Aviation Investigation Final Report

Location:	Watsonville, California	**Accident Number:**	WPR11FA316
Date & Time:	July 7, 2011, 19:28 Local	**Registration:**	N7759M
Aircraft:	Mooney M20F	**Aircraft Damage:**	Substantial
Defining Event:	Aerodynamic stall/spin	**Injuries:**	4 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot departed from his home airport situated about 3 miles east-northeast of the ocean with a low-lying stratus cloud layer. The takeoff was conducted while it was still daylight. Eyewitness and photographic evidence indicated that the stratus layer was nearby, to the southwest, south and southeast of the airport at the time of the takeoff. The airport was non-towered, and was equipped with two similar-length runways, designated as 2/20 and 8/26. Airplane performance, and terrain and obstacle clearance considerations did not preclude a takeoff from any of the four possible runway options. However, the takeoff was conducted from runway 20, directly towards the cloud layer.

Eyewitnesses and recovered GPS data indicated that the airplane began a sharp left turn prior to reaching the end of the runway, at an altitude of about 400 feet above ground level (agl). That turn was consistent with an effort to avoid the cloud layer, but contrary to published airport noise abatement guidance that prohibited departure turns prior to the airport boundary, or at altitudes below 900 feet agl. The airplane did not enter the cloud, but during the turn, the airplane stalled, entered a spin, and descended rapidly to the ground. The airplane struck a parking lot and building less than 700 feet from the departure runway. Post-accident examination of the airplane and engine did not reveal any anomalies or failures that would have precluded normal operation.

At least two headsets, one of which was a noise cancelling unit, were located in the wreckage. According to the airplane co-owner, the vane-activated, electrically-powered stall warning horn was inaudible to a pilot wearing a headset, and the owners' attempts to rectify that situation were unsuccessful. Post-accident testing of the vane switch and warning horn indicated that they were functional, but the horn volume was not measured or compared to any known standard.

During airplane manufacture, the final position of the stall warning vane and switch assembly on the wing is determined during the production flight test of each individual airplane, in order to ensure system activation at the proper angle of attack. No records of the as-delivered vane position were available, and the as-delivered position of the vane could not be discerned by examination of the wreckage. Examination of the vane assembly revealed that it had been modified, and was not installed in accordance with the manufacturer's design drawings. In addition, no information regarding the accuracy of the modified stall warning system was located. The investigation was unable to determine whether the system would have provided sufficient, or even any, notification of a stall, presuming the horn was audible to the pilot, which in this case it was not.

Despite three other runway alternatives, the pilot knowingly and intentionally decided to depart from the runway most closely aligned towards the stratus layer, with the apparent plan to turn to avoid it once airborne. While his runway choice may have been influenced by habit pattern, existing traffic, or a previous taxi event at that airport, the investigation was unable to determine why the pilot chose that runway, instead of using any of the other three alternatives which would have taken him away from the cloud layer. He then inadvertently stalled and spun the airplane during the avoidance turn, at an altitude which did not allow recovery.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's decision to conduct a takeoff towards a nearby low-lying cloud layer, and his failure to maintain aircraft control during the subsequent turn, stall, and spin during his attempt to avoid the cloud layer. Contributing to the accident was the pilot's inability to recognize an incipient stall, and prevent the full stall. His ability to recognize and prevent the stall was hindered by an inaudible stall warning system of questionable accuracy.

Findings

Personnel issues	Decision making/judgment - Pilot
Personnel issues	Aircraft control - Pilot
Personnel issues	(general) - Pilot
Aircraft	Angle of attack - Not attained/maintained

Factual Information

History of Flight

Prior to flight	Miscellaneous/other
Initial climb	Loss of control in flight
Maneuvering	Aerodynamic stall/spin (Defining event)

On July 7, 2011, about 1928 Pacific daylight time, a Mooney M-20F, N7759M, was substantially damaged when it impacted a parking lot and a building shortly after takeoff from Watsonville Municipal Airport (WVI), Watsonville, California. The private pilot and the three passengers were fatally injured. The personal flight was operated under the provisions of Title 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed, and no flight plan was filed for the flight.

The airplane was co-owned by the pilot and another individual. According to the co-owner, the airplane was based at WVI. Relatives reported that the pilot, his wife, and their two children planned to travel to Groveland, California, for the weekend. Lockheed Martin Flight Services (LMFS) information indicated that the pilot contacted LMFS by telephone about 1023 on the day of the accident, and again about 1417, to obtain weather briefings. The pilot informed the LMFS representative that his intended destination was Pine Mountain Lake Airport (E45), Groveland.

According to multiple information sources, a fog bank/stratus layer that moved inland (towards the airport) from the Pacific Ocean, and was typical for that locale during that time of year, was located just southwest of the airport at the time of the takeoff. That cloud phenomenon was often referred to as the "marine layer." According to information provided by several eyewitnesses, the airplane departed from WVI runway 20. One pilot witness reported that the airplane climb path was shallow, and that the airplane would not clear the stratus layer. Two other witnesses, one of whom was a pilot, in two other separate locations, reported that the climb angle after takeoff appeared "steep." Both observed the airplane commence a very rapid left roll when it was approximately 500 feet above the departure end of runway 20. The airplane appeared to roll until it was "nearly inverted," and the nose "dropped," so that it was pointing towards the ground. It descended rapidly, and completed about two "tight turns" or "spirals" before it appeared to begin to recover, and then disappeared behind trees. Both witnesses observed fire and smoke immediately thereafter.

Ground scars indicated that the airplane first impacted a parking lot about 700 feet southeast of the departure end of runway 20, traveled about 130 feet east-southeast, and struck the building. Parallel slash marks in the pavement were consistent with propeller strikes from an engine that was developing power. The airplane structure was severely deformed by the impact, and portions were consumed by post impact fire.

Pilot Information

Certificate:	Private	**Age:**	44
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 Without waivers/limitations	**Last FAA Medical Exam:**	July 15, 2010
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	March 17, 2011
Flight Time:	152 hours (Total, all aircraft), 141 hours (Total, this make and model)		

According to Federal Aviation Administration (FAA) records, the pilot was issued his private pilot certificate, with an airplane single engine land rating, on March 17, 2011. His most recent FAA third-class medical certificate was issued in July 2010.

The pilot did not pass his first private pilot practical examination on February 11, 2011, at which time he had a total flight experience of 57.4 hours. He also did not pass his second private pilot practical examination on March 1, 2011, at which time he had a total flight experience of 69.0 hours. One of the segments on the second examination that the pilot's performance was determined to be unsatisfactory was "Performance Maneuver - Steep Turns." However, he was retested on that and other aspects on March 17, and his performance was satisfactory, in compliance with applicable FAA requirements.

The pilot's original flight logbook was not located. The airplane co-owner provided copies of some pages of the pilot's logbook that he had obtained previously; the most recent entry in those copies was dated April 24, 2011. According to those records, as of that date, the pilot had accrued a total of 151.5 hours of flight experience. Based on the available records, it appeared that the pilot had accrued all but about 15 hours of his experience in the accident airplane.

Aircraft and Owner/Operator Information

Aircraft Make:	Mooney	**Registration:**	N7759M
Model/Series:	M20F	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	22-0019
Landing Gear Type:	Retractable - Tricycle	**Seats:**	4
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	2740 lbs
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:		**Engine Manufacturer:**	LYCOMING
ELT:	Installed	**Engine Model/Series:**	IO-360 SER
Registered Owner:	David Edward Houghton	**Rated Power:**	180 Horsepower
Operator:	David Edward Houghton	**Operating Certificate(s) Held:**	None

According to FAA information, the airplane was manufactured in 1974, and was equipped with a Lycoming IO-360 series engine and a McCauley 3-blade propeller. The airplane was first registered to the pilot and co-owner on November 24, 2010.

The most recent annual inspection was completed in August 2010. At that time, the engine/airframe had a total of 3,902.0 hours, and the engine had 303.4 hours since major overhaul.

According to the co-owner, on an unspecified date before April 2011, one of the main landing gear doors was damaged while the pilot was taxiing the airplane on an unspecified taxiway at WVI. That door was subsequently repaired. On April 6, 2011, two main landing gear doors were damaged when the pilot landed on an unprepared strip in Mexico. Those two doors and two other main landing gear doors were removed at some point thereafter, and had not been repaired or reinstalled at the time of the accident. No record of the removal was located in the maintenance records. The co-owner reported that there "was never any noticeable flight performance deterioration due to the removal of the doors."

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	WVI,163 ft msl	**Distance from Accident Site:**	1 Nautical Miles
Observation Time:	18:53 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	6 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	190°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.9 inches Hg	**Temperature/Dew Point:**	16°C / 12°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Watsonville, CA (WVI)	**Type of Flight Plan Filed:**	None
Destination:	Groveland, CA	**Type of Clearance:**	None
Departure Time:	19:20 Local	**Type of Airspace:**	

Pilot Weather Briefings

According to information and recordings provided by LMFS, on the day of the accident, the pilot called LMFS on two separate occasions to obtain weather information. During the pilot's first call at 1023, he stated that he planned to fly VFR (visual flight rules) from WVI to E45, and had a planned departure time of 1800, which was nearly 1 1/2 hours earlier than his actual departure time. The LMFS briefer informed the pilot that there was an AIRMET for IFR (instrument flight rules) conditions (specifically low ceilings) along the coast that was valid until 2000, and that VFR from the departure airport was not recommended. The briefer told the pilot that there were currently ceilings "as low as 400 feet in the surrounding area." However, the briefer noted that 2000 was "a long way out" from the current time, that the forecast conditions might not occur, and that the forecast update cycle provided for one more update prior to the pilot's planned departure time.

The pilot's second call to LMFS at 1417 was initially for an "abbreviated briefing." He again indicated that he was planning an 1800 departure. The previous weather forecast had been revised, and the new forecast called for scattered clouds at 1,000 feet, with the marine layer moving inland about 2100. This briefer noted that there was a "very strong marine layer along the coast," that the "immediate coast was socked in" from about 120 miles north to 100 miles south of WVI, and advised the pilot to "check back in right before you go." The pilot then asked about the forecast for a departure the next morning (Saturday), and was informed that the marine layer was expected to affect WVI until at least 1100.

Meteorological Detection Equipment and Observations

WVI was equipped with a segmented circle, a wind sock, and an automated surface observation system (ASOS). The segmented circle/wind sock was situated about 500 feet southwest of the intersection of the two runways. The ASOS sensors were located about 200 feet west of the north end of the paved surface of runway 2, near the northern boundary of the airport.

According to the National Oceanographic and Atmospheric Administration web site, the ASOS system detects significant meteorological changes, disseminating hourly and special observations via predetermined networks. ASOS routinely and automatically provides computer-generated voice observations directly to aircraft in the vicinity of airports, which is also available via a telephone and data links. ASOS transmits a special report when conditions exceed preselected weather element thresholds.

The WVI ASOS included detection and recording of such parameters as sky condition (cloud height and amount) up to 12,000 feet, visibility, and obstructions to vision such as fog and haze.

The ASOS ceilometer was a Vaisala Model CT12K, which utilized laser transmission and reflection to determine cloud height. The ceilometer beam width is confined to a divergence of ± 2.5 milliradians, so that at 12,000 feet the beam's sample area is a circle with a diameter of 60 feet. The ceilometer beam is aimed perpendicular to the local horizontal (i.e., 'straight up'), and does not pivot or sweep. Processing algorithms are used to determine cloud coverage quantifications such as few, scattered, etc.

The WVI 1853 (35 minutes before the accident) ASOS observation included winds from 190 degrees at 6 knots; visibility 10 miles, clear skies; temperature 14 degrees C; dew point 12 degrees C; and an altimeter setting of 29.91 inches of mercury.

The WVI 1953 (25 minutes after the accident) ASOS observation included winds from 200 degrees at 4 knots; visibility 10 miles, clear skies; temperature 16 degrees C; dew point 12 degrees C; and an altimeter setting of 29.91 inches of mercury.

Eyewitness Reports

Multiple witnesses reported that the layer of stratus clouds that was typical for the region during that time of year was present just southwest of the airport. One witness, who was a pilot, and who was leaving the airport at the time of the accident, reported that the boundary of the stratus layer appeared to be coincident with California Highway 1, which ran perpendicular to runway 2/20, just west southwest of the departure end of runway 20.

Photographic Evidence

Photographs taken by first responders in the period between 20 and 26 minutes after the accident show the stratus layer to the south and east of the accident site. Although a qualitative assessment only, the stratus layer appears to be quite close to the accident site.

Airport Manager Information

The airport manager, who was also a certificated flight instructor (CFI), described the WVI weather conditions as follows:
"Standard Central Coast [weather]; characterized from May to September with coastal stratus in the morning, clearing by noon with the potential to roll back in during early evening or on occasion remain clear till late evening, then slowly building up."

He also noted that the local WVI "pilot community is aware of these conditions and the departure/arrival options if you are VFR only…. CFIs take great pains in flying with students during this time to reinforce that the fog is insidious and deceptive." He also noted the importance for local pilots to obtain and understand temperature/dew point spread, cloud clearance, and cross-wind runway information.

Refer to the docket associated with this accident for additional meteorological information.

Airport Information

Airport:	Watsonville Municipal WVI	**Runway Surface Type:**	Asphalt
Airport Elevation:	163 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	20	**IFR Approach:**	None
Runway Length/Width:	4501 ft / 150 ft	**VFR Approach/Landing:**	None

WVI was a non-towered airport situated about 2 miles northwest of Watsonville, and about 3 miles east-northeast of the Pacific Ocean. Airport elevation was 163 feet above mean sea level (msl). WVI was equipped with two paved runways, designated as 2/20 and 8/26. Runway 2/20 measured 4,501 feet by 150 feet, while runway 8/26 measured 3,999 feet by 100 feet. The full length of each could be used for takeoff.

Runway 2/20 was oriented approximately perpendicular to the local shoreline, and therefore aligned approximately towards the source of the stratus layer. All runways were designated as left traffic, and runway 20 was designated as the "preferred calm wind runway" in the noise abatement guidance published by the airport. The guidance also stated "no turns before crossing the freeway" [California highway 1] for departures from runway 20. Highway 1 was located about 1/4 mile beyond (west-southwest) the departure end of runway 20; the accident site was approximately abeam the departure end of runway 20. The guidance prohibited departure turns below 900 feet above ground level (agl), and advised pilots that "Safety always supersedes noise abatement procedures."

According to one witness, a Piper Archer had departed runway 20 just prior to the accident airplane, but the investigation was unable to determine whether any other aircraft departed or arrived in the period surrounding the accident time.

According to the airport manager, some pilots avoid using runway 8 due to the deteriorated condition of the taxiway normally used to access it. The investigation was unable to determine whether the previous landing gear door damage incurred by the accident pilot during taxi occurred on this taxiway, or elsewhere on WVI. In July 2013, the manager reported that an approximate 8-year effort to obtain required approvals to repair the taxiway had recently been successful, and that the repair project was moving ahead. That recent approval was not related to, or influenced by, the accident.

The airport manager noted that due to an attempt by the City of Watsonville to close runway 8/26, the pilots increased its utilization, particularly when the fog/stratus layer was approaching the airport. He also noted that "recently" (prior to the accident) although runway 8/26 is designated as left traffic, the "fog was forcing a right pattern."

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:	3 Fatal	**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	4 Fatal	**Latitude, Longitude:**	36.935554,-121.789718(est)

The airplane impacted a parking lot and then a building of an annex of Watsonville Community Hospital. The initial impact location was 677 feet, on a true bearing of 131 degrees, from the center of the departure end of runway 20. The initial impact point was about 130 feet from the building, and the building impact point was on a bearing of 113 degrees true from the initial impact point. Ground scars were consistent with the airplane striking the parking lot in a relatively level, upright attitude. Pavement scars and markings were consistent with the main landing gear being in the retracted position at ground impact, and the engine developing significant power.

A fire erupted after impact, and damaged or consumed portions of the airplane, which remained partially embedded in the building.

The engine mount, cowl, and propeller were severely disrupted by the impact. The engine was essentially intact, but had sustained crush damage in the aft and up directions. Several engine accessories were fracture-separated from the engine. No abnormal oil deposits or streaking were observed on the internal engine compartment areas, or on the airplane exterior surfaces.

The propeller hub was highly fragmented, and none of the three blades was retained in the hub. All three propeller blades exhibited significant bending/twisting deformation, scoring, and gouging. There was no evidence of any pre-impact failures or malfunctions of the engine or propeller that would have precluded continued normal operation and flight.

The fuselage was found on its left side, with the inboard section of the left wing located under the airplane, and the outboard section of the left wing fracture-separated from the airplane. The right wing was completely separated from the airplane at the wing root, and was found outside the building. The fuel cap for the right wing tank was absent from its receptacle, and was not located on site, despite multiple searches. A ground search of WVI did not locate the fuel cap. However, sooting patterns on the cap receptacle in the wing were consistent with the cap being in place for at least a portion of the sooting period. The flaps were determined to be retracted at the time of impact. No main landing gear doors were located on scene

The empennage was partially intact, with the left horizontal stabilizer fracture-separated from it, and the vertical stabilizer bent about 90 degrees near the mid span station. The as-found extension of the pitch trim actuator was consistent with a normal take-off trim setting.

All primary and secondary aerodynamic and flight control surfaces, and their balance weights, were located at the accident site. Partial control continuity was established for the right aileron, right elevator, and rudder. Damage precluded additional control continuity determination.

The cockpit/cabin was severely deformed by the impact, and was almost completely separated from the wing structure. The two front seats remained partially attached to their cabin floor attach points, but the rear bench seat was separated from the cabin floor, and was found forward of the front seats. The pilot and younger son were seated in the front left and right seats, respectively. Both front seat occupants' lap and shoulder harnesses were found fastened/buckled and affixed to their respective cabin attach points. The mother and older son were seated in the aft bench seat. Both rear seat occupants' lap belts were found fastened/buckled, but had separated from their respective cabin attach points. The rear seats were not equipped with shoulder harnesses.

At least two headsets were found in the wreckage; one appeared to be a Lightspeed Zulu active noise reduction model, and one was a David Clark brand. Both appeared to have been in use at the time of the accident.

The throttle, propeller, and mixture controls were retained in the cockpit mount, and attached to their respective actuation cables. Engine cable continuity could not be determined due to impact damage. Both control yokes were present but impact and fire damaged. Most instruments on the pilot-side panel were impact and/or fire damaged.

A Garmin GPSMap 396, a JPI model EDM-800 engine analyzer, and a Horizon Instruments P-1000 Digital Engine Tachometer were recovered and sent to the NTSB Recorders Laboratory in Washington DC for data download. The GPS data was successfully downloaded, and the data and results are discussed later in this report. The engine analyzer was not configured to retain data; therefore no data was available for the accident flight. The tachometer was only capable of displaying, but not recording, any parameter values, and therefore no data was recovered from the device.

Medical and Pathological Information

An autopsy was performed on the pilot by the Santa Cruz County (California) Sheriff-Coroner Office. The autopsy determined that the cause of death was "injuries sustained in the plane crash." Forensic toxicology was performed on specimens from the pilot by NMS Labs of Willow Grove, Pennsylvania, for the Santa Cruz Coroner. The toxicology report stated that the examination "did not reveal any positive findings of toxicological significance." The FAA Civil Aeromedical Institute conducted forensic toxicology examinations on specimens from the pilot, and reported that no carbon monoxide, cyanide, ethanol, or any screened drugs were detected.

Additional Information

Airplane Performance Information

The accident flight calculated weight (2,650 lbs) and moment (128,709 in-lbs) values were evaluated against the airplane weight and balance envelope; the results indicated that the airplane was loaded within the allowable weight and balance limits.

The Garmin GPSMap 396 that was recovered from the wreckage contained data from the accident flight. The data consisted of 11 usable points for the accident flight; parameters included time, latitude, longitude, and GPS altitude. The recovered data was used by NTSB engineering personnel to estimate/calculate some basic airplane performance parameters. Those results were then compared to the airplane manufacturer's Owner's Manual (OM) performance data.

The data indicated that the airplane took the runway at 1927:02, started its takeoff roll about 7 seconds later, and became airborne about 1927:30. Between 1927:44 and 1927:56, the ground track began deviating to the southeast (airplane left). At 1927:58, the airplane was abeam the departure end of runway 20, offset about 300 feet southeast of the centerline, at an altitude of about 430 feet agl. The maximum altitude of about 440 feet agl was recorded at 1928:01, and the next GPS data point was the last recorded point. That point was recorded at 1928:05, and was located approximately coincident with the impact location.

The airplane achieved a steady-state climb rate of about 800 feet per minute (fpm) from about 1927:30 to 1927:50, and then over the next 8 seconds, the rate began to decay slowly. The airplane then began a very rapid descent. Calculated airspeed values that utilized a constant ASOS-based wind speed and direction were initially about 73 mph and then decreased approximately linearly to about 55 mph. The OM specified a flaps-retracted, power-off, wings-level stall speed of 68 mph, which increases to 80 mph in a 40 degree bank. The OM did not contain any performance data regarding flight with the landing gear doors removed.

Since the (input) GPS data was at such a low sample rate, the (output) calculated performance values are necessarily coarse, and should be considered approximations. Furthermore, the calculation technique for the pitch and roll angles assumes non-stalled, coordinated flight, which may not be representative of the entire accident flight. In particular, the calculation technique is not able to capture a spin, such as that reported by some witnesses to the accident.

Given these and other limitations, the observed takeoff and climb performance was not significantly different from the predicted performance.

Stall Warning System

The airspeed indicator (ASI) is the primary device for stall avoidance in the accident airplane, while the stall warning system provides a secondary defense mechanism.

The speed arc markings on the ASI were determined to be congruent with the FAA-approved and required values. During post accident functional testing of the ASI, an internal gasket was determined to be leaking. The testing revealed that ASI indications for input test speeds below 100 mph were initially no more than 2 mph high, but that a gasket leak could result in a subsequently lower indication. It could not be determined how much lower that indication would be, and it could not be determined whether the leaking gasket was a result of the accident and post impact fire.

The airplane was equipped with a stall warning system, which consisted of a wing-mounted sensor vane and switch assembly wired to an audible electric horn installed in the cockpit. The M20 series aircraft were manufactured under the CAR 3 regulations, and the section specific to the stall warning system was 3.721. The system is also compliant with FAR 23.1431, paragraph 6. According to the airplane manufacturer's OM, "A stall warning horn, …triggered by a sensing vane on the left wing leading edge, will sound when airspeed drops to near stall speed. The sound becomes steady as the aircraft approaches a complete stall."

At airplane manufacture, the stall warning horn in the M20F was a Mallory Sonalert Products SC628R. The volume output of the horn is dependent on the current supplied. At 12 volts, the horn volume would be approximately 82 db at a distance of 2 feet. Any degradation in the grounding of the horn wiring circuit would decrease the effective voltage, and thereby decrease the volume of the horn.

According to the maintenance records, a new stall warning horn switch was installed in December 2003, when the airplane had a total time in service (TT) of about 3,442 hours. A June 2007 (TT about 3,818 hours) maintenance records entry catalogued an effort to "troubleshoot and repair [an] inoperative" stall warning horn. A February 2008 entry (TT about 3,878 hours) stated that a technician had "replaced [a] broken wire to [the] stall warning" system.

Post-accident interviews with the airplane co-owner revealed that the co-owner had never determined the accuracy of the stall warning system, that the stall warning horn volume was low, and that the stall warning horn was inaudible to a pilot wearing a noise-cancelling headset. The co-owner stated that he and the pilot "both considered the stall warning system to be totally inadequate and ineffective - totally useless. The stall warning horn could never be heard in flight over engine noise and the muffling effect of headphones." The co-owner never heard the stall warning in flight, and he stated that the pilot told him "that he could barely hear the horn if he removed his headset." The co-owner stated that at the pilot's "insistence," the day before the accident, he took the airplane to a Mooney service center to address the system performance, and that the "center's conclusion was that the audio level could not be increased with current FAA approved parts." The co-owner had never stalled the airplane or verified the accuracy of the stall warning system. He knew that the pilot had intentionally approached stalls with the airplane during his flight training, but the co-owner did not know whether the pilot had ever tried to check the accuracy of the stall warning system.

The stall warning horn was located in the wreckage. The horn appeared to be the component originally installed at the time of airplane manufacture. The wiring remained attached to the switch. The horn was removed and 12 volts were applied to it; the horn sounded a steady tone, per design. The volume was not able to be measured.

Both the stall warning vane/switch assembly and the section of the left wing that it was mounted in were essentially undamaged. Examination of the stall warning vane/switch assembly revealed that it was not the original as-manufactured/delivered installation.

According to the airplane manufacturer's engineering drawings, the stall warning vane/switch assembly is installed in the wing leading edge at a fixed spanwise location with four screws. Two of these screws attach through vertical slots in the wing leading edge, which fixes the vane assembly spanwise location. This permits the assembly to be adjusted in the vertical plane, and then secured in position with the other two screws. The final vertical position of the vane assembly on the wing is determined during the flight test of each individual airplane, in order to ensure vane/switch activation at the proper airspeed/angle of attack. No records of the as-delivered stall warning vane vertical position were available, and the as-delivered vertical position of the stall vane assembly could not be discerned by examination of the wreckage.

Comparison of the as-found stall warning vane assembly installation with the manufacturer's installation drawing revealed that an extra section of sheet metal was installed between the vane assembly and the wing skin. Compared to the as-designed configuration, this additional sheet recessed the vane assembly slightly further (the thickness of the sheet, approximately 0.040 inches) into the wing. In addition, the pivot axis of the vane was canted about 2 degrees outboard end down relative to its design orientation. Given these variations plus the manufacturer's method for determination of final vertical vane position, the investigation was unable to determine the accuracy of the system as installed on the accident airplane. The accuracy of the stall warning system can only be verified in flight, and cannot be determined by any ground-based means.

Step 6 of the "Preflight Check" subsection in the OM "Normal Procedures" includes the item "Pitot Tube and Stall Switch Vane – UNOBSTRUCTED." The only other OM Normal Procedures guidance regarding the stall system or stalls appeared in a subsection entitled "STALLS," and stated that stalls should be practiced to "learn how to recognize an incipient stall and to take prompt corrective action before the airplane completely stalls."

Stall and Spin Information

According to the FAA Airplane Flying Handbook (AFH, FAA-H-8083-3), "A stall occurs when the smooth airflow over the airplane’s wing is disrupted, and the lift degenerates rapidly. This is caused when the wing exceeds its critical angle of attack."

The AFH stated that "The objectives in performing intentional stalls are to familiarize the pilot with the conditions that produce stalls, to assist in recognizing an approaching stall, and to develop the habit of taking prompt preventive or corrective action." The AFH stated that "most stalls require some loss of altitude during recovery. The longer it takes to recognize the approaching stall, the more complete the stall is likely to become, and the greater the loss of altitude to be expected."

The AFH noted that stalls "can occur at any airspeed, in any attitude, with any power setting." Factors that affect the stalling characteristics of an airplane include center of gravity location, roll attitude, pitch attitude, flight control coordination, drag, and power. The AFH stated that "A number of factors may be induced as the result of other factors. For example, when the airplane is in a nose-high turning attitude, the angle of bank has a tendency to increase."

The FAA Pilot's Handbook of Aeronautical Knowledge (PHAK, FAA-8083-25) stated that stall speed increases with bank angle and load factor, and that stall speed increases non-linearly with increasing bank angle. According to the airplane manufacturer's OM, the clean zero-bank stall speed at a weight of 2,740 pounds was 68 mph, while the speeds for 20, 40, and 60-degree bank angles were 71, 80, and 98 mph, respectively.

FAA Guidance on Noise-Cancelling Headsets

Noise cancelling headsets, more accurately referred to as active noise reduction (ANR) headsets, employ electronics to actively cancel certain frequency sounds, and thereby reduce the overall noise exposure of the wearer. In 2007, the FAA issued InFO (Information for Operators) 07001, with the subject line of "Noise Attenuation Properties of Noise-Canceling Headsets." The stated purpose of the InFO was to alert "operators, directors of operations (DOs), chief pilots, and flight crewmembers who may be using noise-canceling headsets of the potential for misdetection of audible alarms and other environmental sounds." The InFO cautioned that when flight crew members were using ANR devices, "electronic attenuation of important environmental sounds and alarms may occur." The InFO advised personnel to "evaluate their use of noise-canceling headsets," with the aim of determining the compatibility of individual ANR headsets with aircraft sounds and aural alarms, and to discontinue use of any headsets which prevent the pilot from hearing any aural alarms.

FAA Technical Standard Order TSO C139 "Aircraft Audio Systems and Equipment" was issued in August 2005; in part, it cancelled and superseded TSO-C57a, "Headsets and Speakers." TSO C139 refers to RTCA DO-214 "Audio Systems Characteristics and Minimum Performance Standards for Aircraft Audio Systems and Equipment" issued March 1993 for virtually all its standards. Neither that document nor the TSOC139 specified attenuation frequencies or compatibility with cockpit aural warnings

The Zulu headset found in the wreckage did not comply with any TSO, nor was it required to. The David Clark headset was too damaged to specifically identify its model number or TSO compliance. The investigation did not discover any regulatory requirements or frequency-specific guidance for compatibility of the accident headsets with cockpit aural warning systems.

Administrative Information

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Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=81041