NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

January 14, 2015

POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT

NTSB No: DCA15MA029

A. ACCIDENT INFORMATION

Location: Gaithersburg, Maryland

Date: December 8, 2014

Time: 1045 Eastern Standard Time (EST)

Aircraft: Embraer Phenom E50P, registration number N100EQ

B. POWERPLANTS GROUP MEMBERS

Safety Board Member:	Jean-Pierre Scarfo Powerplant Lead Engineer Washington D.C.
Pratt & Whitney Canada Member:	Thomas Berthe Service Investigator Longueuil, Quebec, Canada

C. SUMMARY

On December 8, 2014, about 1041 Eastern Standard Time (EST), an Embraer EMB-500 Phenom 100, N100EQ, impacted terrain and houses about 0.75 miles short of runway 14 while on approach to Montgomery County Airpark (GAI), Gaithersburg, Maryland. The airline transport rated pilot and two passengers were fatally injured as well as three persons on the ground. The airplane was destroyed during the impact and ensuing fire. Marginal visual meteorological conditions prevailed at the time and the flight was operating on an instrument flight rules (IFR) flight plan. The airplane was registered to and operated by Sage Aviation LLC., of Chapel Hill, North Carolina, under the provisions of 14 Code of Federal Regulations Part 91 as a personal flight. The flight originated from Horace Williams Airport (IGX), Chapel Hill, North Carolina, with GAI as its intended destination.

The initial examination of both engines was performed on-sight on December 8 and 9, 2014. No evidence of an uncontainment, engine case breaches, or catastrophic engine failure was found along with no indications of an in-flight pre-crash fire. The No. 2 engine did exhibit fire damage to the underside of the engine cowl in the vicinity of fracture fluid tubes and consistent with a post-crash ground fire. Neither engine exhibited any significant fan impact or ingestion damage nor was there evidence of any significant pre or post-crash foreign object ingestion. The engines were removed from the accident site and transported to a wreckage salvage storage facility in Clayton, Delaware when on December 11, 2014 an additional external examination was conducted. With the engine cowlings removed, the outside of the engine as well as the rear of the engine were exposed for better examination and documentation. Again no evidence was found to indicate an uncontainment, engine case breach, or catastrophic engine failure. Continuity of the low pressure and high pressure rotor systems was verified on both engines. No additional disassembly of the engines was performed. A review of the engine and throttle parameters from the flight data recorder for the last ten minutes of the flight did not show any engine anomalies or irregularities.

1.0 ENGINE INFORMATION

1.1 Engine History

The accident airplane was powered by two Pratt & Whitney Canada (PWC), PW617F-E turbofan engines. According to PWC's customer management system, the left engine (No. 1) was serial number (SN) LC0157 and the right engine (No. 2) was SN LC0158. According to PWC, both engines had accumulated 773 hours time since new as of September 25, 2014 and 538 cycles since new as of October 31, 2014.

1.2 Engine Description

The PW617F-E engine (**Figures 1** and **2**) is a two spool turbofan engine with a full length annular by-pass duct and features a low pressure (LP) rotor system comprised of single-stage LP compressor (fan) driven by a single-stage low pressure turbine (LPT), a two-stage high pressure (HP) rotor system comprised of a mixed flow single-stage axial and single-stage centrifugal stage HP compressor driven by a single-stage high pressure turbine (HPT), and a single reverse-flow annular combustion chamber (**Figure 3**). The HP and LP rotor system are mechanically independent. Air enters the engine through the fan and concentric dividing ducts split the air into bypass and core flow streams. Fan bypass air flows into the bypass duct before exiting with the core air flow through a common exhaust mixer. Air exits the LP turbine through the exhaust case and exhaust mixer to mix with the bypass air flow (**Figure 4**).

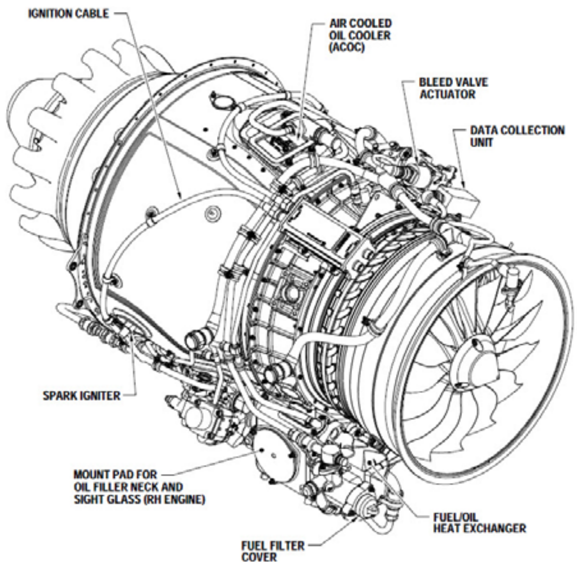

Figure 1: Right Top of Engine

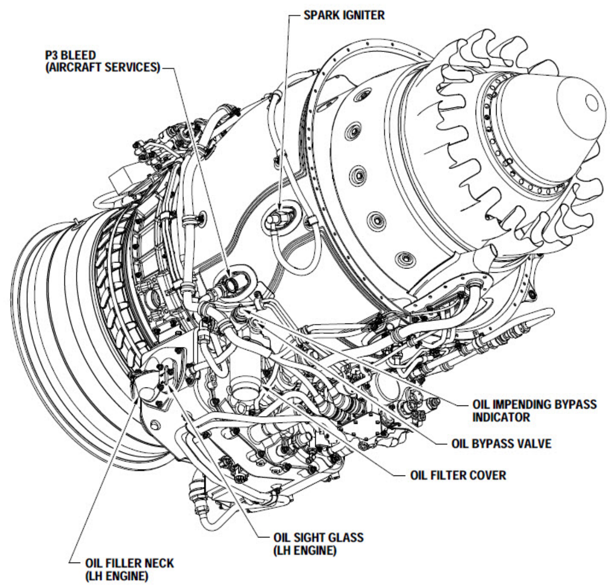

Figure 2: Left Bottom of Engine

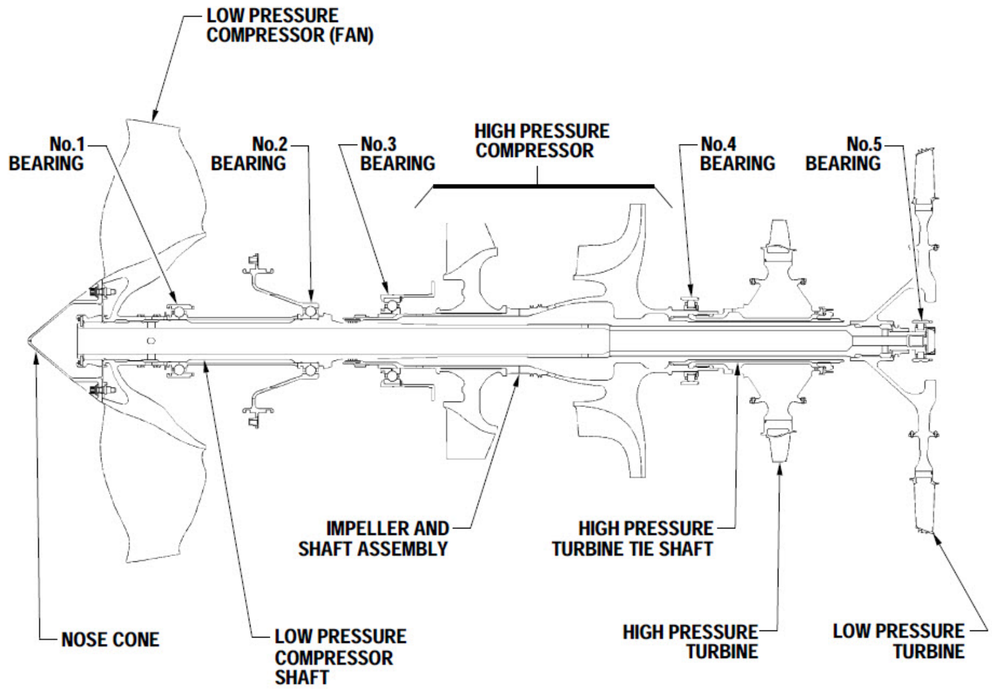

FIGURE 3: MAIN BEARINGS AND SHAFTS

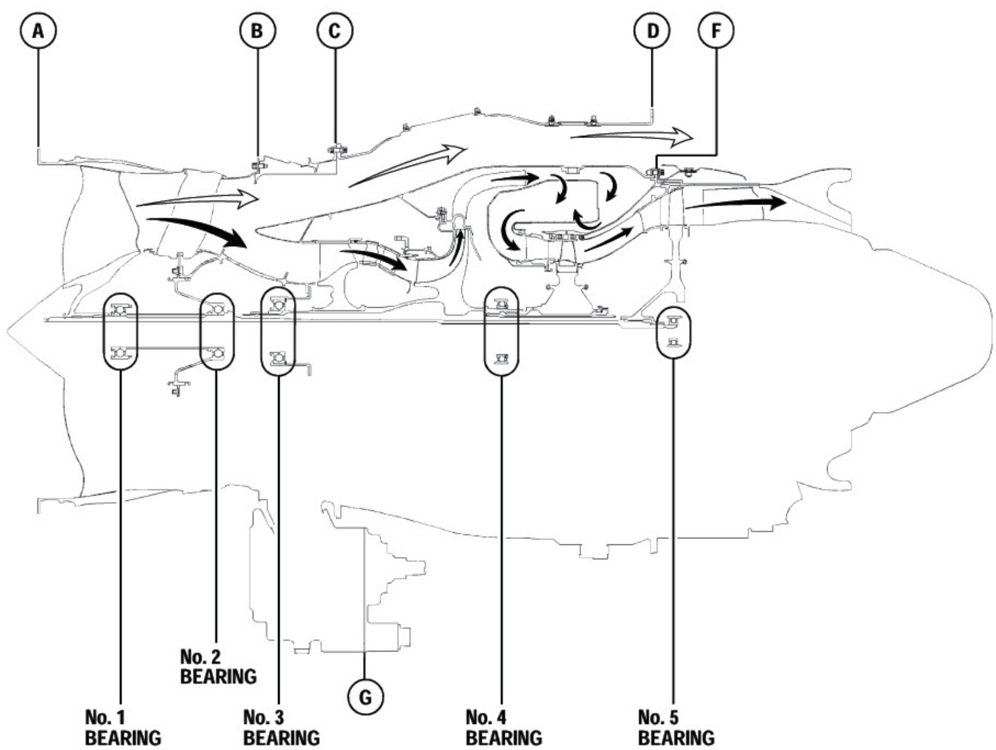

FIGURE 4: ENGINE AIR FLOW, FLANGES AND MAIN BEARINGS
BLACKS ARROWS REPRESENT CORE AIR FLOW AND WHITE ARROWS REPRESENT BYPASS AIR FLOW

The engine is controlled by a twin channel Full Authority Digital Electronic Control (FADEC) system that regulates engine operation in response to inputs from the pilot, airframe and engine mounted sensors. An engine mounted Data Collection Unit (DCU) stores specific engine information such as engine trims, cumulative engine data (number of flight legs, flight time, number of starts etc.) trend monitoring data and engine identification.

According to the engine's Transport Canada Type Certificate Data Sheet (TCDS) E-37, Issue 3, dated April 7, 2009, the PW617F-E has a maximum takeoff thrust rating of 1,695 pounds (749.5 dekanewton (daN)), maximum thrust rating of 1,820 pounds (809.6 daN), and maximum continuous thrust rating of 1,598 pounds (710.8 daN), and are based on dry sea level static International Civil Aviation Organization (ICAO) standard of 59°F (15°C) and 29.92 inch-mercury (760 millimeters-mercury).

All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF). The direction of rotation of the engine rotors is clockwise. All numbering starts with the No. 1 position at the 12:00 o'clock location and progresses sequentially clockwise ALF.

2.0 ON-SITE ENGINE EVALUATION

2.1 General Observations

Both engines were collocated at the accident site and were detached from the airplane. The engine installed positions were determined by engine mount orientation. The engine identified as the No. 1 was located near the airplane empennage at the wreckage site while the engine identified as the No. 2 was located in the back yard of the house that experienced the house fire approximately 60 feet from the No. 1 engine (**Photo 1**). The cowls and exhaust pipe (airframe supplied hardware) on both engines remained attached, exhibited tears, and neither exhibited any signs of an in-flight fire or damage consistent with an engine uncontainment. The exhaust pipe on both engines was folded over and collapsed onto itself so that the turbine could not be examined in-situ.

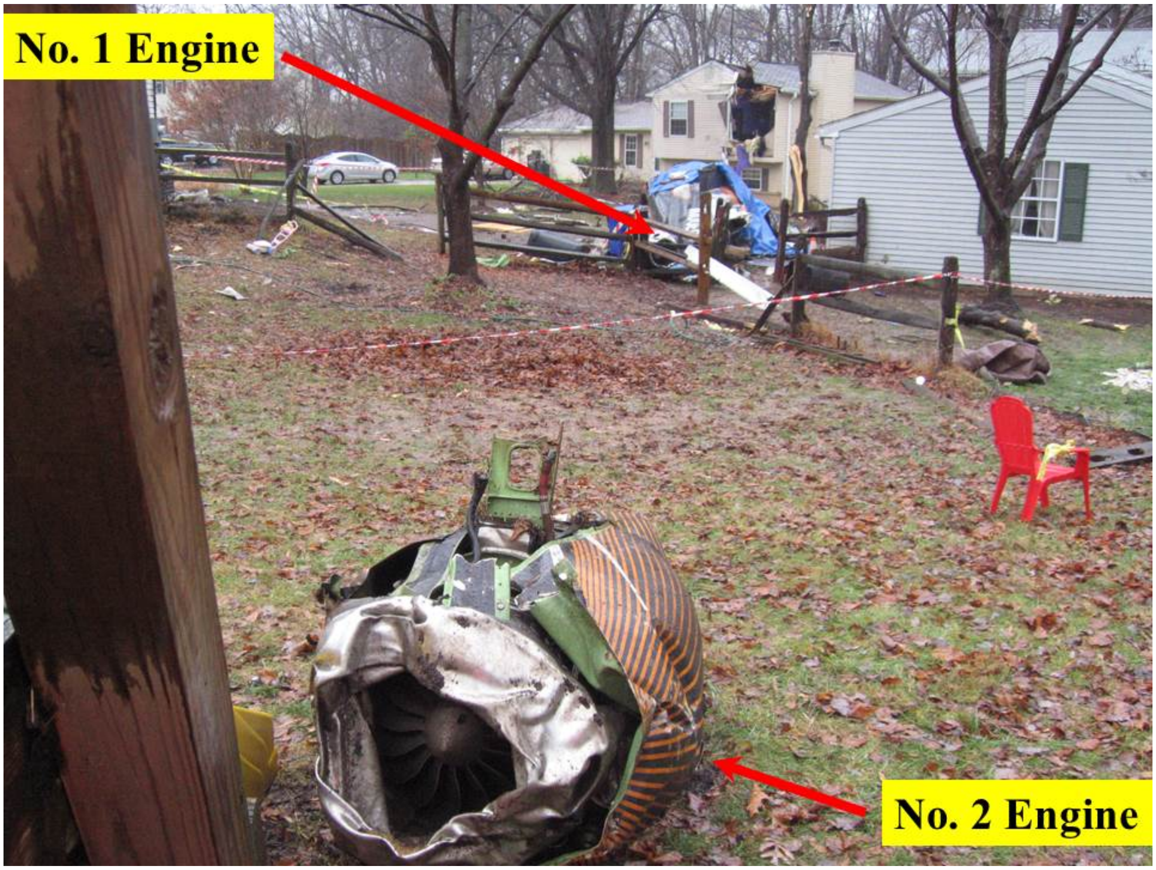

Photo 1: Both Engines Located at the Crash Site

2.2 No. 1 (Left) Engine

The engine was found resting upside down with the inlet of the engine facing away from the nose of the airplane (**Photos 2** and **3**). Part of the cowl on the bottom of the engine was torn, exposing the gearbox, which exhibited some impact damage. The inlet nose cowl remained attached to the engine, was intact, and exhibited some rounded inward impact damage consistent with soft-body impact (**Photo 4**). The exhaust pipe was partially detached from the rest of the engine exposing part of the exhaust mixer (also referred to as the forced mixer). The exhaust mixer exhibited some impact damage and some of the mixer lobes were compressed inwards (**Photo 5**). No signs of a ground fire were noted.

PHOTO 2: NO. 1 ENGINE IN-SITU (BOTTOM OF ENGINE FACING UP)

PHOTO 3: NO. 1 ENGINE IN-SITU (RESTING NEAR THE EMPENNAGE)

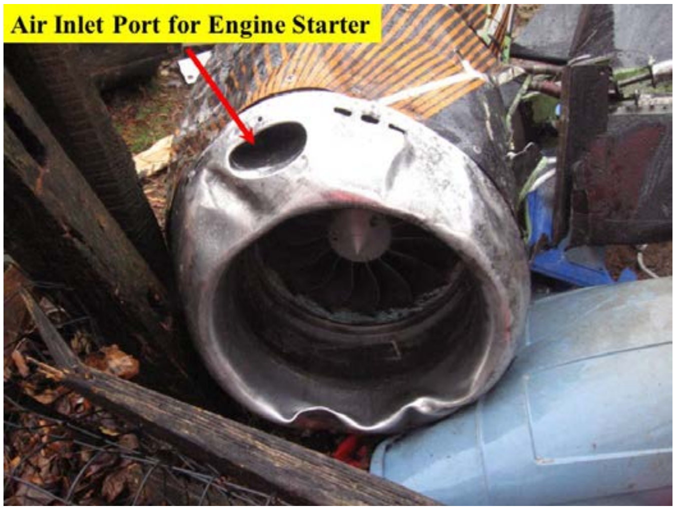

PHOTO 4: INLET NOSE COWL WITH ROUND-BOTTOM IMPACT DAMAGE

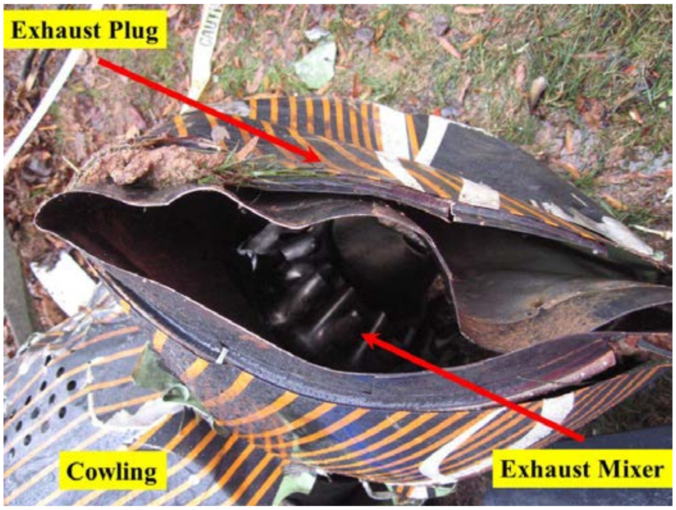

PHOTO 5: DISTORTED EXHAUST PIPE AND PARTIAL VIEW OF EXHAUST MIXER

Examination of the LP rotor (fan) through the inlet revealed that the compressor inlet cone (also referred to as the spinner) was intact, still attached to the LP compressor rotor disk (fan disk), and undamaged; and that all of the fan blades[1] were present, intact, and full length. A few blades exhibited slight leading edge tip curl in the direction opposite rotation (**PHOTO 6** – yellow circle) with a few blades exhibited small leading edge round-bottom impact damage consistent with soft-body impact damage (**PHOTO 6** – blue arrow). The fan blade rub strip (bluish color) made of an epoxy resin abradable liner exhibited contact rub down to the case fan case (**PHOTO 6**). The fan case was intact and no case breaches were noted. The fan was able to be turned freely by hand and some scrapping of the fan blades against the fan case was noted. No appreciable earth or debris was noted in or on the fan and

[1] The fan rotor is a titanium integrally-bladed rotor (IBR) that features 15 blades.

looking past the fan blades, again no appreciable earth or debris was noted. Since the turbine could not be observed in-situ, continuity between the LP compressor and the LP turbine rotors could not be confirmed on-site.

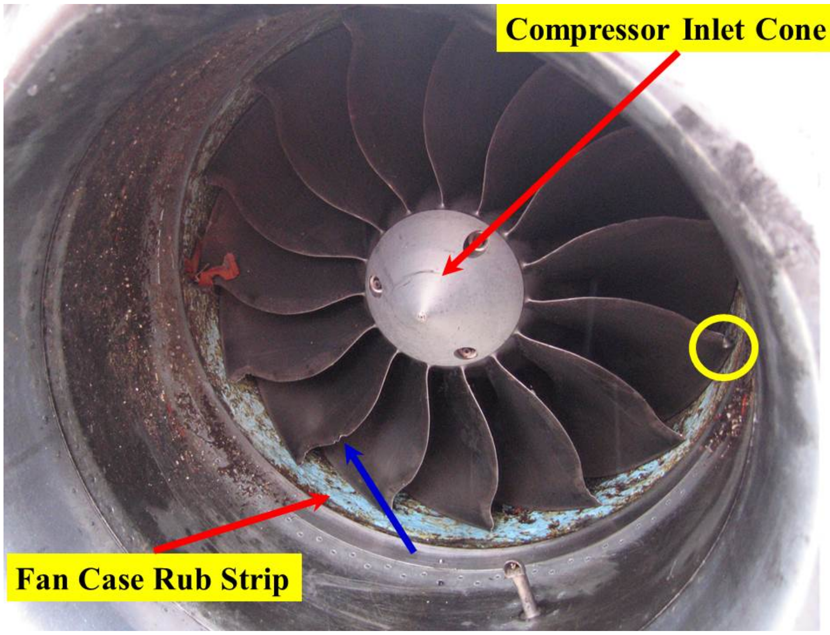

Photo 6: Fan Blades Intact and Whole with Minor Leading Edge Damage

2.3 No. 2 (Right) Engine

The engine was found resting on its right side with the inlet of the engine facing away from the nose of the airplane (**Photo 7**). Part of the cowl on top of the engine was torn exposing the DCU. The inlet nose cowl remained attached to the engine, was intact, crushed rearwards, and exhibited rounded inward impact damage consistent with soft-body impact (**Photo 8**). The exhaust pipe remained attached to the engine and collapsed to the point that the exhaust mixer was barely visible (**Photo 9**). A small localized ground fire (**Photo 10** – red area) and corresponding thermal damage to the bottom of the cowl was noted (**Photo 10** – yellow area). Several engine fluid tubes were found fractured in the vicinity of the ground fire.

Photo 7: No. 2 Engine In-Situ (Top & Left Side of Engine Facing Camera)

Photo 8: Inlet Cowl with Several Round-Bottom Impacts

PHOTO 9: DISTORTED EXHAUST PIPE

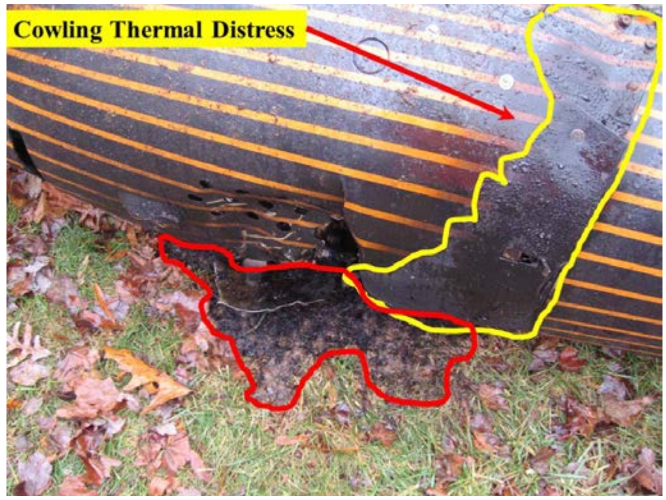

PHOTO 10: LOCALIZED GROUND FIRE

Similar to the No. 1 engine, examination of the LP rotor through the inlet revealed that the compressor inlet cone was intact, still attached to the LP compressor rotor disk, and undamaged; and that all of the fan blades were present, intact, and full length. A few blades exhibited slight leading edge tip curl in the direction opposite rotation (**PHOTO 11** – yellow circle) and no leading edge impact damage was noted. The fan case was intact, no case breaches were noted, and the case inner diameter (flow path) exhibited a thin layer was dirt but no appreciable earth or debris was noted on or between the fan blades (**PHOTO 11**). Looking past the fan blades, again no appreciable earth or debris was noted. The fan was able to be turned freely and smoothly by hand and no scrapping of the fan blades against the fan case was noted. Since the turbine could not be observed in-situ, continuity between the LP compressor and the LP turbine rotors could not be confirmed on-site.

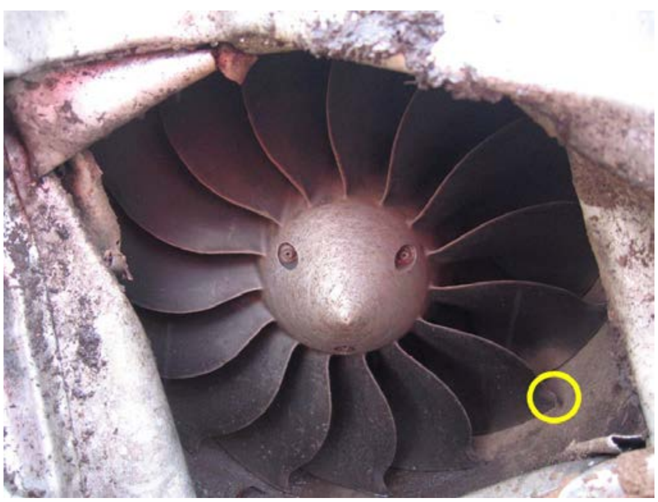

PHOTO 11: FAN BLADES INTACT AND WHOLE WITH TIP CURL

PHOTO 12: FAN CASE FLOW PATH WITH THIN LAYER OF DIRT

3.0 ADDITIONAL OFF-SIGHT EXAMINATION

Both engine were removed from the accident site and transported to the Anglin Aircraft Recovery Services, L.L.C. facility in Clayton, Delaware for additional examination and evaluation. Persons from the NTSB, PWC, and the Federal Aviation Administration (FAA) convened at the Anglin facility on December 11, 2014 to conduct the examination and completed its work that same day. Both engines were brought into hanger and the cowlings and exhaust pipe were removed to facilitate external examination of the engines.

3.1 No. 1 Engine Observations

The air inlet port in the inlet nose cowl for the starter generator was free of dirt and debris. With the cowlings removed, examination of the inside of the cowling revealed no thermal distress and the service door (next to the white card labeled “L”) located on the bottom of the cowl was intact, in place, remained latched (**Photo 13**). The data plate on the gearbox confirmed the engine to be SN LC0157 (**Photo 14**).

Photo 13: Cowling In Good Condition

Photo 14: Engine No. 1 Data: SN LC0157

The bottom of the engine exhibited impact damage consisting of flattened and distorted piping and fractured attachment bolt lugs on the gearbox (**Photo 15**). Some sooting and thermal distress, consisting of cushion clamp oxidation and melted electrical wire protective sheathing, was noted from about the 3:00 (engine mount location) to about the 5:00 o’clock location in the general vicinity of the gearbox. The gearbox remained secured to the engine and appeared to be intact; no signs of oil streaking or leaking from the gearbox were observed nor were there fresh oil residue noted on the inside of the cowling. The engine bypass duct was still in place but was cracked/torn at the 6:00 o’clock location; sections of the rear flange were missing, and the rear flange engine bypass duct-to-airframe bypass duct attachment bolts were ripped through.

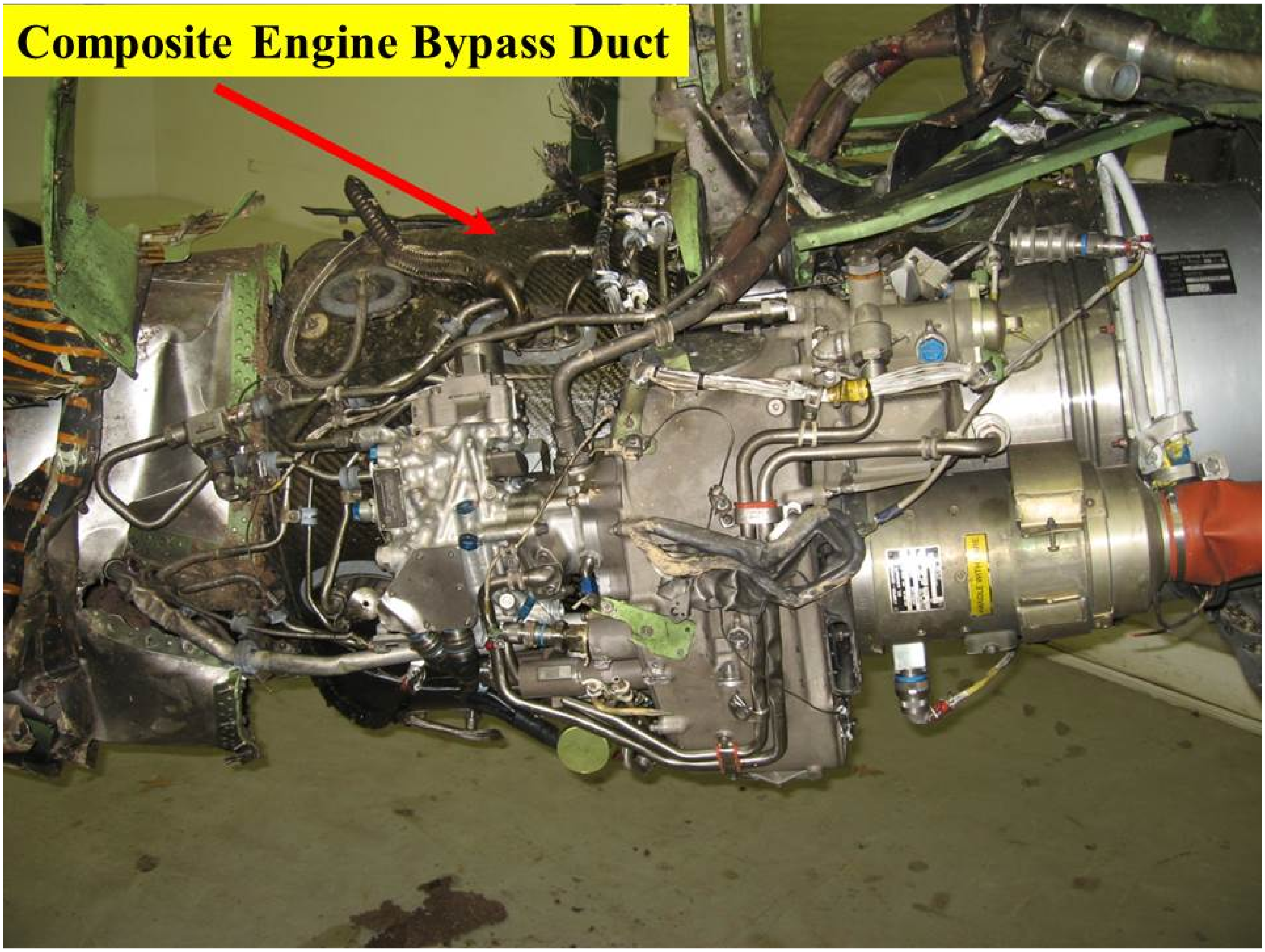

PHOTO 15: BOTTOM OF NO. 1 ENGINE – IMPACT DAMAGE BUT NO THERMAL DISTRESS

The magnetic chip detector was removed from the gearbox and it was clean with no debris on the tip. The oil filter was removed and it appeared clean and free of debris; the oil from the filter housing appeared clear, clean, and there was no acrid smell (**PHOTO 16**). The fuel filter was also removed and it appeared to be clean and free of debris as well.

The rear end of the annular bypass duct (actually the airframe duct), which is integral with the exhaust pipe, had completely separated from the engine at the "D"-flange; the engine bypass duct-to-airframe bypass duct flange remained connected to the engine by piping only (**PHOTOS 17** and **18**).

PHOTO 16: CLEAN OIL MAGNETIC CHIP DETECTOR (LEFT) AND OIL FILTER (RIGHT)

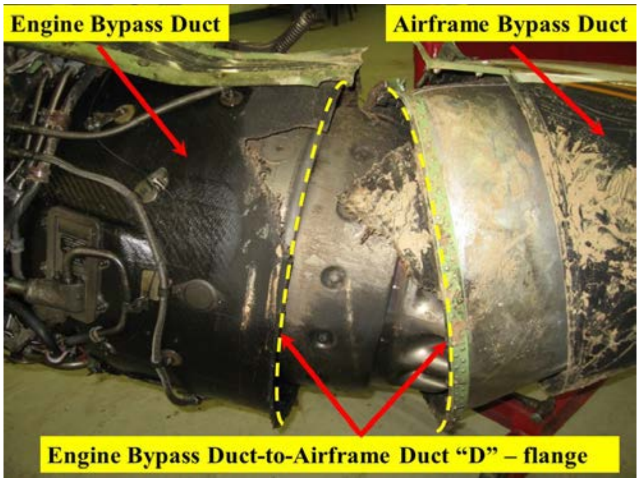

PHOTO 17: SEPARATED BYPASS DUCT (TOP VIEW)

PHOTO 18: SEPARATED BYPASS DUCT (BOTTOM VIEW WITH PIPING STILL ATTACHED)

With the exhaust pipe removed, the exhaust mixer was exposed, it was intact and the end cone was crushed in the direction from about the 9:00 to 3:00 o'clock position, and several of the exhaust mixer lobes were pressed radially inwards (**PHOTO 19**). Looking through the exhaust mixer, all the LPT blades were present, intact, and in good condition (**PHOTO 20**). The fan was rotated by hand and the LPT rotated along with it, confirming continuity of the LP rotor system. Again as the fan was turned the fan blades scrapped along the fan case. Covers on the starter generator were removed and the starter generator was rotated using a screw driver; sounds coming from the HP rotor system were heard consistent with the HP rotor system turning and continuity.

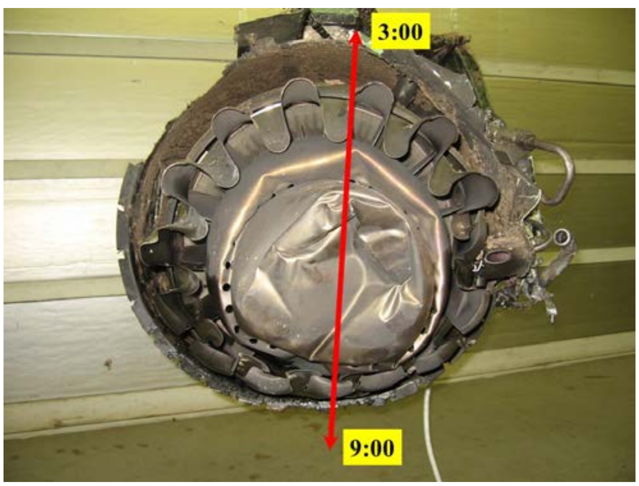

PHOTO 19: CRUSH END CONE

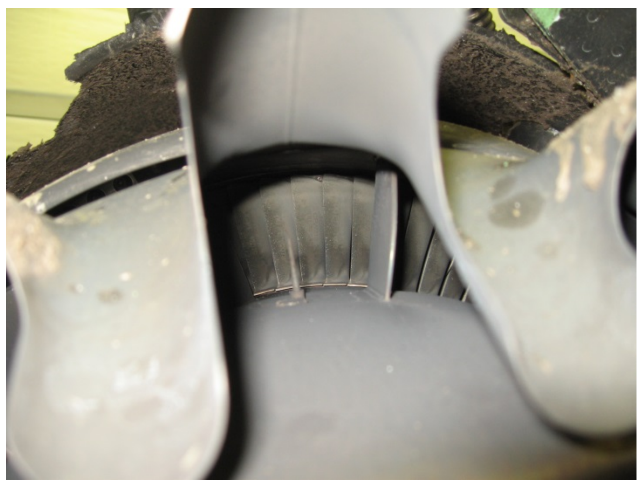

PHOTO 20: LPT BLADES INTACT AND GOOD CONDITION

Closer examination of the fan blades found more blades that exhibited leading edge impact damage and tip curl than what was originally observed on-site: however, overall the fan blades were in relatively good condition (**PHOTOS 21**). Looking past the fan blades revealed no appreciable dirt or debris except at the bottom of the engine (6:00 o'clock position) and minor impact damage was visible downstream on the fan exit vanes (**PHOTOS 22**). An overall visual examination of all the engine cases did not find any evidence of breaches of the core or uncontainments. The engine mounts remained secure to the engine and to the airframe pylon strut.

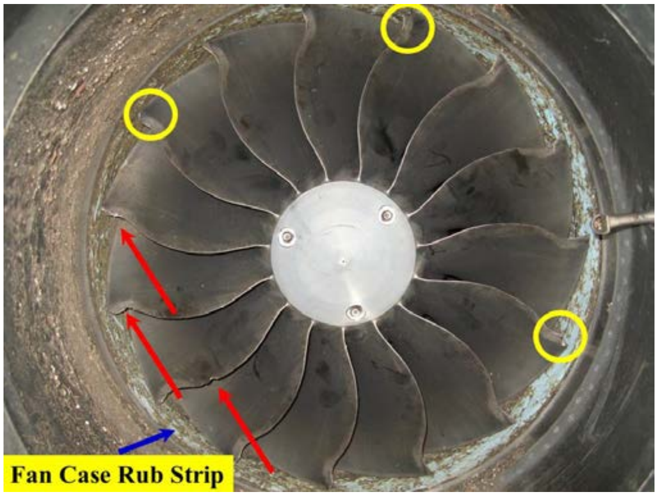

PHOTO 21: NO. 1 ENGINE FAN BLADE DAMAGE

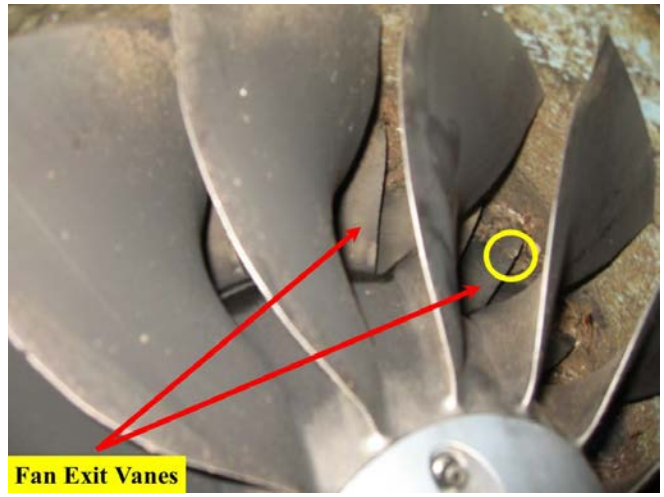

PHOTO 22: DIRT AND DEBRIS IN COMPRESSOR AND DAMAGE DOWNSTREAM OF FAN BLADES

3.2 NO. 2 ENGINE OBSERVATIONS

The air inlet port was plugged with dirt; however, the exhaust portion of the inlet port that leads directly to the starter appeared to be clean. With the cowlings removed, the inside of the cowling exhibited thermal distress and some signs of melting (**PHOTO 23**) unlike the No. 1 engine that was free of thermal distress. The service door was distorted but remained latched and in place. The data plate on the gearbox confirmed the engine to be SN LC0158 (**PHOTO 24**).

PHOTO 23: COWLING THERMAL DAMAGE

PHOTO 24: ENGINE NO. 2 : SN LC0158

The bottom of the engine exhibited impact damage, sooting, thermal distress, and some of the piping was flattened, distorted or fractured (**PHOTOS 25** and **26**). The thermal distress ranged from the aft side of the gearbox to "D"-flange (the engine bypass duct-to-airframe bypass duct flange) and consisted of cushion clamp oxidation and melted electrical wire protective sheathing.

PHOTO 25: THERMAL DISTRESS AND IMPACT DAMAGE

PHOTO 26: THERMAL DISTRESS AND IMPACT DAMAGE

The gearbox remained secured to the engine and it appeared to be intact and no signs of oil streaking or leaking from the gearbox were observed, nor was there fresh oil residue noted on the inside of the cowling. Similar to the No. 1 engine, the No. 2 engine bypass duct was still in place, exhibited impact and thermal damage, and a section of the rear flange was torn and missing. The rear flange was torn and separated from about the 8:00 to 1:00 o'clock location (**PHOTO 27**). Unlike the No.1 engine, the airframe bypass duct still remained attached to the engine bypass duct.

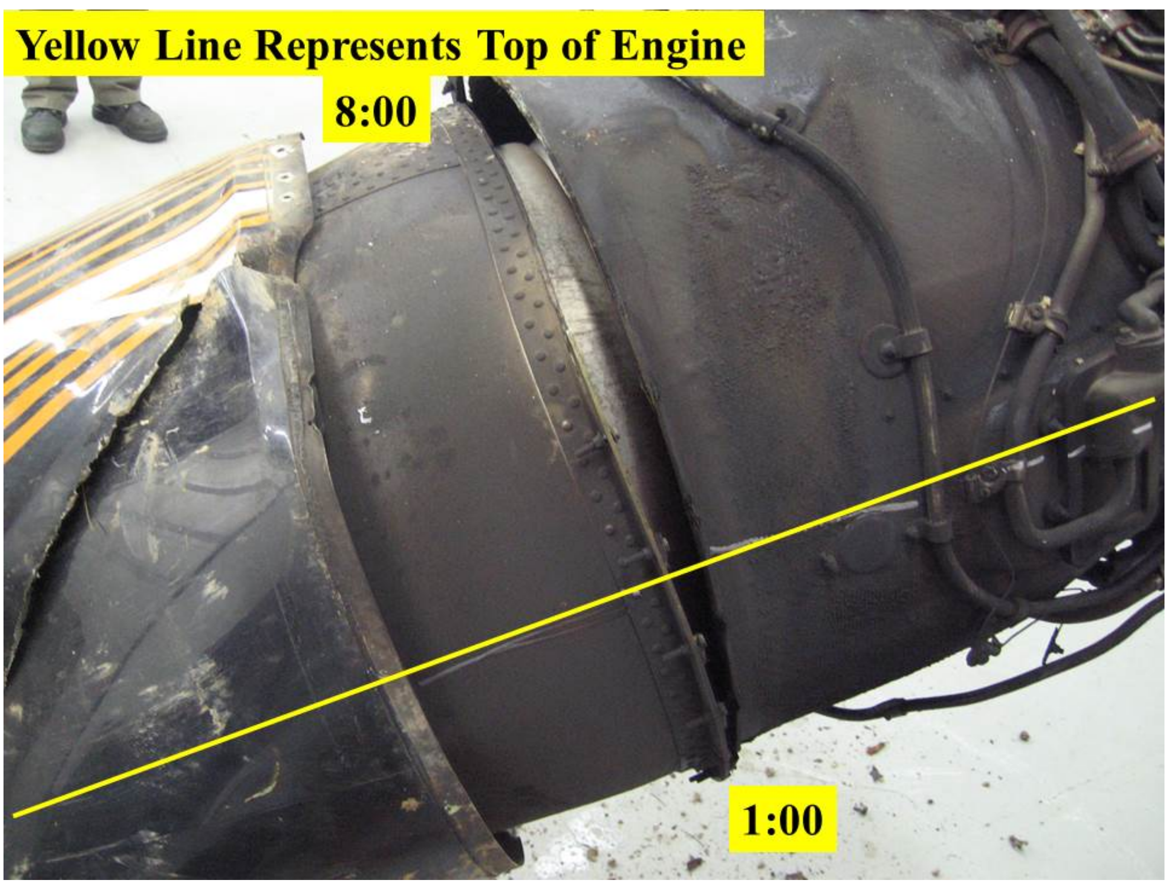

PHOTO 27: FRACTURED ANNULAR BYPASS DUCT

The magnetic chip detector was removed from the gearbox and it was clean with no debris on the tip. The oil filter was removed and it appeared clean and free of debris; the oil from the filter housing appeared clear, clean, and there was no acrid smell (**PHOTO 28**). The fuel filter was also removed and it appeared to be clean and free of debris as well.

PHOTO 28: CLEAN OIL MAGNETIC CHIP DETECTOR AND OIL FILTER

With the exhaust pipe removed, the exhaust mixer was exposed and it was intact and in good condition with some of the exhaust mixer lobes pressed radially inwards (**PHOTO 29**). The end cone appeared to be undamaged. Looking through the exhaust mixer, all the LPT blades were present, intact, and in good condition (**PHOTO 30**). The fan was rotated by hand and the LPT rotated along with it, confirming continuity of the LP rotor system. Once again covers on the starter generator were removed and the starter generator was rotated using a screw driver; sounds coming from the HP rotor system were heard consistent with the HP rotor system turning and continuity.

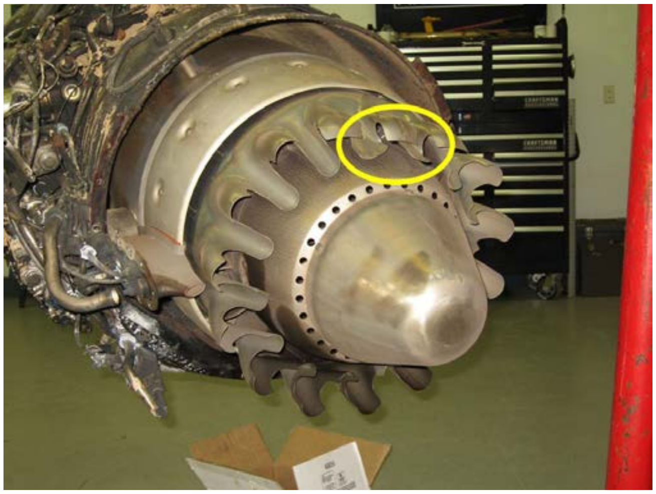

PHOTO 29: MIXER TUBE DAMAGE

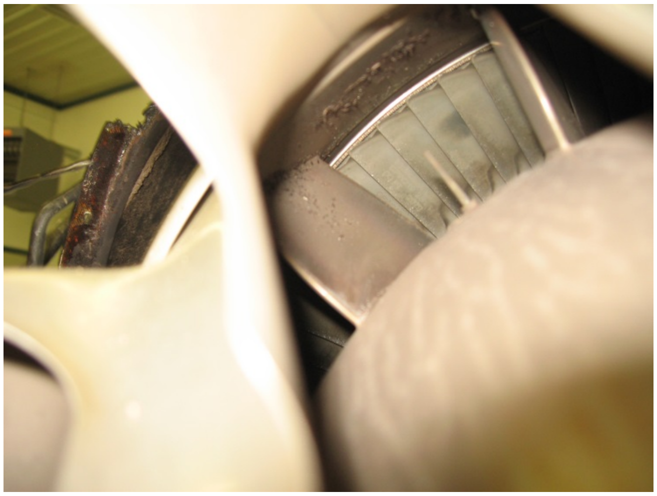

PHOTO 30: LPT BLADES INTACT AND GOOD CONDITION

Closer examination past the fan blades revealed no appreciable dirt or debris (**PHOTOS 31** and **32**) and no visible damage downstream on the fan exit vanes. An overall visual examination of all the engine cases did not find any evidence of breaches of the core or uncontainments. The engine mounts remained secure to the engine and to the airframe pylon strut.


PHOTO 31: VIEW PAST FAN BLADES


PHOTO 32: VIEW PAST FAN BLADES

4.0 FLIGHT DATA RECORDER INFORMATION

The flight data recorder (FDR) was sent to the NTSB's Headquarters in Washington DC and was readout by the Vehicle Recorder Group. The focus of the FDR data examination as it relates to the engines was primarily to look at throttle lever angle (TLA) changes and relate those changes to corresponding changes to engine fan speed (N1) and engine core speed (N2) (**FIGURE 5**). The sample rate for TLA, N1, and N2, are all once per second; however, none of the parameters are sampled at the exact same time within that second. On this particular FDR, each second is divided into 102 increments and the recorded data for TLA, N1, and N2 are staggered time-wise from one another. A review of the last ten minutes of the flight indicated the following:

1) TLA for engine 1 and 2 were matched within 1° of each other throughout
2) TLA changes for each engine were in tandem – no split in TLA was observed
3) N1 for engine 1 and 2 were matched within several percent of each other throughout
4) N2 for engine 1 and 2 were matched within 1% percent of each other throughout
5) Each engine responded to an advance in TLA with a corresponding increase in N1 and N2
6) Each engine responded to a decrease in TLA with a corresponding decrease in N1 and N2
7) For each engine, when a TLA change was initiated, a corresponding change in N1 and N2 was observed within the subsequent sample (within 1 second)

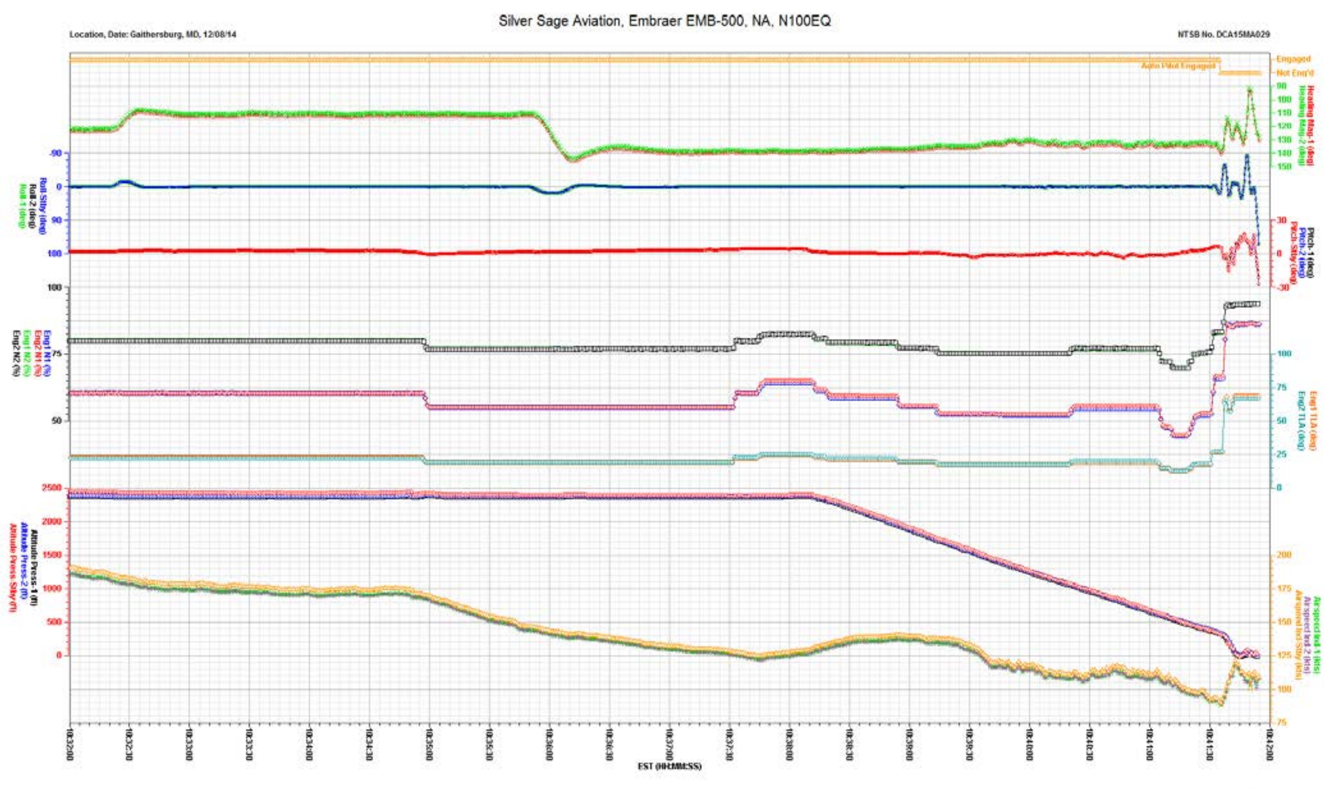

FIGURE 5: FDR PLOT FOR THE LAST 10 MINUTES OF FLIGHT

Jean-Pierre Scarfo
Aerospace Engineer
Powerplant Lead