Aviation Investigation Final Report

Location:	Rockford, Illinois	**Accident Number:**	CEN18LA047
Date & Time:	December 4, 2017, 18:02 Local	**Registration:**	N500KR
Aircraft:	Beech C90	**Aircraft Damage:**	Substantial
Defining Event:	Fuel exhaustion	**Injuries:**	2 Serious, 2 Minor
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The private pilot departed on a cross-country flight in his high-performance, turbine-powered airplane with full tanks of fuel. He landed and had the airplane serviced with 150 gallons of fuel. He subsequently departed on the return flight. As the airplane approached the destination airport, the pilot asked for priority handling and reported that the airplane "lost a transfer pump and had a little less fuel than he thought," and he did not want to come in with a single engine. When asked if he needed assistance, he replied "negative." The pilot was cleared to perform a visual approach to runway 19 during night conditions. As the airplane approached the airport, the pilot requested the runway lights for runway 25 be turned on and reported that the airplane lost engine power in one engine. The controller advised that the lights on runway 25 were being turned on and issued a landing clearance. The airplane impacted terrain before the threshold for runway 25.

During examination of the recovered wreckage, flight control continuity was established. No useable amount of fuel was found in any of the airplane's fuel tanks; however, fuel was observed in the fuel lines. All transfer pumps and boost pumps were operational. The engine-driven fuel pumps on both engines contained fuel in their respective fuel filter bowls. Both pumps were able to rotate when their input shafts were manipulated by hand. Disassembly of both pumps revealed that their inlet filters were free of obstructions. Bearing surfaces in both pumps exhibited pitting consistent with pump operation with inadequate fuel lubrication and fuel not reaching the pump. The examination revealed no evidence of airframe or engine preimpact malfunctions or failures that would have precluded normal operation of the airplane.

Performance calculations using a flight planning method described in the airplane flight manual indicated that the airplane could have made the return flight with about 18 gallons (119 lbs) of fuel remaining. However, performance calculations using a fuel burn simulation method developed from the fuel burn and data from the airplane flight manual indicated that the airplane would have run out of fuel on approach. Regulations require that a flight depart with enough fuel to fly to the first point of intended landing and, assuming normal cruising speed, at night, to fly after that for at least 45 minutes. The

calculated 45-minute night reserves required about 56 gallons (366 lbs) of fuel using a maximum recommended cruise power setting or about 37.8 gallons (246 lbs) of fuel using a maximum range power setting. Regardless of the flight planning method he could have used, the pilot did not depart on the accident flight with the required fuel reserves and exhausted all useable fuel while on approach to the destination.

Probable Cause and Findings

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

The pilot's inadequate preflight planning and his decision to depart without the required fuel reserve, which resulted in fuel exhaustion during a night approach and subsequent loss of engine power.

Findings

Aircraft	Fuel - Fluid level
Personnel issues	Decision making/judgment - Pilot
Personnel issues	Fuel planning - Pilot

Factual Information

History of Flight

Prior to flight	Preflight or dispatch event
Approach	Fuel exhaustion (Defining event)
Approach	Loss of engine power (total)
Emergency descent	Collision with terr/obj (non-CFIT)

On December 4, 2017, about 1805 central standard time, a Beech C90 airplane, N500KR, impacted terrain near the Chicago/Rockford International Airport (RFD), Rockford, Illinois. The private pilot and one passenger sustained serious injuries and two passengers sustained minor injuries. The airplane sustained substantial fuselage damage during the impact. The airplane was registered to and operated by the pilot as a 14 *Code of Federal Regulations* Part 91 personal flight. Night visual meteorological conditions prevailed in the area about the time of the accident, and the flight was issued a local instrument flight rules (IFR) clearance. The flight originated from the Kissimmee Gateway Airport (ISM), near Kissimmee, Florida, about 1343 and was destined for RFD.

According to information from the Federal Aviation Administration (FAA), the flight was given an IFR clearance as the airplane was nearing RFD. The pilot asked for priority handling. When asked for the reason for the priority handling, the pilot responded that he "lost a transfer pump and had a little less fuel than he thought." He also said that he did not want to "come in with a single engine." The pilot was queried if he needed assistance and he replied "negative."

The pilot was cleared to perform a visual approach to runway 19. As the airplane approached the airport, the pilot requested the runway lights for runway 25 be turned on and reported that the airplane lost engine power in one engine. The controller advised that the lights on runway 25 were being turned on and issued a landing clearance. That was the last transmission from the airplane. The airplane subsequently impacted terrain before the threshold for runway 25.

Pilot Information

Certificate:	Private	**Age:**	46,Male
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	**Last FAA Medical Exam:**	May 17, 2017
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	(Estimated) 2500 hours (Total, all aircraft)		

The 46-year-old pilot held an FAA private pilot certificate with airplane single and multi-engine land and instrument ratings. He also held an FAA third class airman medical certificate, dated May 17, 2017. According to information from the FAA, the pilot reported that he had accumulated 2,500 hours of total flight time. The pilot's experience was requested from a point of contact for the pilot and a King Air C90 Recurrent Training Course certificate, dated October 25, 2017, was provided.

Aircraft and Owner/Operator Information

Aircraft Make:	Beech	**Registration:**	N500KR
Model/Series:	C90	**Aircraft Category:**	Airplane
Year of Manufacture:	1977	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	LJ-708
Landing Gear Type:	Retractable - Tricycle	**Seats:**	
Date/Type of Last Inspection:	August 25, 2017 Continuous airworthiness	**Certified Max Gross Wt.:**	9989 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo prop
Airframe Total Time:	9856.7 Hrs as of last inspection	**Engine Manufacturer:**	Pratt & Whitney
ELT:	C91 installed	**Engine Model/Series:**	PT6
Registered Owner:	On file	**Rated Power:**	550 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

N500KR, a 1977 model Beech C90A King Air, was an all-metal, pressurized, low-wing, retractable landing gear, twin-engine airplane with serial number LJ-708. According to the airplane flight manual (AFM), the airplane could operate at altitudes up to 30,000 ft. The airplane was equipped with two Pratt

& Whitney Canada (PWC) turbo propeller PT6A-21 engines each rated at 550 horsepower, each driving their own McCauley 4-blade, constant speed, fully reversing, aluminum alloy propeller. The left-hand engine had serial number 24390 and the right-hand engine had serial number 24387. An airplane maintenance record endorsement dated August 25, 2017, showed that the airplane was inspected in accordance with a phase 3 and 4 inspection program and that the airplane had accumulated 9,856.7 hours of total time.

The PT6A-21 engines have three-stage axial and single stage centrifugal compressors, driven by single stage reaction turbines. The power turbine, another single stage reaction turbine, drives the propeller shaft. Both the compressor turbine and the power turbine are located in the approximate center of the engine with their shafts extending in opposite directions. The accessory drive at the aft end of the engine provides power to drive the fuel pump, fuel control unit, oil pump, starter-generator, and tachometer.

The engine fuel system consists of an engine-driven fuel pump, a fuel control unit, a flow divider, inlet manifold, thirteen manifolds nozzles, and two fuel drain valves. The fuel pump fuel control unit assembly is mounted on the engine accessory case and is shaft-driven at a speed proportional to that of the compressor turbine.

The fuel system consists of two separate systems connected by a crossfeed system. Fuel for each engine is supplied from a nacelle tank and four interconnected wing tanks for a total of 192 gallons of usable fuel for each side with all tanks full. The outboard wing tanks supply the center section wing tank by gravity flow. The nacelle tank draws its fuel supply from the center section tank. Since the center section tank is lower than the other wing tanks and the nacelle tank, the fuel is transferred to the nacelle tank by the fuel transfer pump in the low spot of the center section tank. Each system has two filler openings, one in the nacelle tank and one in the leading-edge tank. Servicing the nacelle tank first, then the wing tanks, assures that the system is properly filled.

A crossfeed valve in the left-hand fuel system connects the two systems when the crossfeed valve is OPEN.

Each system has a submerged boost pump in the nacelle tank that supplies the motive force to transfer fuel as well as fuel boost to one or both engines. With one engine inoperative, the crossfeed system allows fuel from the inoperative side to be supplied to the operating engine. The fuel system is vented through a recessed ram scoop vent that is coupled to an external vent, located on the underside of the wing, adjacent to the nacelle. The external vent is heated to prevent icing. One vent acts as a back-up for the other should one or the other become blocked.

The boost pumps are submerged, rotary, vane-type impeller pumps, electrically driven. One pump is located in each nacelle tank.

Fuel transfer is accomplished when the TRANSFER PUMP switches are turned ON, unless the nacelle tanks are full. A TRANSFER TEST switch (placarded L and R) is provided to verify the operation of each pump when its nacelle tank is full. The nacelle tanks will continue to fill until the fuel reaches the upper transfer limit and a float switch turns the pump off. As the engines burns fuel from the nacelle tanks (60-gallon capacity each tank), fuel from the wing tanks transfers into the nacelle tanks when their level drops approximately 10 gallons. When 131 gallons of fuel (each side) are used from the wing tanks

(132 gallons usable each side), a pressure sensing switch reacts to a pressure drop in the fuel transfer line. After 30 seconds. the transfer pump shuts off and the annunciator panel illuminates, showing a NO FUEL TRANSFER light. The NO FUEL TRANSFER light also functions as an operation indicator for the transfer pump. Extinguishing the NO FUEL TRANSFER light is accomplished by turning the transfer switch OFF. If the transfer pump fails to operate during flight, gravity feed will perform the transfer. When the nacelle tank level drops to approximately 150 lbs, the gravity feed port in the nacelle tank opens and gravity flow from the wing tank starts. All wing fuel except 28 gallons from each wing will transfer during gravity feed.

Crossfeeding fuel is authorized only in the event of engine failure or electric boost pump failure. The crossfeed system is controlled by a three-position switch placarded OPEN, CLOSED, and AUTO. The valve can be manually opened or closed, but under normal flight conditions it is left in the AUTO position. In the AUTO position, the fuel pressure switches are connected into the crossfeed control circuit. In the event of a boost pump failure, which causes a drop in fuel pressure, these pressure switches open the crossfeed valve allowing the remaining boost pump to supply fuel to both engines.

The airplane is equipped with a capacitance fuel gaging system. The fuel panel utilizes a fuel quantity indicator for each side. A toggle switch, located between the two fuel quantity indicators, can be placed in the TOTAL position to provide an indication of all fuel in the system, or in the NACELLE position to indicate the quantity of fuel in the nacelle tanks only. Nacelle position is provided in order to verify nacelle fuel quantity during operations with NO FUEL TRANSFER illuminated where it is desirable to monitor gravity feed from wing tanks. Fuel quantity gages indicate pounds of fuel.

The first step of the "AFTER STARTING AND TAXI" checklist in the AFM stated, "Transfer Pumps - ON." The second step of the "SHUTDOWN AND SECURING" checklist stated, "Transfer Pumps - OFF."

The AFM limitation section, in part, stated, "Operation of either engine with its corresponding fuel pressure light (L FUEL PRESS or R FUEL PRESS annunciator) illuminated is limited to 10 hours before overhaul or replacement of the engine-driven fuel pump."

An automatic feathering system was an option for this airplane type. However, there was no autofeather switch in its placarded position, indicating no autofeather system was installed in this airplane.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night
Observation Facility, Elevation:	KRFD,743 ft msl	**Distance from Accident Site:**	1 Nautical Miles
Observation Time:	17:54 Local	**Direction from Accident Site:**	218°
Lowest Cloud Condition:		**Visibility**	10 miles
Lowest Ceiling:	Overcast / 3800 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	18 knots / 25 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	190°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.48 inches Hg	**Temperature/Dew Point:**	16°C / 9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	ORLANDO, FL (ISM)	**Type of Flight Plan Filed:**	IFR
Destination:	Rockford, IL (RFD)	**Type of Clearance:**	IFR
Departure Time:	15:45 Local	**Type of Airspace:**	

A National Transportation Safety Board (NTSB) senior meteorologist collected weather data and produced a Weather Study. The study is appended to the docket material associated with this investigation.

Airport Information

Airport:	CHICAGO/ROCKFORD INTL RFD	**Runway Surface Type:**	Asphalt;Concrete
Airport Elevation:	742 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:	19	**IFR Approach:**	None
Runway Length/Width:	8200 ft / 150 ft	**VFR Approach/Landing:**	Full stop

RFD was a tower-controlled airport, owned and operated by the Greater Rockford Airport Authority. The airport had a surveyed elevation of 742 ft msl and was served by two intersecting paved runways 1-19 and 7-25. Runway 1-19 was an 8,200 ft by 150-ft grooved asphalt and concrete runway. Runway 7-25 was a 10,002 ft by 150-ft grooved asphalt and concrete runway with a 3% upslope. Runway 25 had runway end identifier lighting and high intensity runway lighting.

Wreckage and Impact Information

Crew Injuries:	1 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 Serious, 2 Minor	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Serious, 2 Minor	**Latitude, Longitude:**	42.203056,-89.082496(est)

An RFD deputy director, in part, reported that from first responders and his knowledge of the scene, there was never any visible fuel exiting the aircraft while it was sitting on the ground or while it was being lifted and moved. No pooled fuel was observed. However, there was a slight fuel smell around the airplane.

The wreckage was recovered to a hangar at RFD and the airframe and engine were subsequently examined by air safety investigators from the airplane and engine manufacturers, FAA inspectors, and the NTSB investigator in charge. The empennage was found separated from the fuselage aft of the rear pressure bulkhead. The ends of a rudder trim cable exhibited a separation consistent with overload and the rudder torque tube was found separated from its bellcrank. Flight control continuity was established.

Both the left and right transfer pump switches were found in the OFF position. The airplane's battery was reconnected. Both the left and right transfer pumps and the right boost pump were operational using the airplane's wiring. However, a wire going to the left boost pump was found separated in an area of structural damage. The left boost pump was operational when battery power was applied directly to that pump's wiring. No useable amount of fuel was found in any of the airplane fuel tanks. However, a liquid consistent with fuel was observed in fuel lines.

All engine cable control continuity was established to the left engine and right engine power and condition control cable continuity was established. The right engine's propeller control was bound when it was manipulated by hand. None of the propeller blades exhibited any leading-edge damage and both spinners did not exhibit any rotational witness marks.

The first stage blades in both engines' compressor section were manipulated by hand and continuity was established to their respective accessory gearboxes. Some of the left engine power turbine blades exhibited fracture witness marks. Observation of the right engines power turbine blades revealed that they were intact.

The engine driven fuel pumps on both engines were removed. Liquid consistent with fuel was found in both engines' fuel filter bowls. However, both their bowl fuel filters were discolored. Both pumps were able to rotate when their input shafts were manipulated by hand. Disassembly of both pumps revealed that their inlet filters were free of obstructions. Bearing surfaces in both pumps exhibited pitting consistent with pump operation with inadequate fuel lubrication.

No airframe or engine preimpact anomalies were found that would have prevented normal operation of the airplane.

The Stratus unit was recovered from the cockpit and was shipped to the NTSB Vehicle Recorder Laboratory.

Flight recorders

The airplane was equipped with an Appareo Stratus 2S unit. The Stratus is a battery-operated ADS-B receiver with Global Positioning System (GPS) capability designed to interface with an iPad, iPhone, or iPod Touch running the ForeFlight Mobile application via Wi-Fi. The Stratus uses ADS-B to provide access to NEXRAD radar, meteorological terminal air reports, terminal aerodrome forecasts, notices to airmen and other FAA products via the ForeFlight application installed on a mobile device. The Stratus supports limited reception and display of ADS-B traffic information. Certain models include a complete Attitude Heading Reference System (AHRS) that permits supplemental attitude information on the connected mobile device.

Tests and Research

An NTSB vehicle recorder specialist examined the Appareo Stratus 2S and found it was received in good condition. Power was applied to the unit using NTSB recorder laboratory equipment. Data was downloaded from the device to ForeFlight Mobile on an NTSB iPad using Wi-Fi. The data extracted included 4 hours and 15 minutes of the accident flight on December 4, 2017 and four hours of the prior flight on December 1, 2017. Data was recorded at a rate of five samples per second.

Graphical overlays of the Appareo data were generated using Google Earth. An overlay of the prior flight on December 1, 2017, revealed the flight departed from RFD about 17:59 and arrived at ISM about 22:17. The accident flight on December 4, 2017, was recorded in three portions: from 13:43 to 13:50, from 13:54 to 14:09, and from 14:10 to 18:05. The recorder specialist's report is appended to the docket material associated with this investigation.

An NTSB aircraft performance national resource specialist used collected data and produced a performance study for the accident flight and the flight before it. The fuel remaining at the time of the accident was computed in two ways: (1) Using the flight planning methods described in the AFM, using eight waypoints in between ISM and RFD; and (2) Using a fuel burn simulation developed from the fuel burn and other performance data published in the performance section of the AFM. The simulation models fuel burn as a function of engine shaft horsepower (SHP) and pressure altitude, and computes the SHP developed during the flights using AFM performance data, the ground speed and rate of climb recorded by the Stratus device, and winds aloft forecasts. Both methods required computing 8.5 hours of fuel burn over the two RFD-ISM and ISM-RFD flights. The calculations assume full fuel at departure for the 4.17-hour RFD-ISM flight on December 1, and refueling with 150 gallons of fuel at ISM prior to the 4.33-hour return flight to RFD on December 4.

The results of the flight planning method indicated that the airplane could have made the return flight to RFD with about 119 lbs (18 gal.) of fuel remaining. The results of the fuel burn simulation method indicated that the airplane would have run out of fuel on approach to RFD. The aircraft performance national resource specialist's report is appended to the docket material associated with this investigation.

Additional Information

A note in the AFM, in reference to the flight planning method, in part, stated, "The associated conditions define the specific conditions for which performance parameters have been determined. They are not intended to be used as instructions; however, performance values determined from charts can only be achieved if specified conditions exist."

Federal Aviation Regulations 91.151 Fuel requirements for flight in VFR conditions, in part, stated:

(a) No person may begin a flight in an airplane under VFR conditions unless (considering wind and forecast weather conditions) there is enough fuel to fly to the first point of intended landing and, assuming normal cruising speed—
...
(2) At night, to fly after that for at least 45 minutes.

The calculated 45-minute night reserves required about 366 lbs or 56 gallons of fuel using a maximum recommended cruise power setting or about 246 lbs or 37.8 gallons of fuel using a maximum range power setting.

Administrative Information

Investigator In Charge (IIC):	Malinowski, Edward
Additional Participating Persons:	Sandra Boerman; Federal Aviation Administration; Des Plaines, IL Henry Soderlund; Textron Aviation; Wichita, KS Marc Hamilton; Transportation Safety Board of Canada; Ottawa, Ontario Marc Gratton; Pratt & Whitney Canada; Longueuil, Québec Kristofer Garberg; Appareo Systems LLC; Fargo, ND Jeff Davis; Pratt & Whitney Canada; Bridgeport, WV
Original Publish Date:	July 8, 2019
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=96419