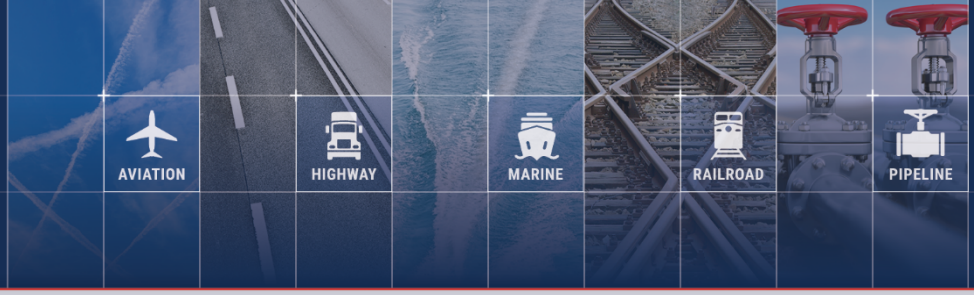

Aviation Investigation Final Report

Location:	Smyrna, Tennessee	**Accident Number:**	ERA21FA234
Date & Time:	May 29, 2021, 10:55 Local	**Registration:**	N66BK
Aircraft:	Cessna 501	**Aircraft Damage:**	Destroyed
Defining Event:	Loss of control in flight	**Injuries:**	7 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The instrument-rated pilot of the business jet airplane, pilot-rated passenger, and five passengers departed on a cross-country flight and entered the clouds while performing a climbing right turn. The airplane then began to descend, and air traffic control (ATC) asked the pilot to confirm altitude and heading. The pilot did not respond. After a second query from ATC, the pilot acknowledged the instructions. The airplane entered a climbing right turn followed by a left turn. After ATC made several attempts to contact the pilot, the airplane entered a rapid descending left turn and impacted a shallow reservoir at a high rate of speed.

Postaccident examination of the recovered wreckage and both engines revealed no evidence of any preimpact mechanical malfunctions or failures that would have precluded normal operation.

Flight track data revealed that after takeoff, the airplane entered the clouds and made a series of heading changes, along with several climbs and descents, before it entered a steep, descending left turn. This type of maneuvering was consistent with the onset of a type of spatial disorientation known as somatogravic illusion. According to a National Transportation Safety Board performance study, accelerations associated with the airplane's increasing airspeed were likely perceived by the pilot as the airplane pitching up although it was in a continuous descent. This occurred because the pilot was experiencing spatial disorientation and he likely did not effectively use his instrumentation during takeoff and climb. As a result of the pilot experiencing spatial disorientation, he likely experienced a high workload managing the flight profile, which would have had a further adverse effect on his performance. As such, the airplane entered a high acceleration, unusual attitude, descending left turn from which the pilot was not able to recover.

The pilot and the pilot-rated passenger did not report any medication use or medical

conditions to the Federal Aviation Administration on their recent and only medical certification examinations. Postaccident specimens were insufficient to evaluate the presence of any natural disease during autopsy. However, given the circumstances of this accident, it is unlikely that the pilot's or pilot-rated passenger's medical condition were factors in this accident.

Low levels of ethanol were detected in the pilot's muscle tissue and the pilot-rated passenger's muscle and kidney tissue; n-butanol was also detected in the pilot's muscle tissue. Given the length of time to recover the airplane occupants from the water and the circumstances of this accident, it is reasonable that some or all of the identified ethanol in the pilot and the pilot-rated passenger were from sources other than ingestion. Thus, the identified ethanol in the pilot and the pilot-rated passenger did not contribute to this accident.

Probable Cause and Findings

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

The pilot's loss of airplane control during climb due to spatial disorientation.

Findings

Personnel issues	Aircraft control - Pilot
Personnel issues	Spatial disorientation - Pilot

Factual Information

History of Flight

Initial climb	Loss of control in flight (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)

HISTORY OF FLIGHT

On May 29, 2021, about 1055 central standard time, N66BK, a Cessna Citation CE-501, was destroyed when it impacted Lake Percy Priest shortly after takeoff from Smyrna Airport (MQY), Smyrna, Tennessee. The pilot, pilot-rated passenger, and five passengers were fatally injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 flight.

The pilot filed an instrument flight rules flight plan and was destined for the Palm Beach International (PBI) Airport, West Palm Beach, Florida. He purchased 414 gallons of Jet A fuel prior to the flight, which topped off the fuel tanks for a total of 574 gallons. The pilot then taxied to runway 32.

A review of air traffic control communications and radar data provided by the Federal Aviation Administration (FAA) revealed the pilot was cleared for takeoff and instructed to turn to a heading of 90° and to climb and maintain 3,000 ft mean sea level (msl). The pilot initially read back the clearance as “at or above 3,000 ft,” and the controller corrected him to climb and maintain 3,000 ft.

The airplane departed about 1053:06 and made a climbing right turn to the east and was instructed to contact Nashville departure control. About 1054:27, when the airplane was about 3 miles north of the airport, a departure controller contacted the airplane and asked if they were “on frequency.” The pilot responded and said, “N66BK with you.” The controller then instructed the pilot to turn right heading 130°; however, the pilot did not acknowledge. About 1054:46, the controller asked the pilot if he copied the heading instruction. The pilot responded about 4 seconds later and said, “130…Bravo Kilo.”

About 1055:11, the controller instructed N66BK to climb and maintain 15,000 ft msl, but there was no response from the pilot. The controller then made multiple attempts to re-establish communications with the flight; however, there were no further responses.

A review of radar data from the time the pilot established contact with departure control (about 1054:27) until the time the radar track for the flight ended (1055:05), revealed the airplane made a series of heading changes along with several climbs and descents before it entered a steep, descending left turn. The last radar return indicated the airplane was at an altitude of about 700 ft msl, descending at a rate of about 31,000 fpm, on a heading of 090°.

A witness was fishing about 50 yards west of the Fate Sanders Recreation Area boat ramp located on Lake Percy Priest, about 2.7 miles northeast of MQY. He described the weather as a very low ceiling in mist. The witness heard what he thought was a low flying military jet before he saw the airplane impact the lake in a “straight down” attitude with the nose of the airplane impacting the water first. He did not see any evidence of fire or an explosion on impact.

Another witness, who was fishing from a boat on Stuart Creek, said he heard what sounded like an “extreme vertical acceleration for about 3-4 seconds” followed by a “boom.” He said the airplane sounded like a military jet.

METEROLOGICAL INFORMATION

At 1056, the weather reported at MQY was wind from 310° at 10 knots, visibility 10 miles, overcast ceiling 1,300 ft, temperature 14° C, and dewpoint 12° C, with a barometric altimeter setting of 30.04 inHg.

PILOT INFORMATION

The pilot held a commercial pilot certificate with ratings for airplane single-engine and multiengine land, and instrument airplane. He also held a private pilot certificate with a rotorcraft-helicopter rating. The pilot was type-rated in the Cessna CE-500 airplane with no restrictions. His last FAA second-class medical certificate was issued on November 12, 2019, with the limitation that he “must wear corrective lenses.” At the time of the exam, the pilot reported taking no medications and having no medical conditions.

A review of the plot’s logbook revealed he had a total of about 1,680.5 flight hours; of which, 83 hours were in the accident airplane. He logged 39.8 hours of total actual instrument flight experience with 5.9 hours in the accident airplane.

The pilot attended the Citation II Initial training course at the Flight Safety International Training Center in Atlanta, Georgia, from January 13 to 24, 2020. According to Flight Safety International, the pilot did not meet the requisite performance level to attempt the CE-500 type-rating check ride. This training included 7 simulator sessions, for a total of 14 hours of pilot flying time, as well as acting as pilot monitoring for a total of 12 hours over the first 6 sessions. The last session was limited to 2 hours of pilot flying.

After the accident pilot returned from the Flight Safety International Training Center, he received training from a flight instructor in the accident airplane between February 24, 2020, and March 8, 2020, for a total of 11.4 hours. According to the flight instructor, the pilot “did not care for” the training at Flight Safety International and needed more one-on-one training rather than a group setting. He said he saw no issues with the accident pilot’s ability to operate in instrument meteorological conditions (IMC). The flight instructor stated that the pilot did not have any issues operating the accident airplane’s autopilot or the navigation systems, but he was more familiar with the Garmin 750 that was installed on another airplane he owned, a

Mitsubishi MU2 (turbine twin engine airplane), than the Garmin 430/530 installed on the accident airplane.

On March 11, 2020, the pilot completed a check-ride with an designated pilot examiner (DPE) and received a CE-500 type rating. According to the pilot's logbook, the type-rating check ride was conducted in the accident airplane and entered as a 2.3-hour long flight. In an interview, the DPE stated that the pilot was a very competent pilot and that he had full confidence in his ability to operate the CE-501 in IMC.

The accident pilot's logbook also revealed that he flew with another pilot on several occasions after he obtained his type rating. In an interview, this pilot stated that the accident pilot had no issues operating the accident airplane and was very thorough in using the checklist. However, he did "struggle" when operating in IMC and when using the airplane's autopilot, which was a "...bit complicated and caused the pilot confusion." The pilot said, the accident pilot was "weak" when it came to flying in IMC and would "struggle" with instrument approaches outside of his local flying area or if he did not receive radar vectors onto an approach. The accident pilot was very reliant on his iPad to help him understand his "time in space." The accident pilot was interested in taking the accident airplane to New York, Los Angeles, and Atlanta; however, the pilot said that he "made it very clear that he [accident pilot] was not proficient enough to operate in those areas."

The pilot-rated passenger earned a commercial pilot certificate with a rating for airplane multiengine land two days before the accident. At that time, he reported a total of 310 hours of flight experience on his FAA Airman Certificate and/or Rating Application. The pilot-rated passenger also held an instrument rating on his commercial pilot certificate and had private pilot certificate privilege ratings for airplane single engine land and rotorcraft-helicopter. The pilot rated passenger's last FAA third-class medical was issued on November 16, 2017, without limitations. At the time of the exam, he reported taking no medications and having no medical conditions. He was not type-rated in the accident airplane.

AIRCRAFT INFORMATION

The Cessna CE-501 was a seven-place business jet airplane powered by two Pratt & Whitney Canada JT15D-1B turbofan engines. A review of the airplane's maintenance records revealed the last phase inspections (Cessna Phase I thru IV, and Phase B) were completed on February 25, 2021. At that time the airplane had a total time of 4,781.4 hours. The hour meter time was 4,731.6. The airplane was equipped and certified to operate in IMC.

WRECKAGE INFORMATION

The airplane impacted Lake Percy Priest about 2.7 miles northeast of MQY in 2 to 8-foot-deep water. The impact was consistent with the airplane traveling at a high rate of speed when it impacted the water. First responders and rescue personnel used under water side sonar to identify larger pieces of wreckage, along with underwater divers to feel for debris. The recovery was hampered due to poor water visibility and the deep mud/silt that made up the lakebed.

Despite being heavily fragmented, about two-thirds of the wreckage was recovered, including both engines, the main cabin door (pins were out), portions of the main cabin windows, the left nose baggage door, all three-landing gear, the tail section, and sections of both wings, including the flaps and ailerons. Several fractured seat frames and pieces of the interior were also recovered. There was no evidence of fire on any of the recovered sections of airplane. One of the main landing gear actuators was found in the wreckage and it was fully retracted.

Examination of the left- and right-wing sections that were recovered revealed that the left wing sustained more damage than the right. Flight control continuity could not be fully established for the ailerons and flaps due to impact damage; however, examination of the flight control cables that were recovered exhibited facture features consistent with overload separation. Both the left and right flap cables were attached to their respective bell cranks. The flap actuator was recovered, and the flaps were fully retracted.

The left and right horizontal stabilizers exhibited symmetric leading edge impact damage. Both elevators sustained impact damage. The vertical stabilizer was pushed aft about 60° and exhibited leading edge impact damage. The rudder remained partially attached an exhibited impact damage. Flight control continuity could not be fully established for the rudder and elevators due to impact damage; however, examination of the flight control cables that were recovered exhibited fracture surfaces consistent with overload.

Several cockpit instruments were recovered and exhibited impact and water damage. The pilot-side heading indicator was found on 340° and the attitude indicator was 60° nose down and in a 45° left turn. The co-pilot side attitude indicator, an airspeed indicator, and several other instruments were undetermined/unreadable due to impact damage.

The power quadrant was recovered and exhibited impact and water damage. The right engine power level was in the full aft position and the left power lever was in the full forward position. The airplane was equipped with an autopilot; however, the autopilot panel or any connections were not recovered.

Postaccident engine examination found evidence of powered rotation at impact. No evidence of preimpact mechanical malfunction or failure that would have precluded normal operation was found.

An annunciator panel was found in the wreckage and sent to the National Transportation Safety Board Materials Laboratory for examination. The panel’s individual annunciator lights were x-rayed to examine the filament in each bulb; however, due to the damage sustained by the panel from impact, the damage noted to some of the filaments was inconclusive.

MEDICAL AND PATHOLOGICAL INFORMATION

According to the Office of the Medical Examiner, Nashville, Tennessee, autopsy report, the cause of death of the pilot was multiple blunt traumatic injuries and the manner of death was

accident. The exam was limited by fragmentation and no internal organs were available for examination.

Toxicology testing performed by the FAA Forensic Sciences Laboratory detected ethanol in the pilot's muscle tissue at 0.052 grams per hectogram (gm/hg). N-butanol was also detected in his muscle tissue. No other drugs were detected in muscle tissue.

According to the Office of the Medical Examiner, Nashville, Tennessee, autopsy report, the cause of death of the pilot-rated passenger was multiple blunt traumatic injuries and the manner of death was accident. The exam was limited by fragmentation and in organs available for examination, no contributory natural disease was identified by the medical examiner.

Toxicology testing performed by the FAA Forensic Sciences Laboratory detected ethanol in the pilot-rated passenger's muscle and kidney tissue at 0.021 gm/hg and 0.013 gm/hg, respectively. No other tested for drugs were detected in muscle tissue.

ADDITIONAL INFORMATION

An airplane performance study was conducted utilizing Automatic Dependent Surveillance-Broadcast (ADS-B) data provided by the FAA and a simplified aerodynamic model of the airplane. The data revealed that after departure, the airplane began climbing at a rate of 2,000 fpm, with a 5 to 10 degree nose up pitch. By 1053:50 the airplane had entered the clouds and had begun a right turn (30° bank) towards its intended heading of 130°. The nose started lowering after 1054 and the rate of climb reduced. The pitch angle went nose down and the airplane began to descend at 10:54:18, at which time the airplane had reached an altitude of 2,900 ft msl while at an airspeed of 200 kts. As it descended, the right turn tightened, and the airplane reached a maximum right bank angle of 60° by 1054:35 accelerating to nearly 290 kts of airspeed. The descent was arrested at 1,875 ft at 1054:41 and the airplane again climbed, this time at more than 6,000 ft/min, with a nose-up pitch of 13°. The airplane reached its maximum altitude of 2,975 ft at 1054:55 before beginning a steep descent while in a 60° left wing down roll. The final ADS-B point was recorded at 1055:05 at an altitude of 1,025 ft over Percy Priest Reservoir.

To obtain a more detailed estimate of performance throughout the flight and to confirm the consistency of the recorded ADS-B data with the performance capabilities of the airplane, a six degree-of-freedom (6-DOF) simulation of the flight was performed. The objective of the simulation was to obtain a physics-based estimate of the trajectory and orientation of the airplane throughout the flight that was consistent with the performance capabilities of the Cessna 501 and the ADS-B data.

The simulation calculated airplane load factors for the flight which were used to determine the "apparent" pitch and roll angles. Based on the simulation calculations, it was determined that it was possible that during the descents, the pilot perceived that the aircraft was nose-up rather than nose-down due to the airplane's accelerations. Throughout the whole of the flight, it was also possible that the roll angle could have felt much less extreme than it actually was.

As a result of these pitch and roll motions, and changes in acceleration/deceleration, a pilot's vestibular system, which allows the inner ear to have a sense of balance and spatial orientation, can get disrupted and is unable to distinguish between load factors due to motion versus load factors due to gravity. On its own, the inner ear cannot differentiate between accelerations and tilt. Additional sensory inputs, such as visual cues, are needed to correctly perceive attitude and acceleration. When a pilot misperceives attitude and acceleration it is known as "somatogravic illusion" and can cause spatial disorientation. The pilot, who was instrument rated, had limited visual cues outside the airplane because of the instrument meteorological conditions. He would have had to use the airplane's instrumentation to understand his position in space and make appropriate changes to the airplane's trajectory while operating in a high workload environment.

According to the FAA's Pilot's Handbook of Aeronautical Knowledge, Chapter 17 - Aeromedical Factors, "A rapid acceleration, such as experienced during takeoff, stimulates the otolith organs in the same way as tilting the head backwards. This action may create what is known as the "somatogravic illusion" of being in a nose-up attitude, especially in conditions with poor visual references. The disoriented pilot may push the aircraft into a nose-low or dive attitude. A rapid deceleration by quick reduction of the throttle(s) can have the opposite effect, with the disoriented pilot pulling the aircraft into a nose-up or stall attitude."

Pilot Information

Certificate:	Commercial; Private	**Age:**	59,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Unknown
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	November 12, 2019
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	March 11, 2020
Flight Time:	1680.5 hours (Total, all aircraft), 83 hours (Total, this make and model)		

Pilot-rated passenger Information

Certificate:	Commercial; Private	**Age:**	39,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Unknown
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 3 Without waivers/limitations	**Last FAA Medical Exam:**	November 16, 2017
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	May 27, 2021
Flight Time:	310 hours (Total, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	**Registration:**	N66BK
Model/Series:	501 Citation	**Aircraft Category:**	Airplane
Year of Manufacture:	1982	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	501-0254
Landing Gear Type:	Retractable - Tricycle	**Seats:**	7
Date/Type of Last Inspection:	February 25, 2021 Continuous airworthiness	**Certified Max Gross Wt.:**	11850 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:	4781.4 Hrs as of last inspection	**Engine Manufacturer:**	P&WC
ELT:	Installed, not activated	**Engine Model/Series:**	JT15D-1B
Registered Owner:	JL&GL PRODUCTIONS LP	**Rated Power:**	2200 Lbs thrust
Operator:	JL&GL PRODUCTIONS LP	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument (IMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	MQY,543 ft msl	**Distance from Accident Site:**	230 Nautical Miles
Observation Time:	10:56 Local	**Direction from Accident Site:**	2.3°
Lowest Cloud Condition:		**Visibility**	10 miles
Lowest Ceiling:	Overcast / 1300 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	10 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	310°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.04 inches Hg	**Temperature/Dew Point:**	14°C / 12°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Smyrna, TN (MQY)	**Type of Flight Plan Filed:**	IFR
Destination:	West Palm Beach, FL (PBI)	**Type of Clearance:**	IFR
Departure Time:	10:53 Local	**Type of Airspace:**	Class D

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	6 Fatal	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	7 Fatal	**Latitude, Longitude:**	36.033375,-86.481392(est)

Administrative Information

Investigator In Charge (IIC):	Read, Leah
Additional Participating Persons:	Henry Soderlund; Textron Aviation; Wichita, KS Helen Tsai; TSB Canada Karel Kurry; P&WC
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Last Revision Date:	
Investigation Class:	Class 3
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=103165