Aviation Investigation Final Report

Location:	Effingham, South Carolina	**Accident Number:**	ERA12LA500
Date & Time:	August 11, 2012, 13:10 Local	**Registration:**	N11JK
Aircraft:	Beech V35B	**Aircraft Damage:**	Substantial
Defining Event:	Loss of engine power (total)	**Injuries:**	2 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot reported that he was conducting a cross-country instrument flight rules flight, and, during the cruise portion of the flight, he intermittently encountered areas of instrument meteorological conditions (IMC). About 1 hour 50 minutes into the flight, an air traffic controller advised the pilot of an area of moderate-to-extreme precipitation 20 miles ahead, extending along the intended route of flight for 100 miles. Eight minutes later, the pilot contacted an air traffic controller and requested a descent from 12,000 to 10,000 ft mean sea level (msl) "for weather," but he did not receive a reply to the request, and the airplane continued on-course. After an additional 8 minutes, the pilot reattempted to contact a controller but was interrupted by another pilot, and he again received no response. The pilot attempted to contact a controller a third time and requested a turn to get out of the weather. This time a controller responded and advised the pilot to turn left, but, just as the pilot initiated the left turn, the airplane encountered an area of severe turbulence. The pilot reported that, while in the turbulence, the airplane encountered an updraft that put the airplane in a 4,000 ft per minute climb and that the airspeed reached 253 knots, which exceeded the airplane's never-exceed airspeed. The airplane then encountered a downdraft, which caused the airplane to lose 3,000 ft of altitude, and the primary flight display simultaneously "went black." When the display returned, it showed a message advising the pilot to "level the wings" while the attitude and heading reference system realigned. The pilot subsequently used the standby instrumentation to control the airplane while he initiated an emergency descent. The airplane exited the turbulence and IMC about 4,000 ft msl, and, shortly thereafter, the propeller separated from the engine. The pilot subsequently performed a forced landing to a cornfield, and the airplane sustained substantial damage to the fuselage and both wings.

The pilot reported that he received a weather briefing before departing on the accident flight. According to audio recordings of the briefing, the weather briefer advised the pilot of the adverse conditions along his route of flight; the pilot replied, "Ok, I guess we'll deal with that when we get there, if we have to go around it or stop, that's fine." An air traffic controller again advised the pilot of the severe weather conditions at least 20 miles ahead of the encounter. It is unlikely that the pilot's initial unanswered request to descend to 10,000 ft msl would have prevented the weather encounter, and the pilot's second and third unsuccessful attempts to contact the controller occurred more than 15 minutes after he was first advised of the weather conditions. The pilot was clearly made aware that severe weather conditions existed along his route of flight, but he waited until too far into the flight to try and avoid them, which ultimately led to the flight's encountering the conditions that resulted in the in-flight loss of control.

The air traffic controller complied with the Federal Aviation Administration's minimum requirement for "additional services" by providing the hazardous weather information to the pilot when he first checked in, but additional information by the controller would have been valuable. For example, as the flight continued tracking directly into known heavy-to-extreme precipitation that other aircraft were deviating around, the controller should have realized that the pilot was not taking action to avoid the weather and either suggested a deviation or at least updated him about the proximity of the hazardous weather that the airplane was rapidly approaching. Regardless, it was ultimately the pilot's responsibility to avoid the severe weather.

The propeller hub was found detached from the airplane due to a failure caused by reverse bending fatigue of the mounting bolts connecting the hub assembly to the engine crankshaft mounting flange. All of the bolts exhibited features consistent with fatigue cracking in a circular direction along the same direction as the wear marks on the hub case aft face. The reverse bending failure of the hub mounting bolts was indicative of a loose connection between the hub and the crankshaft. None of the airplane's documented maintenance indicated that the propeller hub was removed during the year before the accident.

The engine's fractured connecting rod exhibited a small thumbnail fatigue crack on one side. However, this small amount of fatigue likely occurred after the fatigue cracking had begun on the propeller bolts. Cracking in the propeller bolts would likely have created unbalanced loading in all of the connected components, including the crankshaft and connecting rod. Once the propeller separated from the crankshaft, the crankshaft absorbed the entire load exerted by the engine, and this increased loading likely in turn increased the friction at the contact surfaces beyond the capacity of the lubrication. Without sufficient lubricating capacity at the journals, the material would begin to heat excessively, creating local material deformation. The underlying reasons for the loose connection between the propeller hub and the crankshaft could not be determined, but it is likely that the extreme forces encountered during the flight's weather-induced upset and loss of control resulted in the ultimate failure of the connecting bolts.

Probable Cause and Findings

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

The pilot's failure to avoid an encounter with known adverse weather conditions, which resulted in an in-flight upset, temporary loss of control, and loading of the airframe, engine, and propeller that led to the in-flight separation of the propeller and the subsequent forced landing. The root cause for the separation of the propeller could not be determined based on the available information.

Findings

Personnel issues	Decision making/judgment - Pilot
Aircraft	Directional control - Attain/maintain not possible
Aircraft	Propeller assembly - Damaged/degraded
Aircraft	Propeller assembly - Failure
Not determined	(general) - Unknown/Not determined
Environmental issues	Thunderstorm - Effect on operation

Factual Information

History of Flight

Enroute-cruise	Windshear or thunderstorm
Enroute-cruise	Loss of control in flight
Maneuvering	Powerplant sys/comp malf/fail
Maneuvering	Part(s) separation from AC
Maneuvering	Loss of engine power (total) (Defining event)
Emergency descent	Off-field or emergency landing

On August 11, 2012, about 1310 eastern daylight time, a Beech V35B, N11JK, was substantially damaged during a forced landing near Effingham, South Carolina. The private pilot and the passenger were not injured. Instrument meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan was filed for the flight. The flight departed Manassas Regional Airport (HEF), Manassas, Virginia at 1052, and was destined for Flagler County Airport (XFL), Palm Coast, Florida. The personal flight was conducted under the provisions of Title 14 Code of Federal Regulations Part 91.

According to the pilot, prior to departing on the accident flight, he used a computer-based application to receive a textual weather briefing, and checked the weather conditions on the website of the National Oceanic and Atmospheric Administration (NOAA). He also contacted Lockheed Martin Flight Services, and after filing his IFR flight plan, briefly discussed weather conditions with the briefer. Review of the archived audio from the contact showed that the pilot was subsequently advised of two current convective SIGMETs, in the vicinities of central South Carolina and northern Florida. The pilot replied that he was aware of the SIGMETs. The briefer further advised that a line of weather was 130 miles west of the destination, and that the flight would likely arrive there before the adverse weather conditions did. The briefer then advised the pilot, "Probably the stuff in South Carolina could be the one that actually impacts your route of flight." The pilot responded, "Ok, I guess we'll deal with that when we get there, if we have to go around it or stop, that's fine." The briefer concluded the exchange, "…that's only about 50 miles off to the west." He then advised that the weather conditions at the destination airport, as well as locations further south, were generally favorable.

The flight departed from HEF about 1052 and proceeded uneventfully until approaching the northern South Carolina border, about 1240. The flight was given a frequency change by air traffic control (ATC), and first attempted to contact Jacksonville Air Route Traffic Control Center (ZJX) at 1243; however, due to frequency congestion at the time, the controller did not hear the transmission. The pilot subsequently checked-in with ZJX, and reported that the airplane was level at 12,000 feet. The controller acknowledged and issued the local altimeter setting as well as an advisory for moderate to extreme precipitation 20 miles ahead extending to the south for 100 miles, which the pilot acknowledged. At 1244, the controller issued a broadcast to all aircraft that stated AIRMET "Tango" for Tennessee, Louisiana, Mississippi, Alabama, and coastal waters was available on HIWAS , flight watch, or flight service frequencies.

At 1252, the pilot requested to descend to 10,000 feet, "for weather". This transmission was not acknowledged by the controller and at 1300:12 the pilot re-attempted contact but was interrupted by another aircraft calling, and again received no response. At 1300:32 the accident pilot called again and requested a turn to get out of the weather. The controller instructed the pilot to deviate left and then proceed direct to CHS VOR, Charleston, South Carolina, when able. At 1302:49, the controller informed the pilot that he thought he would be in the weather for another minute, and the weather would then be clear to Charleston. At 1302:56, the pilot reported that he had encountered heavy turbulence and was unable to maintain altitude. The controller acknowledged, informed the pilot that he was almost out of the weather, and instructed him to continue flying his present heading.

At 1303:56, the accident pilot attempted to contact ZJX and the transmission was cut off by another aircraft calling. The controller then instructed all aircraft to stand by, and instructed the accident pilot to retry his transmission. The accident pilot again reported that he was losing altitude and had also "lost" his attitude and heading reference system (AHRS). The controller then asked the pilot if he could level the airplane and instructed him to fly heading 090. At 1304:56 the controller asked the pilot to verify his altitude, and the pilot responded that he was at 4,000 feet and was underneath the weather. The controller then asked the pilot if he was stabilized and level at 4,000 feet. At 1305:18 the pilot stated he was at 3,000 feet and then his transmission was cut off.

At 1305:29, the controller instructed the pilot to contact Florence Regional Airport (FLO), Florence, South Carolina, approach control and at 1305:35 the pilot responded stating that the airplane had lost engine power. The controller instructed the pilot to make a left turn to heading 360 toward Florence, and the pilot acknowledged. At 1306:03 the controller informed the pilot that FLO was 15 miles from the airplane's position, on an approximate heading of 20 degrees. At 1306:48 the controller informed the pilot about the available landing runways at FLO, along with the current weather conditions. At 1307:51 the controller asked the pilot if he could change radio frequencies or if he would rather remain with him, and the accident pilot responded stating "…let me stay with you, I'm a little busy right now". At 1308:08 the controller cleared the pilot to land on any runway at FLO.

At 1308:51 the pilot stated that he did not think he was going to make the airport, could not see it, and was going to have to land in a field. At 1309:05 the accident pilot stated "Jacksonville, one one juliet kilo can't make the airport" which was the last recorded transmission received from the pilot. At 1312:05 another airplane relayed to ZJX that they were in contact with the accident pilot, and that he was on the ground and they were okay, but that the engine was on fire and they needed fire and rescue to respond.

Pilot Information

Certificate:	Private	**Age:**	47
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Unknown
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:**	September 28, 2010
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	(Estimated) 800 hours (Total, all aircraft), 150 hours (Total, this make and model)		

The pilot held a private pilot certificate with ratings for airplane single engine and instrument airplane. His most recent FAA third-class medical certificate was issued on September 28, 2010. He reported that at the time of the accident he had accumulated about 800 total hours of flight experience. Additionally, he reported that he had received about 40 hours of dual flight instruction in the accident airplane as required by his insurance carrier, and had since accumulated 150 total hours of flight experience in the airplane.

Aircraft and Owner/Operator Information

Aircraft Make:	Beech	**Registration:**	N11JK
Model/Series:	V35B	**Aircraft Category:**	Airplane
Year of Manufacture:	1973	**Amateur Built:**	
Airworthiness Certificate:	Utility	**Serial Number:**	D-9509
Landing Gear Type:	Retractable - Tricycle	**Seats:**	6
Date/Type of Last Inspection:	December 23, 2011 Annual	**Certified Max Gross Wt.:**	3400 lbs
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:	2847 Hrs as of last inspection	**Engine Manufacturer:**	Continental Motors
ELT:	Installed	**Engine Model/Series:**	IO-520-BB
Registered Owner:	KENNEDY JOHN M	**Rated Power:**	285 Horsepower
Operator:	KENNEDY JOHN M	**Operating Certificate(s) Held:**	None

According to FAA airworthiness records, the airplane was manufactured in 1973. It was originally equipped with a Continental Motors IO-520-BA engine. In May 2001 and May 2009 the engine was disassembled, cleaned, and inspected following two separate propeller strike/sudden stoppage incidents. Following the propeller strike event in 2009, an MT Propeller MTV-9-D/210-58, three-blade composite propeller was installed onto the engine. In July 2011, the engine was removed and modified with the installation of a turbo-normalizing system in accordance with Western Skyways STC SA8676SW. Maintenance log entries documenting the modification of the engine also noted the removal and reinstallation of the propeller, and no subsequent entries in any of the maintenance logs documented additional removal or reinstallation of the propeller. An annual inspection of the airframe, engine, and propeller was completed in December 2011, at which time the airframe and engine had accumulated 2,847 total hours of operation, 908 hours of which were accumulated since the engine's last major overhaul in 1987. The airplane's most recent maintenance log entry detailed an engine oil and oil filter change on March 15, 2012, at an airframe total time of 2,878 flight hours.

According to FAA aircraft registration records, the pilot purchased the accident airplane in September 2008. Review of maintenance records showed that in October 2008, the airplane's avionics were reconfigured to include the installation of a Garmin GNS 430W and a Garmin MX-20 MFD at an airframe total time of 2,613 hours. In June 2009, an Aspen Pro 1000 EFIS and a Garmin GDL-90 UAT (ADSB) Data Link Sensor was installed, at an airframe total time of 2,636 hours. In June 2010, the Aspen Pro 1000 EFIS and the Garmin GDL-90 were removed and a Garmin G-500 system was installed, at an airframe total time of 2,701 hours. In September 2010, a Garmin GDL-69 (satellite) Weather Data Link system was installed, at an airframe total time of 2,723 hours. In June 2011, a Garmin GTN-750 navigation/communication/GPS receiver was installed, at an airframe total time of 2,783 hours.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument (IMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	FLO,147 ft msl	**Distance from Accident Site:**	6 Nautical Miles
Observation Time:	13:30 Local	**Direction from Accident Site:**	10°
Lowest Cloud Condition:	Few / 3300 ft AGL	**Visibility**	2 miles
Lowest Ceiling:	Broken / 4900 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots / 25 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	220°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	22°C / 20°C
Precipitation and Obscuration:	N/A - None - Mist		
Departure Point:	Manassas, VA (HEF)	**Type of Flight Plan Filed:**	IFR
Destination:	Palm Coast, FL (XFL)	**Type of Clearance:**	IFR
Departure Time:	10:52 Local	**Type of Airspace:**	

The National Weather Service (NWS) Surface Analysis Chart for 1400 depicted a stationary front stretched northeastward from central Georgia up the East Coast. A cold front stretched southwestward from central Georgia into Alabama. Several outflow boundaries were located across South Carolina and Georgia; these outflow boundaries, along with the frontal boundaries, acted as lifting mechanisms to help produce clouds and precipitation. The station models around the accident site depicted a southwest to south wind between 5 and 20 knots, partly cloudy skies, and thunderstorms. The low-level environment surrounding the accident site was warm and moist, conducive to the creation of moderately unstable conditions which, when combined with the lifting mechanisms, resulted in clouds, rain showers, and strong thunderstorms.

The Area Forecast issued at 0718 forecasted a broken ceiling at 1,000 feet msl with the cloud tops at 10,000 feet msl. The ceilings were forecast to rise to 3,000 feet msl between 1100 and 1300. Scattered light rain showers and thunderstorms were forecast across central South Carolina with tops to FL380.

Florence Regional Airport was the closest official weather station to the accident site, and had an Automated Surface Observing System whose reports were supplemented by the air traffic control tower. FLO was located 4 miles north of the accident site, at an elevation of 147 feet. The following observations were taken and disseminated during the times surrounding the accident:

FLO weather at 1253 included wind from 220 degrees at 6 knots, 10 miles visibility, scattered clouds at 3,400 feet agl, scattered clouds at 11,000 feet agl, temperature of 29 degrees C, dew point temperature of 23 degrees C, and an altimeter setting of 29.92 inches of mercury. Remarks: automated station with a precipitation discriminator, sea-level pressure 1012.9 hPa, temperature 29.4 degrees C, dew point temperature 22.8 degrees C.

FLO weather at 1330 included wind from 220 degrees at 8 knots with gusts to 25 knots, 1 and three-quarter miles visibility, heavy rain and mist, few clouds at 3,300 feet agl, a broken ceiling at 4,900 feet agl, temperature of 22 degrees C, dew point temperature of 20 degrees C, and an altimeter setting of 29.97 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 260 degrees at 33 knots at 1314, rain began 1314, one-hourly precipitation of 0.08 inches.

FLO weather at 1333 included wind from 250 degrees at 4 knots, 2 miles visibility, a thunderstorm and rain, few clouds at 3,400 feet agl, a broken ceiling at 4,900 feet agl, broken skies at 11,000 feet agl, temperature of 22 degrees C, dew point temperature of 20 degrees C, and an altimeter setting of 29.96 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 260 degrees at 33 knots at 1314, rain began 1314, thunderstorm began at 1333, one-hourly precipitation of 0.09 inches.

The observations from the airports surrounding the accident site at the time of the accident indicated thunderstorms and lightning prevailed. Surface winds at the airports were variable and gusty around the accident time, likely due to the strong winds initiated by the area of thunderstorms.

A North American Mesoscale (NAM) model sounding was generated for the accident site for 1400. The model sounding depicted a moist, conditionally-unstable vertical environment and a freezing level of 14,612 feet. The environment would generally have been supportive of cloud formation, rain showers, and thunderstorms. The sounding identified the possibility of clouds between the surface and 24,000 feet, and indicated the possible presence of clear-air turbulence and low-level wind shear from the surface through 10,000 feet.

Visible data from the Geostationary Operational Environmental Satellite number 13 from 1302 and 1315 revealed cumuliform clouds at the accident site with the line of cumuliform clouds moving eastward with time. Inspection of the infrared imagery indicated cooler (higher) clouds tops at and just to the west of the accident site at the accident time. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1400 NAM sounding, the approximate cloud-top heights over the accident site were 35,000 feet at 1315.

The radar summary image from 1315 depicted reflectivity in the vicinity of the accident site with 45 to 55 dBZ values, and indicated the presence of very strong to extreme echoes around the accident time.

The closest NWS Weather Surveillance Radar (WSR-88D) was located near Wilmington, North Carolina (LTX), approximately 65 miles east of the accident site at an elevation of 64 feet. The reflectivity image for the 1.3-degree elevation scan initiated at 1301, and the base reflectivity image for the 0.5-degree elevation scans initiated at 1305 and 1310 showed that 50 to 65 dBZ values occurred along the airplane's ATC radar-recorded flight track, indicating that the airplane likely encountered very strong to extreme precipitation. Lightning flash data from 1245 to 1305 was plotted and revealed that lightning encompassed the airplane's flight track, with over 1,800 individual lightning flashes occurring during that period. Given the base reflectivity and lightning data, the airplane likely encountered very strong to extreme precipitation.

Figure 1 - LTX WSR-88D reflectivity for the 1.3 degrees elevation scan initiated at 1301 with lightning flash data from 1245 to 1305
A 3-dimensional view of the LTX WSR-88D base reflectivity for the elevation scans initiated at 1301 and 1305 showed the accident flight encountering greater than 50 dBZ values at both time points. Much like the base reflectivity discussed previously, the flight likely encountered intense to extreme precipitation while flying through a line of thunderstorms.

Figure 2 - 3-dimensional LTX base reflectivity from the scan initiated at 1301 and the ATC Flight Track SIGMETs 26E and 23E were valid at the accident time along the accident route of flight. These SIGMETs advised of a line of thunderstorms and an area of thunderstorms moving from 250 degrees at 25 knots with tops above FL450. The thunderstorm line was 35 miles wide.

A special weather statement was issued by the NWS in Wilmington, North Carolina, at 1229 for the line of strong thunderstorms the accident aircraft would encounter. These thunderstorms were moving northeastward at 40 mph with pea-sized hail and gusty winds of 40 to 50 mph possible at the surface.

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 None	**Latitude, Longitude:**	34.104721,-79.73278(est)

According to a Federal Aviation Administration inspector, the airplane's propeller was separated from the engine at the propeller flange, and was later recovered about 6 nautical miles southwest of the accident site. The airframe came to rest in a corn field. The right main and nose landing gear had collapsed during the forced landing, and the forward portion of the fuselage and right wing were substantially damaged. The engine was subsequently disassembled and examined. Components from the engine including the crankshaft, as well as the number 4 and 6 connecting rods, and the propeller were forwarded to the NTSB Materials Laboratory for detailed examination.

According to the Materials Laboratory Factual Report, two of the blades had broken off of the propeller hub assembly, while the third remained attached and intact. The hub spinner shell exhibited a small dent in an area adjacent to the engine, showing cracking in the surface plating on the shell (but not the shell itself). Except for the aft hub section that mated to the crankshaft flange, no other indications of damage were observed externally on the hub assembly. The crankshaft exhibited material deformation and heat tinting on two of the connecting rod journals. A connecting rod had fractured approximately 2.5 inches from the small end with the rod bushing.

The aft side of the propeller hub separated from the forward side of the crankshaft due to the failure of eight hub-mounting bolts. The fractured mounting bolts were labeled 1 through 8. Both the mating faces of aft of the hub and forward flange of the crankshaft showed pairs of hemispherical-shaped wear marks at each bolt hole. The hemispherical marks were 180 degrees from each other at each respective hole, located along a circular path relative to each other. All eight bolts exhibited two thumbnail crack features located 180 degrees from each other, corresponding with the hemispherical wear marks on the hub case aft surface. The thumbnail cracks exhibited crack arrest marks emanating from the surface of the bolts. The regions of the fracture surfaces between the thumbnail cracks were generally rougher and of lower luster than the thumbnail regions. These fracture characteristics were consistent with failure from reverse bending fatigue. In this failure mode, fatigue cracks developed on opposite sides of the part until the cracks penetrated deep enough for the remaining cross-section in between to succumb to overstress. In general, the thumbnail portions of the bolt fracture surfaces were approximately half the bolt cross-sections. Bolt 7 exhibited the deepest fatigue crack penetration in the bolt cross-section.

The hub assembly was disassembled, and none of the internal hub components, including the piston rod, spring, and plastic bushings, exhibited any indications of preexisting damage such as cracking or deformation. The internal parts appeared to be well greased, showing no signs of wear or excessive temperature exposure.

The engine crankshaft number 6 connecting rod bearing journal showed plastic deformation in the form of smearing, batter, and cutting into the surface. Circumferential wear marks were present on the journal. The areas on the journal outside the plastically-deformed center displayed indications of rust-colored oxidation. These features were consistent with high temperature exposure and wear due to interaction with an adjacent component, the connecting rod.

The number 4 piston connecting rod journal surface showed circumferential wear, heat tinting, and oxidation consistent with high temperature exposure. The number 4 piston connecting rod exhibited rust-colored oxidation on the rod cap, I-beam, and rod bolts adjacent to the crankshaft. These features were consistent with high temperature exposure.

The number 6 connecting rod had fractured along the I-beam approximately 2.5 inches from the small end of the rod. Most of the fracture surface exhibited a dark color, with tortuous fracture surface. The fracture surface exhibited indications of heat tinting near one edge. This tinted area showed crack arrest features consistent with a small thumbnail crack. The fracture surface was examined in a scanning electron microscope. While most of the fracture surface had been damaged, isolated areas within the thumbnail region exhibited features consistent with fatigue striations. No indications of other failure modes were found in this area. The fatigue thumbnail region had been oxidized enough to obscure much of the fracture features. All the areas outside of the thumbnail region exhibited dimple rupture features consistent with failure by overstress. Across the entire fracture surface, small lead-based particles were found. These particles were consistent with additives found in leaded aviation fuel.

Electronic Devices

Several components of the airplane's G-500 system were forwarded to the NTSB Vehicle Recorders Laboratory for detailed examination. The Garmin G-500 system was comprised of several sub-units, including a Garmin GDU-620, GRS-77, and GIA-63. The GDU-620 was a panel-mounted primary flight/multi-function display (PFD/MFD) utilizing two side-by-side color displays. The PFD function of the unit was designed to display flight performance data such as airspeed, altitude, vertical speed, aircraft attitude, and navigation data. The MFD function of the unit could display data stored on data-cards inserted in the front panel, and from other sources, including custom maps, IFR charts, VFR charts, terrain, traffic information, lighting, and weather radar. The Garmin GRS-77 was an Attitude Heading and Reference System (AHRS) designed to provide attitude and heading information to Garmin Integrated Flight Decks (G1000, G1000H, G950, G900X, G500, G500H, G600). The GRS-77 employed accelerometers and rate sensors, together with GPS data from the Garmin GIA-63, to compute aircraft heading and attitude, and sends this information to the flight display using an ARINC 429 digital interface. The Garmin GDL-69 was a remote datalink receiver designed to receive and distribute data from an XM WX Satellite Weather subscription to a compatible PFD / MFD.

According to the manufacturer, the GDU-620 unit was a display only, and did not record any information. Upon arrival at the NTSB Vehicle Recorder Laboratory, an exterior examination revealed the unit had no visible damage. According to the manufacturer, GDU-620, GRS-77, and GIA-64 only recorded internal fault codes. Multiple requests for manufacturer support in downloading and interpreting these fault codes ultimately met with no response.

The airplane was equipped with a J.P. Instruments (JPI) EDM-700, a panel mounted instrument that enabled the operator to monitor and record up to 24 parameters related to engine operations. Depending on the installation, engine parameters monitored include: exhaust gas temperature (EGT), cylinder head temperature (CHT), oil pressure and temperature, manifold pressure, outside air temperature, turbine inlet temperature (TIT), engine revolutions per minute, compressor discharge temperature, fuel flow, carburetor temperature, and battery voltage. The unit contained non-volatile memory for data storage of the parameters recorded and calculated. The rate at which the data was stored could be selected by the operator between ranges of 2 to 500 seconds per sample. The memory was able to store up to 20 hours of data at a 6 second sample rate. The data was available for download by the operator using the J.P. Instruments software.

Download of the airplane's EDM-700 showed data applicable to the accident flight that began recording at 1035:43. After 1130:43, all recorded parameters remained fairly steady until about 1258, when engine values began to change. At 1259:53, CHT began to decrease. At 1300:48, EGT decreased rapidly, and TIT began to decrease. Between 1301:30 and 1307:49, EGT values fluctuated. At 1307:49, all recorded values changed from prior trends. The EGT and TIT values began a steady decrease until the end of the recording. The voltage (Batt-1) decreased from a prior steady value of 14.2 Volts to about 11.5 Volts. The oil temperature also increased. The number 6 CHT (CHT-6) value began to report invalid data; the other CHT values began to decrease. Between 1308:25 and 1308:49, the unit did not record any data. When the recording resumed at 1308:49, the number 3 CHT (CHT-3) and number 5 CHT (CHT-5) began reporting invalid data. The recording ended at 1313:38.

Additional Information

Air Traffic Controller Interviews

Each of the four air traffic controllers working the airspace surrounding the accident events was interviewed separately. The Radar Associate Controller (RA) stated that when he assumed his position, the accident pilot already on frequency and recalled that there had been a lot of deviation requests by other aircraft as a result of the weather. He next observed the accident flight had lost approximately 800 feet of altitude and had passed that information along to the Radar Controller (RC) to ensure he was also aware. He said the RC then instructed the Radar Developmental (RD) controller to ask the pilot what his altitude was, and the accident pilot replied that he had encountered heavy turbulence and advised he was unable to maintain altitude. The RA then initiated a "point out" with FLO approach control and advised them that the accident flight was unable to maintain altitude. According to the RA, the FLO approach controller then, after referencing other traffic, approved the point out and stated that the accident flight was radar contact. The RA also stated that he continued to relay the status of the accident flight with FLO throughout the event.

When asked, the RA did not recall seeing the accident flight tracking towards the adverse weather, and did not recall the accident pilot requesting to deviate around weather until he had already encountered the heavy turbulence. He felt that, often, the weather information displayed on the radar display was not accurate, or was very slow to update. When asked to elaborate, he stated that he believed there was a 15 minute delay for Weather and Radar Processor (WARP) data to update on the radar display screen. Because of the delay, he stated it was not common to suggest deviations around weather or to suggest headings without a pilot's request to deviate. He stated that he did not recall the cloud tops at the time, nor did he remember the accident pilot being asked for a pilot report (PIREP). As he recalled, the accident flight was the only low flying aircraft in the sector around the time of the accident. He stated that he did not know what type aircraft the flight was, but assumed it was a single engine prop based on the speed.

The RD controller recalled that upon initial check in, he issued the accident pilot the current weather. He remembered there being heavy precipitation along the west side of the sector. He recalled the accident flight encountering weather and the accident pilot requesting to deviate. He thought he had issued a turn to a heading of 090, at which point the pilot stated he had encountered severe turbulence. He then noticed that the pilot had lost several thousand feet very quickly and the pilot stated he had lost his AHRS. He stated that the RC controller then assumed responsibility of the position and training was discontinued. He recalled the RC controller asked the pilot if he could maintain altitude and it was shortly after that the pilot reported he had lost engine power. He said the RC controller then issued the pilot a heading to FLO, and after the flight had turned toward the airport, the pilot reported that he was not going to reach the airport, and would have to put it down in a field.

The RD controller further stated that there had been airliners diverting around the adverse weather for quite some time. He felt the deviations correlated accurately with the weather being displayed by WARP at the time, but said pilots do not always request to deviate so he generally did not ask pilots if they would like a deviation around weather. He stated that general aviation pilots would routinely fly through weather that was displayed on radar, so he did not find it odd that the accident flight was continuing toward the displayed weather even though airliners were deviating around it. He said that WARP data really "wasn't that great," but that it was better than nothing. He estimated WARP latency to be 5-10 minutes. When asking for updated weather, he stated that he would ask pilots rather than the front line manager since he felt pilots had a better idea of current weather conditions than someone on the ground did.

The RC recalled that when the accident pilot checked in, the RD controller advised the pilot of the precipitation being shown via WARP and also read the current AIRMET to him. The next time the RC recalled hearing from the accident pilot was when he asked for a vector out of the weather. The RD controller instructed the accident pilot to make a left turn and, when able, proceed direct to CHS. The RC then noticed the accident flight had lost altitude and asked the pilot if he was able to maintain his altitude. When the accident pilot advised he was unable to maintain his altitude, he discontinued training on the position and took over for the RD controller. He stated that he then issued the pilot a heading to FLO, and the pilot stated he would not be able to make it to the airport and would be landing in a field.

The RC said it was common for airliners to deviate around weather, but that some typically general aviation pilots would still fly through, so he did not find it unusual that that the accident flight was flying opposite direction of all the deviating airliners. He said that by the time the accident pilot called for a heading to get out of the weather he was already visibly in it according to displayed WARP data. He said he had not heard the accident pilot request a descent to 10,000 feet and if he had, stated he would have approved it. He initially issued a frequency change to the accident pilot once he had reported out of the weather and felt that he was in stabilized flight and FLO had reported that he was visible on radar. He said that due to frequency limitation at low altitude in that area, he felt it would be better to put the pilot in contact with the receiving facility in order to maintain communications with him until landing.

Pilot Interview

During a post-accident interview, the accident pilot stated that the airplane's G-500 received automatic updates from NEXRAD, and that the typical latency was between 1 to 200 minutes. The G-500 indicated the displayed data was three minutes old just prior to entering the thunderstorm. He said he used the Garmin information as a "situational awareness tool." On the MFD (Multi-Function Display) he could access winds aloft and METARS, which he used for flight planning. The aircraft was also equipped with traffic advisories, but he was not monitoring it at the time. The aircraft previously equipped ADS-B, but he generally was not satisfied with the information it provided. He was pleased with the G-500 and felt that the manuals were user friendly and easy to understand. He generally had more confidence in the weather data that ATC had than what was available to him in the aircraft.

Prior to the flight he filed his flight plan online, checked the weather on the NOAA website, and received a weather briefing from the Lockheed Martin Flight Service. He thought he had an hour to make it to his destination before weather moved in and was prepared to divert and wait out the weather if he needed to. He stated that enroute, the 48 knot actual headwinds were much greater than the forecasted headwinds of 25 knots. He had planned a fuel stop at XFL, but did not have an alternate because the weather at his destination did not require one. He had 74 gallons of fuel onboard, which would have given him a five hour range, for the four hour flight.

He said that in general he received good service from ATC in previous trips along the same route of flight, although that was mostly in VFR conditions. He usually requested and received flight following because of all of the warning areas along that route of flight. On the day of the accident his initial attempt to contact ZJX went unanswered; when he called a second time ATC advised him there was light to moderate precipitation 20 miles ahead of him. He did not think that the clouds looked any different than what he had been flying through. As he got closer to the system he was apprehensive about what he saw, but he believed that ATC would continue to advise him of the any adverse conditions, and "wouldn't put me in weather."

The NEXRAD was displaying light precipitation 10 miles from his position. He compared the cloud coverage displayed on his G-500 with what he was seeing out of his window, but not with NEXRAD. He had been in and out of clouds for 20 miles and felt that the clouds in front of him looked benign. He normally stayed 10 miles from NEXRAD weather returns, and he also had lightning advisory capability via his XM weather service subscription, but it was not displaying any lightning at that time. Just prior to entering the clouds, several SIGMETs appeared on the screen, and he was surprised as he had never seen SIGMETs pop up on the G-500 before. The SIGMETs indicated that the cell was moving east towards his projected flight path. He asked ATC for a deviation for weather, but did not get a response.

When he entered the clouds there was light drizzle and smooth air. Shortly after that he experienced heavy precipitation and extreme turbulence. He advised ATC that he needed to deviate; ATC issued him a left turn but did not specify how many degrees to turn. He began the left turn, and then experienced an updraft that put the aircraft in a 4,000-foot per minute climb and the airspeed indicated 253 knots, exceeding the airplane's never exceed speed. He experienced a tumbling backward sensation when he reduced power in an attempt to control the airspeed. He encountered a downdraft and lost 3,000 feet, and simultaneously the G-500 system "went black." When the display returned it displayed a message advising the pilot to "level the wings" while the attitude and heading reference system realigned. The standby attitude indicator also tumbled, and eventually corrected itself. He reported to ATC that he had lost his AHRS, but did not know if they understood what he was stating. The pilot subsequently utilized the standby instrumentation to control the airplane while he initiated an emergency descent.

When he broke out of the clouds at 4,000 feet, he assessed the airplane and attempted to maintain level flight. At 3,500 feet the propeller separated from the engine, and he informed ATC that he had lost engine power and needed to land. ATC gave him a heading towards FLO, but he was unable to make it to the airport and executed an emergency landing in a field five miles south the airport.

When reflecting about the events leading up to the accident, he felt frustrated that ATC issued a left turn without specifying how many degrees. He also felt that generally, general aviation aircraft were sometimes neglected by ATC, and that additional weather training would be beneficial for private pilots.

Federal Aviation Administration Order 7110.65, "Air Traffic Control."

According to the FAA Order 7110.65:

1−1−1 PURPOSE OF THIS ORDER
This order prescribes air traffic control procedures and phraseology for use by persons providing air traffic control services. Controllers are required to be familiar with the provisions of this order that pertain to their operational responsibilities and to exercise their best judgment if they encounter situations that are not covered by it.

The FAA addressed the providing of "additional services" within order 7110.65. There was a minimum requirement that a controller must comply with in many situations, and then there was the capability of air traffic control to provide "additional services" when necessary. The 7110.65 stated in part:

2−1−1 ATC SERVICE
The primary purpose of the ATC system is to prevent a collision between aircraft operating in the system and to provide a safe, orderly and expeditious flow of traffic, and to provide support for National Security and Homeland Defense. In addition to its primary function, the ATC system has the capability to provide, with certain limitations, additional services. The ability to provide additional services is limited by many factors, such as the volume of traffic, frequency congestion, quality of radar, controller workload, higher priority duties, and the physical inability to scan and detect those situations that fall in this category. It is recognized that these services cannot be provided in cases in which the provision of services is precluded by the above factors. Consistent with the aforementioned conditions, controllers must provide additional service procedures to the extent permitted by higher priority duties and other circumstances. The provision of additional services is not optional on the part of the controller, but rather is required when the work situation permits.

Administrative Information

Investigator In Charge (IIC):	Diaz, Dennis
Additional Participating Persons:	Daryl McMillan; FAA/FSDO; Columbia, SC
Original Publish Date:	July 7, 2015
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=84633