



National Transportation Safety Board Aviation Accident Final Report

Location:	SAVANNAH, GA	Accident Number:	ERA16LA082
Date & Time:	01/06/2016, 0835 EST	Registration:	N978AF
Aircraft:	PILATUS AIRCRAFT LTD PC-12	Aircraft Damage:	Substantial
Defining Event:	Flight instrument malf/fail	Injuries:	2 Minor
Flight Conducted Under:	Part 91: General Aviation - Positioning		

Analysis

The two airline transport pilots reported that takeoff acceleration in the single-engine, turboprop-equipped airplane was normal; however, shortly after rotation and during initial climb, a crew alerting system (CAS) warning activated. The CAS indicated excessively high engine torque. According to the copilot, who was the pilot flying, when he looked down, he saw a torque value of 5.3 pounds per square inch (psi). The pilot, who was monitoring from the left seat, reported that he saw a "low torque CAS message." He added that the copilot told him to "declare an emergency and run the checklist." With about 2,700 ft of runway remaining and the airplane at 200 ft mean sea level, the copilot chose to land immediately and executed a 90° left descending turn to land in grass. The airplane touched down and rolled about 600 ft before impacting a ditch, which resulted in substantial damage to the airplane and a postimpact fire.

Data retrieved from the airplane's modular avionics unit revealed that all engine indications and parameters were normal throughout the takeoff roll and rotation; however, during the initial climb, the torque indication increased rapidly from about 45.0 to 71.0 psi; fault history data confirmed that the engine torque caution and warning were displayed during this time and that the other engine parameters remained normal. Four seconds later, the torque decreased to 47.3 psi, which coincided with a simultaneous drop in other engine parameters, consistent with the copilot reducing engine power following the CAS warning. The CAS was not equipped to display warnings for low torque values; a CAS warning or caution would only activate if an exceedance of torque tolerances occurred. Therefore, although both pilots reported seeing a low torque indication, given that the CAS is not equipped to display warnings for low values and that the data did not indicate a low torque condition occurred during the flight, it is likely that the pilots misinterpreted the CAS warning.

Examination of the engine and torque indicating system revealed no evidence of any preaccident mechanical malfunctions or failures that would have precluded normal operation, and the cause of the high torque indication could not be determined. Given that no anomalies were found with the engine and torque indicating system during postaccident examination and that all other engine parameters remained normal throughout the flight, it is likely that the high torque indication was erroneous.

The Pilot's Operating Handbook for the airplane stated that, following a CAS warning or caution for engine torque, engine power should be reduced if the torque value was above 44.3 psi. It also stated that, if the CAS warning or caution remained after the engine power was reduced, then the airplane should be landed as soon as possible using minimum power. Despite the pilots' misinterpretation of the torque indication, they should have followed the POH guidance on how to respond to an engine torque indication. However, the pilots chose to declare an emergency and immediately land after seeing the CAS warning during a critical phase of flight rather than troubleshooting the CAS message by reducing engine power to determine whether the CAS message could be resolved and despite onboard data indicating that the reduction in power resulted in the torque value returning to normal. The pilots reacted by reducing engine power substantially, which left them with no option but to conduct an off-runway emergency landing.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilots' failure to follow proper procedures in response to a crew alerting system warning for high engine torque values, which necessitated an off-runway emergency landing during which the airplane sustained substantial damage due to postimpact fire. Contributing to the accident was the erroneous engine torque indication for reasons that could not be determined.

Findings

Aircraft	Engine (turbine/turboprop) - Malfunction (Factor)
Personnel issues	Decision making/judgment - Flight crew (Cause) Unnecessary action - Flight crew (Cause) Use of policy/procedure - Flight crew (Cause)
Environmental issues	Sloped/uneven terrain - Contributed to outcome

Factual Information

History of Flight

Initial climb	Flight instrument malf/fail (Defining event)
Landing-landing roll	Off-field or emergency landing Collision with terr/obj (non-CFIT)

On January 6, 2016, about 0835 eastern standard time, a Pilatus PC-12/47E, N978AF, collided with a ditch during a precautionary landing after takeoff from Savannah/Hilton Head International Airport (SAV), Savannah, Georgia. The pilot and copilot sustained minor injuries, and the airplane was substantially damaged. The airplane was registered to Upper Deck Holdings, Inc. and was being operated by PlaneSense, Inc., as a Title 14 *Code of Federal Regulations* Part 91 positioning flight. Visual meteorological conditions prevailed, and an instrument flight rules flight plan was filed for the flight to Blue Grass Airport (LEX), Lexington, Kentucky.

The pilot in the left seat was the pilot monitoring and the copilot in the right seat was the pilot flying. The crew had the full length of the runway 1 available (7,002 ft) for takeoff. The pilots reported that the acceleration and takeoff was normal and after establishing a positive rate of climb, the crew received an auditory annunciation and a red crew alerting system (CAS) torque warning. The engine torque indicated 5.3 pounds per square inch (psi); the nominal torque value for the conditions that day was reported by the crew to be 43.3 psi. With about 2,700 ft of runway remaining while at an altitude of 200 ft msl, the copilot elected to land immediately; the copilot pushed the nose down and executed a 90° left descending turn and subsequently landed in the grass. Although he applied "hard" braking in an attempt to stop, the airplane impacted a drainage ditch, resulting in substantial impact damage and a postimpact fire.

The pilot reported that, after takeoff, he observed a low torque CAS message and the copilot told him to "declare an emergency and run the checklist." The pilot confirmed that the landing gear were extended and the copilot turned the airplane to the left toward open ground between the runways and the terminal. About 60 seconds elapsed from the start of the takeoff roll until the accident.

The airport was equipped with security cameras that captured the airplane from its initial climb through the landing and collision. One camera, pointed toward the west-southwest, recorded the airplane's left descending turn and its landing in the grass, followed by impact and smoke. A second camera, mounted on the control tower, pointed toward the southeast and showed the airplane during the initial climb before it leveled off and entered a descending left turn; it also showed the airplane land and roll through the grass before colliding with the ditch.

Pilot Information

Certificate:	Airline Transport	Age:	66, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Left
Other Aircraft Rating(s):	Glider	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 1 With Waivers/Limitations	Last FAA Medical Exam:	11/19/2015
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	12/16/2015
Flight Time:	23141 hours (Total, all aircraft), 534 hours (Total, this make and model), 18410 hours (Pilot In Command, all aircraft), 154 hours (Last 90 days, all aircraft), 35 hours (Last 30 days, all aircraft), 4 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport	Age:	52, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Right
Other Aircraft Rating(s):	None	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine	Toxicology Performed:	No
Medical Certification:	Class 2 Without Waivers/Limitations	Last FAA Medical Exam:	01/16/2015
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	09/14/2015
Flight Time:	7900 hours (Total, all aircraft), 5100 hours (Total, this make and model), 7700 hours (Pilot In Command, all aircraft), 168 hours (Last 90 days, all aircraft), 37 hours (Last 30 days, all aircraft), 0 hours (Last 24 hours, all aircraft)		

A review of Federal Aviation Administration (FAA) airman records revealed that the pilot held an airline transport pilot certificate with airplane single- and multi-engine land ratings. His most recent FAA first-class airman medical certificate was issued on November 19, 2015. He reported 23,141 total hours of flight experience with 534 hours in the accident airplane make and model at the time of the accident. He reported 154 hours and 35 hours of flight experience in the 90 days and 30 days before the accident, respectively. His most recent flight review was completed on September 14, 2015, in the PC-12.

The copilot held an airline transport pilot certificate with airplane single- and multi-engine land ratings. He held instructor ratings for airplane single engine, airplane multi-engine, and instrument airplane. His most recent FAA second-class medical certificate was issued on January 16, 2015. He reported 7,900 total hours of flight experience at the time of the accident, and 5,100 hours in the accident airplane make and model. He reported 168 hours and 37 hours

of flight experience in the 90 days and 30 days before the accident, respectively. His most recent flight review was completed on September 14, 2015, in the PC-12.

Aircraft and Owner/Operator Information

Aircraft Make:	PILATUS AIRCRAFT LTD	Registration:	N978AF
Model/Series:	PC-12 47E	Aircraft Category:	Airplane
Year of Manufacture:	2008	Amateur Built:	No
Airworthiness Certificate:	Normal	Serial Number:	1078
Landing Gear Type:	Retractable - Tricycle	Seats:	8
Date/Type of Last Inspection:	12/31/2015, AAIP	Certified Max Gross Wt.:	10450 lbs
Time Since Last Inspection:	20 Hours	Engines:	1 Turbo Prop
Airframe Total Time:	4209 Hours at time of accident	Engine Manufacturer:	P&W CANADA
ELT:	C126 installed, not activated	Engine Model/Series:	PT6A-67P
Registered Owner:	Upper Deck Holdings Inc.	Rated Power:	1200 hp
Operator:	PlaneSense, Inc.	Operating Certificate(s) Held:	On-demand Air Taxi (135)

According to FAA records, the low wing, T-tail, retractable-gear airplane was powered by a Pratt & Whitney Canada PT6A-67P, 1,200 shaft horsepower turboprop engine equipped with a Hartzell, four-bladed, hydraulically-actuated, constant-speed propeller assembly. The airplane was issued a normal category airworthiness certificate on December 19, 2008.

Maintenance records indicated that the airplane's most recent Approved Aircraft Inspection Program (AAIP) inspection was conducted on December 31, 2015, at an airframe total time of 4,189 hours and engine total time of 4,189 hours, with 3,976 cycles since new.

According to the operator, the airplane's estimated takeoff weight at the time of the accident was 9,100 lbs, which was 1,350 lbs below its maximum gross weight of 10,450 lbs. Takeoff distance performance calculations from the pilots operating handbook (POH) indicated that the runway required to safely take off and climb over a 50 ft obstacle using 15° of flaps at this weight was 2,000 ft; the runway being used was 7,002 ft long and according to the aircraft condition monitoring system (ACMS) data, the airplane rotated for takeoff about 2,100 ft down the runway.

According to the POH, red CAS warning messages required immediate corrective action by the pilot and amber caution messages required the pilot's attention, but not an immediate action. Whenever a red or amber message illuminated, the master warning or caution lamp would illuminate. A continuous chime would sound with red messages. A single chime would sound with all amber messages.

The torque and engine temperature indications in the cockpit were depicted with pointer-type display gauges and digital values (see figure 1). During normal operations, all digital values were displayed in white against a black background. The torque analog scale range was from 0 to 55 psi and the digital scale range was from 0 to 70 psi. Two white torque tick marks were on the analog scale at 15 psi and 25 psi. An amber tick mark at 36.95 psi indicated maximum climb/cruise torque, and a red tick mark at 44.34 psi indicated maximum continuous torque. A green arc on the torque gauge from 0 psi to the amber tick mark indicated normal operating torque range and beyond the amber tick mark, the gray arc is the maximum torque range. When the excessive torque warning occurred, the digital indicator and pointer were displayed in red with the associated CAS message. There were no associated CAS messages for low torque values, only high torque exceedances activated a CAS caution or warning.

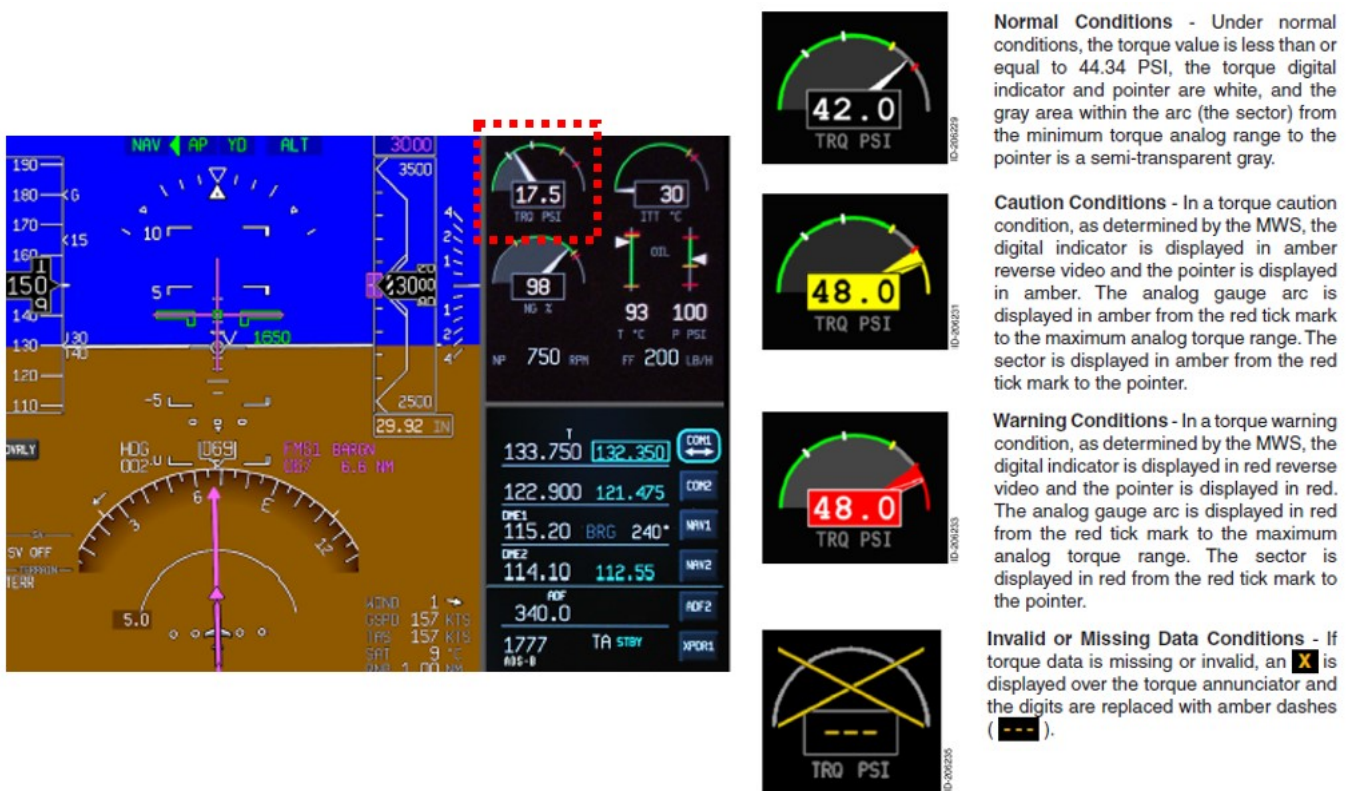


Figure 1. Primary Flight Display (PFD) and engine instruments window showing torque conditions examples.

The POH section 3, Emergency Procedures, Section 3.6.4, outlined the procedures for an engine torque CAS warning or caution:

1. **TORQUE** – Check torque indication
 2. If torque above 44.3 psi, reduce power
- If torque CAS warning or caution remains,

3. Aircraft – Land as soon as possible, using minimum power. If possible always retain glide capability, to the selected landing airfield, in case of total engine failure

The POH defined "Land as soon as possible" as landing without delay at the nearest airport where a safe approach and landing could be reasonably assured.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	Condition of Light:	Day
Observation Facility, Elevation:	SAV, 50 ft msl	Distance from Accident Site:	1 Nautical Miles
Observation Time:	0853 EST	Direction from Accident Site:	
Lowest Cloud Condition:		Visibility	10 Miles
Lowest Ceiling:	Broken / 4300 ft agl	Visibility (RVR):	
Wind Speed/Gusts:	9 knots /	Turbulence Type Forecast/Actual:	/ None
Wind Direction:	20°	Turbulence Severity Forecast/Actual:	/ N/A
Altimeter Setting:	30.46 inches Hg	Temperature/Dew Point:	1°C / -7°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	SAVANNAH, GA (SAV)	Type of Flight Plan Filed:	IFR
Destination:	Lexington, KY (LEX)	Type of Clearance:	IFR
Departure Time:	0830 EST	Type of Airspace:	Class C

At 0853, the reported weather at SAV included wind from 020° at 9 knots, 10 statute miles visibility, broken clouds at 4,300 ft, temperature 1°C, dew point -7°C, and an altimeter setting of 30.46 inches of mercury.

Airport Information

Airport:	Savaanh/Hilton Head Intl (SAV)	Runway Surface Type:	Concrete
Airport Elevation:	50 ft	Runway Surface Condition:	Dry
Runway Used:	01	IFR Approach:	None
Runway Length/Width:	7002 ft / 150 ft	VFR Approach/Landing:	Precautionary Landing

SAV was located about 7 miles northwest of Savannah, Georgia, and was classified by the FAA as a public airport. The airport elevation was 50.2 ft mean sea level (msl). It was equipped with two intersecting runways in a 10/28 and 01/19 configuration. Runway 1 was a 7,002-ft-long

and 150-ft-wide concrete runway in good condition.

Wreckage and Impact Information

Crew Injuries:	2 Minor	Aircraft Damage:	Substantial
Passenger Injuries:	N/A	Aircraft Fire:	On-Ground
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	2 Minor	Latitude, Longitude:	32.127500, -81.202222 (est)

The airplane came to rest in a drainage ditch about 2,300 ft west of runway 1 and 1,800 ft south of the main terminal. The airplane was oriented on a 270° heading. There were three distinct landing gear ground tracks that measured about 700 ft in length in the grass leading up to the airplane. The airplane displayed substantial airframe damage caused by the impact and fire. The engine compartment sustained impact and fire damage, the cockpit was charred, and the airframe was buckled in multiple locations. The cockpit area was nearly separated from the fuselage and both wings sustained significant structural damage.

The engine was examined at Pratt & Whitney Canada Corp., St. Hubert, Quebec, Canada. The engine was covered in soot. The compressor section showed no evidence of pre-impact anomalies. Aside from the thermal and impact damage, there was no evidence of pre-impact anomalies noted with the gearboxes, governor, torque limiter, or fuel control unit (FCU) bellows that would have prevented normal operation.

Testing of the FCU bellows was conducted at Woodward, Inc. The bellows were installed in an exemplar unit and placed on the test stand. The compressor discharge pressure (CDP) was initially set to 125 psi absolute (psia), resulting in a fuel flow of 816 lbs/hour, which was maintained for 6 minutes without the fuel flow changing. The CDP pressure was then set to 100 psia. The control sustained a fuel flow of 475 lbs/hour, which was maintained for 8 minutes without a change in fuel flow. There were no anomalies observed during the test.

The modular avionics unit (MAU) contained data from the custom I/O module (CSIO). The CSIO module was examined and downloaded by Honeywell. According to Honeywell, examination revealed a small amount of debris on "a couple of pins" of the unit internal to the CSIO. The source of the debris could not be determined; however, all tests associated with the reading of the engine torque signals resulted in values within the required specifications and showed no faults or anomalies relevant to the accident.

The torque transducer did not show any signs of excessive mechanical damage, bent connections, or damage to the pressure port or sleeve. Pin continuity was confirmed. The harness was attached to the transducer. Testing of the wire resistances revealed no anomalies. The connector pins were clean and free of oxidation, dirt, and dust; some small scratches did not affect the connection. Additional testing of the transducer, which included input, output,

voltage output over temperature range, and visual inspection yielded normal results. Testing of the torque transducer did not show any mechanical anomaly.

Additional Information

An actuator input/output processor module and an advanced graphics module were installed in the MAU. These components are part of the Honeywell Apex avionics system which captures data in the ACMS. The ACMS contains engine trend, cockpit and flight specific non-volatile memory files was downloaded. In addition, the fault history database (FHDB) that contained discreet airplane system condition data was downloaded.

Takeoff power was applied about 0834:46, at which time the torque value was 10.6 psi, the fuel flow was 353 lbs fuel used per hour (lbs/hour), the gas generator (Ng) speed was 80.2%, and the inter turbine temperature (ITT) was 603°.

About 1,500 ft down the runway while at 90 kts, the torque was at 40.9 psi, the fuel flow was 713 lbs/hour, the Ng speed was 94.5%, and the ITT was 711°.

At 0835:03, during rotation, the airplane was at 93 kts indicating a torque value of 44.9 psi, fuel flow 691 lbs/hour, the Ng speed was 94.2%, and the ITT was 709°.

Six seconds later, while on initial climb at 107 knots at 127 ft msl, the torque indication climbed to 71 psi while the fuel flow, Ng speed, and ITT remained within normal limits. The fault history data confirmed that the engine torque caution and warning were displayed during this time.

Four seconds later, the torque, fuel flow, Ng, and ITT values decreased to 47.3 psi, 683 lbs/hour, 93.6%, and 705°, respectively. As the copilot initiated the left descending turn, the torque and fuel flow were at 6.6 psi and 335 lbs/hour, respectively, the Ng was 80.4%, and the ITT was at 607° and decreasing. As the airplane descended and continued the turn to a heading about 260° on final approach for landing, the torque value increased to 18.9 psi and the fuel flow, Ng, and ITT all increased simultaneously until touchdown. The recorded parameters did not include flight control positions or power control lever position.

Administrative Information

Investigator In Charge (IIC):	Lawrence A Mccarter	Report Date:	12/16/2019
Additional Participating Persons:	Rick Hoy; FAA/FSDO; Atlanta, GA Wolf Landmann; Kulite Semiconductor Products, inc.; Leonia, NJ		
Publish Date:	12/16/2019		
Note:	The NTSB did not travel to the scene of this accident.		
Investigation Docket:	http://dms.nts.gov/pubdms/search/dockList.cfm?mKey=92537		

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