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

April 16, 2009

POWERPLANT GROUP CHAIRMAN'S FIELD NOTES

NTSB No: DCA-09-MA-027

A. ACCIDENT

Location:	Clarence Center, New York
Date:	February 12, 2009
Time:	22:17 Eastern Standard Time (EST)
Aircraft:	Colgan Air Inc. Bombardier Dash 8-400, N200WQ, flight number 3407

B. POWERPLANTS GROUP

Safety Board Group Chairman:	Jean-Pierre Scarfo Powerplant Lead Engineer Washington D.C.
Federal Aviation Administration Members:	Ian Dargin Engineer – FAA Engine & Propeller Directorate Engine Certification Office Burlington, Massachusetts
	Mary Beth Moran Aviation Safety Inspector - FAA Flight Standards District Office Rochester, New York
Colgan Air Member:	Gerry Shutrump Director of Quality Control Manassas, Virginia
Airline Pilot's Association Member:	Rod Herrig ALPA Representative - Airlines Safety Houston, Texas
Pratt & Whitney Canada Member:	Marc Gratton Air Safety Investigator Longueuil, Quebec Canada

C. SUMMARY

On February 12, 2009, about 22:17 Eastern Standard Time (EST), a Colgan Air Inc., Bombardier Dash 8-400, N200WQ, doing business as (d.b.a.) Continental Connection flight 3407, crashed during an instrument approach to runway 23 at the Buffalo-Niagara International Airport (BUF), Buffalo, New York. The crash site was approximately 5 nautical miles northeast of the airport in Clarence Center, New York, and mostly confined to one residential house. The four flight crew and 45 passengers were fatally injured and the aircraft was destroyed by impact forces and post crash fire. There was one ground fatality. Night visual meteorological conditions prevailed at the time of the accident. The flight was a Code of Federal Regulations (CFR) Part 121 scheduled passenger flight from Liberty International Airport (EWR), Newark, New Jersey to BUF.

Examination of both Pratt & Whiney Canada PW150A engines and the Dowty R408/6-123-F17 propellers was conducted on-site and no further disassembly was performed. The stage 1 low pressure compressor in both engines revealed damage, such as blades bent in the direction opposite rotation, fractured blades, airfoil leading edge impact damage, and ingestion of dirt consistent with the engine rotating at impact. Inspection of the aft end of both engine revealed that all the stage 2 power turbine blades, the turbine support case struts, and the indicated turbine temperature probes were all intact, present, and showed no indication of impact damage indicative of an upstream internal turbine failure. No evidence of any uncontainments was noted in either engine. The reduction gearbox remained coupled to their respective propeller and the propeller shaft was intact and remained attached to the second stage bull gear housed in the reduction gearbox.

Each of the six propeller blades from both of the propellers were accounted for and found at the accident site consistent with no in-flight propeller blade loss. The propeller hub and pitch change cylinders for each propeller remained attached, were intact, and no signs of oil streaks were noted on either indicating an in-flight leak. For the No. 1 propeller (left-hand side aft looking forward), all the propeller tips were found and each blade was almost full length fractured at the butt end of the blade. Three of the six counterweights remained attached to their respective propeller blade outer sleeve, while the other three had become separated and were not recovered by the Powerplant Group.

For the No. 2 propeller (right-hand side aft looking forward), all the propeller tips were found and four (4) of the six (6) blades were almost full length fractured at the butt end of the blade, with one (1) blade missing the outer half of the airfoil. There was an impact trench located next to where the No. 2 engine/propeller came to rest. In this trench, four (4) full length propeller blades, all fractured at the blade counterweight location, were found imbedded in the mud and all oriented in the same general direction, roughly perpendicular to the airplane path of travel more consistent with the propeller blade pitch in the operating range than in the feathered position. All six counterweights remained attached to their respective propeller blade outer sleeve.

A review of the Digital Flight Data Recorder (DFDR) data for the accident flight was performed looking at power level position, engine parameters, propeller speed, and torque values for each engine and propeller. The DFDR showed that engine and propellers parameters moved appropriately in response to power lever changes. Additionally, the No. 1 engine and propeller parameters matched those of the No. 2 engine parameters at all power lever positions. No torque splits between the No. 1 and No. 2 propellers were noted for the same power lever position as well as no splits in the power lever position itself.

D. DETAILS OF THE INVESTIGATION

1.0 ENGINE INFORMATION

1.1 ENGINE AND PROPELLER HISTORY

The accident airplane was equipped with two Pratt & Whitney Canada (P&WC) PW150A turboprop engines and two Dowty R408/6-123-F17 propellers. The engines and propellers involved in this accident were installed on the airplane when Bombardier delivered the airplane new to Colgan Air in April 2008. Neither the engines nor the propellers have ever been removed from the airplane since its delivery; therefore, neither has undergone overhaul or any maintenance, other than normal servicing. At the time of the accident, the engines and propellers had accumulated the 1,809 cycles since new (CSN) and 1,819.3 flight hours time since new (TSN). See **APPENDIX 1** for details.

1.2 ENGINE INFORMATION

The PW150A turboprop engine consists of a reduction gearbox module and a turbomachinery module with the flanges bolted together to form a rigid integral unit that drives the propeller via a two-stage reduction gearbox. Three major rotating assemblies compose the heart of the engine. One assembly consists of the three stage, axial flow, low pressure compressor and its single stage low pressure compressor turbine; another assembly consists of the single stage centrifugal high pressure compressor and its single stage high pressure turbine; and the third consists of a two stage power turbine and the power turbine shaft. The three rotating assemblies are not connected together and rotate at different speeds and in opposite directions. This design is referred to as "Free Turbine Engine"[1] and allows the pilot to vary the propeller speed independently of the compressor speed. Starter cranking torque is also lower since only the high pressure rotor is initially rotated on start. The engine is started by activating the starter mounted on the accessory gearbox. The engine also employs an annular reverse flow combustion chamber contained in the gas generator case.

The reduction gearbox reduces the power turbine speed (17,501 revolutions per minute (RPM)) to one suitable for propeller operation (1,020 RPM). A fuel metering unit mounted on the accessory gearbox regulates fuel flow to the fuel nozzles in response to power requirements and flight conditions. The propeller electronic control (PEC) controls the speed of the propeller through the propeller control unit (PCU), mounted on the reduction gearbox by varying blade angle depending on power requirements, pilot speed selection, and flight conditions.

All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF) as is the convention. The direction of rotation of the propellers, low pressure (LP) rotor and power turbine are clockwise while the high pressure (HP) compressor is counterclockwise. All numbering in the circumferential direction starts with the No. 1 position at the 12:00 o'clock position, or immediately clockwise from the 12:00 o'clock position, and progresses sequentially clockwise, ALF.

[1] The turbine drives an output reduction gearbox of the turboprop or turboshaft engine rather than a compressor in turbofan or turbojet engines. This design permits variable gearbox speed output at constant core engine speed and constant gearbox speed output over a range of core engine speeds.

1.3 PROPELLER INFORMATION

The six bladed propeller is constant speed, variable pitch, with full feathering and full reverse capabilities. The propeller is installed on the engine reduction gearbox propeller drive flange by 15 threaded studs and nuts. The three location dowels help with the correct propeller installation and transmit some of the drive torque. The blades are installed in a flange mounted aluminum hub. Installed on the hub is an aluminum alloy cylinder assembly that houses the pitch change actuator. A spinner is attached to the propeller composite backplate.

Each blade is an all-composite airfoil construction with a steel outer root sleeve. The airfoil has a foam core and twin carbon fiber spars with an overall braided carbon/glass fiber shell. A plug seals the inner sleeve. Lead wool is installed as necessary in balance tubes at the root end of the blade to balance the blade and is plugged to keep the lead wool in position. A polyurethane spray coat for erosion protection is applied to the complete blade surface. A nickel leading edge guard is installed for blade erosion protection. A heater element to de-ice 70% of the blade radius is installed on the blade leading edge. The operating pins on the base of each blade engage between the faces of the crosshead, to give blade rotation.

The hub assembly has a one-piece aluminum hub, with 15 integral steel mounting studs and 3 location/drive dowels. The hub supports six blades and has six pairs of blade root bearings. The lower bearing is an angular contact ball race, and the upper bearing is a taper roller race. A backplate constructed of carbon fiber composite, and attached to the hub forms the aerodynamic interface between the spinner and engine nacelle. A slipring is used to transfer electrical power for blade deicing. The slip ring is installed directly onto the backplate and has aluminum alloy housing with three bronze rings in a plastic moulding. The target screws that supply propeller speed and phase angle feedback are located on the external diameter of the slipring.

2.0 ON-SITE AND IN-SITU ENGINE EXAMINATION

The following engine and propeller descriptions are in the 'as-found' condition. No disassembly of the engine or propeller was performed; therefore, not all parts were visible for examination. The descriptions only pertain to those areas that were accessible and visible.

2.1 NO. 1 ENGINE PW 150A, SN PCE-FA0452 (LEFT-HAND SIDE)

The engine was found resting right side up on the ground (correct installed position) within the main wreckage field to the left of what remained of the fuselage and oriented in the direction parallel with the fuselage. Heavy heat distress and fire damage was noted over the entire engine, with the reduction gearbox (RGB) front and rear housings, the accessory drive cover, the front inlet case, low pressure case, and accessory gearbox completely consumed (**PHOTOS 1 & 2**). The accessory gears were found loose on the ground on the right side of the engine as it lay. None of the teeth of any of the accessory gears exhibited any pre-impact damage.

PHOTO 1: 'AS FOUND' RIGHT-HAND SIDE OF NO. 1 ENGINE IN WRECKAGE

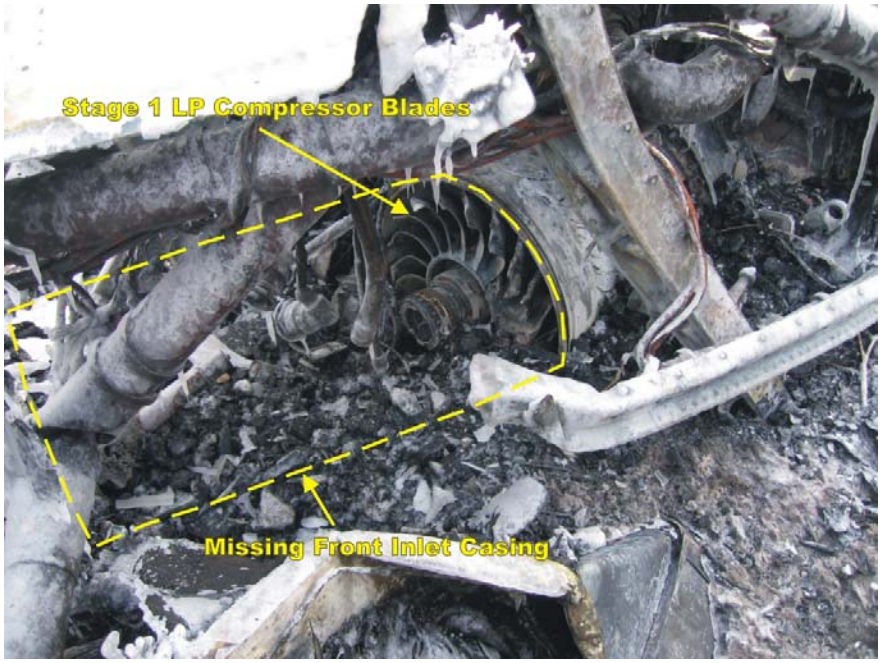

PHOTO 2: 'AS FOUND' RIGHT-HAND SIDE OF NO. 1 ENGINE IN WRECKAGE

A trussed tubular frame assembly supports the engine and propeller within the airframe. The RGB rear housing has three engine mounting pads that are used to attach the engine and propeller to the engine front frame assembly within the airframe. Two of the supports are located on either side of the RGB rear housing with the third on top. The top, left-hand and right-hand RGB mounts were in-place; however, the elastometers was missing, presumably burned away (**PHOTO 3**). The engine front frame assembly was intact as was the mid frame assembly; however, the mid frame was distorted and bent. The upper right-hand and upper left-hand struts that connect the mid frame to the front frame were intact except for the eyelet on left-hand strut that connects to the mid frame, which was broken and bent. The upper left-hand strut from the forward frame to the mid frame engine was bent while the lower strut was intact. The upper right-hand strut was fractured while the lower was intact.

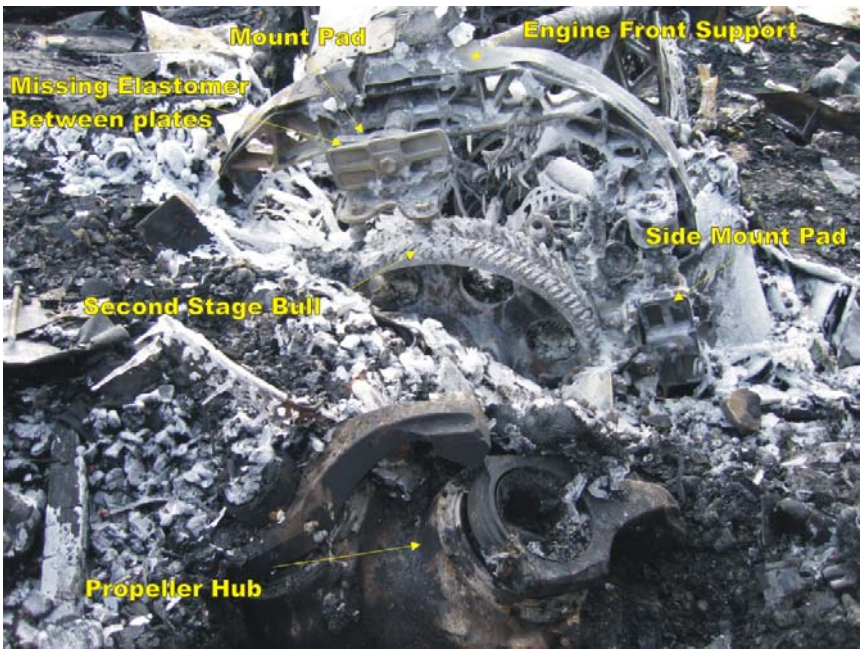

PHOTO 3: MISSING REDUCTION GEARBOX ASSEMBLY

With the RGB housings completely consumed, the RGB internal gears were exposed. The second stage bull gear (referred to simply as the bull gear) was intact, appeared undamaged, and still coupled to the propeller shaft that in turn was still connected to the propeller. The propeller beta tube was intact and still attached to the propeller hub through the bull gear (**PHOTO 4**). The No. 15 roller bearing, located on the aft side of the bull gear, was present and the cage was fractured with two (2) of the roller elements missing. The No. 18 ball bearing and No. 19 roller bearing, both located on the forward side of the bull gear were present. The outer race of the No. 18 ball bearing was still in place so the rolling elements could not be examined; however, the No. 19 roller bearing rolling elements were visible and one (1) roller was missing. In the vicinity of the bull gear covered by debris, both first stage helical gear & second stage pinion gear assemblies,[2] along with the torque shaft assembly with the helical input shaft still attached, were recovered (**PHOTO 5**). No pre-impact damage to any of the gears was noted.

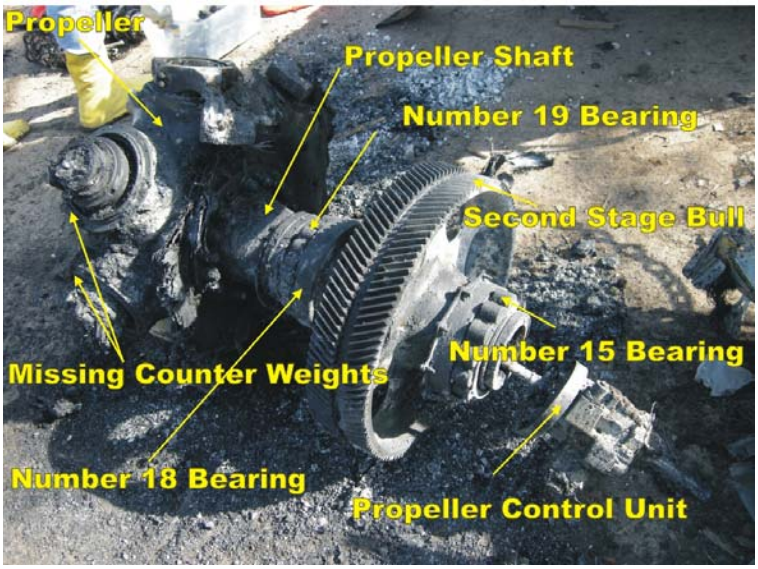

PHOTO 4: PROPELLER & RGB COMPONENTS

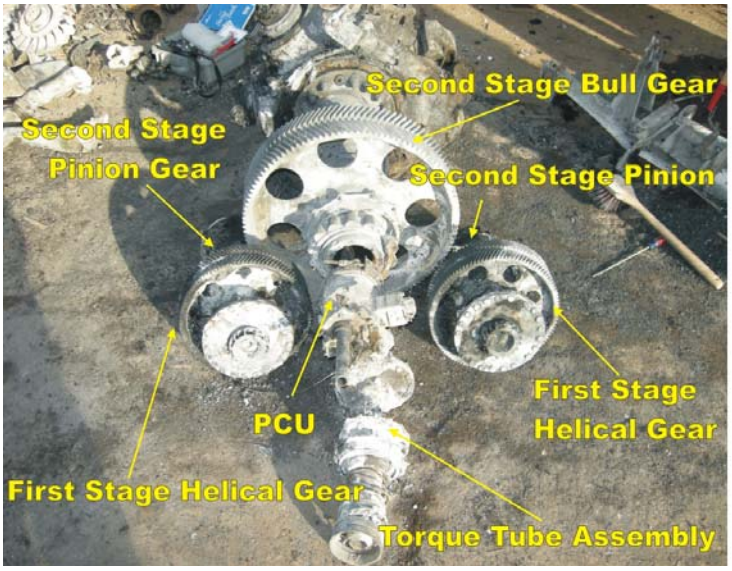

PHOTO 5: RGB COMPONENTS

With the front inlet case completely consumed, the power turbine (PT) shaft and the stage 1 low pressure compressor (LPC) blades[3] and vanes were visible, along the No. 2.5 roller bearing. The No. 2.5 roller bearing cage was still attached to the front of the LP shaft. The cage appeared intact but all the roller elements were missing. All the stage 1 LPC blades were all visible, present, heavily bent in the direction opposite rotation, and exhibited blade tip damage and missing blade tip material. Some blades exhibited leading edge (LE) tip curl in the forward direction (**PHOTO 6**). The front end of the power turbine (PT) shaft was visible within the LP shaft and it appeared to be fractured just forward of the stage 1 LPC disk.

[2] The first stage helical gear and second stage pinion gear is a single unit
[3] The stage 1 LPC disk is a 'bladed-disk design where the blades are not removable from the disk but are instead an integral part.

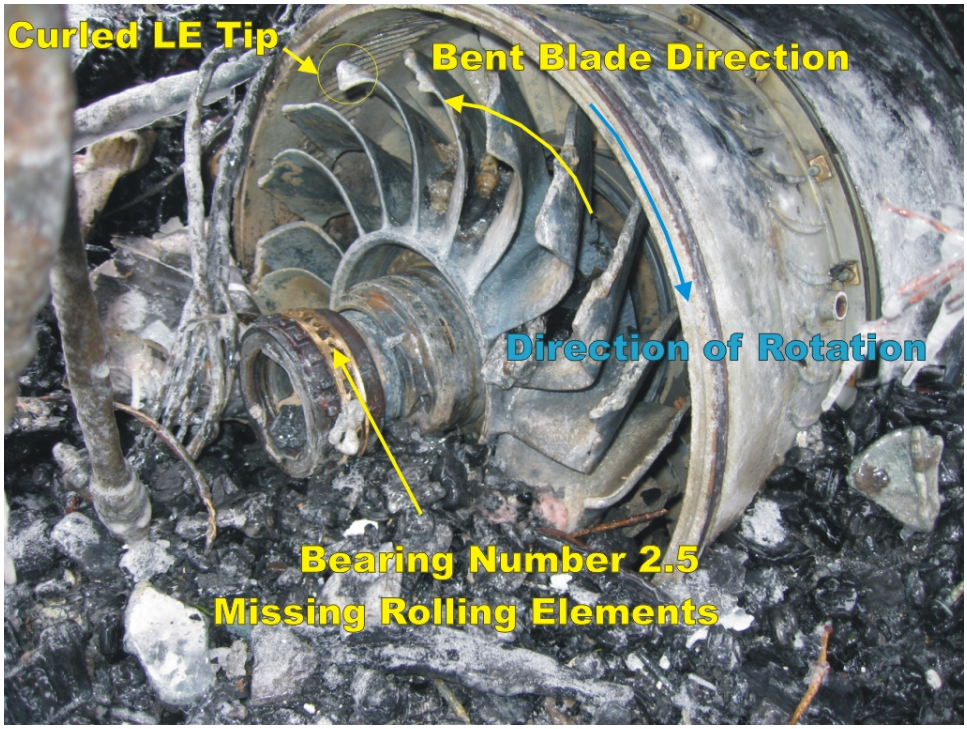

PHOTO 6: STAGE 1 LPC BLADE & NO. 2.5 BEARING DAMAGE

The stage 1 and stage 2 LPC disks are threaded together and secure by a locking ring and snap ring. The stage 1 LPC disk was found loose and decoupled from the stage 2 disk and was easily removed by hand. The lock ring and snap ring looked intact. With the stage 1 LPC blisk removed, the fractured PT shaft was visible. The PT shaft exhibited a spiral fracture with the fracture surface at about a 45° angle (**PHOTO 7**). The outer diameter of the PT shaft exhibited circumferential rub mark from the fractured end to almost the shoulder where the shaft diameter changes.

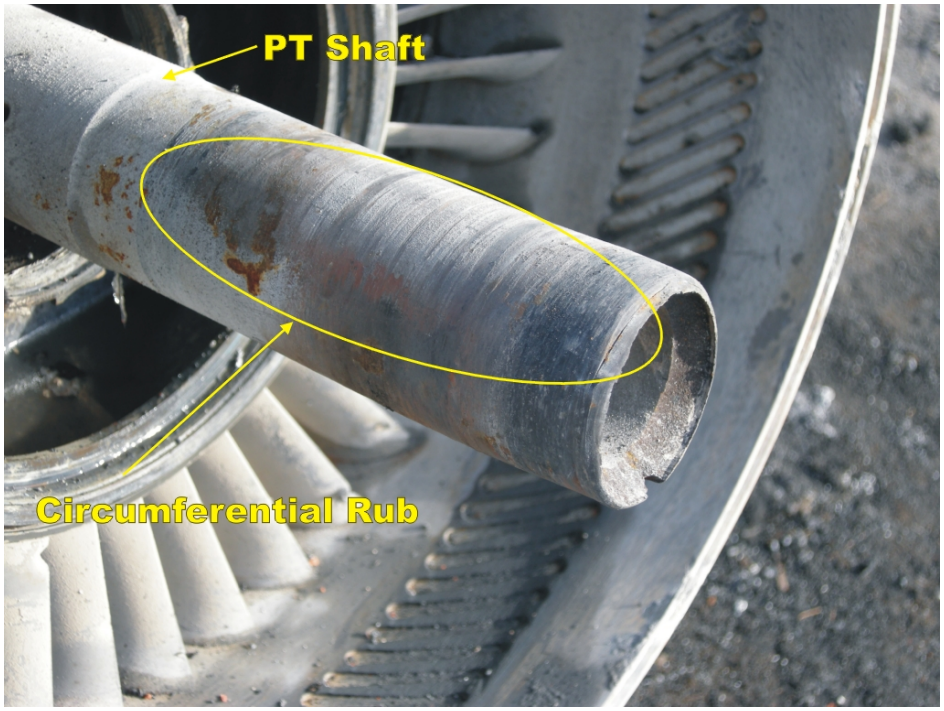

PHOTO 7: FRACTURED POWER TURBINE SHAFT

All the stage 1 LPC stator vanes were present and intact, with some exhibiting LE tears, LE airfoils bent in both the direction of rotation and in the direction opposite rotation, and some trailing edge (TE) impact damage and material loss near the outer shroud (**PHOTO 8**). Looking through the stage 1 LPC stator vanes, the stage 2 LPC blades were visible. All the stage 2 LPC blades were present; most blade tips were curled in the direction opposite rotation, and some exhibited material loss. Dirt and mud was visible up to the stage 2 LPC blades (**PHOTO 9**).

PHOTO 8: STAGE 1 LPC STATOR VANES

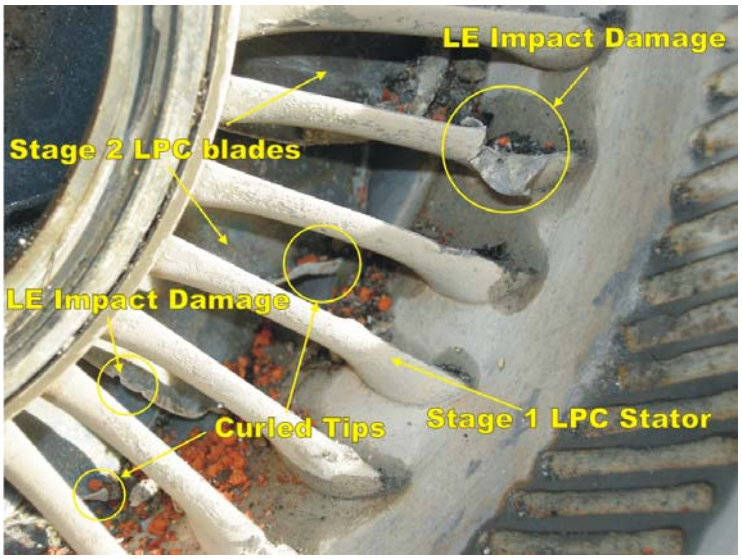

PHOTO 9: DAMAGED STAGE 1 LPC STATOR VANES AND STAGE 2 BLADES

The exhaust duct had to be cut to gain access into the turbine support case. The exhaust cone was pushed forward and the rear flange of the turbine support case was distorted slightly inward at the 5:00 and 10:00 o'clock positions. All the turbine support case struts were intact with two slightly bent. All the indicated turbine temperature (ITT) probes, which are located between the exhaust struts, were present and undamaged. All the stage 2 PT blades were present, intact, and exhibited no visible damage (**PHOTO 10**).

PHOTO 10: STAGE 2 POWER TURBINE BLADES PRESENT AND INTACT

2.2 No. 1 Propeller Dowty R408/6-123-F17, SN DAP 0451 (Left-Hand Side)

The propeller was found attached to the second stage bull gear and was partially covered with burnt housing debris with less than half of the propeller was exposed (**See Photo 3**). The propeller was unearthed to facilitate examination. The propeller pitch change cylinder was still attached to the hub, actuator, and backplate assembly (for simplicity this will be referred to as solely the hub) and appeared to be intact and undamaged. No oil or oil staining was noted around the cylinder. The hub was intact and appeared to be undamaged. None of the airfoils of any of the six (6) propeller blades remained attached to propeller. The three (3) blade positions sequentially around about the top (as the propeller was situated in the ground) had complete sets of counterweight assemblies (counterweight arm, counterweight, and rear collar[4]) still attached, while the three (3) blade positions that were buried in the ground were missing their complete counterweight assembly (**Photo 11** and **See Photo 4**). The missing counterweight assemblies were not recovered but examination at each location revealed the presence of the blade root and the balance tube. Each of the three (3) counterweight assemblies that remained attached was in a slightly different orientation. In the clockwise direction starting with the first in the rotation direction, the counterweight arm was: 1) near 0° - almost straight back,[5] 2) about at 45°, and 3) slightly less than 90° with the centerline of the engine.

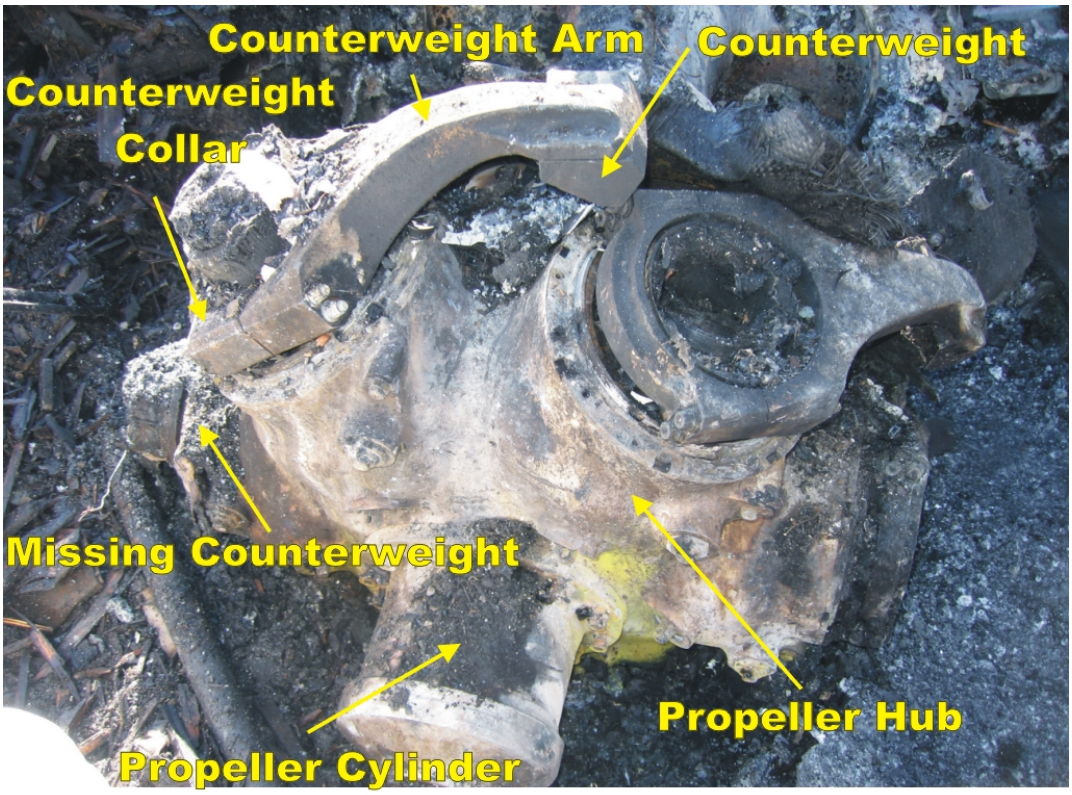

Photo 11: 'As Found' Propeller No. 1 in Wreckage

Several blades were found in the basement of the house under airplane and house debris. **Photos 12 and 13** show representative samples of recovered blades in-situ. The part identification label is affixed to the airfoil usually near the root. None of the labels remained, so the propeller part number (PN) or serial number (SN) could be determined from the propeller blades themselves to compare with the maintenance

[4] In the illustrated part catalog, the counterweight arm is designated as the counterweight arm and rear collar together. These parts do not have individual PNs or identifiers, even though they are physically two separate parts.
[5] 0° for reference is the counterweight arm pointing straight back down the centerline of the engine

records. With the lack of specific blade sequencing, the blades were arbitrarily identified for documentation purposes. See **TABLE 1** for propeller blade description and photos.

PHOTO 12: PROPELLER BLADE FOUND IN BASEMENT

PHOTO 13: PROPELLER BLADE FOUND IN BASEMENT

TABLE 1: PROPELLER BLADE DESCRIPTION FOR THE NO. 1 PROPELLER

Blade #	Description	Blade #	Description
AL	The outer third of the blade airfoil remained but was heavily burned and heat distressed. The LE erosion guard was intact and some LE soft body damage was noted. Matching blade sections it was determined that blade tip "AL" matched with the inboard section of blade "FL" to make a full blade (**PHOTO 14**).	DL	The blade airfoil was about two-thirds length with the tip and blade shank missing. What remained was heavily burned and heat distressed (**PHOTO 17**).
BL	The blade airfoil was almost full length but was missing the shank of the blade. What remained was heavily burned and heat distressed. No LE impact marks were noted (**PHOTO 15**).	EL	The blade was almost full length but was missing the shank of the blade. What remained and was heavily burned and heat distressed This blade was found in the near the basement of the house (**PHOTO 18**).
CL	The blade airfoil was almost full length but was missing the shank of the blade. This blade was found in the basement of the house. The inboard portion airfoil was fire damaged while the outboard half was not. The blade tip was missing and the LE exhibited significant impact damage. The LE erosion guard was intact. A small piece of blade LE was recovered on the front lawn between residence 6039 and 6045 Long Street. Matching fracture features, this small piece corresponded with the missing piece from this blade (**PHOTO 16**).	FL	The inner half of the airfoil blade length was present with the outboard section and the blade shank missing. What remained was heavily burned and heat distressed. Matching blade sections it was determined that blade tip "AL" matched with the inboard section of blade "FL" to make a full blade (**PHOTO 19**).
		GL	The blade airfoil was almost full length and was found near the basement area. The blade was heavily burned and heat distressed (**PHOTO 20**).

PHOTO 14: PROPELLER BLADE 'AL'

PHOTO 15: PROPELLER BLADE 'BL'

PHOTO 16: PROPELLER BLADE 'CL'

PHOTO 17: PROPELLER BLADE 'DL'

PHOTO 18: PROPELLER BLADE 'EL'

PHOTO 19: PROPELLER BLADE 'AL' &'FL'

PHOTO 20: PROPELLER BLADE 'GL'

2.3 No. 2 Engine PW 150A, SN PCE-FA0453 (Right-Hand Side)

The engine was found resting on its left-hand side underneath the right-hand main landing gear and wing structure, to the right of what remained of the fuselage and oriented away from fuselage (**Photo 21**). The RGB was found resting on its left-hand side in the same general direction as the rest of the engine with the propeller still attached. The RGB front and rear housings were fractured at the "A" flange (RGB front case-to-RGB rear case flange) exposing the second stage bull gear (**Photo 22**). The visible second stage bull gear teeth appeared to be undamaged and in good condition. The propeller and the RGB were found as a unit separated from the rest of the engine and due to the airplane wreckage, house debris and mud; they could not be clearly examined in-situ. Instead a more detailed examination was performed once the mud was removed and the engine and propeller were moved from their resting position.

The engine forward frame assembly was intact. The engine mount and shock absorber (isolator) assembly at the 3:00 o'clock position was intact with the upper strut fracture and the lower strut intact. The right-hand engine mount (isolator) was found resting on the RGB and appeared intact with the shock absorber elastomer still in place while the right mount was still in place but not engaged with the forward frame.

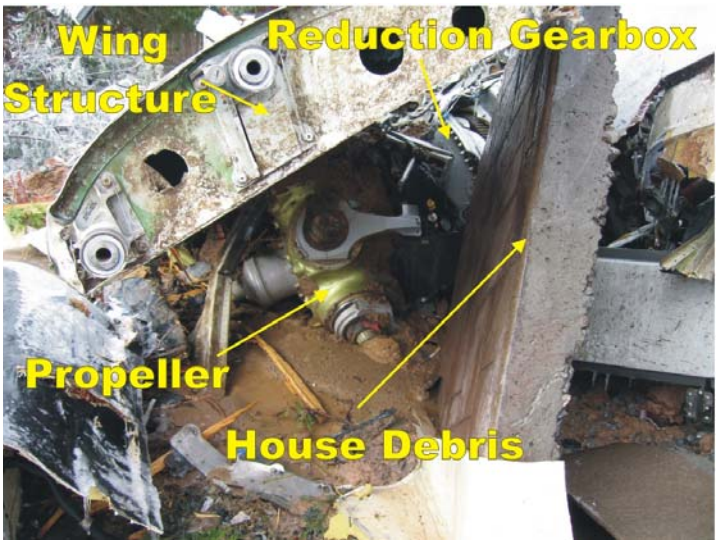

Photo 21: 'As Found' No. 2 Prop & Engine

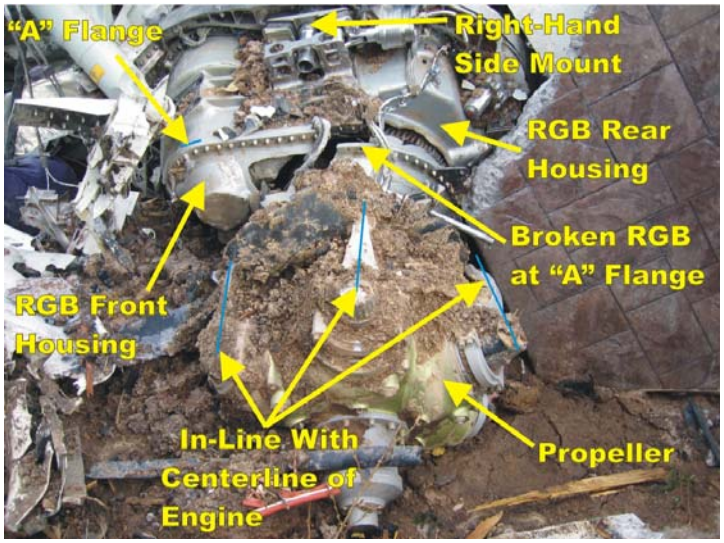

Photo 22: 'As Found' No. 1 Propeller & RGB

With the propeller and RGB unit removed, examination of the RGB revealed that the front and rear housings were fractured, pushed inwards, and mud packed in the housing at the 6:00 o'clock position consistent with a hard impact with the ground (**Photo 23**). Looking at the back of the RGB, the housing was fractured at the "B" flange (RGB rear case-to-front inlet case flange) and the helical input drive shaft was found fractured near the forward flange. The overspeed governor and the hydraulic pump remained attached to the RGB while the propeller electronic control (PEC), the alternating current (AC) generator, fuel metering unit, and started generator were all separated and found loose. The propeller beta tube was present and still attached to the propeller through the RGB. The front inlet case was fractured and missing with only part of the front flange still attached to the RGB rear housing (**Photo 24**).

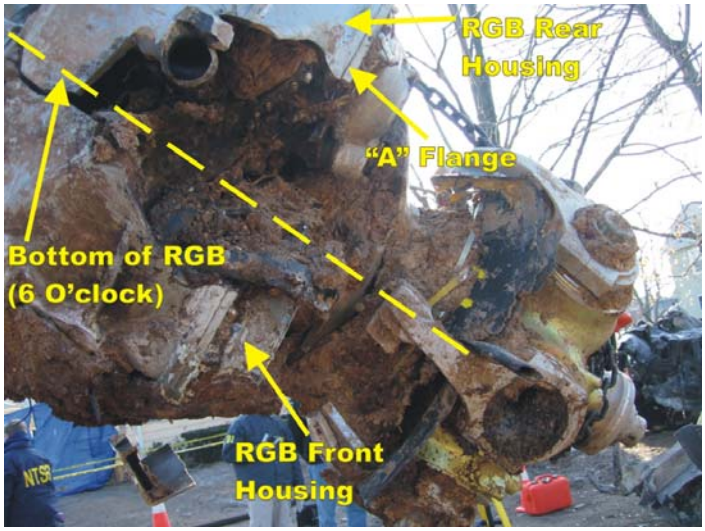

PHOTO 23: BOTTOM OF RGB

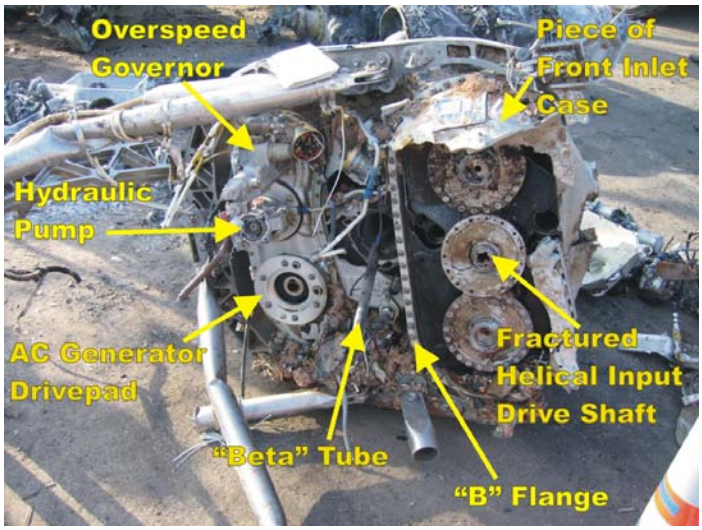

PHOTO 24: BACK OF RGB & FRONT INLET CASE

The front part of the engine could not be examined in-situ due to the engine's orientation within the wreckage and the airplane debris on top of it; however, part of the aft end of the engine was visible through the airplane wreckage (PHOTO 25). The exhaust duct was detached from the engine and the aft end of the engine was buried beneath earth and house rubble from about the 6:00 to 12:00 o'clock position. The exhaust cone was crushed forward and the turbine support case rear flange was crushed inward and forward from the 12:00 to 3:00 o'clock position. The engine was removed from within the wreckage to facilitate more detailed examination.

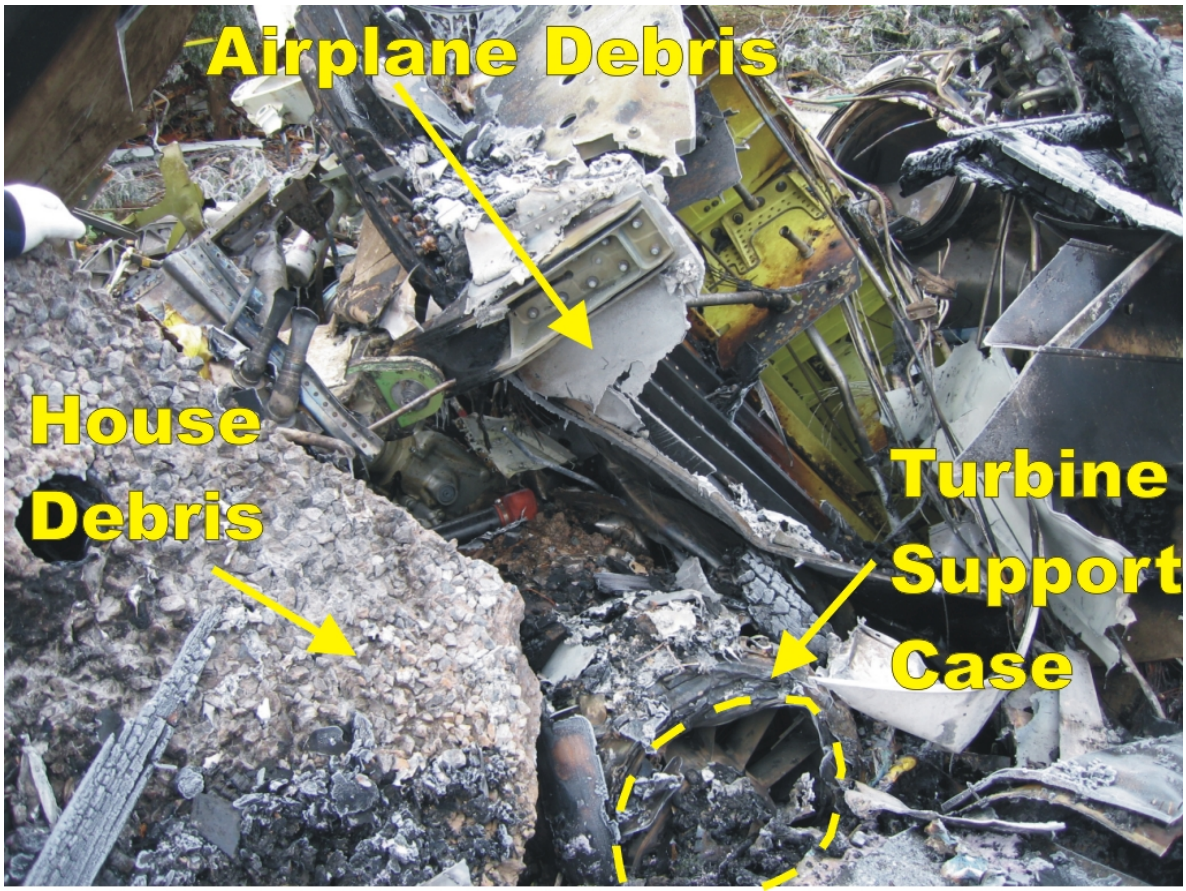

PHOTO 25: 'AS FOUND' AFT END OF NO. 2 ENGINE

The LP case was still attached to the front of the engine but was missing the bottom half. Looking through the LP case, the case struts and air passages were coated with mud and the stage 1 LPC blades were bent in the direction of opposite rotation, fractured, and exhibited leading edge impact damage (**PHOTOS 26, 27 AND 28**).

PHOTO 26: BENT BLADES

PHOTO 27: FRACTURED BLADES

PHOTO 28: CURLED BLADES

To gain better access to all the stage 1 LPC blades, the Powerplant Group broke off the LP case. All the stage 1 LPC blades were present and exhibited a variety of different fracture features. The vast majority of stage 1 LPC blades exhibited some form of impact damage and missing some material. Most, but not all of the blades were bent in the direction opposite rotation, while a few appeared to be fairly straight (**PHOTO 29**). Four (4) blades exhibited large portions of their airfoil missing with one (1) blade fractured near the root. Mud was observed up to the stage 1 LPC vanes.

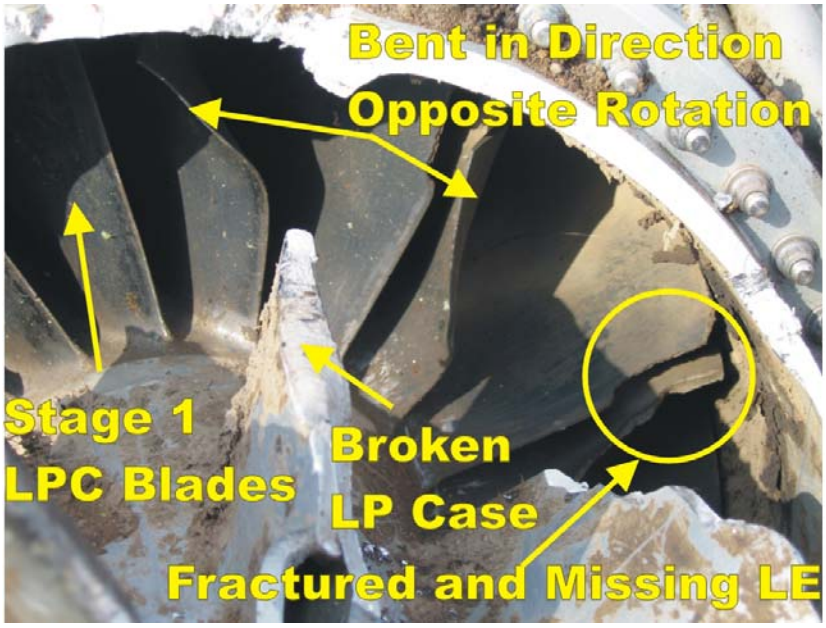

PHOTO 29: STAGE 1 LPC BLADES EXHIBITING VARIOUS FORMS OF DAMAGE

The rear flange of the turbine support case was pried opened by the Powerplant Group to gain better access to the back end of the engine. All the turbine support case struts were intact and whole, with several near the 1:00 o'clock position buckled and deformed (**PHOTO 30**). All eight (8) ITT probes appeared intact and undamaged. Neither the turbine support case struts nor the ITT probes exhibited impact damage consistent with debris coming from the power turbine section. Looking through the turbine support case, all the stage 2 PT blades were full length and all the blade tip outer shrouds were still present. The stage 2 PT blades

exhibited TE impact damage out near the outer shroud, with some missing a portion of the airfoil itself (**PHOTO 31**). The airfoil TE in the vicinity of the missing material exhibited a 'bluish-color', consistent with heat distress and was pushed/folded forward, closing down the exit area. The stage 2 PT disk and the blade fir trees exhibited a light circular rub mark.

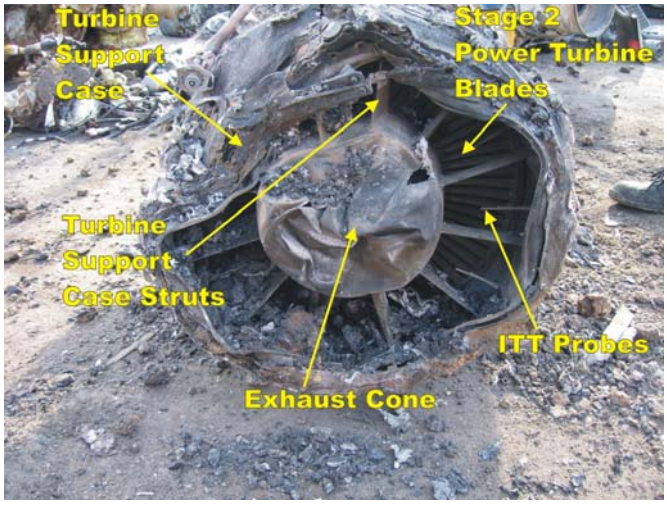

PHOTO 30: TURBINE SUPPORT CASE DAMAGE

PHOTO 31: STAGE 2 LPT BLADE TE BLUEING

2.4 NO. 2 PROPELLER DOWTY R408/6-123-F17, SN DAP 0452

The propeller was found attached to the RGB and was covered with mud. Only three (3) of the six (6) propeller blade positions were visible in-situ. The propeller was unearthed and cleared of as much mud as possible in order to facilitate examination. The propeller pitch change cylinder was still attached to the hub and appeared to be intact and undamaged. No oil or oil staining was noted around the cylinder. The hub was intact and appeared to be undamaged. None of the airfoils of any of the six (6) propeller blades remained attached to propeller; however, all six (6) counterweight assemblies were present and, at each blade location, a part of the blade root was present, at five (5) of the six (6) locations the balance tube was also present (**PHOTO 32**). All the counterweight assemblies were pointing almost straight back with a few counterweight assemblies at a slightly different orientation.

PHOTO 32: NO. 2 PROPELLER WITH COUNTERWEIGHT ASSEMBLIES POINTING ALMOST STRAIGHT BACK

There was an impact trench located aft and to the right of the No. 2 engine location, estimated to be about 15 to 18 feet from the engine and propeller location. In this trench, four (4) full length propeller blades, all fractured at the blade collar location, were found imbedded in the mud and all oriented in the same general direction, roughly perpendicular to path of travel (**PHOTO 33**). A partial propeller blade was also found resting on the ground just forward of the RGB, identified as "GR" and one full length blade was found in the basement.

PHOTO 33: NO. 2 PROPELLER BLADES FOUND IN TRENCH NEXT TO MAIN WRECKAGE

The propeller blades were removed and washed in order to document the blade condition and to find the blade SNs in order to determine the installation location of each blade. Similar to the No. 1 propeller blades, none of the labels remained on the No. 2 propeller blades, so no PN or SN identification could be determined. With the lack of specific blade sequencing, the blades were arbitrarily identified for documentation purposes. See **TABLE 2** for propeller blade description and photos.

TABLE 2: PROPELLER BLADE DESCRIPTION FOR THE NO. 2 PROPELLER

Blade #	Description	Blade #	Description
AR	A piece of the outboard LE tip, roughly 2 feet in length was recovered near the RGB. The tip LE exhibited two small round-bottom soft body impacts (**PHOTO 34**).	DR	The blade was full length and broken at the butt end of the blade. This blade exhibited the most damage of any of the full length blades recovered. The outboard section of the de-icing boot was torn with no corresponding impact mark. Trailing edge was missing material near the butt end and the two halves had delaminated along the trailing edge spine. The butt end of the blade was cracked **(PHOTO 37)**.
BR	The blade was full length and broken at the butt end of the blade. The de-icing boot was intact but torn near the outboard end, at the mid span - in the vicinity of one of the leading edge impact marks -, and at the butt end. The leading edge exhibited two soft impact marks located about 2 feet from the blade tip (**PHOTO 35**).	ER	The blade was full length and broken at the butt end of the blade. The blade tip was slightly bent in the direction opposite of rotation. The leading edge had become delaminated. A significant impact mark (piece missing) was noted about 8 to 10 inches from the de-icing boot outboard edge **(PHOTO 38)**.
CR	The blade was full length and broken at the butt end of the blade. The de-icing boot was intact and torn near the outboard end but no corresponding leading edge impact was noted at the tear. A longitudinal crack ran from the butt end of the blade to about 1.5 feet outward along the back of the blade **(PHOTO 36)**.	FR	This piece of propeller tip was very similar to blade identified as "AR" except the outermost part of the tip was also missing. This piece of propeller blade was found in the main wreckage impact site, in the basement of the house towards the right side of the basement vertical wall **(PHOTO 39)**.
		GR	A partial propeller blade was also found resting on the ground just forward of the RGB. This piece of airfoil measured about 2-feet long and was fractured transversely across the airfoil. The piece was fractured beyond the butt end of the blade and could not be positively identified as either coming from "AR" or "FR" but through process of eliminating it is thought to be a part of a blade definitely from the No. 2 propeller **(PHOTO 40)**.

PHOTO 34: PROPELLER BLADE 'AR''

PHOTO 35: PROPELLER BLADE 'BR'

PHOTO 36: PROPELLER BLADE 'CR'

PHOTO 37: PROPELLER BLADE 'DR'

PHOTO 38: PROPELLER BLADE 'ER'

PHOTO 39: PROPELLER BLADE 'FR'

PHOTO 40: PROPELLER BLADE 'GR'

3.0 FLIGHT DATA RECORDER INFORMATION

The engine sequence of events is based on data from the digital flight data recorder (DFDR) for the event flight number 3407. The DFDR was sent to the Safety Board Headquarters in Washington DC and was read out by the Vehicle Recorder Group. **FIGURE 1** is a DFDR plot for the last moments of the accident flight, **TABLE 3** provides a quick reference for the engine sequence, and **TABLE 4** provides a short timeline of engine events. For additional details on the DFDR data, see the Data Recorder Specialists Report. For reference purposes, time = zero seconds (T=0s) corresponds to the FDR data time of 21:57:28 eastern standard time (EST) and is designated as the time when the airplane is at a stable cruise condition, just before beginning the initial descent into Buffalo Niagara International Airport (BUF). Reference times have been rounded to the nearest second and the following nomenclature is for guidance: PL stands for power lever, NH stands for high pressure rotor speed, NL stand for low pressure rotor speed, and NP stands for propeller speed.

At T=0s, both engines No. 1 and No. 2 exhibited normal engine parameter values consistent with cruise. About fifteen seconds later, at T=+15s (21:57:43), the aircraft began its descent with a PL reduction followed by a reduction in engine and propeller parameters reflecting the decrease in power commanded, and a steady drop in altitude. The FDR data shows several PL transients, with appropriate engine and propeller parameters shifts, to stabilize the descent. The altitude hold mode is activated at T=+1002s (22:14:10) and the airplane slowly stops its descent and levels off at about 2400 feet pressure altitude.

At about T=+1120s (22:16:00), the PLs were brought back, the engine and propeller parameters along with the airspeed started to decreased; however, the altitude remained relatively constant. The engine and propeller parameters stabilized at T=+1124s (22:16:04) and continue at those levels until T= +1140s (22:16:28). Although the engine and propeller parameters remained stable, the airspeed continued a gradual decrease until T=+1147s (22:16:35) where it became erratic. Prior to the airspeed becoming erratic, the FDR data indicated that at T=+1140s (22:16:28) the autopilot became disengaged and the airplane started to pitch up, and at T=+1141s (22:16:29) the control column force shifted from a positive value to a negative value (back pressure),[6] and the PL was advanced with the corresponding engine and propeller parameters increasing. One (1) second later, at T=+1142s (22:16:30), the stick shaker was activated and one (1) second after that T=+1143s (22:16:31), the engine and propeller parameters reach their maximum sustained value and remained at those values until the end of the recording. At T=+1146s (22:16:34),[7] the stick pusher activated and both the stick shaker and stick pusher remained activated until the end of the recording.

TABLE 3: ACCIDENT SEQUENCE RELATIVE TO ENGINE PARAMETERS

	ENGINE & PROPELLER NO. 1					ENGINE & PROPELLER NO. 2				
Time (EST)	%PL	%NH	%NL	NP	Torque	%PL	%NH	%NL	NP	Torque
21:57:28	70	90	87	849	75	70	91	87	849	75.5
21:57:43	70	91	87	849	75	69	90	87	849	75
22:16:00	45	81	72	849	30	44	80	72	849	28
22:16:04	42	73	60	852	5.5	42	71	57	852	3
22:16:28	52	76	63	1019	7	53	75	61	1022	6.5
22:16:31	71	85	77	1024	52.5	70	86	79	1023	5.8

[6] The control column force is recorded approximate every two (2) seconds. T here was no recorded value for FDR data time 22:16:28; however, the value at 22:16:27 was +0.45 and the value at 22:16:29 was –18.02. The control force value remained negative to the end of the recording.

[7] The values for stick shaker and sticker pusher are recorder every four (4) seconds.

TABLE 4: GENERAL TIME LINE FOR ENGINE & PROPELLER PARAMETERS		
Time (EST)	**Time**	**Pertinent Engine Parameters**
21:57:28	T=0s	Cruise condition
21:57:43	T=+15s	Airplane begins initial descent into BUF
22:14:10	T=+1002s	Altitude mode activated and airplanes starts to arrest its descent
22:16:00	T=+1124s	Power levers reduced with corresponding decrease in engine & prop parameters and a decrease in airspeed
22:16:28	T=+1140s	Autopilot is disengaged and airplane starts to pitch up.
22:16:29	T=+1141s	Control column force goes negative and power levers advances with corresponding increase in engine & prop parameters
22:16:30	T=+1142s	Stick shaker activates
22:16:31	T=+1143s	Engine & prop parameters reach maximum values.
22:16:34	T=+1146s	Stick pusher is activated.
22:16:35	T=+1147s	Airspeed is erratic (uncontrolled)

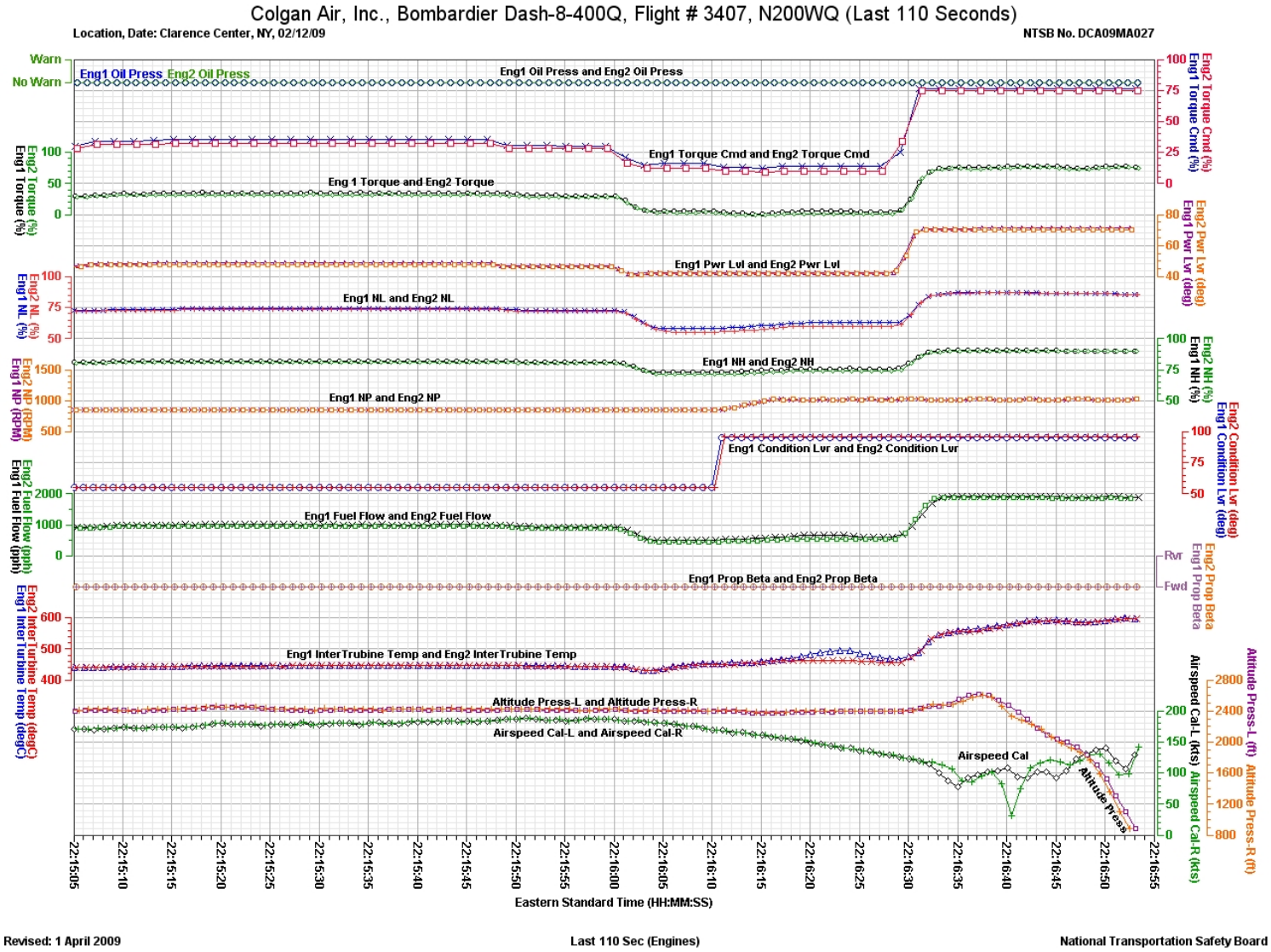

FIGURE 1: FLIGHT DATA RECORDER PLOT

Jean-Pierre Scarfo
Aerospace Engineer
Powerplant Lead Engineer

APPENDIX 1: ENGINE AND PROPELLER TIMES AND CYCLES

Title:	Aircraft Information Form	Date: 2/12/09	Page 1 of 1

AIRCRAFT

Make/Model/Series	Current Registration No.	Date of Last MX Visit	List of Passenger Accommodations (LOPA)
Bomb/DHC-8-402	N200WQ	(02/12/09)	Yes No
Serial No.	**Previous Registration No.**	**Date of Last "C" CK.**	**Repair Assessment Available?**
4200	N/A	(MM/DD/YY) N/A NEW A/C	Yes No
Line or Fuselage No.	**Total Time (TT)**	**Last Operator**	
784	1819.3	(Designator) N/A NEW A/C	
Date of Manufacture	**Total Cycles (TC)**	**Current Operator**	**Bridging Document Available?**
04/12/08	1809	(Designator) COLGAN AIR	Yes N/A No
TC Data Sheet (No.)	**Interior Configuration**		
A13NM	(# of PAX) 74		

WGT

Operator's Empty Wgt.	Max Structural Wgt.	Max Take-Off Wgt.	Date of Last Weighing
39792.1 lbs	65,400 lbs	65,200 lbs	(MM/DD/YY) 04/12/08
Max Zero Fuel Wgt.	**Max Taxi or Ramp Wgt.**	**Max Landing Wgt.**	**Current Acft Equip List?**
58,000 lbs	65,400 lbs	62,000 lbs	Yes No

POWERPLANT

Power Plant 1	Power Plant 2	Power Plant 3	Power Plant 4
Make/Model/Series	**Make/Model/Series**	**Make/Model/Series**	**Make/Model/Series**
PW 150A	PW 150A	N/A	N/A
Serial No.	**Serial No.**	**Serial No.**	**Serial No.**
PCE-FA0452	PCE-FA0453		
Total Time (TT)	**Total Time (TT)**	**Total Time (TT)**	**Total Time (TT)**
1819.3	1819.3		
Total Cycles (TC)	**Total Cycles (TC)**	**Total Cycles (TC)**	**Total Cycles (TC)**
1809	1809		
Time Since Overhaul (TSO)	**Time Since Overhaul (TSO)**	**Time Since Overhaul (TSO)**	**Time Since Overhaul (TSO)**
N/A ON CONDITION	N/A ON CONDITION		

Powerplant Type Certificate Data Sheet (No.) E00062EN

PROPS

Propeller 1	Propeller 2	Propeller 3	Propeller 4
Make/Model/Series	**Make/Model/Series**	**Make/Model/Series**	**Make/Model/Series**
DOWTY/cR408/6-123-F/17	DOWTY/cR408/6-123-F/17	N/A	N/A
Serial No.	**Serial No.**	**Serial No.**	**Serial No.**
DAP 0451	DAP 0452		
Total Time (TT)	**Total Time (TT)**	**Total Time (TT)**	**Total Time (TT)**
1819.3	1819.3		
Total Cycles (TC)	**Total Cycles (TC)**	**Total Cycles (TC)**	**Total Cycles (TC)**
1809	1809		

Propeller Type Certificate Data Sheet (No.) P17BO

APU

Make/Model/Series	Total Time (TT)	Time Since Overhaul (TSO)	Applicable to Acft TCDS?
HAMILTON/SUNDSTRAND	661.7	N/A ON CONDITION	Yes No
Serial No.	**Total Cycles (TC)**		
SP-E074722	NA		

LDG GEAR

Nose Gear	RH Main Gear	LH Main Gear	Other Gear Assemblies
Make/Part Number	**Make/Part Number**	**Make/Part Number**	**Make/Part Number**
Goodrich/47100-15	Goodrich/46250-11	Goodrich/46250-11	N/A
Serial No.	**Serial No.**	**Serial No.**	**Serial Nos.**
MA0228	MA0425	MA0424	/
Total Time (TT)	**Total Time (TT)**	**Total Time (TT)**	**Total Time (TT)**
1819.3	1819.3	1819.3	/
Total Cycles (TC)	**Total Cycles (TC)**	**Total Cycles (TC)**	**Total Cycles (TC)**
1809	1809	1809	/
Time Since Overhaul (TSO)	**Time Since Overhaul (TSO)**	**Time Since Overhaul (TSO)**	**Time Since Overhaul (TSO)**
1819.3	1819.3	1819.3	/

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