NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

January 18, 2014

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT
NTSB ID: DCA13MA133

A. ACCIDENT

Location:	Birmingham, Alabama
Date:	August 14, 2013
Time:	0447 Central Daylight Time (CDT)
Aircraft:	Airbus 300-600, United Parcel Service flight 1354, N155UP

B. POWERPLANTS GROUP

Chairman:	Carol Horgan National Transportation Safety Board Washington, DC
Member:	Jeffrey S. Logue United Parcel Service Louisville, Kentucky
Member:	Hongyang Bao Pratt & Whitney East Hartford, Connecticut
Member:	Jim Gess (participated August 15-16, 2013) International Pilots Association Atlanta, Georgia
Member:	Brian R. Stephenson Teamsters Local 2727 Louisville, Kentucky
Technical Advisor:	Christian Marty (participated August 16-20, 2013) Airbus Blagnac, France

C. SUMMARY

On August, 14, 2013, at about 0447 central daylight time (CDT), United Parcel Service (UPS) flight 1354, an Airbus A300-600, N155UP, crashed short of runway 18 while on approach to Birmingham-Shuttlesworth International Airport (BHM), Birmingham, Alabama. The captain and first officer were fatally injured and the airplane was destroyed. The scheduled cargo flight was operating under the provisions of 14 Code of Federal Regulations (CFR) Part 121 and originated from Louisville International-Standiford Field Airport (SDF), Louisville, Kentucky.

D. DETAILS OF THE INVESTIGATION

1.0 Engine information

The airplane was powered by two Pratt & Whitney PW4158(3) turbofan engines.

1.1 Engine description

The PW4158(3) is a high-bypass, dual-rotor turbofan engine featuring a 94-inch diameter fan and four-stage low pressure compressor (LPC) driven by a four-stage low pressure turbine (LPT); an annular combustor; and an 11-stage high pressure compressor (HPC) driven by a two-stage high pressure turbine (HPT). The PW4158 has a 58,000 pound thrust rating.

1.2 Engine data

According to the airplane's maintenance records, the engine installed in the No. 1 position was serial number (S/N) P729825 and the engine installed in the No. 2 position was S/N P728586. See Table 1.

Position	Model	S/N	Installed	Last Shop Visit	Time Since New	Cycles Since New	Time Since Repair	Cycles Since Repair
1	PW4158(3)	P729825	05/12/2011	01/22/2011	10,890	6,756	2,471	1,542
2	PW4158(3)	P728586	01/30/2012	06/08/2011	11,169	7,086	1,693	1,062

Table 1. Engine data

1.3 Engine history

A review of the airplane powerplant service records for the 90 days prior to the accident found only routine maintenance was performed, with no significant discrepancies. The records showed that both engines underwent performance restoration workscopes during their last shop visits (HPC, HPT, diffuser, combustor, and turbine nozzle overhauls; and LPC, LPT, main gearbox, fan case, intermediate case, and turbine exhaust case repair).

A review of the maintenance fault codes downloaded from the electronic engine control (EEC) non-volatile memory (NVM) chips found that "Surge Detected" fault codes were set by both the

No. 1 and No. 2 engine EECs during the crash sequence.[1] There were no faults set indicating significant discrepancies for the 90 days prior to the accident.

1.4 Engine installation

The Airbus A300 engine nacelles are underwing-mounted and are about 52 feet apart. See Figure 1.

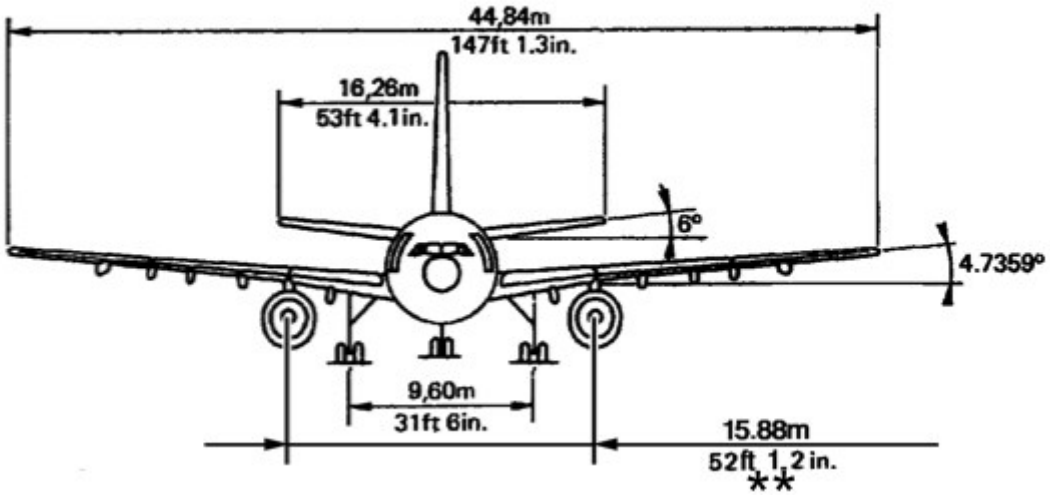

Figure 1. Airbus 300 configuration

2.0 Wreckage distribution

An aerial survey of the airplane's flight path identified the initial point of impact as a tree strike in a forested area 6,440 feet due north of the runway 18 threshold.[2] Ground scars indicated that the airplane contacted the ground 1,416 feet from the initial tree strike and collided with rising terrain about 360 feet further south. The forward section of the fuselage came to rest 4,070 feet north of the runway 18 threshold. Both engines were located about 1,000 feet northwest of the forward fuselage section. The aft fuselage, right wing, and empennage were found 3,650 feet north of the runway 18 threshold. See Figure 2.

---

[1] Engine surge is a response of the entire engine characterized by large fluctuations in engine pressures with significant flow reduction or reversal in the compression system.

[2] Distance measurements in this report are from preliminary survey data collected at the site by the Federal Bureau of Investigation.

Figure 2. Overview of accident site showing the airplane's energy path

3.0 Wreckage path

The Powerplants Group documented the path of the airplane from the initial point of impact in the forested area to the final resting place of the engines.

3.1 Initial point of impact to airport perimeter fence

Tree limbs and pieces of nacelle and wing material and were found on the forest floor and caught in trees at the initial point of impact. Many of the tree limbs displayed cleanly cut ends and areas of missing bark. See Figure 3.

Figure 3. Cleanly cut 2-inch diameter tree limb found at the initial tree strike area

A large number of tree branch segments, stripped of bark and of similar lengths (4 to 6 inches), and having clean, angled cuts on one or both ends were also noted in this area. See Figure 4.

Figure 4. Examples of the branch segments found near damaged trees

The lengths and cut angles of the branch segment were consistent with the geometry of the PW4158 engine fan (See Figure 5), suggesting that the segments were produced when tree limbs were ingested by the engine and cut by the fan blades ("processed"). See Figure 6.

Figure 5. PW4000 fan inlet and "processed" branch segments

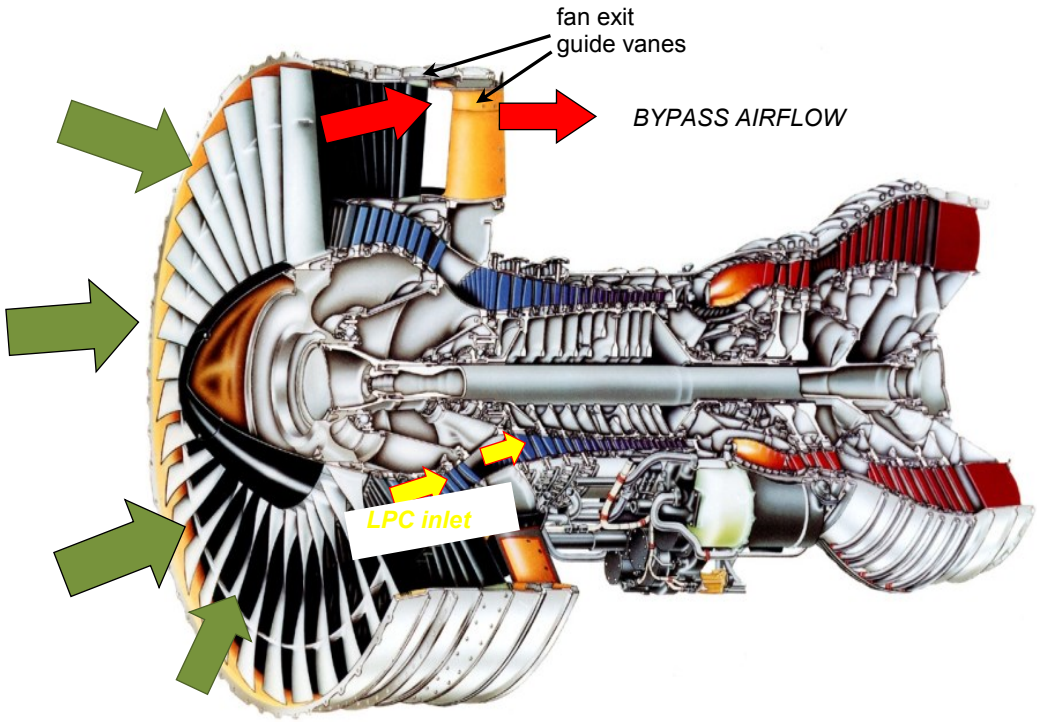

Figure 6. Cutaway view of PW4000 showing engine ingestion paths

South of the forested area, a series of 15 additional tree and telephone pole strikes indicated that the airplane flew low over the residential area for about 950 feet, to the airport perimeter fence. The northernmost of the tree strikes was a large pine tree located close to the southern edge of the forested area, 6,254 feet north and three feet west of the runway 18 threshold centerline. "Processed" branch segments were found near the pine. Nacelle and engine fragments, including most of a fan exit guide vane, a 10.6-inch by 6.0-inch piece of inlet cowl lip skin, and a fragment of engine inlet cowl outer barrel skin were recovered about 50 feet east of the pine tree strike, also near the forest edge. See Figures 7 through 9.

Figure 7. Fan exit guide vane fragment

Figure 8. Inlet cowl lip skin fragment

Figure 9. Inlet cowl outer barrel skin fragment

Large and small tree branches and a light amount airplane fragments was scattered over an approximately 50 foot wide (east to west) debris field that followed the tree damage for about 950 feet, to the airport perimeter fence. The airplane debris was primarily composed of small fragments of wing, nacelle and inlet material. Additional "processed" branch segments were also found.

3.2 Airport

Little nacelle or engine debris was noted beyond the airport fence until just beyond the first ground scar, which began about 500 feet south of the airport fence and 5,024 feet north of the

runway 18 threshold. The ground scar indicated that the airplane struck the ground, travelled about 470 feet further south and collided with upward-sloping terrain. Deep furrows and depressions were found in the slope ground scar. See Figure 10. Blackened vegetation and the odor of fuel indicated that a ground fire had occurred in this area.

Figure 10. Abruptly rising terrain about 470 feet south of the first ground scar

The amount of nacelle and engine debris increased considerably beyond the base of the rising terrain. Engine nacelle and thrust reverser components were found embedded in several of the depressions. Thrust reverser cascade and translating cowl material began to appear, along with additional fan exit guide vanes. An engine inlet cowl with an intact P2T2 probe was found on the rising terrain. The S/N of the P2T2 probe identified the inlet cowl as No. 1 engine material. The probe was clogged with wood debris. The 10.6-inch by 6.0-inch inlet cowl lip skin fragment found near the initial tree strike was matched to a missing section of the No. 1 engine cowl lip. See Figure 11.

Figure 11. No.1 inlet cowl showing wood jammed in P2T2 probe and missing skin fragment

The forward section of the airplane fuselage was found on top of the slope. The engines were found resting about 1,000 feet northwest of the forward fuselage section, 4,070 feet north of the runway 18 threshold and about 25 feet apart. See Figures 12 and 13.

Figure 12. View of the engines, looking southeast

Figure 13. View of the engines, looking southwest

4.0 Engines

4.1 No. 1 engine

The engine data plate located on the fan case identified the No. 1 engine. It was resting on its (3 o'clock[3]) side. The pylon and a small section of wing remained attached to the engine. See Figure 14. The engine showed no indication of uncontainment or pre-impact fire.

4.1.1 Nacelle

The No. 1 engine inlet cowl, exhaust sleeve, and the bulk of the engine cowling except for the outboard portions of the fan cowl and thrust reverser had been shed.

[3] O'clock refers to approximate circumferential locations in a clockwise direction, viewed from the rear of the engine looking forward.

Figure 14. Left side view of the No. 1 engine

4.1.2 Core engine and externals

Inspection of the No. 1 engine core found no indications of uncontainment or pre-impact fire. The gearbox was fractured and some internal components were liberated. The external engine components exhibited thermal damage consistent with post-impact fire. The exhaust cone exhibited deformation (crushing) that was centered at four o'clock.[4] The No. 2.5 bleed valve actuator was in the open position. The variable stator vane (VSV) actuator was not accessible for examination. The EEC housing was fractured.

[4] The exhaust nozzles of both engines were liberated and both were found about 100 feet west of the engines. One of them was deformed at the same circumferential location as the No.1 engine exhaust cone.

Local (no rotation) borescope inspections (BSI) were performed through the LPC inlet and the 2.5 bleed port. Large masses of wood shavings were observed inside the LPC. See Figure 15. There was no evidence of rotational contact between the LPC rotor and adjacent stationary structures in the inspected areas.

Figure 15. Borescope images taken inside the No. 1 engine low pressure compressor

Examination of the turbine exhaust found ashes and a charcoal-like material on the outer platform surfaces and on the tip shroud inner diameter of the LPT last stage blades. There was an odor of burnt wood. No metal shavings or particles were observed. The last stage of the LPT appeared intact.

The EEC (P/N 791100-6-109, S/N 4000-2755) was removed for recovery of fault code memory.

4.1.3 Fan

All of the No. 1 engine intermediate case struts except the 12 o'clock strut were fractured and the fan case was leaning aft, with the most pronounced lean at 8 o'clock. The spinner was caved in and the spinner cap was inside the cone segment of the spinner. See Figure 16.

Figure 16. No. 1 engine fan inlet

Between 4 and 1 o'clock, the No. 1 engine fan blades were severely bent aft and in the direction of rotation and both the fan and the LPC were packed with soil. The soil in the fan section and LPC appeared consistent with the soil at the ground scar in the slope (red clay, grass and small stones). Six blades between 1 and 3 o'clock showed only minor damage. Five consecutive fan blades between 3 and 4 o'clock were bent S-shaped. Three blades (at 1, 3 and 8 o'clock) were fractured inboard of the midspan shroud. Multiple fan leading edges exhibited soft body damage. Two or three blades were missing leading edge tip material. Several small tree branches were observed behind the fan within the fan case. The portions of the fan abradable lining available for inspection exhibited several radial, linear impact marks and no circumferential rubbing. Most of the fan exit guide vanes were liberated.

4.2 No. 2 engine

The engine data plate located on the fan case identified the No. 2 engine. The core engine was resting on its (9 o'clock) side, but all of the intermediate case struts were fractured and the fan/intermediate case was resting on its 5 o'clock position. The fan case still enclosed the fan. The engine had separated from the pylon at the engine mount locations. There were no indications of uncontainment or pre-impact fire.

4.2.1 Nacelle

All nacelle components had been shed. See Figure 17.

Figure 17. Right side view of the No. 2 engine

4.2.2 Core engine and externals

The No. 2 engine LPC inlet was blocked by soil between 1 and 6 o'clock. The gearbox was fractured. The fuel pump housing was fractured at the interstage fuel filter, and it and adjacent components were thermally damaged. The EEC housing was fractured. The VSV actuator rod was extended about 1 3/8 inches. The No. 2.5 bleed was in the open position. Many of the observable 2.5 bleed ports were full of wood shavings and leaves. See Figure 18. The exit screen of the right 2.9 bleed valve was partially blocked by wood shavings. See Figure 19.

Figure 18. Wood debris at No. 2 engine 2.5 bleed screen and ports

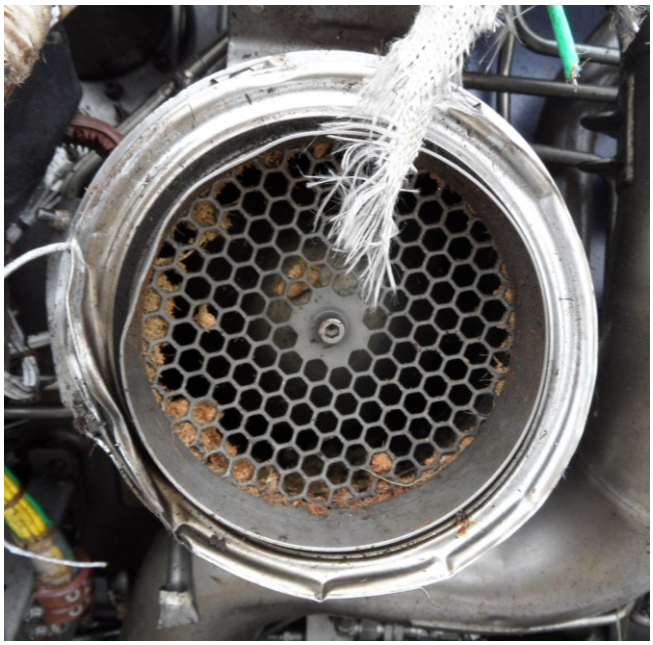

Figure 19. Wood debris captured by the No. 2 engine 2.9 bleed valve exit screen

A local BSI through the No. 2 engine LPC inlet and the 2.5 bleed port found large amounts of wood shavings inside the LPC.[5] There was no evidence of rotational contact between the LPC rotor and adjacent stationary structures in the inspected areas. Examination of the turbine exhaust found ashes and a charcoal-like material on the outer platform surfaces and on the tip shroud inner diameter of the LPT last stage blades. There was an odor of burnt wood. No metal shavings or particles were observed. The last stage of the LPT appeared intact.

The EEC, P/N 791100-6-109, S/N 4000-3087 was removed for recovery of fault code memory.

4.2.3 Fan

There was relatively minor damage to three consecutive No. 2 engine fan blades from 12 to 1 o'clock (relative to the engine core)[6]. An arc of blades between 1 and 6 o'clock were severely deformed, with ten fractured; all were bent aft and in the direction of rotation. Seven consecutive blades between 6 and 8 o'clock showed relatively minor damage. The blades between 8 and 12 o'clock were bent in the direction of rotation outboard of the midspan shroud. Multiple blade leading edges showed soft body impact damage. The spinner was liberated and was found nearby in a deformed condition. All of the fan exit guide vanes were liberated. The fan abradable lining had several radial, linear impact marks but exhibited no heavy circumferential rubbing. See Figure 20.

[5] As viewed on the screen of the borescope instrument by the Powerplants Group members. No images were taken of the debris in the No. 2 engine.

[6] Clock locations are in reference to the core engine and not the fan case.

Figure 20. Inlet view of No. 2 engine

5.0 Auxiliary power unit

The auxiliary power unit (APU) data plate showed Honeywell Model GTCP 331-250H, S/N P1552. The APU was documented with photographs. No anomalies were noted.

6.0 EEC downloads

Members of the Powerplants Group met at United Technologies Aerospace Systems (UTAS) in Windsor Locks, Connecticut, on August 26, 2013 to witness the download of the EEC NVM fault data.

The EEC monitors airplane and engine parameters and selects optimum fuel flows for given flight conditions. Certain parameter anomalies set fault codes that aid in maintenance planning. The maintenance fault codes can sometimes provide useful information about an engine's condition during an event. The EEC design includes two redundant digital channels (Channels A and B).

6.1 EEC S/N 4000-2755, removed from the No. 1 engine

The EEC housing and cover were fractured and partially coated with dried mud. Water was

found on the channel separator.[7] A small amount of particulate contamination was found on the burner pressure (Pb) sensor inlet screen; this contamination appeared consistent with the mud found on the housing/cover. The Channel A data were downloaded directly from the U211 and U212 memory chips, due to processor module damage. The Channel B processor module was intact and data were downloaded with the chips installed on the module.

The downloaded data showed that a "Surge Detected" fault code set during the accident sequence at 7,040 gas producer revolutions per minute (rpm), which is approximately 71.1% N2.[8] See Table 2.

6.2 EEC S/N 4000-3087, removed from the No. 2 engine

The housing and cover of the EEC were fractured and partially coated with dried mud. Particle contaminants were found on the burner pressure (Pb) sensor inlet screen; this contamination appeared consistent with the mud found on the housing/cover. Both the Channel A and Channel B processor modules were damaged and the data were downloaded from the U211 and U212 memory chips.

The downloaded data showed that a "Surge Detected" fault code set during the accident flight at 7,168 gas producer rpm, which is approximately 72.4% N2.

engine S/N	*pos*	*model*	*P/N*	*S/N*	*last shop visit*	*Level A fault codes*	*N2*
P729825	1	EEC131-1	791100-6-109	4000-2755	11/22/2010	03 (SURGE DETECTED)	71.1%
P728586	2	EEC131-1	791100-6-109	4000-3087	10/25/2010	03 (SURGE DETECTED)	72.4%

Table 2. EEC download data

Carol M. Horgan
Powerplants Group Chairman

[7] Both EECs were exposed to heavy rain after the accident.

[8] The surge fault code is set when the burner pressure (Pb) rate of change or, if Pb is failed, the exhaust duct pressure rate of change indicates an engine surge condition.