Aviation Investigation Final Report

Location:	Kerrville, Texas	**Accident Number:**	CEN19FA124
Date & Time:	April 22, 2019, 08:51 Local	**Registration:**	N501CE
Aircraft:	Beech 58	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	6 Fatal
Flight Conducted Under:	Part 91: General aviation		

Analysis

The pilot was conducting an instrument flight rules (IFR) flight in a twin-engine airplane with five passengers. During a GPS approach to the destination airport, both engines lost total power within 10 seconds of each other; the left engine regained near full power about 40 seconds later, which it maintained until the end of recorded data. As the pilot continued the approach, he did not ensure the flaps were up or feather the propeller of the inoperative right engine, which was contrary to the airplane manufacturer's emergency procedures guidance.

As the airplane descended with the right engine inoperative below the cloud ceiling to about 500 ft agl, its flightpath leveled and airspeed decreased below the minimum controllable airspeed (Vmc). The airplane's continued flight profile below Vmc with the unfeathered propeller of the inoperative right engine, the left engine near full power, and the airplane's aft center of gravity resulted in a right-turning spin and ground impact.

The pilot's filed flight plan indicated a minimum fuel load required of 58 gallons, although this did not account for the instrument approach and alternate airports. However, the pilot's flight planning log indicated only 50 or 54 gallons of fuel onboard. Thus, based solely on the pilot's logs, there was insufficient fuel onboard the airplane to embark on the flight. Because the airplane was beyond its maximum gross weight with just 50 gallons of fuel onboard, it is likely that the pilot did not want to add additional fuel. Thus, the pilot's decision to depart on the accident flight without adequate fuel onboard showed poor judgement.

Although the pilot departed without an adequate fuel reserve for the IFR flight, an actual fuel load of 50 or 54 gallons would have been sufficient to reach the destination airport (the airplane burned about 42 gallons just before the crash site about 6 miles from the airport). However, when the airplane was fueled at the pilot's request 8 days (five flights) before the accident flight, it was not completely filled. Because the pilot was not present for the fueling and did not crosscheck the fuel receipt with his fuel-planning logs, he did not recognize that the error meant he had less than 50 gallons of fuel onboard before departing on the accident flight. As evidenced by the close correlation between the pilot's fuel logs and the engine data monitoring (EDM) fuel consumption data for the accident flight and the five flights before it, the pilot mainly relied on EDM data to determine the quantity of fuel onboard the airplane. Thus, the fueling error introduced 8 days before the accident was carried through the pilot's planning logs for the next six flights, including the accident flight.

Further review of the accident airplane's fueling records, the pilot's flight-planning logs, and fuel consumption data from the EDM revealed that the airplane actually had about 12 gallons less fuel than the pilot indicated in his fuel log for the accident flight. Thus, the lack of sufficient fuel for the accident flight resulted in the airplane's engine power loss during the approach.

In addition, the abnormally high resistances in both fuel quantity transmitters would have caused the cockpit fuel quantity indicators for both wings to read about 5 gallons higher each than the actual fuel present, corresponding to an additional 1/16th tank on each of the indicators. Thus, because of the high resistances in both fuel quantity transmitters, the pilot's belief that 50 (or 54) gallons of fuel were onboard at takeoff (rather than the actual fuel level of 38 gallons) may have been corroborated by the fuel quantity indicators; however, the effect of the inaccurate indications on the pilot's actions are uncertain.

The pilot's autopsy indicated he had severe coronary artery disease, which placed him at increased risk of a sudden cardiac event. However, the accident sequence was not consistent with acute pilot impairment or incapacitation as recorded data indicate that the pilot was controlling the airplane up until the airplane dropped below its minimum controllable airspeed, so it is unlikely that the pilot's coronary artery disease or any sudden medical event contributed to this accident.

In summary, multiple errors before takeoff led to a loss of engine power due to fuel exhaustion. The pilot did not accurately record the amount of fuel added after fueling, the pilot did not verify the amount of fuel onboard the airplane, the fuel quantity transmitters did not accurately indicate the amount of fuel onboard, and the pilot decided to take off with inadequate fuel to conduct the IFR flight in an overweight airplane. Lastly, during the flight, once the right engine lost power, the pilot failed to properly configure the airplane per the manufacturer's emergency procedures guidance and allowed the airspeed to drop below the point at which the airplane could maintain flight.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's inadequate preflight fuel planning and fuel management, which resulted in a loss of engine power due to fuel exhaustion. Also causal was the pilot's failure to follow the one-engine inoperative checklist and maintain the airplane's minimum controllable airspeed by properly configuring the airplane, which resulted in a loss of airplane controllability.

Findings

Personnel issues	Fuel planning - Pilot
Personnel issues	Decision making/judgment - Pilot
Aircraft	Fuel - Fluid management
Aircraft	Fuel - Fluid level
Personnel issues	Use of checklist - Pilot
Aircraft	Airspeed - Not attained/maintained
Aircraft	Engine out capability - Incorrect use/operation
Aircraft	(general) - Not attained/maintained
Personnel issues	Aircraft control - Pilot
Aircraft	Fuel quantity indicator - Damaged/degraded
Personnel issues	Flight planning/navigation - Pilot
Personnel issues	Weight/balance calculations - Pilot
Aircraft	Maximum weight - Capability exceeded

Factual Information

History of Flight

Approach	Fuel exhaustion
Approach-IFR final approach	Loss of control in flight (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On April 22, 2019, at 0851 central daylight time, a Beech 58 airplane, N501CE, was substantially damaged when it was involved in an accident near Kerrville Municipal Airport (ERV), Kerrville, Texas. The pilot and five passengers died. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 business flight.

According to airport surveillance video from West Houston Airport (IWS), Houston, Texas, the pilot accomplished an abbreviated preflight inspection of the airplane, during which he appeared to visually check the exterior left-wing fuel level sight gauge but not the right-wing fuel level sight gauge; the pilot did not sump any of the 10 fuel drains. The pilot returned to the terminal to meet the passengers, and after both engines were started, the airplane departed about 0730.

According to air traffic control (ATC) and automatic dependent surveillance-broadcast (ADS-B) information, after departing IWS, the pilot obtained an instrument flight rules (IFR) clearance and was instructed to climb to 3,000 ft mean sea level (msl). The flight proceeded toward ERV, climbing to a cruise altitude of 6,000 ft msl. About 0824, the pilot requested the RNAV (GPS) instrument approach for runway 12 and was cleared for the approach via a procedure turn and to descend to 4,000 ft. About 0833, the pilot reported his descent to 4,000 ft and the controller advised that "bases were 2,400," which the pilot acknowledged.

About 0839, the pilot was cleared for the GPS instrument approach to runway 12 and instructed to maintain 4,000 ft to the initial fix for the approach (OBUCO) (see figure 1). Once the airplane was in-bound to the airport, about 0843, the controller directed the pilot to switch to the ERV advisory frequency, which was unmonitored. The GPS instrument approach profile for runway 12 included a descent to 3,300 ft msl at 5.3 nautical miles from the runway.

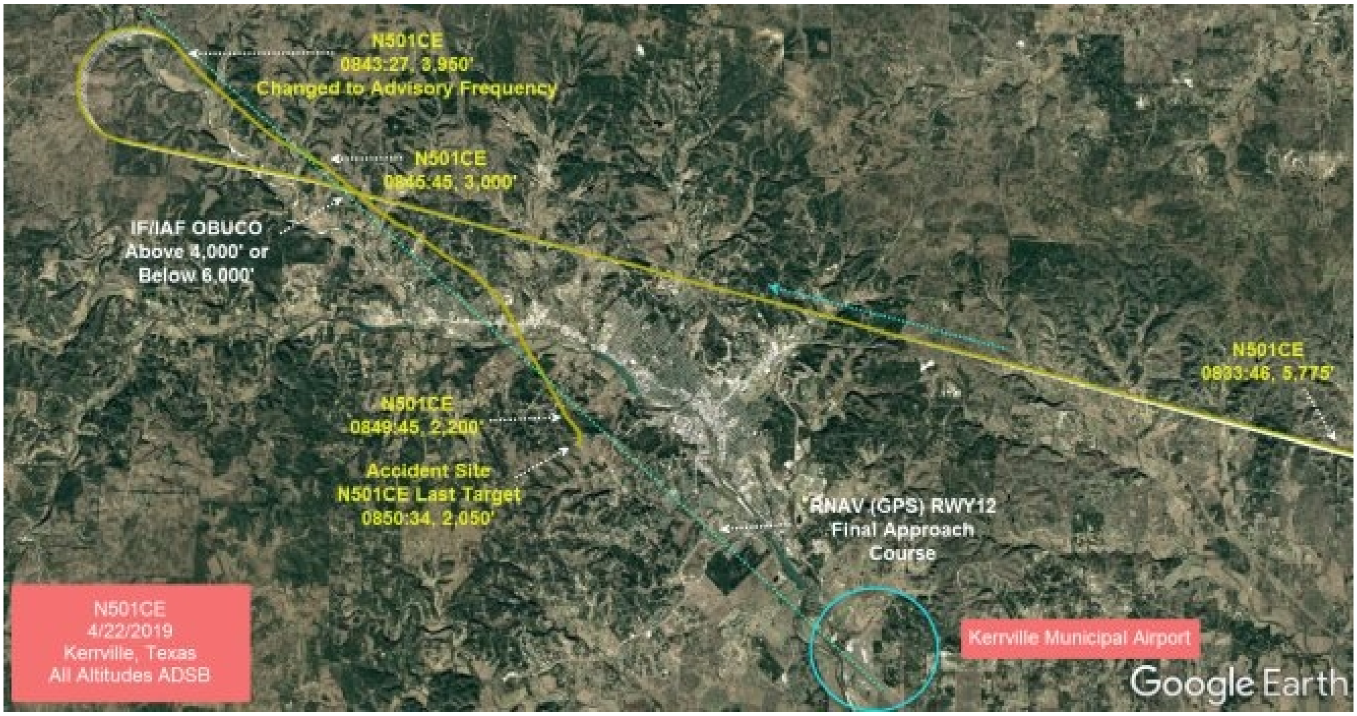

Figure 1. A Google Earth aerial view of terrain near the accident site with overlaid ADS-B data and approach information.

According to ADS-B data, the airplane maintained an altitude of 3,900 ft until about 0844:59, when it began a steady descent; the airplane was about 13 miles from the runway. Data from the airplane's engine data monitor (EDM) indicate that the left engine lost power about 0845 followed by the right engine about 10 seconds later. ADS-B data indicated that the airplane steadily descended well below the approach profile.

EDM data indicated that, about 40 seconds after losing power, the left engine regained near full power, which it maintained until the end of recorded EDM data about 0851. ADS-B data indicated that the airplane slowed below the minimum controllable airspeed (Vmc) of 83 knots as it descended from about 500 to 300 ft agl, and the descent rate decreased. A witness on the ground saw the airplane on final approach at a low altitude, when it entered a right turn, began a right spiral, and disappeared behind a ridge line.

Pilot Information

Certificate:	Airline transport; Private	**Age:**	65,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	3-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	October 10, 2018
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	November 1, 2018
Flight Time:	(Estimated) 5671 hours (Total, all aircraft), 2409 hours (Total, this make and model), 5565 hours (Pilot In Command, all aircraft), 106 hours (Last 90 days, all aircraft), 59 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Passenger Information

Certificate:		**Age:**	55,Male
Airplane Rating(s):		**Seat Occupied:**	Right
Other Aircraft Rating(s):		**Restraint Used:**	3-point
Instrument Rating(s):		**Second Pilot Present:**	No
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

Passenger Information

Certificate:		**Age:**	58,Male
Airplane Rating(s):		**Seat Occupied:**	Left
Other Aircraft Rating(s):		**Restraint Used:**	3-point
Instrument Rating(s):		**Second Pilot Present:**	No
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

Passenger Information

Certificate:		**Age:**	55,Male
Airplane Rating(s):		**Seat Occupied:**	Right
Other Aircraft Rating(s):		**Restraint Used:**	3-point
Instrument Rating(s):		**Second Pilot Present:**	No
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

Passenger Information

Certificate:		**Age:**	54,Female
Airplane Rating(s):		**Seat Occupied:**	Left
Other Aircraft Rating(s):		**Restraint Used:**	3-point
Instrument Rating(s):		**Second Pilot Present:**	No
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

Passenger Information

Certificate:		**Age:**	45,Female
Airplane Rating(s):		**Seat Occupied:**	Right
Other Aircraft Rating(s):		**Restraint Used:**	None
Instrument Rating(s):		**Second Pilot Present:**	No
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

A flight instructor who frequently flew with the pilot and conducted his most recent flight review stated the pilot's mechanical flying skills were very good but, on occasion, his understanding of technical issues was not as strong. The flight instructor noticed a few times when the pilot did not perform well during unexpected in-flight issues. He stated the pilot normally planned to land with at least 1 hour of fuel remaining.

Aircraft and Owner/Operator Information

Aircraft Make:	Beech	**Registration:**	N501CE
Model/Series:	58	**Aircraft Category:**	Airplane
Year of Manufacture:	1999	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	TH-1888
Landing Gear Type:	Retractable -	**Seats:**	6
Date/Type of Last Inspection:	August 27, 2018 Annual	**Certified Max Gross Wt.:**	5500 lbs
Time Since Last Inspection:	105 Hrs	**Engines:**	2 Reciprocating
Airframe Total Time:	3834 Hrs at time of accident	**Engine Manufacturer:**	Continental
ELT:	C91A installed, not activated	**Engine Model/Series:**	IO-550C
Registered Owner:		**Rated Power:**	300 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

Fuel System

The airplane's fuel system comprised three fuel cells and one wet tip tank for each wing. Total fuel capacity for the airplane was 200 gallons; the three fuel cells in each wing held a total of 83 gallons of usable fuel and 3 gallons of unusable fuel, and the wet tip tank held 14 gallons of fuel, all of which was usable.

The wing fuel cells and wet tip tanks were interconnected so that all usable fuel was available with the fuel selector valve for each wing in the ON position and supplying fuel to its respective engine. The CROSSFEED position on the fuel selector was only to be used in an emergency. Each wing had two flush-type fuel filler caps: one located in the outboard end of each outboard leading-edge fuel cell and one in the wet tip fuel tank.

Fuel quantity was measured by float-type units that electrically transmitted a single indication for each wing system to fuel quantity indicators in the cockpit. The fuel quantity indicator would show full until the respective wing fuel cells contained less than about 75 gallons. According to an American Bonanza Society (ABS) technical representative, the three fuel quantity transmitters in each wing were wired in series with one another. Fuel quantity would be at least 75 gallons at 199 ohms and 3 gallons of unusable fuel at 0 ohms. In this range, the resistance value of the transmitter circuits in each wing was designed to be directly proportional to the amount of fuel.

The caution range (yellow band) on the cockpit fuel quantity indicators was from 0 to 1/8th of the amount indicated by the fuel quantity indicator (about 9.33 gallons usable per wing).

Fuel level sight gauges on the leading edge of each wing only indicated fuel levels from 40 to 60 gallons per wing. It was not possible to use a dipstick to check fuel quantity due to each wing's dihedral and the location of the filler caps.

Fueling Information

Fueling of an exemplar 1999 Beech 58 showed that when the airplane's wing fuel cells were filled as much as possible from the inboard wing filler caps, the wet tip tanks became partially filled because of the wing's dihedral, resulting in a total of 188 gallons of fuel (182 usable) on board. In order to fill the wet tip tanks, about 6 gallons of fuel would be added to each tip tank through the wet tip tank fuel filler cap.

Fuel Consumption

The accident airplane's EDM indicated that the airplane consumed about 28 gallons of fuel per hour (gph) during the accident flight while at cruise power. According to the airplane's pilot operating handbook (POH), the airplane consumed about 34 gph of fuel at maximum cruise power (200 kts) and about 18 gph at economy cruise power (163 kts).

Weight and Balance

The airplane's maximum gross weight was 5,500 lbs. Based on passenger weights provided by the medical examiner, the airplane's takeoff weight was calculated as 5,598 lbs with 50 gallons of usable fuel and 5,526 lbs with 38 gallons of usable fuel. The airplane's center of gravity was 86.7 inches at the time of the accident; the acceptable cg range with low fuel was 77.7 to 86.2 inches.

Airplane Performance

The Beech 58 engine-out procedure in the POH directed flaps to be retracted and the propeller of the inoperative engine to be feathered. The airplane's performance charts indicated a one-engine-inoperative climb capability of about 300 feet per minute (fpm) with the inoperative engine's propeller feathered, flaps up, and a gross weight of 5,300 lbs.

A flight operations pilot for the airplane manufacturer who regularly performed single-engine drag demonstrations reported that lowering flaps from 0° to 15° with one engine inoperative resulted in a 150-fpm decrease in climb rate and an unfeathered propeller configuration resulted in a 400-fpm decrease in climb rate.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument (IMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KERV,1617 ft msl	**Distance from Accident Site:**	6 Nautical Miles
Observation Time:	08:55 Local	**Direction from Accident Site:**	121°
Lowest Cloud Condition:		**Visibility**	10 miles
Lowest Ceiling:	Overcast / 1200 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	11 knots / 17 knots	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:	170°	**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:	30.04 inches Hg	**Temperature/Dew Point:**	18°C / 16°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Houston, TX (IWS)	**Type of Flight Plan Filed:**	IFR
Destination:	Kerrville, TX (ERV)	**Type of Clearance:**	IFR
Departure Time:	07:29 Local	**Type of Airspace:**	Class E

The 1,200 ft agl ceiling reported by the ERV automated weather observation system correlated to a ceiling at the accident site of about 950 ft agl. A pilot who flew an approach to ERV reported 2,400 ft msl cloud bases, which correlated to a ceiling at the accident site of about 550 ft agl.

Airport Information

Airport:	Kerrville Muni/Louis Schreiner ERV	**Runway Surface Type:**	Asphalt
Airport Elevation:	1616 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	12	**IFR Approach:**	Global positioning system;RNAV
Runway Length/Width:	6004 ft / 100 ft	**VFR Approach/Landing:**	Full stop

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:	5 Fatal	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	6 Fatal	**Latitude, Longitude:**	30.0375,-99.185836

The airplane impacted a rocky ravine about 120 yards from the final radar data point and about 6 miles from the airport. There was no postimpact fire and the airplane came to rest upright on a heading of 246° (see figure 2). The wreckage was contained within the footprint of the airplane, indicating a low forward groundspeed. Elevation at the accident site was 1,868 ft msl and trees about 40 yards northeast were the nearest obstructions.

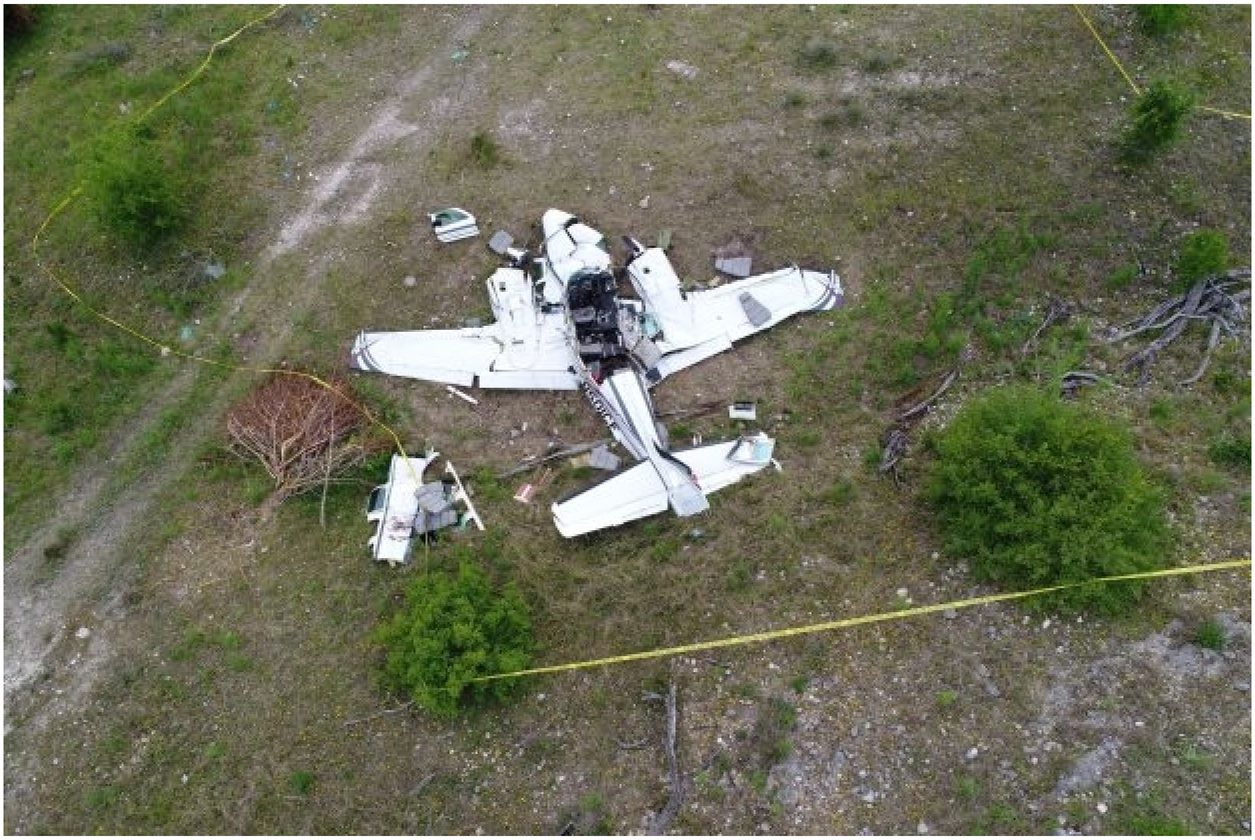

Figure 2. Photograph of an aerial view of the accident site

All flight control surfaces were present and flight control cable continuity was established from the tail surfaces to the aft empennage, where the cables were bound by the cabin floor, which was crushed by impact forces. Aileron and aileron trim tab cable continuity was established from the control surface to the wing root.

About 1 gallon of fuel was drained from the left-wing fuel cells on the day of the accident. When the left wing was lifted at the wing tip on the day after the accident, about 1 cup of fuel was observed in the left-wing fuel cells and about 1 cup of fuel drained from a breached area near the engine nacelle. No fuel was observed in the right-wing wet tip tank or the right-wing fuel cells. All fuel tank caps were secured. There was no evidence of fuel blight on the area surrounding the airplane.

Four of the six fuel cells were in their installed position with no obstructions. The left-wing box cell was loose at the top due to impact damage and the right-wing inboard leading-edge fuel cell was in the installed position, except where cut by recovery personnel.

The left fuel selector was near the ON position; it was positioned about 1/4 toward OFF. A small amount of fuel was found in the left fuel selector valve and fuel strainer. The right fuel selector was in the ON position. No fuel was present in the right fuel selector valve or fuel strainer. No water was detected.

Postaccident resistance testing of the six fuel quantity transmitters revealed a total transmitter resistance at the empty setting of 13.7 ohms in the left wing and 14.6 ohms in the right wing. Factory specification resistance for each of the six individual transmitters was 0 to 0.5 ohm at the empty setting.

According to the ABS technical representative, the additional resistance found in the six transmitters corresponded to a reading of about 5 gallons more than the actual fuel for each wing, (or about 1/16 tank more than the actual amount shown on each fuel quantity indicator), which would equal about 20 to 24 minutes of flying time. Impact damage precluded testing for additional resistance in the fuel quantity circuits.

Both fuel quantity gauges and engine fuel flow transducers were tested, with no anomalies noted. Testing reports are in the docket for this investigation.

The landing gear were in a retracted position. The left-wing flap actuator position corresponded to a 15° flap setting; the right-wing flap actuator was fractured. Both electric fuel boost pump switches were at the high position. The throttle, propeller, and mixture controls were all near the full-forward position.

The propeller for the left engine separated from the engine during the impact sequence. Blades 'A' and 'B' remained attached to the hub. Blade 'A' exhibited leading-edge burnishing and was bent aft at the tip. Blade 'B' exhibited leading-edge gouging, chordwise and spanwise scratching, and was curled forward from the root. Blade 'C' was located under the left-engine cowling and curled aft at the tip with gouging.

The propeller for the right engine remained attached to the engine and all three blades remained in the hub. Blade 'A' was straight with minimal damage. blade 'B' was bent aft at the root, and blade 'C' was straight, with light leading-edge gouging along the outer half of the blade. The position of the three blades was not feathered and was in or near the low-pitch stop position.

Both engines were examined, and no engine anomalies were observed that would have prevented normal operation.

Additional Information

EDM Data

A J.P. Instruments EDM-760 was recovered from the wreckage and downloaded. Data from the last 10 flights, including the accident flight, were recorded at 6-second intervals; these data included fuel flow, fuel used, exhaust gas temperatures, cylinder head temperatures, and shock cooling rate of the two engines.

After fuel flow to the left engine decreased to 0 gph where it remained for about 40 seconds, fuel flow increased to about 32 gph and remained near 30 gph for the remainder of the recorded data. After fuel flow to the right engine decreased to 0 gph, it remained near 0 until about 4 minutes before the end of the data, when it increased to about 15 gph for a few seconds and then returned to 0. About 3 minutes before the end of the data, the right engine fuel flow rose to between 2 and 6 gph for about 30 seconds and then returned to 0, where it remained for the remainder of the recorded data.

Total fuel used on the accident flight was about 42 gallons, with the left and right engines consuming 22 and 20 gallons, respectively. Based on the left engine restarting and running at 30 gph for about 6 minutes, the total fuel used at the time of the power loss of both engines was about 39 gallons.

Total fuel used between the fueling on April 14 and the accident flight, was 214.7 gallons, with the left and right engines consuming 108 and 106.7 gallons, respectively.

Performance Study

As stated above, the wreckage examination found that the flaps were positioned at 15° and the right engine propeller was not feathered. The NTSB's performance study found that had the pilot feathered the propeller of the inoperative right engine and retracted the flaps, the resulting reduction in drag would have been sufficient to maintain the airplane's glideslope to the runway assuming that the left engine maintained thrust.

Fuel Planning

For IFR flight plans, 14 *CFR* 91.167 requires enough fuel to reach the destination airport and an alternate airport, plus 45 minutes of flight time at normal cruising speed.

Before departure, the pilot planned several routes from IWS to ERV using the ForeFlight mobile flight-planning application. The pilot checked airport information at ERV and two airports between IWS and ERV (the airports were closer to IWS than ERV). He did not check information for alternate airports in the vicinity of ERV.

The pilot filed an IFR flight plan using flightplan.com, which included a navigation log that provided fuel calculations based on information entered by the pilot. Estimated fuel consumption for the flight was about 38 gallons, which included 5 gallons of taxi fuel; the navigation log included fuel required for the IFR flight of about 58 gallons, including a 45-minute fuel reserve at normal cruising speed of 20.3 gallons. The navigation log did not include fuel for an instrument approach at ERV, and an alternate airport was not designated. Postaccident calculations of the fuel required for the IFR flight indicated that a minimum of 67 gallons would be required, which included fuel for an instrument approach to ERV, 6 gallons of fuel for an instrument approach at the closest alternate airport, and 20 gallons of reserve fuel.

Flight Planning Log

The pilot used a flight-planning log to record starting and ending fuel for each flight. The log showed the date, departure and landing locations, the tachometer start and stop times, the total flight time, and the beginning and ending fuel (in gallons) for each flight. The pilot likely based the fuel consumption information on the EDM data. Figure 3 shows the six previous flights, beginning on April 14, as well as the accident flight.

S 2019 GOLF TOURNAMENT

N501CE	N 501CE	N	N	N
04/14/19				
DLL	MEI			
IWS MEI	IWS			
3824.7	3827.5			
3822.0	3824.7			
2.7	2.8			
115/25	145/60	/	/	/
90	85			

MISSION:

	N 501CE	N 501CE	N 501CE	N 501CE	N 501CE	N
DATE:	4/15	4/15	4/15	4/17	4/17	
FROM:	IWS	MDD	GLE	IWS	DWH	
TO:	MDD	GLE	IWS	DWH	IWS	
STOP:	3829.6	3831.1	3832.8	3832.9	3833.2	
START:	3827.5	3829.6	3831.1	3832.8	3832.9	
TOTAL:	2.1	1.5	1.7	0.1	0.3	
FUEL:	194/133	133/90	90 138	68/61	61 150	/

MISSION:

	N 501CE	N 501CE	N
DATE:	4/22	4/22	
FROM:	IWS	ERV	
TO:	ERV	IWS	
STOP:			
START:	3833.2		
TOTAL:			
FUEL:	54/	/	

Figure 3. Pilot's Flight-Planning Logs

According to the fueling company manager at IWS, the pilot would typically order fuel over the telephone and would not be present when the airplane was fueled. The pilot's normal fuel order was to fill only the wing fuel cells (not the wet tip tanks). The pilot's fuel order 8 days before the accident (on April 14) was taken over the phone and transcribed on a service request form as "T/O x 4." In postaccident interviews, the fueler stated that he understood the order as written to be a "top off" of the wing fuel cells and wet tip tanks for both wings and recalled fueling the airplane until the main fuel cells and wet tip tanks were completely full. The fuel receipt from the IWS fueling company on the evening of April 14 indicated that 113 gallons of fuel were added.

Before the fueling on April 14, the pilot's fuel log indicated an ending fuel of 60 gallons (see the top of figure 3). As shown in figure 3, the pilot recorded 194 gallons as the starting fuel for the first flight on April 15. However, based on the fuel quantity indicated on the fuel receipt, the total fuel should have been recorded as 173 gallons (60 gallons on the fuel log plus the 113 gallons on the fuel receipt); thus, the pilot's fuel log indicated a starting fuel load 21 gallons more than it should have been on April 15.

The log indicated that the ending fuel for the flight before the accident flight, on April 17, was 50 gallons; however, it appears that the pilot wrote 54 as the beginning fuel for the accident flight (highlighted at bottom of figure 3). The investigation was unable to determine the reason for this difference given that no fuel order or fuel receipt for the period between April 17 and the day of the accident was located, and the fueling company at IWS does not offer a self-service fueling option.

Given the noted errors above, the investigation used the EDM fuel consumption data to determine how much fuel was actually onboard the airplane after the 113 gallons were added on April 14. Based on the confirmed fueling of 30 gallons on April 17 and the EDM fuel consumption data for the flights between April 14 and the accident, the investigation determined that usable starting fuel on April 15 was about 182 gallons, which was 12 gallons less than the amount the pilot recorded.

Spin Avoidance and Recovery Guidance

In March 2006, Raytheon Aircraft Corporation (RAC) issued Safety Communiqué No. 249, "Spin Avoidance and Spin Recovery Characteristics," which includes the following information:

A spin can occur whenever an airplane is stalled and is subject to yaw input. Yaw input can be provided by rudder, asymmetric power, aileron, p-factor, or any combination of these forces. Any time asymmetric power is allowed to continue through spin entry and into a developed spin, a dangerous and possible unrecoverable spin (to the left or right) could be encountered.

According to the FAA Airplane Flying Handbook:

No multi-engine airplane is certified for spins, and their spin characteristic is generally poor. As very few twins have been spin tested (none are required to), the recommended spin recovery techniques are based only on the best information available. The departure from controlled flight may be quite abrupt and possibly disorienting.

FAA Advisory Circular 61-67C, "Stall and Spin Awareness Training," includes the follow information:

The center of gravity has a significant effect on stability and stall/spin recovery. As the center of gravity is moved aft, the amount of elevator deflection needed to stall the airplane at a given load factor will be reduced. An increased angle of attack will be achieved with less elevator control force. This could make the entry into inadvertent stalls easier, and during the subsequent recovery, it would be easier to generate higher load factors due to the reduced elevator control forces.

Although the hilly, rocky, and wooded terrain near the accident site offered limited forced landing options, a plateau with a dirt road was in front of the airplane before the right turn at the end of the flight.

American Bonanza Society Article

After the accident, the June 2019 issue of *American Bonanza Society Magazine* published an article reminding pilots of prudent actions when refueling and noting the following:

Whenever possible, personally fuel your airplane, or watch it being refueled. Ensure that the proper type and quantity of fuel is added in the tanks you want it put into. Compare the fuel bill to your expectations. Check the amount of fuel that was added against the amount you thought you would need. If there is a big discrepancy, figure it out, whether less fuel than you expected was put in or you needed more than you thought because your fuel tracking was flawed on prior flights.

Ensure your fuel gauges are accurate. Our Australian friends are required to have their fuel gauges calibrated .... and a placard next to the gauges that show the instrument error for each marking on the gauges, similar in concept to a compass correction card. It is possible for our fuel gauges to be reliable.

Fuel Quantity System Maintenance Guidance

The Beech 58 annual inspection guide specified checking "for proper operation and unusual fluctuations" of fuel quantity gauges. The Beech maintenance manual recommended fuel quantity transmitters be overhauled or replaced as necessary.

In general, no FAA regulations and little guidance addressed periodically checking the accuracy of fuel quantity indicators. In response to a reported safety concern, a 2003 special airworthiness information bulletin (SAIB) recommended owners of Cessna 100, 200, 300, and 400 airplanes perform calibration checks of both the empty and full positions of their airplanes' gauging system at the next inspection then at 5-year intervals.

The NTSB is aware that, based on this accident and other fuel-related accidents involving resistance-type fuel quantity gauging systems, the FAA is working on an SAIB addressing all aircraft with such systems.

Medical and Pathological Information

An autopsy of the pilot was performed at the Travis County Medical Examiner's Office, Austin, Texas. The cause of death was blunt force injuries. The autopsy found atherosclerotic arterial disease, including greater than 90% stenosis of the right coronary artery, greater than 90% stenosis of the left anterior descending coronary artery, 60% to 70% stenosis of the left main coronary artery, 40% to 50% stenosis of the left circumflex coronary artery, and 20% to 30% stenoses of the right and left coronary ostia (all percentages approximate). The autopsy found no other significant natural disease.

Toxicology testing of the pilot's tissue and fluid samples performed at the Federal Aviation Administration (FAA) Forensic Sciences Laboratory detected naproxen, fexofenadine, azacyclonol, rosuvastatin, and irbesartan in blood and urine. These drugs are not considered impairing.

According to the pilot's girlfriend, the pilot was well rested and in good health, both mentally and physically, before the accident flight. Airport surveillance video showed that the pilot appeared to be alert during the hour before the flight.

Administrative Information

Investigator In Charge (IIC):	Folkerts, Michael		
Additional Participating Persons:	Frank Fortmann; Flight Standards District Office; San Antonio, TX Mike Council; Continental Aerospace Technologies; Mobile, AL Jennifer Barclay; Textron Aviation Inc; Witchita, KS		
Original Publish Date:	July 21, 2020	**Investigation Class:**	2
Note:	The NTSB traveled to the scene of this accident.		
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=99291		