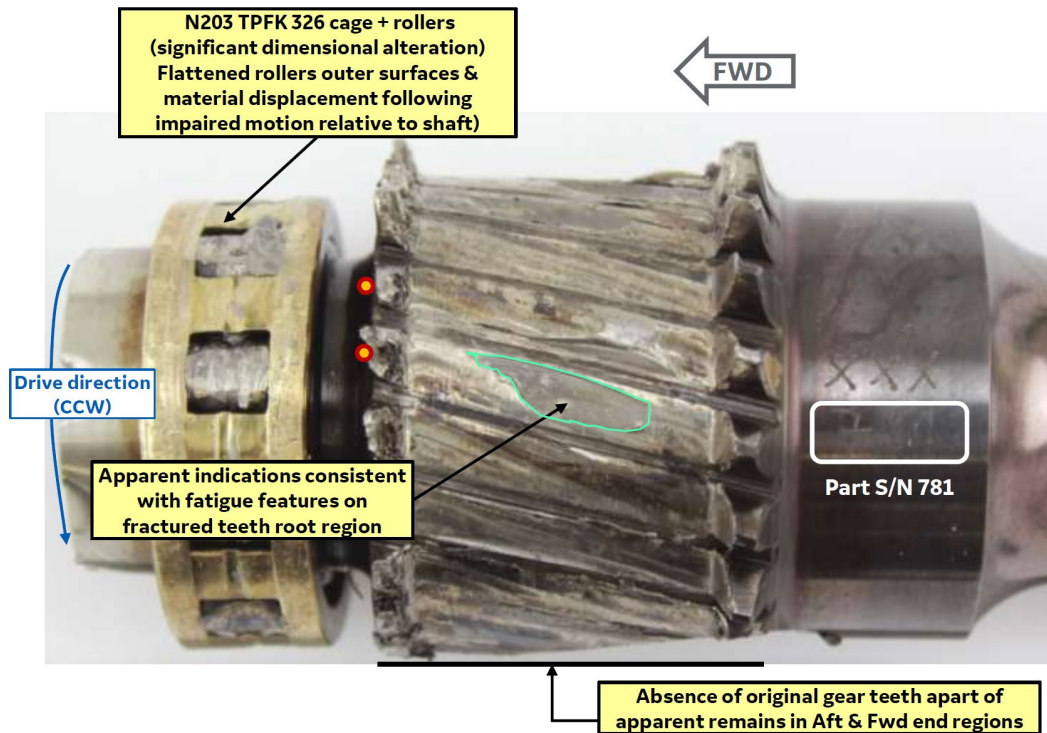


Photo 13: Fatigue Features Seen on Eight Adjacent Teeth of Stage 1 Planetary Gear s/n A1815
(Photo Courtesy of GEAC)

Fatigue macro-features were found emanating from the loaded tooth faces on several sun gear teeth root land fracture surfaces (**Photo 14**). Imprint witness marks were found on the liberated sun gear teeth debris indicating high contact stress from the mating planetary gear teeth. Microstructure and micro-hardness tests demonstrated the sun gear material conformed to the intended material specifications.



Apparent macro-fractographic features ●

Photo 14: Forward End of Sun Gear

(Photo Courtesy of GEAC)

The crown wheel was found with deformed metal debris lodged between the gear teeth (**Photo 15**). This debris was consistent with the M5 nut material used to secure the torque meter support flange to the countershaft casing.

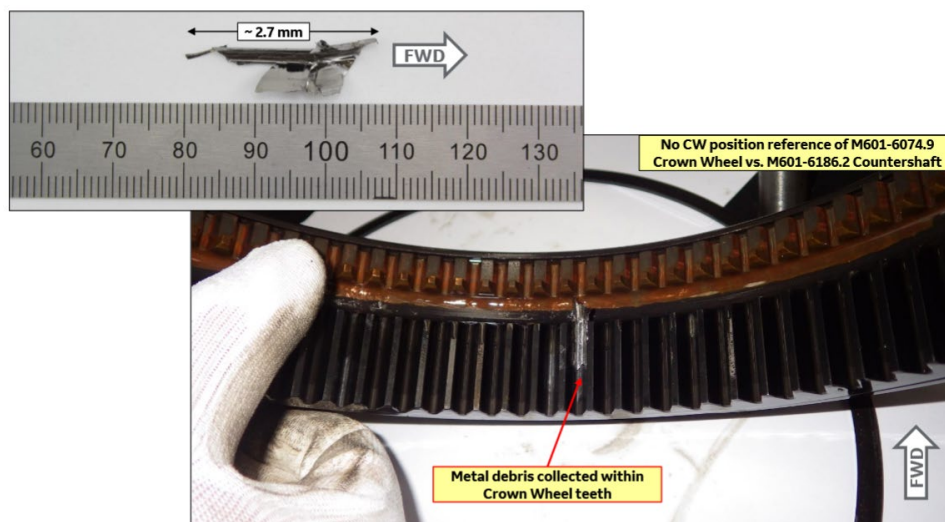


Photo 15: Crushed Metal Debris Found Lodged in Crown Wheel

(Photo Courtesy of GEAC)

Mapping of the seized T-head bolts that connect the PT shaft to the PT disk showed three failure components (**Photo 16**).

1. Shear from the 9 o'clock (bolt no. 7) to 3 o'clock (bolt no. 3) positions ALF indicated by the T-head bolts having 45° fracture surfaces;
2. Torsion from the 7 o'clock (bolt no. 6) to 6 o'clock (bolt no. 5) positions ALF indicated by the T-head bolts having flat fracture surfaces; and,
3. Axial at the 5 o'clock (bolt no. 4) position ALF indicated by the T-head bolt necking.

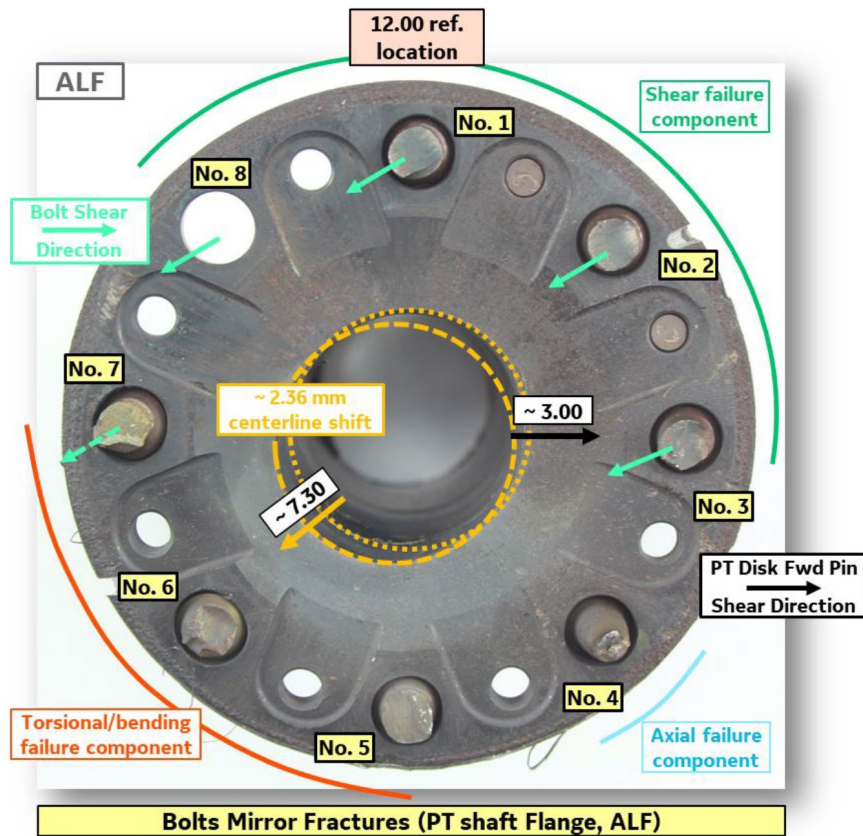


Photo 16: Distinct Failure Components Seen in PT Shaft Flange Bolt Fractures
(Photo Courtesy of GEAC)

The PT disk (**Photo 17**) had circumferential rub marks on the forward side inboard disk web approximately 180° around the circumference. The disk forward pin was sheared outboard at approximately the 3 o'clock position ALF. The fracture surface was smeared and had a blueish tint.

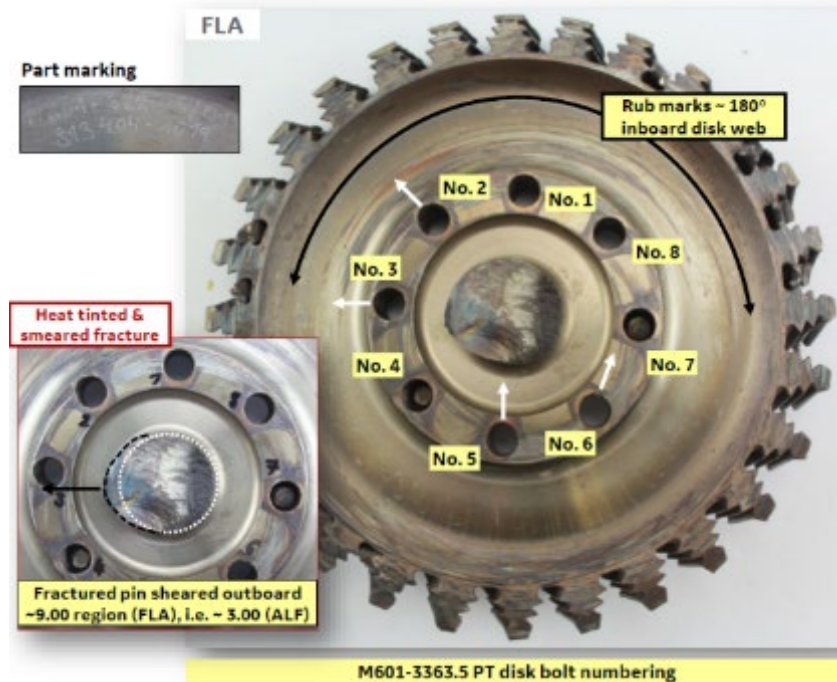


Photo 17: Fractured PT Disk Pin and Circumferential Rub Marks Seen on Forward Side
(Photo Courtesy of GEAC)

5.0 Recorder Data

The incident airplane was equipped with an Electronics International, Inc. MVP-50T engine monitor. The operator shipped the monitor to the NTSB Vehicle Recorders Laboratory in Washington, D.C. where the data from 2,289 flights was successfully downloaded. The data was delivered to GEAC on December 7, 2020. Intermittent fluctuations and signal drops in engine torque were recorded during previous flights however no abnormal behavior was observed during the incident flight (**Figure 4**).

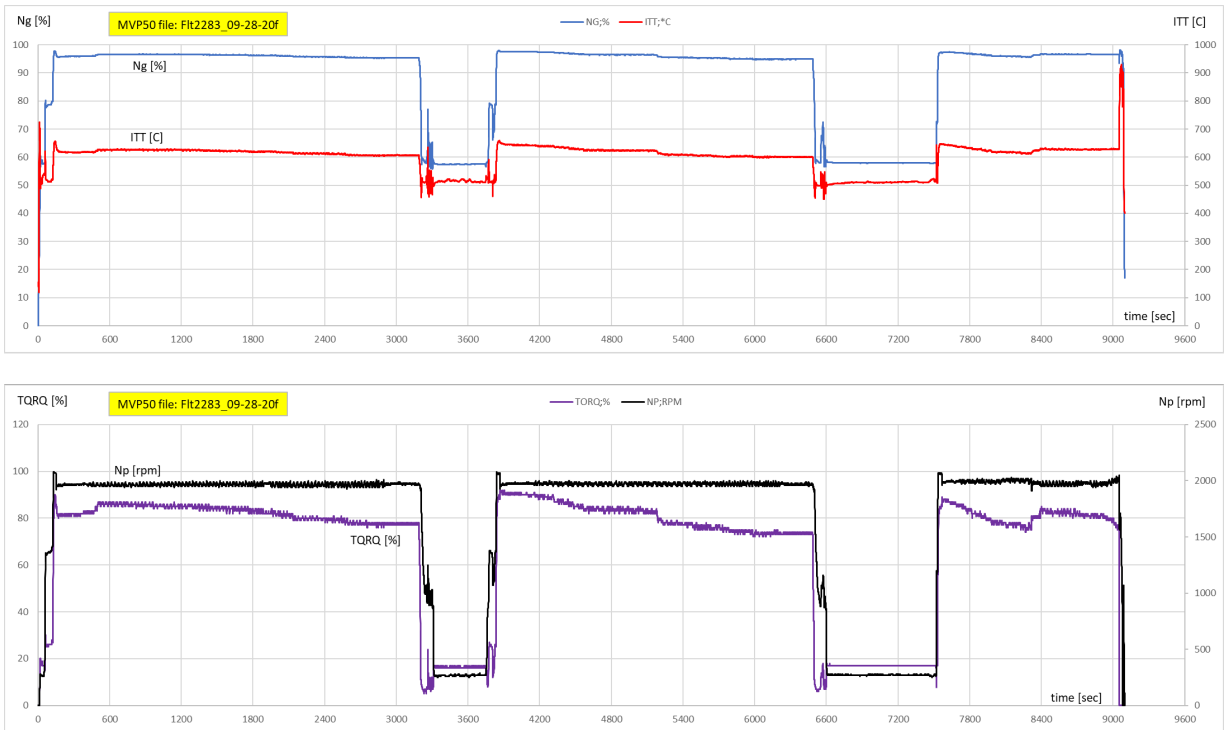


Figure 4: No Abnormal Torque Indications Observed During the Incident Flight

I. CORRECTIVE ACTIONS

GEAC released Service Bulletin SB-H80-72-00-00-0090 on February 23, 2021 defining the inspection of fasteners that secure the torque meter support to the roller bearing housing. Missing nuts, lock washers, or washer locking tabs are not permitted. Nuts and lock washers must not be free to rotate under finger pressure. Engine operation is not permitted if either of the above conditions are found.

J. ATTACHMENTS

Attachment 1: GE Metallurgical Report

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