Aviation Investigation Final Report

Location:	Newburgh, New York	**Accident Number:**	ERA15FA331
Date & Time:	August 28, 2015, 14:07 Local	**Registration:**	N18FJ
Aircraft:	CORNELL W F/SAHAKIAN J A JR GILES 202 (G202)	**Aircraft Damage:**	Destroyed
Defining Event:	Aircraft structural failure	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General aviation - Air race/show		

Analysis

The commercial pilot was practicing his airshow routine in the experimental amateur-built airplane for a performance scheduled the following day. He had completed several maneuvers and was about 5 minutes into the routine when the tail section of the airplane separated from the fuselage during a 45° upline maneuver as the airplane began a left aileron roll. The pilot had performed several aileron rolls, both left and right, at varying pitch attitudes earlier in the routine.

Examination of the wreckage revealed that the fractures that resulted in separation of the tail section likely initiated at the bond between the lower surface of the horizontal stabilizer and the flange attaching the horizontal stabilizer to the left side of the fuselage. The bond failed in tension, consistent with the left side of the horizontal stabilizer moving upward relative to the fuselage (or the fuselage moving downward relative to the horizontal stabilizer). Microscopic examination of the bond surfaces revealed two relatively small regions of poor bond integrity, as evidenced by a lack of fiber pullout or resin transfer between the mating surfaces of the flange and the underside of the horizontal stabilizer. One of these regions was in the area where the bond fracture likely originated. Poor bond quality can result from poor or improper surface preparation before the bond is made, such as improper sanding and incomplete cleaning of the surfaces to be bonded. These two regions contained score marks consistent with having been sanded, as was specified in the build directions. It is possible that these two regions were not thoroughly cleaned or became contaminated after cleaning before the bond was made. Contamination from dust, oil, or other substances could have prevented the resin from adhering to the surface in those regions.

Fourteen years before the accident, in France, another airplane of the same make and model had an in-flight separation of the tail during wings-level flight after performing aerobatic maneuvers. The investigation discovered a similar lack of fiber pull-out or resin transfer in the bond fracture of the same joint. In that case, there were several areas with these features that covered a much larger portion of the bond surface.

Both airplanes exhibited evidence of poor bonding between the horizontal stabilizer and the flange attaching it to the fuselage, a condition that most likely occurred during their manufacture, and both had accrued several hundred flight hours before the bonds failed. The accident airplane was manufactured about 17 years prior to the accident. Although it had been flown in multiple aerobatic competitions and airshows, no evidence of progressive crack growth was observed emanating from the origin area on the fracture surface. This suggests the possibility that the bonds may have fractured after being exposed to higher loads at the time of ultimate failure, rather than the load factors to which they had previously been exposed. However, in both accidents, the tail separation occurred during a maneuver that was relatively benign compared to other maneuvers flown earlier in their flights. The tail section failure on the accident airplane occurred during an aileron roll while on an upline, which would have applied loads to the horizontal stabilizer that were asymmetric (upward on the left stabilizer, consistent with the direction of the initiating "L" flange bond failure, and downward on the right stabilizer), but likely not the highest loads achieved during the accident flight. The airplane vertical load factor during the preceding pull-up maneuver was relatively high, estimated to be between +6 and +9 g. However, the loads on the horizontal stabilizer at that time should have been downward on both sides, which is inconsistent with the tensile fracture of the left "L" flange bond. The recording g-meter found at the accident site indicated the peak load factors reached during the flight were +8 and -4.75 g. Assuming the peak needles were set to 0 before the flight and did not move appreciably during impact, it is likely that the airplane did not exceed the airplane design limits of ± 10 g for vertical load factor during the accident flight. However, the relationship between peak vertical load factor and the strength of the compromised bonds of the "L" flanges is unknown. The airplane had also performed several other maneuvers during the flight, including snap rolls and aileron rolls in both directions. It is possible that the bond had failed or partially failed during one or more previous maneuvers during the accident or during previous flights. While no evidence of progressive crack growth was found in the bond fracture features, failure of multiple elements of the structure were required to produce the observed separation. It is possible that the bond fracture developed over the course of several or many maneuvers without leaving obvious evidence of progressive damage on the fracture surface. Although the "L" flanges in the accident airplane were constructed using three plies of fiber-reinforced cloth, as opposed to the specified four, the lack of the fourth layer likely did not contribute to this accident, as the originating failure was in the bond between the flange and the horizontal stabilizer surface.

In addition, the investigations of both accidents revealed that the "L" flanges and their bonds to their mating surfaces are critical to the strength of the skin joints between the fuselage and the horizontal stabilizer and the vertical stabilizer. The investigation revealed that no snap roll entry speed limitation was designated for this airplane, nor is it for many other aerobatic airplanes, due to a lack of criteria. Snap rolls place considerably high and asymmetrical loads on the horizontal stabilizer. As a result of this investigation, the airplane designer developed an inspection procedure for the empennage, a reminder about common airspeed limitations that should be established, and a suggestion for establishing a snap roll entry speed limitation.

Although the pilot's toxicology results tested positive for Zolpidem, the values were below the normal therapeutic range and there was no evidence that impairment played any role in causing or contributing to the tail separation.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:
Separation of the vertical and horizontal stabilizers from the fuselage due to a fracture that initiated at the bond between the left horizontal stabilizer and the flange that attached the horizontal stabilizer to the fuselage skin. The failure was likely caused by construction techniques that produced poor bond strength in a critical area and the high loads on the horizontal stabilizer from a single or multiple aerobatic maneuver(s).

Findings

Aircraft	Horizontal stabilizer - Failure
Aircraft	Horizontal stab attach fitting - Capability exceeded
Aircraft	Vertical stabilizer - Failure
Aircraft	(general) - Attain/maintain not possible
Personnel issues	Fabrication - Owner/builder
Personnel issues	Aircraft control - Pilot

Factual Information

History of Flight

Maneuvering-aerobatics	Aircraft structural failure (Defining event)
Maneuvering-aerobatics	Loss of control in flight
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On August 28, 2015, at 1407 eastern daylight time, an experimental amateur-built Giles G-202, N18FJ, was destroyed when it collided with terrain after experiencing an in-flight separation of the tail section during a practice aerobatic demonstration flight at Stewart International Airport (SWF), Newburgh, New York. The commercial pilot was fatally injured. The airplane was privately owned and was operated under the provisions of 14 *Code of Federal Regulations* Part 91. Visual meteorological conditions prevailed, and no flight plan was filed for the local flight, which was operating over runway 09/27 at the time of the accident.

The purpose of the flight was to practice for an air show routine scheduled to be performed the following day at the New York Air Show. Witness statements and video recordings indicated that the airplane had performed 4 or 5 maneuvers and was about 5 minutes into the routine when the tail suddenly separated from the fuselage. At that time, the airplane was performing a left aileron roll while climbing at an approximate 45° angle. Several witness photographs and video recordings showed the airplane's fuselage twisting toward the left relative to the tail section before the tail section completely separated from the fuselage. The elevator and rudder appeared to be at or near their neutral positions at the time of separation. No abrupt flight control deflections occurred and no parts were seen separating from the airplane in the moments before the separation. The airplane subsequently impacted a grass field about 1,100 ft south of the runway centerline. The engine was running continuously until impact. Airport personnel recovered the tail section and debris from the north side of the runway, about 1,800 ft north of the main wreckage.

Pilot Information

Certificate:	Commercial	**Age:**	53,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Rear
Other Aircraft Rating(s):	None	**Restraint Used:**	5-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:**	May 19, 2015
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	(Estimated) 3214 hours (Total, all aircraft), 1000 hours (Total, this make and model), 3043 hours (Pilot In Command, all aircraft)		

The pilot, age 53, held a Federal Aviation Administration (FAA) commercial pilot certificate with airplane single engine land and instrument airplane ratings. He was issued a Statement of Acrobatic Competency on March 17, 2014 with a maneuver limitation of solo aerobatics, and an unrestricted altitude limitation. He held an FAA second class medical certificate issued on May 19, 2015, with a restriction for corrective lenses. A review of the pilot's logbook revealed that he had 3,215 total hours of flight experience as of August 23, 2015, with about 1,000 hours in the accident airplane make and model.

Aircraft and Owner/Operator Information

Aircraft Make:	CORNELL W F/SAHAKIAN J A JR	**Registration:**	N18FJ
Model/Series:	GILES 202 (G202)	**Aircraft Category:**	Airplane
Year of Manufacture:	1998	**Amateur Built:**	Yes
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	018
Landing Gear Type:	Tailwheel	**Seats:**	2
Date/Type of Last Inspection:	March 25, 2015 Condition	**Certified Max Gross Wt.:**	1750 lbs
Time Since Last Inspection:	48 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	400 Hrs as of last inspection	**Engine Manufacturer:**	LY-CON
ELT:	C91A installed, not activated	**Engine Model/Series:**	AEIO-360-EXP
Registered Owner:	On file	**Rated Power:**	238 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

The two-seat, low-wing, experimental amateur-built airplane was manufactured in 1998 and powered by a Ly-Con AEIO-360-EXP, 238-horsepower, four-cylinder engine driving an MT-Propeller two-blade, constant-speed propeller. The airplane was constructed of glass-fiber-reinforced epoxy, carbon-fiber-reinforced epoxy, and glass fiber and carbon fiber honeycomb sandwich panels. The fuselage was of a monocoque-type design. The airplane's most recent condition inspection was completed on March 25, 2015, at which time the airplane had accumulated 400 total hours in service. At the time of the accident, the airplane had accumulated about 48 hours since that inspection.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KSWF,491 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	13:45 Local	**Direction from Accident Site:**	101°
Lowest Cloud Condition:	Scattered / 4000 ft AGL	**Visibility**	20 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots /	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:	290°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.19 inches Hg	**Temperature/Dew Point:**	22°C / 13°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Newburgh, NY (SWF)	**Type of Flight Plan Filed:**	None
Destination:	Newburgh, NY (SWF)	**Type of Clearance:**	None
Departure Time:		**Type of Airspace:**	Class D

The 1345 recorded weather observation at SWF included scattered clouds at 4,000 ft above ground level, wind from 290° at 8 knots, visibility 20 statute miles, temperature 22°C, dew point 13°C, and an altimeter setting of 30.19 inches of mercury.

Airport Information

Airport:	STEWART INTL SWF	**Runway Surface Type:**	
Airport Elevation:	491 ft msl	**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	41.50111,-74.107498

The fuselage came to rest on its left side and was heavily fragmented. The right wing separated from the fuselage and came to rest about 30 ft southwest of the main wreckage. The left wing was also separated and found adjacent to the main wreckage. Both wings showed heavy fragmentation of the leading edge, and large sections had fractured and separated from each wing. Flight control continuity was confirmed from the control stick to both ailerons and the elevator through overload fractures in the rod ends of the push-pull tubes. Continuity was established from the rudder pedals, which had separated from the fuselage structure, to the rudder through overload fractures in the left rudder cable and in the right rudder control horn. The engine came to rest partially embedded in soil with both of the wooden propeller blades separated near the hub.

A second debris field was located about 1,800 ft north of the main wreckage. It contained the vertical stabilizer, horizontal stabilizer, and elevator, which remained relatively intact. Several pieces of the structure below and forward of the horizontal stabilizer were found fragmented and separated from the rest of the tail assembly. The rudder and its hinges were found completely separated from and about 600 ft to the east of the vertical stabilizer.

Flight recorders

The airplane was not equipped with a conventional flight recorder, nor was it required to be. It was equipped with 3 video cameras. Video and audio were recovered from one camera.

Medical and Pathological Information

The Office of the Chief Medical Examiner, Orange County, New York, conducted an autopsy on the pilot. The cause of death was determined to be "blunt impacts of head, torso, and extremities."

The FAA Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, conducted toxicological testing of specimens from the pilot. The testing was negative for ethanol and drugs of abuse. Zolpidem, a prescription medication used in the treatment of insomnia, was detected in the liver and cavity blood. This medication may impair mental and/or physical ability required for the performance of potentially hazardous tasks (e.g., driving, operating heavy machinery). Due to adverse side-effects, the FAA recommends waiting at least 24 hours after use before flying.

Survival Aspects

The pilot was wearing a parachute for the flight. Review of the on-board video recording revealed that he did not attempt to open the airplane's canopy after the tail separated. The five-point seatbelt harness buckle was found fastened securely at the accident site.

Tests and Research

Follow-up examinations of the airframe revealed that the horizontal and vertical stabilizer had fractured from the remainder of the airplane in several locations: along the lower side of the horizontal stabilizer at the bonds between the skin panels and the "L" shaped flanges attaching the lower side of the horizontal stabilizer to the vertical stabilizer and fuselage skin panels, at the bond between the upper end of the banjo bulkhead and the lower skin of the horizontal stabilizer, through the fuselage skin forward of the vertical stabilizer, and through the vertical spar at the aft end of the vertical stabilizer (See Figure 1).

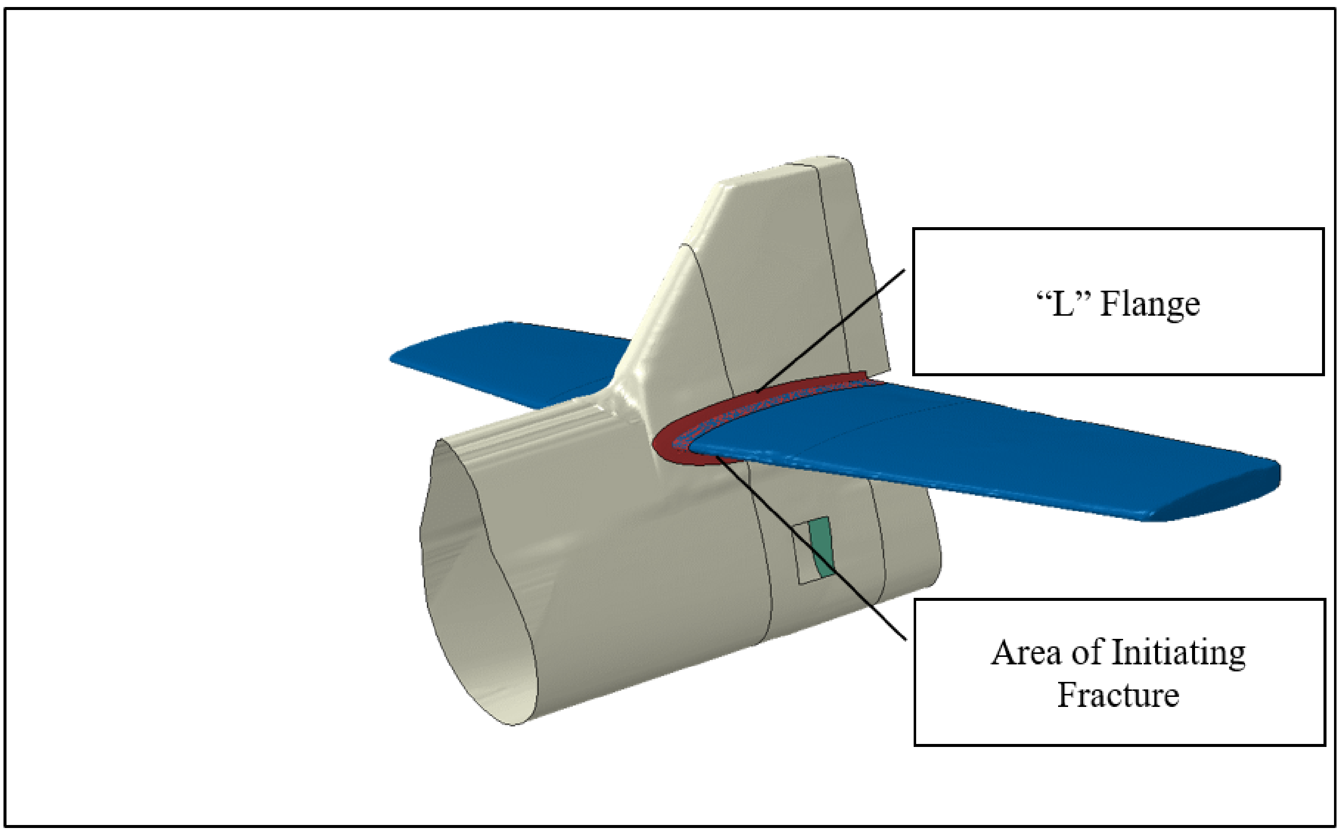

Figure 1 - Horizontal and Vertical Stabilizer Joint

Further examination revealed that the bonds between both right and left "L" flanges, which were constructed of glass-fiber-reinforced cloth and epoxy, were fractured from their mating surfaces on both legs of the "L" (the legs mating to the lower horizontal stabilizer skin and to the fuselage skin) in several locations. The bond between the banjo bulkhead and the horizontal stabilizer lower skin was fractured entirely. Most of the bond surface area in all locations exhibited evidence of fiber pullout and resin transfer; however, two areas that showed limited fiber or resin transfer were located on the left flange where it had mated to the lower skin of the horizontal stabilizer near its leading edge.

A study examining all the fractures in the tail area determined that the first fracture to occur was the bond fracture in the left flange at the bottom of the horizontal stabilizer near its leading edge. The fracture features in this area were consistent with tensile opening, which translates to a relative upward motion of the left side of the horizontal stabilizer (or, relative downward motion of the lower fuselage skin on the left side of the tail). There was no clear evidence of progressive crack growth on any of the fracture surfaces. Some contact damage on the fracture surface was present.

A finite element model was constructed to evaluate areas of concentrated stress in the tail, specifically in the areas of the "L" flanges and the banjo bulkhead/horizontal stabilizer joint. Results from that model identified areas of concentrated local stress in the fuselage and vertical stabilizer skin near the leading edge cutout for the horizontal stabilizer. The stress and size of these areas increased as the model was iterated to simulate less bond strength in the "L" flange leg on the bottom of the horizontal stabilizer. The results further indicated that these stresses were not significantly affected when the model was iterated with less and less bond strength in the banjo bulkhead joint.

The "L" flanges on the accident airplane were constructed of three layers of fiberglass cloth. According to the airplane designer, the "L" flanges were designed to be installed using wet layup techniques, with four layers of fiberglass cloth applied to the outside of the joint. Earlier kit models were built slightly differently, requiring two 2-layer flanges, one on the outside of the joint and one on the inside of the joint.

The steps that describe the installation of these flanges in the airplane build instructions are found in the section detailing the installation of the left vertical stabilizer skin. Those steps indicate that four cloth strips are to be prepared but do not specifically state that all four are to be applied to the joint on the left side of the stabilizer. However, a subsequent note in the instructions refers to those steps as incorporating a "4 ply lay-up." The section in the build instructions describing the installation of the right vertical stabilizer skin does not include any steps for the installation of flanges.

A reddish-brown residue found on the leading edge and underside of the right horizontal stabilizer near its root tested negative for bird remains.

Maintenance Records

The airframe maintenance logbook contained one structural repair entry. On January 15, 2011, at 140 flight hours: "Repaired cracked rudder mount bulkhead."

Similar Accident

On July 21, 2001, another Giles G-202 airplane, French registration F-PQUX, had an in-flight separation of the tail while in level flight after having performed some aerobatic maneuvers. The pilot was killed. The accident investigation, conducted by the French Bureau of Enquiry and Analysis for Civil Aviation Safety, revealed bond fractures in the "L" flanges at the horizontal stabilizer to vertical stabilizer and fuselage skin joints. The investigation discovered that a majority of the flange bond areas did not exhibit fiber pull-out or resin transfer.

Fleet Information

According to the airplane designer, the fleet consists of about 80 airplane kits, 27 of which were the previous G-200 models incorporating the same tail design. A majority of the kits have been completed.

One maintenance facility reported that six G-202 owners had brought their airplanes in for inspection after the accident occurred. Of those, two airplanes did not have the "L" flanges installed. Instead, epoxy adhesive had been used at the horizontal and vertical stabilizer joints. According to the airplane designer, this was one of example of deviations from the building instructions that have been observed over the history of the fleet. Other examples included material substitutions, such as using marine industry fiberglass cloth instead of the specified aerospace-grade material, and assembly procedures inconsistent with those specified in the build instructions.

The company that supplied the Giles kits was sold to another manufacturer, MX Aircraft, which developed new models based on the Giles design and used many of the same structural parts as those used in the Giles airplanes. The MX fleet size and relevant similarities were not examined.

Operational Information

The pilot purchased the airplane in December 2008, at which time it had accrued 73 hours of flight time. The airplane had since flown 376 hours until the last maintenance entry in the logbook, dated 4 days before the accident. The pilot had flown the airplane extensively in aerobatic competitions across the United States. According to his logbook, in the weeks preceding the accident, he had been performing airshow routine practice and preparing for an upcoming world record attempt for the number of turns completed in an inverted flat spin maneuver. On August 15, 2015, the pilot posted a social media photograph of the airplane's recording "g-meter," which displayed the maximum vertical load factors reached as -4.5 and +9 g, with the title "Practicing for the New York and Atlantic City Air Shows…" The meter indicated -4.75 and just under +8 g as found at the accident site.

Video Review

Review of witness video recorded on the day of the accident revealed that, at the time of the tail separation, the airplane was climbing and had just begun an aileron roll to the left. The tail began to separate as the airplane reached an approximate 90° left-wing-down roll attitude while still climbing. The first indication of separation was a relative twisting motion of the tail section, rotating about a point just forward of the vertical stabilizer leading edge in a clockwise direction as viewed from the rear of the airplane. Initially, it appeared as though the tail section stopped rotating with the fuselage at the time of separation, while the fuselage continued its roll in a counterclockwise direction away from the tail section. The airplane's roll rate at the time of the separation was about 320° per second. The video recordings did not contain sufficient references to calculate the airplane's speed at the time of the failure.

Video recordings and still photographs of the preceding maneuver, which included a wings-level descent followed by a pull up to start the climb prior to the accident, did contain sufficient references to estimate some performance parameters. A study of the video and images determined that the airplane's groundspeed was about 211 knots at the bottom of the descent, and the vertical load factor during the transition to the climb was about +7.5 g, with a tolerance estimate of ± 1.5 g. According to the airplane designer, the operational limits for vertical load factor were designed to be ±10 g at a maximum gross weight of 1,400 lbs. Before this maneuver, the airplane had performed many aileron rolls similar to the accident maneuver at various pitch attitudes in both the left and right directions. Video recordings from a 2014 airshow performance with views from inside and outside the cockpit showed a nearly identical pair of maneuvers; a wings-level descent followed by a pull up at a peak indicated airspeed of about 210-220 knots and a peak airplane load factor of about +9 g. This was followed by a series of aileron rolls on an upline, which began at an airspeed of about 170 knots. The g-meter was not visible throughout all the aileron rolls; however, at one point during those rolls, it indicated an airplane load factor of about -2 g.

Another maneuver of interest was captured by the on-board video recording. Just after takeoff, the airplane performed a double snap roll, a maneuver that places significant loads on the airplane, particularly the tail. A study of the video recording estimated that the airplane's groundspeed at the start of the snap rolls was about 130 knots. The video view did not show any of the instruments in the cockpit. The airplane designer conducted several flight tests to emulate the takeoff conditions observed in the accident on-board video. Based on those tests, he estimated that the airspeed during the accident takeoff may have been as high as 170 knots at the start of the snap rolls. According to the airplane designer, no maximum snap roll entry speed was established for the G-202, nor is one established for many aerobatic airplanes due to an absence of criteria. He further stated that one industry estimation for maximum snap roll entry speed is based on a formula related to the stall speed and the designed vertical load limit. He stated that for the prototype G-202, that estimation is about 120 knots.

Administrative Information

Investigator In Charge (IIC):	Brazy, Douglass
Additional Participating Persons:	Daniel Prince; Federal Aviation Administration; Teterboro, NJ Eric Minnis; Bully Aero; Burlington, NC Chris Meyer; MX Aircraft; North Wilkesboro, NC Richard Giles; Self (Airplane Designer); Portland, OR Greg Howard; Aero Maintenance, Inc.; Vancouver, WA
Original Publish Date:	September 18, 2017
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=91882