Aviation Investigation Final Report

Location:	Berthoud, Colorado	**Accident Number:**	CEN17FA111
Date & Time:	February 27, 2017, 07:41 Local	**Registration:**	N2461N
Aircraft:	Cessna 172S	**Aircraft Damage:**	Substantial
Defining Event:	Aerodynamic stall/spin	**Injuries:**	2 Fatal
Flight Conducted Under:	Part 91: General aviation - Instructional		

Analysis

The flight instructor and the commercial pilot receiving instruction were conducting a local training flight to practice aerodynamic spins. A review of air traffic control radar track data established that the airplane entered two aerodynamic spins during the flight. The first aerodynamic spin began at 10,300 ft mean sea level (msl), and the airplane descended about 1,000 ft before it recovered into a climb. The airplane then made a series of climbing turns until reaching 10,800 ft msl where it entered a second aerodynamic spin. The airplane did not recover from the second spin before it descended below available radar coverage at 6,800 ft msl (about 1,700 ft above the ground). Multiple witnesses reported seeing the airplane descending in a nose-down spin. One witness stated that the airplane completed about 5 turns in the spin before it descended behind a tree line into a reservoir.

The airplane's Pilot Operating Handbook specified that at least 1,000 ft of altitude loss should be expected for a one-turn spin and recovery and that a six-turn spin and recovery may require more than twice that altitude loss because the airplane can develop a rapid rate of rotation and a steep nose-down pitch attitude. A postaccident examination revealed no evidence of a mechanical malfunction or failure that would have precluded normal operation during the flight. Additionally, the examination did not identify any foreign object debris that would have limited full movement of the flight controls during the flight, and the airplane's weight and balance were within the specified limits to conduct aerodynamic spins. It is likely that the pilots did not apply prompt and/or correct flight control inputs to adequately recover from the intentional aerodynamic spin.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The failure of the pilots to apply prompt and/or correct flight control inputs to adequately recover from the intentional aerodynamic spin.

Findings

Personnel issues	Aircraft control - Pilot
Personnel issues	Aircraft control - Instructor/check pilot
Aircraft	(general) - Incorrect use/operation

Factual Information

History of Flight

Maneuvering	Aerodynamic stall/spin (Defining event)
Maneuvering	Collision with terr/obj (non-CFIT)

On February 27, 2017, about 0741 mountain standard time, a Cessna 172S airplane, N2461N, collided with a reservoir while maneuvering near Berthoud, Colorado. The flight instructor and the pilot receiving instruction were fatally injured, and the airplane was substantially damaged. The airplane was owned by McAir Aviation, LLC, and was operated by the company under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 91. Day visual meteorological conditions prevailed for the local instructional flight that departed Rocky Mountain Metropolitan Airport (BJC), Broomfield, Colorado, at 0724.

According to the operator, the purpose of the flight was for the pilot receiving instruction to demonstrate his ability to enter and recover from aerodynamic spins as part of his required training toward a flight instructor certificate.

According to a review of air traffic control radar track data, the first radar contact with the airplane was at 0724:01 shortly after it departed runway 30R at BJC. After takeoff, the airplane proceeded north toward Longmont, Colorado. At 0734:30, the airplane crossed over Colorado Highway 66 at 10,000 ft mean sea level (msl). At 0736:12, the airplane was about 1 mile east of the Highland Reservoir No. 2 at 10,300 ft msl. According to calculations based on radar data, the airplane turned to a westerly course as the ground speed decreased below 40 knots. Between 0736:53 and 0737:07, the airplane descended from 10,300 ft msl to 9,300 ft msl, and the calculated average descent rate was about 4,300 ft per minute during the 14 second descent. Following the rapid descent, the airplane entered a climb to 10,800 ft msl and completed a turn from an east course to a west course. At 0740:35, about 1 mile south of the Culver Reservoir (also known as Blue Mountain Reservoir), the airplane completed a 90° right turn, and the ground speed decreased below 40 knots. Between 0741:03 and 0741:40, the airplane descended from 10,800 ft msl to 6,800 ft msl, and the calculated average descent rate was about 6,500 ft per minute. The last radar data point was at 0741:40 at 6,800 ft msl when the airplane descended below available radar coverage (about 1,700 ft above the ground).

A witness reported that she was outside feeding her horses when she observed the airplane flying overhead. She reported hearing a reduction in engine power before seeing the airplane pitch nose-down and enter a spin toward the ground. She stated that the airplane completed about 5 turns in the spin before it descended below a tree line located between her position and Culver Reservoir. She reported that the airplane rotated slowly throughout the spin maneuver and that she did not hear the engine regain power. The witness also indicated that it was very common for airplanes to complete similar maneuvers in the airspace near her property.

Another witness reported that he initially heard the airplane overfly his residence. He stated that he heard a reduction in engine power and then saw the airplane through a window descending nose-down in

a spin. The witness reported that the airplane was rotating slowly during the spin maneuver. He also noted that he did not observe any smoke or flames coming from the airplane. The airplane descended below a tree line located between his residence and Culver Reservoir. Although the witness did not see the airplane impact the reservoir, he reported hearing a sound consistent with a ground impact.

Pilot Information

Certificate:	Commercial	**Age:**	23,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	3-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 Without waivers/limitations	**Last FAA Medical Exam:**	January 6, 2015
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	August 31, 2016
Flight Time:	(Estimated) 550 hours (Total, all aircraft)		

Flight instructor Information

Certificate:	Commercial; Flight instructor	**Age:**	58,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	3-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane single-engine; Instrument airplane	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	June 24, 2016
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	June 30, 2016
Flight Time:	(Estimated) 6678.5 hours (Total, all aircraft)		

According to Federal Aviation Administration (FAA) records, the 58-year-old flight instructor held a commercial pilot certificate with ratings for airplane single-engine land and instrument airplane. He also held a flight instructor certificate with ratings for airplane single-engine land and instrument airplane. His last aviation medical examination was on June 24, 2016, when he was issued a second-class medical certificate with a limitation to have glasses available for near vision. A search of FAA records showed no previous accidents, incidents, or enforcement proceedings. He was employed by McAir Aviation as the chief pilot in charge of flight instruction. On June 30, 2016, the FAA renewed his chief pilot authorization following an oral examination and checkride in a Cessna 172S. The operator reported that the flight instructor had a total flight experience of 6,678.5 hours.

According to FAA records, the 23-year-old pilot receiving instruction held a commercial pilot certificate with ratings for airplane single-engine land and instrument airplane. The commercial pilot certificate was issued on August 31, 2016. His last aviation medical examination was on January 6, 2015, when he

was issued a third-class medical certificate with no limitations or restrictions. A search of FAA records showed no previous accidents, incidents, or enforcement proceedings. A pilot logbook was not recovered during the investigation; however, according to his father, the pilot receiving instruction had about 550 hours total flight experience of which about 400 hours had been flown during the previous year.

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N2461N
Model/Series:	172S	**Aircraft Category:**	Airplane
Year of Manufacture:	2005	**Amateur Built:**	
Airworthiness Certificate:	Normal; Utility	**Serial Number:**	172S10043
Landing Gear Type:	Tricycle	**Seats:**	2
Date/Type of Last Inspection:	January 12, 2017 100 hour	**Certified Max Gross Wt.:**	2550 lbs
Time Since Last Inspection:	52 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	4703 Hrs at time of accident	**Engine Manufacturer:**	Lycoming
ELT:	C91A installed, activated, did not aid in locating accident	**Engine Model/Series:**	IO-360-L2A
Registered Owner:	McAir Aviation, LLC	**Rated Power:**	180 Horsepower
Operator:	McAir Aviation, LLC	**Operating Certificate(s) Held:**	Pilot school (141)

The 2005-model-year airplane, serial number 172S10043, was a high-wing monoplane of aluminum semi-monocoque construction. The airplane was powered by a 180-horsepower, 4-cylinder, Lycoming IO-360-L2A reciprocating engine, serial number L-31665-51A. The engine provided thrust through a fixed-pitch, two-blade, McCauley model 1A170E/JHA7660 propeller, serial number ZF23025. The airplane was equipped with a fixed tricycle landing gear and wing flaps and had a certified maximum gross weight of 2,550 pounds. The FAA issued the airplane a standard airworthiness certificate on November 29, 2005.

According to dispatch documentation, the airplane's hour meter indicated 6,053.7 hours before the flight. The airplane's hour meter indicated 6,054.2 hours at the accident site. At the time of the accident, the airframe had accumulated a total service time of 4,703 hours. The engine had accumulated a total service time of 5,994.6 hours since new and 1,862 hours since its most recent overhaul on December 21, 2012. The propeller had accumulated a total service time of 4,703 hours and 1,862 hours since its most recent overhaul on January 4, 2013. The last annual inspection of the airplane was completed on October 25, 2016, at 4,552.1 total airframe hours. A 100-hour inspection was completed on January 12, 2017, at 4,651.2 total airframe hours. The rudder return springs were replaced on January 24, 2017, at 4,668.8 total airframe hours. The rear bench seat and rear seat restraints were removed on February 13, 2017. A postaccident review of the maintenance records found no history of unresolved airworthiness issues.

The airplane had two fuel tanks, one located in each wing, and a total fuel capacity of 56 gallons (53

gallons usable). According to dispatch records, the airplane departed with 27 gallons of fuel.

The dispatch records included a weight-and-balance calculation worksheet for the flight. According to the worksheet, the combined weight of the flight instructor and the pilot receiving instruction was 325 pounds; the airplane departure weight was 2,173.5 pounds; and the calculated moment arm was 40.3 inches aft-of-datum. The postmortem weights of the flight instructor and the pilot-receiving-instruction were 204 pounds and 150 pounds, respectively. A postaccident weight-and-balance calculation, using the postmortem weights and a fuel consumption rate of 11 gallons per hour, established that the airplane was operating within the constraints of the utility category at the time of the accident.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	FNL,5016 ft msl	**Distance from Accident Site:**	15 Nautical Miles
Observation Time:	07:56 Local	**Direction from Accident Site:**	30°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots / None	**Turbulence Type Forecast/Actual:**	Clear air / Clear air
Wind Direction:	50°	**Turbulence Severity Forecast/Actual:**	Moderate / Moderate
Altimeter Setting:	29.68 inches Hg	**Temperature/Dew Point:**	-7°C / -9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Bloomfield, CO (BJC)	**Type of Flight Plan Filed:**	None
Destination:	Bloomfield, CO (BJC)	**Type of Clearance:**	None
Departure Time:	07:24 Local	**Type of Airspace:**	Class E

A postaccident review of available meteorological data established that day visual meteorological conditions prevailed at the accident site. The nearest aviation weather reporting station was located at Fort Collins-Loveland Municipal Airport (FNL) about 15 miles north-northeast of the accident site. At 0756, about 15 minutes after the accident, the FNL automated surface observing system reported wind 050° at 5 knots, 10 miles surface visibility, a clear sky, temperature -7°C, dew point -9°C, and an altimeter setting 29.68 inches of mercury.

Wreckage and Impact Information

Crew Injuries:	2 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Fatal	**Latitude, Longitude:**	40.267223,-105.154167

The airplane wreckage was found partially submerged in Culver Reservoir at an altitude of 5,142 ft msl. Airbags were used to float the airplane to the shore where it was subsequently recovered by a crane. All major structural components and flight controls remained intact. The aileron and flap control cables were disconnected at the wing root turnbuckles by the salvage company before the wings were removed for transport. The elevator and rudder cable circuits were not disconnected during wreckage recovery.

The leading edge of the right wing was crushed upward and aft to the front spar about 45°. The leading edge of the left wing was crushed flat. The aft fuselage and tail cone were compressed on the right side and buckled slightly outward on the left side. The engine was compressed up and aft into the firewall. Aileron control cable continuity was established from the left and right aileron bell cranks to the center wing area where they had been disconnected to facilitate recovery of the wreckage. The aileron autopilot roll servo cables remained on the capstan and attached to the bell crank. The aileron cables remained installed on the left and right control column sprockets and were wrapped around the interconnect pulley. A measurement of the wing flap actuator was consistent with the flaps being fully retracted at impact.

Elevator control cable continuity was established from the forward elevator bell crank to the aft elevator bell crank. The forward elevator bell crank was bent due to floor compression damage that was sustained during impact. The elevator autopilot pitch servo cables were on the capstan, and the bridal cables remained attached to the control cable. Rudder control cable continuity was established from the rudder torque tubes to the rudder horn. The rudder stops exhibited normal wear signatures. The rudder return springs remained attached to the rudder assemblies, and no anomalies were observed with their installation. The rudder torque tube bearing block covers exhibited fracture features consistent with impact-related damage. The parking brake cable on the left side left brake pedal was fractured. The pilot side left brake master cylinder connection rod was fractured near the brake pedal attachment.

The examination did not identify any foreign object debris within the cabin, cockpit, wings, or the aft fuselage that would have limited full movement of the flight controls during the flight. Both structural seat pans exhibited downward deformation. A headset bag was located under each of the cockpit seats, and the headset bags were trapped by the deformed seat pans. A fuel sample that was obtained from the fuel strainer assembly tested negative for water contamination using water-detection paste. The postaccident airframe examination revealed no evidence of a mechanical malfunction or failure that would have precluded normal operation during the flight.

The engine had partially separated from the firewall. The top spark plugs, valve covers, and all rear accessories were removed to facilitate the examination. Mechanical continuity was confirmed from the engine components to their respective cockpit controls, with exception of the mixture control rod end

that had separated at the shaft but remained connected to the mixture control arm. The fracture of the mixture control rod end exhibited features consistent with an overstress failure. Internal engine and valve train continuity were established as the crankshaft was rotated. Compression and suction were observed on all cylinders in conjunction with crankshaft rotation. The top spark plugs exhibited features consistent with normal engine operation. A borescope inspection revealed no anomalies with the cylinders, valves, pistons, or lower spark plugs.

There were no obstructions observed between the air filter housing and the fuel servo. The exhaust was crushed upward and aft. The intake tubes for cylinders nos. 1 and 2 were found displaced aft from impact damage. The residual water was cleaned out of both magnetos with contact cleaner and compressed air. A spark was produced on all posts when each magneto was rotated by hand. The fuel flow divider, flow transducer, and fuel hoses were clear of contaminates. No anomalies were noted with the mechanical fuel pump when it was operated by hand. The fuel flow divider contained fuel. The oil pickup screen was free of contamination.

The propeller remained attached to the crankshaft flange. One blade was found relatively straight, and the other blade was bent slightly aft. Neither propeller blade exhibited chordwise scoring, rubbing, or burnishing. The postaccident examination revealed no evidence of a mechanical malfunction or failure that would have precluded normal engine operation during the flight.

Medical and Pathological Information

The Larimer County Medical Examiner's Office, Loveland, Colorado, performed autopsies on the flight instructor and the pilot receiving instruction. The cause of death for both individuals was attributed to multiple blunt-force injuries sustained during the accident.

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicology tests on specimens obtained during each autopsy. The flight instructor's toxicology results were negative for carbon monoxide, ethanol, and all tested drugs and medications.

The pilot receiving instruction's toxicology results detected dextromethorphan and its metabolite dextrorphan, doxylamine, and ibuprofen in urine. Dextromethorphan, dextrorphan, and doxylamine were also detected in blood at levels too low to quantify accurately. The testing also identified 35.75 µg/ml of acetaminophen in urine. Acetaminophen is a fever treatment and analgesic commonly available over the counter with the name Tylenol. Ibuprofen is also used to treat pain and fever and is commonly available over the counter with the names Advil and Motrin. Acetaminophen and ibuprofen are not considered impairing. Dextromethorphan is a cough suppressant found in many over the counter cough and cold preparations. In typical doses, dextromethorphan is not considered impairing. Doxylamine is a sedating antihistamine available in a variety of over the counter cold products and sleep aids.

Tests and Research

The airplane was equipped with a Garmin G1000 avionics suite; however, the multifunction display was not equipped with a memory card that could have recorded flight parameters during the flight. The airplane operator confirmed that none of their G1000-equipped Cessna 172S airplanes had a memory card installed.

An Apple iPad Air, Apple iPad Air 2, and an Apple iPhone 5S were recovered from the wreckage and submitted to the NTSB Vehicle Recorder Laboratory for forensic examination. Attempts to repair the damaged Apple iPad Air were unsuccessful, and no information was recovered from the device. The damaged Apple iPad Air 2 was repaired, but forensic efforts to access the password-protected data were not successful. The damaged Apple iPhone 5S was repaired, and photos and an encrypted backup were recovered from the device. The recovered photos were not pertinent to the investigation, and the encrypted backup precluded further review of the device.

Additional Information

According to the airplane's Pilot Operating Handbook (POH), intentional spin maneuvers are approved when the airplane is operated within the specified limits of utility category. The POH indicates that at least 1,000 ft of altitude loss should be allowed for a one-turn spin and recovery, while a six-turn spin and recovery may require more than twice that amount. Full aft elevator and full rudder applied in the direction of the spin should be maintained until spin recovery is initiated. An inadvertent relaxation of either of these controls could result in the development of a nose-down spiral (instead of a spin). The POH stipulates that when training in spins and spin recoveries, a one- or two-turn spin is adequate and should be used. During the first two turns, the spin will progress to a rapid rate of rotation and a steep nose-down attitude. Proper application of recovery controls will yield prompt recoveries within a quarter turn. During extended spins of two to three turns or more, the spin will tend to change into a nose-down spiral, particularly to the right. In the event of a nose-down spiral, a recovery should be accomplished promptly but smoothly by leveling the wings and recovering from the resulting dive.

Administrative Information

Investigator In Charge (IIC):	Fox, Andrew
Additional Participating Persons:	Phillip Potter; Federal Aviation Administration, Denver FSDO; Denver, CO Peter Basile; Textron Aviation; Wichita, KS Troy Helgeson; Lycoming Engines; Milliken, CO
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Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=94777