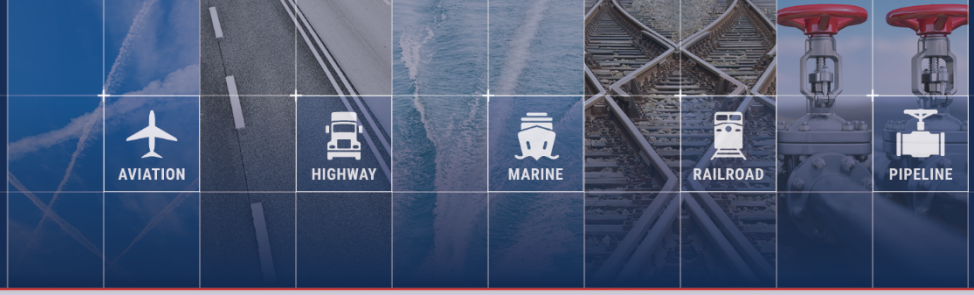

Aviation Investigation Factual Report

Location:	Baltimore, Maryland	**Accident Number:**	NYC08LA291
Date & Time:	August 20, 2008, 12:30 Local	**Registration:**	N441VB
Aircraft:	Cessna 441	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control on ground	**Injuries:**	4 None
Flight Conducted Under:	Part 91: General aviation		

Factual Information

HISTORY OF FLIGHT

On August 20, 2008, about 1230 eastern daylight time, a Cessna 441, N441VB, was substantially damaged when it departed the left side of runway 33R during an aborted takeoff at Baltimore/Washington Thurgood Marshall Airport (BWI), Baltimore, Maryland. The pilot/owner and the three passengers were uninjured. The personal flight was operated under the provisions of 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed, and an instrument flight rules flight plan had been filed.

According to the pilot, the inbound flight to the airport, as well as the accident flight preflight procedures, start-up and taxi-out were normal. However, as the airplane accelerated during the takeoff roll, it moved "slightly to the left" on the runway. The pilot "added power on the left engine," but the airplane continued to the left, and the left wheel departed the left edge of the runway pavement. The pilot aborted the takeoff, and continued to correct the direction of travel by manipulating the engine power levers. The airplane continued to veer to the left, completely departed the paved surface, and struck an earthen mound in the grass. The nose landing gear fractured, and the airplane came to rest approximately 2,500 feet beyond the start of the takeoff roll. The pilot shut down the airplane, and all occupants exited via the main door. BWI airport rescue and fire fighting personnel and equipment responded to the scene, and partially foamed the airplane to prevent a fire.

PERSONNEL INFORMATION

According to Federal Aviation Administration (FAA) and pilot-provided records, the pilot held a private pilot certificate with airplane single-engine land, multi-engine land, and instrument ratings. The pilot reported 2,485 total hours of flight experience, including 1,473 hours in the accident airplane make and model. He reported 3, 27, and 55 hours respectively, in the 30, 60, and 90 days preceding the accident, all of which were in the accident airplane. The pilot's most recent flight review was completed in April 2008, and was conducted in a Cessna 441 "flight simulator." His most recent FAA third-class medical certificate was issued in March, 2007.

AIRCRAFT INFORMATION

The airplane was a low-wing turboprop equipped with two Garrett TPE331-10N turbine engines and McCauley "BlackMac" four-blade, full-feathering, reversible propellers. According to FAA records, the airplane was manufactured in 1980, and was purchased by the current owner in 2000. The most recent 100 hour inspection was completed in February 2008, when the airplane had a total time in service of 3,963 hours.

Engine and Propeller Controls

The principal engine and propeller controls included a power lever and a condition lever for each engine/propeller. Each engine was equipped with a dedicated fuel computer and fuel control unit. The power and condition levers for each engine were electrically linked to the fuel computer for that engine, which in turn was electrically linked to the engine's fuel control unit. The power lever for each engine was also mechanically linked to the engine's fuel control unit.

The engine had two operating modes, "normal" and "manual." In the normal engine operating mode, pilot input commands were processed by the fuel computer, which in turn provided input to the fuel control unit to regulate engine speed. A cockpit switch for each engine could be used to select the manual mode for that engine. Selection of the manual mode deactivated the engine fuel computer, and engine speed was then regulated directly by the pilot's manipulation of the power lever, and the resulting mechanical input to the fuel control unit. The accident takeoff attempt was conducted with the engine switches in the "normal" mode.

The two operating modes for each propeller were "beta" and "propeller-governing," and the power levers were used for control in both modes. Beta mode was for propeller blade angles from flat pitch through reverse, and was to be used only during ground operation. In the beta mode, the power lever hydraulically controlled the propeller blade angle. In the propeller-governing mode, which was to be used for flight, the power lever controlled fuel flow either electrically (in normal mode, fuel computer active) or hydro-mechanically (manual mode, fuel computer inactive), and the propeller governor regulated propeller blade angle by hydraulic actuation. Governor oil pressure was used to drive the propeller blades in the fine pitch direction. The condition levers were used to set the appropriate governor target propeller rpm as a function of the airplane operating regime.

Propeller Start Locks

Each propeller blade was equipped with a propeller start lock. According to the airplane manufacturer's maintenance manual, "When the engine is shut down and propeller governor oil pressure decreases, the blades will be driven into a feathered position by a spring." The purpose of the start locks was "to prevent this procedure by holding the blades in a low pitch position for successful engine start."

The start locks were actuated by centrifugal force, and would "engage when the propeller is moved to reverse immediately following fuel cutoff at shutdown." The airplane manufacturer's information manual, which was a document for pilots that incorporated information from the pilots operating handbook and the FAA-approved airplane flight manual, stated that, "Before starting the engines, the propeller blades must be on the start locks [blades in low pitch]. This is required to minimize propeller drag and resultant high turbine temperatures during the start [hot start]. Additionally, the start locks provide the only means by which the propeller can be set for a functional check of the overspeed governor." The information manual also stated that "if the start locks are not engaged before starting, they can be engaged by actuating the

unfeathering pump switch with the power lever in full reverse."

The information manual further noted that the start locks could be "disengaged after start by moving the power lever toward reverse after engine start." This action would unload the start lock mechanism, allow the start lock to disengage, and permit the propeller blade pitch to be varied for subsequent taxi and flight operations.

A representative of the propeller manufacturer stated that if the start lock remained engaged after the engine was started, a commanded increase in power would result in a propeller overspeed "once the governed blade angle needs to exceed the start lock blade angle. There will be zero psi [governor oil pressure in pounds per square inch] at the prop[eller] (and pressure switch) since the governor's correction for overspeed is to drop oil pressure to coarsen [blade] pitch."

Cockpit Annunciator Panel

The airplane was equipped with an annunciator panel that was located below the glareshield on the center instrument panel, and which consisted of 20 individual, colored annunciator lights for each engine. According to Section 7 (Airplane & Systems Descriptions) of the information manual, the purpose of the panel was to "annunciate items of interest to the pilot in the applicable color of red, amber, green or white." The information manual also stated that "When a hazardous condition exists, requiring immediate corrective action, a red warning light will illuminate. When an impending possibly dangerous condition exists, requiring attention but not necessarily immediate action, an amber light will illuminate. A green or white light will illuminate to indicate a safe or normal configuration..." The airplane was also equipped with a press-to-test button in the center of the annunciator panel that could be used to verify the functionality of the lights.

Beta Light Operation

According to the information manual, the left and right beta lights in the annunciator panel were amber in color, and the purpose of each was to advise the pilot that "the propeller is capable of being reversed." The guidance also stated that illumination of the beta lights was "normal during ground operation."

According to the maintenance manual, "beta mode occurs whenever fuel flow is reduced by moving the power lever aft of FLIGHT IDLE, and engine power will not maintain engine speed at the propeller blade angle selected." The maintenance manual also stated that, "engines operate in beta mode during all normal ground handling [taxi] operations," and, "In beta mode, the power lever controls propeller blade angle. Beta mode operation requires high oil pressure to the propeller which sets blade angle to the pitch control minimum setting. This is accomplished by decreasing engine fuel flow with the power lever until the propeller load decelerates the engine below the propeller governor setting (underspeed). When the [condition lever is set to "START AND TAXI" and the] power lever is moved aft of the flight idle detent, the

fuel control computer resets the propeller governor to 106 percent RPM which instantly increases propeller governor output pressure (beta pressure)," enabling propeller operation in the beta range (blade angles from zero to reverse pitch). Finally, the maintenance manual stated that, "A sensor between the propeller governor and the propeller pitch control illuminates the beta light when the propeller governor produces sufficient oil pressure to operate in the beta mode."

According to the propeller manufacturer representative, the beta light activation system was strictly a function of a governor oil pressure sensing switch, and the system was not equipped with any direct sensors or circuitry regarding the status or position of the start locks. During engine start and taxi, whenever the power lever(s) were set to flight idle power or slightly above, the beta light(s) would always be illuminated, regardless of whether the start locks were engaged or disengaged.

Airplane Normal Procedures

The airplane manufacturer's abbreviated and amplified normal procedures provided guidance intended to ensure that the pilot properly configured the airplane for each mode of operation. The abbreviated procedures were in checklist form, and the amplified procedures consisted of more detailed explanations. In addition to these formats, three means were employed for highlighting information. In order of increasing severity potential, these means were "Note," "Caution," and "Warning." The following paragraphs detail the airplane manufacturer's guidance for pilots regarding the start locks and beta lights:

The abbreviated procedures in the "BEFORE STARTING ENGINES" checklist contained the line item "Annunciator and Warning Lights - PRESS TO TEST." The amplified procedures "STARTING ENGINES - BATTERY START" guidance stated, "Propeller - CLEAR and on start locks" and a "Caution" that stated, "Do not attempt a ground engine start unless the start locks are engaged (propeller in flat pitch). If a start is attempted with the start locks disengaged, a hot start will result." The abbreviated procedures then provided guidance to engage the start locks if they were not engaged.

The amplified procedures in the "STARTING ENGINES WITH AUXILIARY POWER" subsection stated that "the operator must monitor EGT [exhaust gas temperature] during each engine start to guard against a hot start," and that one potential cause for a hot start was excessive propeller drag due to "not having the start locks engaged during the start."

The "BEFORE TAXIING" checklist contained the line item "Start Locks - DISENGAGE," and the amplified procedures detailed the means for the pilot to accomplish it. Specifically, the "BEFORE TAXIING" subsection stated, "Move power levers slowly toward reverse. If the Beta annunciator light(s) goes out, stop power lever movement until light(s) comes on again. Continue movement until a positive indication of reverse thrust is observed (rise in torque, fuel flow and EGT)."

The abbreviated procedures in the "BEFORE TAKEOFF" checklist contained the line item, "Annunciator Panel- CLEAR except Beta Lights," and a similar entry appeared in the amplified procedures in the "BEFORE TAKEOFF" subsection.

The abbreviated procedures in the "TAKEOFF" checklist contained the line item, "Power- SET FOR TAKEOFF." The amplified procedures in the "TAKEOFF" subsection contained a boxed "Note" that stated, "While in position for takeoff, set the brakes and slowly advance the power levers for takeoff. Do not initiate the takeoff roll until propeller governing is established and the BETA annunciator lights are out."

The "SHUTDOWN" checklist did not contain any references to the start locks or beta lights, but the amplified procedures in the "SHUTDOWN" subsection stated "Power Levers- REVERSE and hold until engine RPM decreases below 30 percent to insure start locks engage."

Propeller Start Lock Status Indications

The airplane was not equipped with any dedicated indication or annunciation system to enable a pilot to determine the engagement status of the start locks. According to a representative of the airplane manufacturer, one or more of the following indications would alert a pilot the possibility that a propeller start lock was still engaged: the tendency of the propeller to overspeed when power was added, the inability to obtain reverse thrust, and abnormal airplane response when taxiing. While the accident pilot stated that, "engine start and taxi out were normal," and that he did not observe any unusual indications prior to the takeoff roll, he did not explicitly state whether he did or did not verify that both propellers were able to be reversed after the engines were started.

Engine Manufacturer Representative's Comments

A representative of the engine manufacturer noted that it was possible for the propeller start locks to engage as a result of an accident sequence. According to the representative, it has occurred previously, via the following mechanism: "During a propeller strike, a twisting moment may be imposed on the blades at the time they strike objects such as dirt, asphalt, ice or water. This twisting moment will, based on past experience, typically twist the blades toward the reverse position. If, while the blades are in the reverse position, the RPM level of the propeller decreases to the point where the start lock pin forces overcome the centrifugal forces, the pins will move inward. As the oil pressure to the propeller piston decreases, the blades will move toward the feather position and the start lock mechanism will be engaged."

METEOROLOGICAL INFORMATION

Weather, recorded at BWI at 1254, included variable winds at 3 knots, visibility 10 miles, a few clouds at 6,000 feet, temperature 24 degrees C, dew point 11 degrees C, and an altimeter setting of 30.23 inches of mercury.

WRECKAGE AND IMPACT INFORMATION

BWI runway 33R was 5,000 feet long and 100 feet wide. The runway was concrete, and dry at the time of the accident. The airplane came to rest approximately 2,500 feet beyond the takeoff roll initiation point, and approximately 200 feet west of the edge of the runway. The nose landing gear was fracture-separated at the scissor and the lower segment of the oleo strut. Portions of the nose, lower fuselage and wings sustained crush and scrape damage. The engine mount and nacelle structures sustained deformation damage. All blades on both propellers were scraped, and all exhibited significant bending damage. Some of the propeller-drive and propeller-control components also sustained fracture and/or bending damage.

The airplane was examined at the accident scene and then lifted and transported to a ramp area at BWI for additional examination and disassembly. The engines were removed for repair, and the propellers were shipped to the propeller manufacturer for additional examination.

ADDITIONAL INFORMATION

Propeller Examination

The propellers were examined under FAA oversight at McCauley Propeller Systems, Wichita, Kansas on October 8-9, 2008. The following paragraphs summarize the examination observations and conclusions documented by a representative of the propeller manufacturer:

All eight propeller blades exhibited damage consistent with rotation at impact. There were no indications of metal fatigue, or other pre-impact damage or failure. The feather stop mechanisms of both propellers were undamaged, which was consistent with the blades not being feathered at impact.

All four blades of the right propeller exhibited bending consistent with operating under power at impact. Scoring and burnishing extended from the leading edges along the cambered (back) surfaces of all four blades, which was consistent with normal blade pitch angles at impact. The engine power level and the blade pitch angles at the time of impact were not determined.

The pitch change mechanism for the left propeller assembly was found in the start lock position, and blade damage signatures were consistent with it being in that position, as follows: paint burnishing and metal scoring were present from the mid-camber points to the trailing edges on the outboard stations of all four propeller blades, which was consistent with the outboard stations of the blades being at a negative angle (relative to the plane of rotation) during impact.

The propeller design was such that when the blade pitch was set to the start lock position, normal airfoil twist resulted in a negative blade angle at the outboard blade stations.

The start lock components from the left propeller were also inspected, and no defects, debris,

or other evidence of a malfunction was found.

Based on the findings, the propeller manufacturer representative concluded that "the pilot did not properly unlock" the left propeller after the engine was started.

Pilot Information

Certificate:	Private	**Age:**	51
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 3 Without waivers/limitations	**Last FAA Medical Exam:**	March 13, 2007
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	April 8, 2008
Flight Time:	2485 hours (Total, all aircraft), 1473 hours (Total, this make and model), 2354 hours (Pilot In Command, all aircraft), 55 hours (Last 90 days, all aircraft), 27 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N441VB
Model/Series:	441	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	441-0115
Landing Gear Type:	Retractable - Tricycle	**Seats:**	10
Date/Type of Last Inspection:	February 5, 2008 100 hour	**Certified Max Gross Wt.:**	9914 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo prop
Airframe Total Time:	3963 Hrs as of last inspection	**Engine Manufacturer:**	Garrett
ELT:	Installed, not activated	**Engine Model/Series:**	TPE331-10N
Registered Owner:	Avian LLC	**Rated Power:**	635 Horsepower
Operator:	Avian LLC	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	BWI,142 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	12:54 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Few / 6000 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	3 knots / None	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.22 inches Hg	**Temperature/Dew Point:**	24°C / 11°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Baltimore, MD (BWI)	**Type of Flight Plan Filed:**	IFR
Destination:	Minneapolis, MN (FCM)	**Type of Clearance:**	IFR
Departure Time:	12:30 Local	**Type of Airspace:**	

Airport Information

Airport:	Baltimore/Washington Thurgood BWI	**Runway Surface Type:**	Concrete
Airport Elevation:	146 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	33R	**IFR Approach:**	None
Runway Length/Width:	5000 ft / 100 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	3 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	4 None	**Latitude, Longitude:**	39.183334,-76.660003(est)

Administrative Information

Investigator In Charge (IIC):	Huhn, Michael
Additional Participating Persons:	Robert Monaghan; FAA/FSDO; Baltimore, MD
Report Date:	March 1, 2010
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=68798