National Transportation Safety Board
Aviation Accident Final Report

Location:	Antelope Island, UT	**Accident Number:**	WPR09FA141
Date & Time:	03/03/2009, 0840 MST	**Registration:**	N3683X
Aircraft:	STEPHENSON ZODIAC 601 XL	**Aircraft Damage:**	Substantial
Defining Event:	Aircraft structural failure	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General Aviation - Personal		

Analysis

Radar data and a performance study depicted the airplane flying on a steady northerly course adjacent to mountains at 113 knots calibrated airspeed. The pilot changed course slightly to fly close to or over the mountains. The airplane subsequently experienced an in-flight breakup. All of the airplane's structural components and flight control surfaces were located at the main impact site. There was no evidence of excessive airspeed or maneuvers that would lead to a structural overload and failure of the wings. Turbulence was present in the area, although it was not believed to be severe and likely did not contribute to the failure.

An examination of the airplane wreckage revealed that the left wing spar had buckled upward near the fuselage and the left wing had wrapped around the fuselage near the cockpit. There was compression buckling of the lower spar cap of the left wing's rear spar and compression buckling of the upper and lower spar caps of the right wing's rear spar. The compression damage to both rear spars and the upward buckling of the left wing's main spar are evidence of upward and downward bending of both wings. The upward and downward bending of the wings is consistent with aerodynamic flutter. The structural loading at the inboard section of the left wing was further increased as the trailing edges of the outboard sections moved up and down. Ultimately the left wing failed as it bent upward near the root. Aerodynamic flutter can occur when there is insufficient stiffness in the structure or when the flight controls are not mass-balanced. Counterbalanced flight controls can protect less stiff surfaces at higher airspeeds. The ailerons did not have counterbalances, which would have offered direct protection from aerodynamic flutter.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The in-flight failure of both wings due to aileron flutter. The aileron flutter was the result of inadequate wing stiffness and the lack of aileron counterbalances.

Findings

Aircraft	Wing structure - Failure (Cause)
	Wing structure - Design (Cause)
	Ailerons - Failure (Cause)
	Ailerons - Design (Cause)

Factual Information

HISTORY OF FLIGHT

On March 3, 2009, about 0840 mountain standard time, an experimental amateur-built Stephenson Zodiac 601XL, N3683X, collided with mountainous terrain following the in-flight failures of both wings and an uncontrolled descent on Antelope Island, approximately 12 miles southwest of Syracuse, Utah. The commercial pilot, the sole occupant of the airplane, was killed. The airplane was owned by a private party and was being operated by the pilot as a visual flight rules (VFR) personal/pleasure flight under the provisions of 14 Code of Federal Regulations (CFR) Part 91. Visual meteorological conditions prevailed, and no flight plan was filed for the flight. The flight originated from Tooele, Utah, approximately 15 minutes prior to the accident with an intended destination of Bountiful, Utah.

Family members alerted the Federal Aviation Administration (FAA) that the airplane was overdue and an alert notice (ALNOT) was issued. Search and Rescue personnel discovered the wreckage later that evening in a remote area on the western side of Antelope Island, Utah. The wreckage came to rest on sloping terrain, approximately 1,600 feet below a ridgeline.

According to FAA radar data, a radar target associated with the accident airplane departed Tooele and proceeded north toward Antelope Island; altitude data was not available. The final radar target was depicted over Antelope Island at 0838 about 0.5 miles south of the wreckage location.

Calculations using both radar and meteorological data indicate that the flight was steadily progressing northward at 113 knots calibrated airspeed (KCAS). Details can be found in the Antelope Island Performance Study located in the public docket for this accident.

PERSONNEL INFORMATION

The pilot, age 37, held a commercial pilot certificate with airplane single engine land, multi-engine land and instrument ratings. His most recent FAA second class medical certificate was issued on June 19, 2006. Examination of the pilot's logbook revealed that he had accumulated approximately 371 hours of flight experience, 9.1 hours of which were in the accident airplane. The pilot's first logbook entry for the accident airplane was dated November, 8, 2008. The pilot noted within that entry that it was the airplane's maiden flight.

AIRCRAFT INFORMATION

The airplane was an experimental amateur built Zodiac 601XL, serial number 6-5136. The all-metal 2-place airplane incorporated a low-wing, flexible skin ailerons, and fixed tricycle landing gear. The airplane was equipped with a 120 horsepower Jabiru six-cylinder engine. According to the pilot's logbook, the airplane had completed 9 flights totaling 9.1 hours of flight time. The builder of the airplane reported that the tensions of the control cables were set before the first flight in accordance with instructions provided by Zenith Aircraft, the kit manufacture. The cable tensions were then rechecked approximately 6 flight hours before the accident flight and no change was noted.

The accident airplane was classified as an experimental category amateur-built airplane, and was assembled by the owner from a manufactured kit supplied by Zenith Aircraft, Mexico, Missouri. A designated airworthiness representative (DAR) issued the airplane a special airworthiness certificate on November 3, 2008. The pilot was completing phase one flight-

testing when the accident occurred.

METEOROLOGICAL INFORMATION

The weather conditions reported at Salt Lake City International Airport (KSLC), located about 17 miles southeast of the accident site, at 0853, indicated wind from 160 degrees at 17 knots, visibility of 10 statute miles, a few clouds at 7,000 feet, broken clouds at 20,000 feet, temperature 13 degrees Celsius (C), dewpoint 0 degrees C, and an altimeter setting of 29.93 inches of Mercury. Surface winds in the areas near the airplane's flight path surrounding Salt Lake were generally from the south at 11 to 14 knots, with gusts from 18 to 22 knots. Prevailing wind was generally from the south at about 14 knots, gusting to 20 knots. Turbulence was reported in the area at the time of the accident.

WRECKAGE AND IMPACT INFORMATION

Safety Board investigators responded to the accident. All of the airplane's structural components and flight control surfaces were located at the main impact site. A complete copy of the examination notes are contained in the public docket for this accident.

Fuselage

The main wreckage consisted of the fuselage, wings, empennage and engine. Aft crushing with accordion type bending features was noted along the longitudinal axis, from the engine compartment, aft to the empennage. The propeller hub was in place and remained attached to the crankshaft propeller flange. Both propeller blades were sheared at the hub. The engine remained attached to the mounting assembly and associated firewall structure. Extensive fragmentation and impact related damage was noted to the instrument panel and cockpit controls.

Wings

The left wing was buckled, bent upward, and folded over the cockpit. The upper spar cap, approximately 3 feet from the wing to fuselage attachment point, was bent forward relative to the lateral axis. The upper leading edge skin panel rivets were sheared in multiple locations along the forward spar. The upper spar chord, aft facing flange, was bent down and pressed flat against the aft side of the spar cap and associated spar web. The rear spar was bent upward approximately one foot outboard of the rear spar fuselage attachment bolt. The bottom rear spar cap was buckled near the aileron/flap junction. The upper wing skin exhibited compression wrinkling (mid span) from the upward bend in rear spar, diagonally, outboard and forward, to the front spar.

The upper spar cap remained attached to the fuselage carry thru structure. There were multiple bends in the cap with associated 180-degree rotation of the cap sections, in a counter clockwise direction when viewed looking outboard. The spar cap was separated from the spar web.

The lower spar cap at the wing to fuselage attachment point consisted of two flat non-flanged spar caps. Both had fractured in tensile static overload about 2-inches outboard of the attachment point. The fractures corresponded with the location of the outboard sections of the spar. The lower portion of the spar, below the fastener location, exhibited upward and aft bending. The upper portion of the spar, above the fastener location, exhibited upward and aft bending. The aft bending was more pronounced on the lower fracture, below the attachment fastener.

The rear spar web remained attached to the fuselage at the rear attach point. The spar web fractured, in static overload, in an upward and outboard direction, at the attachment hole. The portion of the rear spar that fractured remained attached to the wing and was deformed and bent around the head of the rear spar attachment bolt.

The right wing remained attached to the fuselage at both the forward upper and lower spar caps. The leading edge exhibited damage consistent with ground impact. The middle and outboard sections of the wing exhibited severe compression damage to the leading edge. The upper and lower wing skins were ballooned outward and separated from the wing ribs. The top and bottom rear spar caps were buckled near the aileron/flap junction. The rear spar web fractured in static overload at the attachment hole in a forward direction.

Both rear spar caps exhibited compression damage at the area where the flap and aileron met. The compression buckling on both the top and bottom spar caps of the right rear spar was consistent with the outboard section of the trailing edge bending both upward and downward. The compression buckling on the bottom spar cap of the left rear spar was consistent with the outboard section of the trailing edge bending downward. The bending trailing edge spars introduced large torsion loads into the entire wing structure.

In addition, the type of damage sustained by the rear spar would normally have to occur prior to the failure of the left wing spar. The attachments at the root of the wing provided the structural resistance to the aerodynamic loads that produced the damage to the rear spar. Once the capability to resist the aerodynamic loads was eliminated, the bending loads in the structure dropped dramatically. The type of damage to the rear spars is not typically consistent with an aerodynamic static overload. While each type of damage noted above may be individually found in cases of aerodynamic static overload, the total numbers of examples and opposite directions of failure are more consistent with aerodynamic flutter. Details of the NTSB Structures Study can be found in the public docket for this accident.

Empennage

The empennage was bent forward, and canted to the left. Both horizontal stabilizers were bent in a downward direction. Both spar caps were bent and fractured. The fracturing occurred at the outboard end of the front spar cap doublers. The top surfaces of the stabilizers exhibited impact damage. Aft crushing and leading edge damage was noted to the vertical stabilizer.

Control Surfaces

The left aileron bell crank remained attached to the aft section of a wing rib. The rib was bent inboard and separated from the wing skin. The aileron push rod remained attached to the bell crank and deflected the left aileron to the full trailing edge down position. There was evidence of over travel to the access hole on the rear spar where the push rod passes thru the spar.

The right aileron bell crank and rib were pulled inboard. The aileron push rod remained attached to the bell crank and deflected the right aileron to the full trailing edge up position. There was evidence of over travel to the access hole on the rear spar where the push rod passes thru the spar.

The left wing flap remained attached to the piano hinge. The inboard third of the hinge halves had opened up and allowed the flap to separate from the wing with no evidence of bending. The flap was bent upward in the areas where the wing trailing edge was also bent upwards.

The right wing flap remained attached to the piano hinge and associated wing. Nominal

damage was noted. Both of the slots that hold the flap actuator pins were elongated at the time of manufacture.

Landing Gear

The main landing gear and nose gear were in place and remained attached to their respective mounting brackets. Impact related damage was noted to the assembly.

All of the fracture surfaces that were examined exhibited features consistent with static overload, with no evidence of metal fatigue or material weakness. There was no evidence of multiple loading, motion or cyclic motion in the left wing, right wing, or empennage. There was no evidence of a pre or post crash fire.

TESTS AND RESEARCH

Aileron/Wing Design

The ailerons were designed to protect from a flutter event through the use of high aileron control cable tension. The high cable tension alters the dynamic interaction between the wing and aileron, similar to increasing the stiffness of the wing. After several accidents in Europe, the United Kingdom Light Aircraft Association designed and flight tested ailerons fitted with counter balances. Counter balances are considered a more direct mitigation strategy to prevent aileron flutter.

Previous Accidents

The NTSB has conducted accident investigations involving four other Zodiac 601 XL airplanes where structural failure was noted as a concern. On February 8, 2006, a CH 601 XL (NTSB case number LAX06LA105), crashed into terrain near Oakdale, California, after its wings collapsed as the airplane entered the traffic pattern of the nearby airport. On November 4, 2006, a CH 601 XL (NTSB case number LAX07FA026), broke up during cruise flight near Yuba City, California. On April 7, 2008, a CH 601 XL (NTSB case number NYC08FA158), broke up in flight near Polk City, Florida. On March 3, 2009, a CH 601 XL (NTSB case number WPR09FA141, broke up during cruise flight near Antelope Island, Utah. The details of each of these investigations are available at http://www.ntsb.gov/ntsb/query.asp.

Structures Study

Safety Board investigators conducted extensive examinations of the airplane wreckage from this accident and other similar accidents. In addition, material was used from the results of flight and static testing, accident investigation reports, and special studies conducted by several investigative and certification authorities from the United States, United Kingdom, Netherlands, and Germany.

Zodiac 601XL Accident Rates

The fatal accident and in-flight breakup rates of the Zodiac 601XL airplanes were compared to the rates for general aviation. The fatal accident rate for 601XLs, excluding breakups, is about 5 to 11 times greater than that for general aviation. The in-flight breakup rate for 601XLs is about 200 to 500 times greater than general aviation as a whole.

There are distinct differences in the nature of the breakups between the two groups. The 601XL group has distinct evidence of flutter in most cases without evidence that the airplanes

departed controlled flight. A general aviation airplane that breaks up in flight typically involves a loss of control or sometimes metal fatigue. Flutter is rarely cited as a primary cause of general aviation in-flight breakups. Details can be found in Accident Rates for Zodiac 601XL Airplanes located in the public docket for this accident.

MEDICAL AND PATHOLOGICAL INFORMATION

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicological testing on the pilot. No traces of ethanol or drugs were detected. An autopsy was performed on the pilot by the Office of the Medical Examiner, Salt Lake City, Utah. The autopsy report attributed the cause of death to "Blunt Force Injuries."

ADDITIONAL INFORMATION

NTSB Recommendation

On April 14, 2009, the NTSB issued eight recommendations to the FAA; one of which was classified as urgent. The urgent recommendation stated, in part, "that the FAA should prohibit further flight of the Zodiac CH-601XL, both S-LSA [Special Light-Sport Aircraft] and experimental, until such time that the FAA determines that the CH-601XL has adequate protection from flutter. The Board also recommended that FAA should give significant consideration to the benefits of installing mass-balanced ailerons and should also address the adequacy of cable tension values specified by Zenair."

On November 6, 2009, the most recent Zodiac 601XL breakup occurred at Agnos, AR. Flutter was cited as the cause of that breakup.

On November 7, 2009, the FAA issued Special Airworthiness Information Bulletin (SAIB) CE-10-08, regarding "airworthiness concerns on all variants of Zodiac CH601XL" aircraft and wing structure modifications. The SAIB states, in part, that to prevent potential catastrophic structural failure owners and operators are recommended to obtain and install the kit manufacturers structural modification kit. The SAIB indicates that the modification kit addresses the structural design changes required to meet a safe condition for flight.

Safety Alert/Safety Directive

On November 7, 2009, in reaction to the subject accident and FAA review of the airframe design, Aircraft Manufacturing and Design, LLC, under the advisement of Zenair, released a Safety Alert/Safety Directive to all Aircraft Manufacturing & Development and Aircraft Manufacturing & Design, LLC of Zodiac 601 XL and CH 605 airplanes. It was also suggested that owners and operators of the CH 601 XL and CH 650 experimental amateur built airplanes also comply with this alert/directive. This document provided corrective actions intended to strengthen and stiffen the wing in order to decrease the likelihood of structural overload and aerodynamic flutter. In addition, the document provided for the installation of aileron counter balances that also decrease the likelihood of aerodynamic flutter of the ailerons. This alert/directive required all owners of the SLSA 601XL to comply with the mandatory upgrade to the wing structure and aileron counterbalance weights before the next flight. The airplanes certificated as experimental, amateur built, are not required to comply with the Safety Directive.

In addition to the upgrade kit, this Safety Alert/Directive also advised owners and operators to

check flight control cable tension, check for aileron free play, and to check flap free play prior to every flight. The owner/operators were also asked to ensure that their air speed indicators indicated the correct speeds, ensure that the canopies latched correctly, and that luggage was also secured before flight. The FAA issued a Special Airworthiness Information Bulletin on November 7, 2009, in response to the subject accident and in response to recommendations issued by the NTSB. The Special Airworthiness Information Bulletin (SAIB) CE-10-08: Wings: Zodiac CH 601 XL and CH 650 Wing Structural Modifications. This SAIB recommended that all owners of the SLSA Zodiac CH 601 XL and CH 650 airplanes comply with the safety alert /directive issued by Aircraft Manufacturing & Design, LLC. In addition, the SAIB recommended that amateur built and experimental aircraft, which share design characteristics with the CH 601 XL and the CH 650, also comply with this safety alert/directive.

History of Flight

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

Pilot Information

Certificate:	Commercial	**Age:**	37, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Sea	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Sport Pilot Without Waivers/Limitations	**Last Medical Exam:**	06/19/2006
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	08/20/2007
Flight Time:	350 hours (Total, all aircraft), 14 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	STEPHENSON	**Registration:**	N3683X
Model/Series:	ZODIAC 601 XL	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	Yes
Airworthiness Certificate:	Experimental	**Serial Number:**	6-5136
Landing Gear Type:	Tricycle	**Seats:**	2
Date/Type of Last Inspection:	11/11/2008, Conditional	**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:	14 Hours	**Engine Manufacturer:**	Jabiru
ELT:	C91 installed, activated, did not aid in locating accident	**Engine Model/Series:**	3300
Registered Owner:	DENNIS STEPHENSON	**Rated Power:**	120 hp
Operator:	Kirk Babbitt	**Air Carrier Operating Certificate:**	None

Meteorological Information and Flight Plan

Observation Facility, Elevation:	KSLC, 4220 ft msl	**Observation Time:**	0853 MST
Distance from Accident Site:	17 Nautical Miles	**Condition of Light:**	Day
Direction from Accident Site:	140°	**Conditions at Accident Site:**	Visual Conditions
Lowest Cloud Condition:	Few / 7000 ft agl	**Temperature/Dew Point:**	13°C / 0°C
Lowest Ceiling:	Broken / 20000 ft agl	**Visibility**	10 Miles
Wind Speed/Gusts, Direction:	17 knots, 160°	**Visibility (RVR):**	
Altimeter Setting:	29.93 inches Hg	**Visibility (RVV):**	
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Tooele, UT (KTVY)	**Type of Flight Plan Filed:**	None
Destination:	Bountiful, UT (BTF)	**Type of Clearance:**	None
Departure Time:	0818 MST	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal		

Administrative Information

Investigator In Charge (IIC):	Dennis J Hogenson	**Adopted Date:**	11/29/2011
Additional Participating Persons:	Lyndsay Carlson; FAA FSDO; Salt Lake City, UT		
Publish Date:	11/29/2011		
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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