Aviation Investigation Final Report

Location:	Duluth, Minnesota	**Accident Number:**	CEN14FA278
Date & Time:	June 7, 2014, 11:21 Local	**Registration:**	N86NW
Aircraft:	HERMANN BJORN LANCAIR IV	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General aviation - Ferry		

Analysis

The pilot/owner was ferrying the airplane from the United States to Europe, and he had installed an auxiliary fuel bladder in place of the rear seat. Before takeoff, the airplane's fuel tanks were topped off, and 60 gallons of fuel were added to the auxiliary fuel bladder. The estimated weight of the airplane during takeoff was about 509 lbs over its maximum gross weight. The estimated center of gravity (CG) of the airplane was 93.2, which was near the aft limit of the CG range.

The flight departed in marginal visual flight rules conditions and, soon after takeoff, climbed into instrument flight rules (IFR) conditions while passing through 1,000 ft above ground level. Air traffic control (ATC) cleared the pilot to fly a northeasterly heading and climb to 12,000 ft, but the pilot did not acknowledge the instruction, and radar track data indicated that the airplane turned right within 1 minute after departure. ATC instructed the pilot to turn back on course, and the pilot complied. The airplane continued on course for about 1.5 minutes, but then it turned right again while still in a climb. ATC instructed the pilot to turn back on course, but the pilot did not respond. The airplane continued to turn right, reached a maximum altitude of about 6,600 ft, and then entered a steep, descending right turn. ATC instructed the pilot to climb immediately, but there was no response, and the airplane continued the steep descending turn and impacted a lake about 5 minutes after departure.

A comparison of the radar track data with the flight data recovered from the airplane's primary flight display (PFD) and multifunction display revealed discrepancies between the two data sources regarding airspeed, bank angle, heading, wind speed, and wind direction, indicating that erroneous information was being displayed on the PFD during the flight. Specifically, the flight data indicated periods of straight and level flight when the radar track data indicated the airplane was banking and changing heading. The erroneous information would have made it difficult for the pilot to control the airplane and navigate effectively in IFR conditions. The reason for the erroneous flight data could not be determined.

The pilot's toxicology report indicated 0.146 ug/ml diphenhydramine (a sedating antihistamine) in cavity blood, which was above the therapeutic range of 0.0250 to 0.1120 ug/ml. Although diphenhydramine

undergoes postmortem redistribution, the postmortem level detected suggests that the pilot likely had impairing levels of diphenhydramine in his system at the time of the accident. To maintain control of the airplane, the pilot would have needed to recognize that the PFD display was faulty and use the information from the standby attitude indicator, turn and bank indicator, and magnetic compass. However, it is likely that diphenhydramine, which impairs cognitive and psychomotor performance, diminished the pilot's ability to recognize and manage the erroneous PFD indications.

The pilot's failure to acknowledge the clearance to turn to the northeast and climb to 12,000 feet only a few seconds after he initiated contact with ATC suggests that his attention was diverted for some reason about that time. The pilot verbally acknowledged and responded to a subsequent call to return to course. However, after about 1.5 minutes the airplane again deviated from course and entered a steep descending turn, most likely due to the pilot experiencing spatial disorientation as a result of the erroneous heading and bank angle information on the PFD and his ineffective use of standby flight instruments in restricted visibility conditions. The airplane's aft CG and over gross weight condition would have reduced the airplane's longitudinal stability, and this likely also contributed to the loss of control.

Probable Cause and Findings

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

The pilot's failure to maintain airplane control while operating in instrument flight rules (IFR) conditions, which was due to spatial disorientation resulting from erroneous heading and bank angle information shown on the primary flight display. Contributing to the accident were the pilot's impairment due to diphenhydramine and his improper decision to operate in IFR conditions with the airplane over gross weight and at an aft center of gravity.

Findings

Aircraft	Attitude & direction - Malfunction
Personnel issues	Spatial disorientation - Pilot
Personnel issues	Aircraft control - Pilot
Environmental issues	Clouds - Effect on operation
Personnel issues	Decision making/judgment - Pilot
Personnel issues	OTC medication - Pilot
Aircraft	Maximum weight - Capability exceeded

Factual Information

History of Flight

Prior to flight	Aircraft loading event
Enroute-climb to cruise	Flight instrument malf/fail
Enroute-climb to cruise	Loss of control in flight (Defining event)
Enroute-climb to cruise	Collision with terr/obj (non-CFIT)

On June 7, 2014, about 1121 central daylight time, an experimental, amateur-built, Hermann Bjorn Lancair IV, N86NW, was destroyed when it impacted Lake Superior after departing from the Duluth International Airport (DLH), Duluth, Minnesota. The pilot, the sole occupant, received fatal injuries. The airplane was registered to A.O. Engineering Inc. and operated by the pilot under the 14 Code of Federal Regulations Part 91 as a personal flight. Marginal visual meteorological conditions prevailed at the time of the accident, and an instrument flight rules (IFR) flight plan was filed. The airplane departed DLH about 1116, and was en route to Goose Bay (YYR), Newfoundland, Canada.

The DLH air traffic control (ATC) transcript of the recorded radio conversations between ATC and the pilot indicated that the tower controller cleared the airplane to depart runway 9 and climb to 6,000 ft on a heading of 060 degrees. At 1117:24, the pilot contacted departure control. Departure control instructed the pilot to turn left and fly direct to Thunder Bay (YQT), and climb and maintain 12,000 ft. The pilot did not acknowledge this instruction. At 1117:25, the radar track data indicated the airplane was heading northeast at 4,467 ft at an airspeed of 131kts.

At 1118:00, departure control stated, "November 86 November Whiskey turn left fly heading 030 please." The pilot responded, "November Whisky left turn. Sorry about that." At 1118:03, the radar track data indicated the airplane was heading to the southeast at 4,689 ft at an airspeed of 167 kts.

At 1118:31, departure control stated, "And, ah Lancair 6 November Whiskey, it will be direct Yankee Quebec Tango present position. Direct present position." The pilot responded, "Present position direct Yankee Quebec Tango." There were no further recorded radio transmissions from the pilot. At 1118:31, the radar track data indicated that the airplane was heading to the northeast at 5,011 ft at 152 kts. The airplane continued on a northeasterly heading until 1119:46 when it started to turn right to a southeasterly heading.

At 1120:14, the airplane was heading to the south, southeast at 6,050 ft at 161 kts. At 1120:17, departure control stated, "November 86 November Whiskey, I still show you, ah, heading southeast bound. Verify you're direct to Yankee Quebec Tango."

At 1120:33, the airplane was heading to the south at 6,350 ft at 118 kts. At 1120:34, departure control stated, "November 86 November Whiskey, it appears you're heading southbound now. Ah, verify you're direct to Yankee Quebec Tango please."

At 1120:52, the airplane's last radar return was recorded. It indicated that the airplane was heading southbound at 2,400 ft at 201 kts.

At 1120:56, departure control stated, "November 86 November Whiskey, ah. Low altitude alert. Check your altitude. Immediately climb and maintain three thousand, immediately."

At 1121:05, departure control stated, "(unintelligible) 86 November Whiskey, climb. Altitude. Immediately maintain six, ah, maintain three thousand, three thousand."

The airplane impacted Lake Superior about 1 mile offshore from Brighton Beach, in Duluth, Minnesota. The airplane wreckage was located in 137 ft of water. The body of the pilot was retrieved from the wreckage on June 9, 2014.

Pilot Information

Certificate:	Commercial	**Age:**	47
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	4-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 With waivers/limitations	**Last FAA Medical Exam:**	October 16, 2013
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	2500 hours (Total, all aircraft), 22 hours (Total, this make and model)		

The pilot was a 47 year-old German citizen who held a Federal Aviation Administration (FAA) commercial pilot certificate with single-engine land, multi-engine land, single-engine sea, and instrument airplane ratings. He held a third class medical certificate dated October 16, 2013, with the limitation for corrective lenses. The pilot's flight logbook was not obtained during the investigation. During his medical examination in October 16, 2013, the pilot reported that his total flight time was 2,500 hours. He had an estimated 22 hours of flight time in the accident airplane.

A witness who knew the pilot for 15 years reported that the pilot was an accomplished general aviation pilot with about 3,000 flight hours. He reported that the accident pilot had purchased a Mooney M20F in 1998 and had made several overseas flights in it, including trips across the South Atlantic and North Atlantic routes.

Aircraft records indicated that the accident pilot purchased the airplane on November 4, 2013. Witnesses who lived in Bend, Oregon, where the airplane was kept in a hangar, reported that the accident pilot received about 3 – 4 hours of airplane ground instruction after he purchased the airplane. It was not determined if the pilot received any dual flight instruction in the airplane. Witness statements and fuel receipts indicated that the accident pilot flew the airplane in December, January, February, and June, including a round trip flight from Bend, Oregon, to Las Vegas, Nevada.

On June 6, 2014, the day before the accident flight, the pilot flew the airplane from Bend, Oregon, to DLH. The time en route was about 4 hours and 32 minutes. The pilot planned to fly to YYR on the day of the accident. Flight planning documents indicated that the pilot planned to fly to Baden Airpark (EDSB) in Rheinmunster, Germany.

Aircraft and Owner/Operator Information

Aircraft Make:	HERMANN BJORN	**Registration:**	N86NW
Model/Series:	LANCAIR IV	**Aircraft Category:**	Airplane
Year of Manufacture:	2005	**Amateur Built:**	Yes
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	LIV-552
Landing Gear Type:	Tricycle	**Seats:**	4
Date/Type of Last Inspection:	September 20, 2013 Condition	**Certified Max Gross Wt.:**	3800 lbs
Time Since Last Inspection:		**Engines:**	1 Turbo prop
Airframe Total Time:	666 Hrs as of last inspection	**Engine Manufacturer:**	Walter
ELT:		**Engine Model/Series:**	XM601E
Registered Owner:	A O ENGINERING INC	**Rated Power:**	750 Lbs thrust
Operator:	Alexander G. Obersteg	**Operating Certificate(s) Held:**	None

The airplane was an experimental, amateur-built, Hermann Bjorn Lancair IV, serial number LIV-552, manufactured in 2005. The airplane was powered by a 750 shaft-horsepower Walter turbo-prop engine manufactured in 1992. The engine was subsequently rebuilt and reconfigured as a Walter XM601E-Prototype with a new serial number of 921012EX in 2003 identifying it as being manufactured specifically for the Lancair installation. The propeller was an Avia propeller which had a steel hub with three aluminum blades. The last conditional maintenance inspection was conducted on September 20, 2013, with a total airframe time of 666.3 hours.

The airplane was equipped with two Chelton CFR Sierra-SV Synthetic Vision Integrated Display Units (IDUs) used for primary flight display (PFD) and multifunction display (MFD), an Avidyne FlightMax Entegra MFD, and Garmin 530 and Garmin 430 radio and nav/com units. In addition, the airplane was equipped with standby flight instruments which included an airspeed indicator, attitude indicator, altimeter, and turn and bank indicator located in the center of the instrument panel.

The accident pilot installed a rubber auxiliary fuel bladder in the back seat of the airplane. The accident pilot sent an email dated March 17, 2014, that he expected that a new bladder tank from TurtlePac should arrive at the hangar where the airplane was kept. It's uncertain when the pilot installed the fuel bladder, but it was observed in the airplane prior to the accident. The lineman at the fixed base operator at DLH reported that the black colored fuel bladder located in the back seat was filled with 60 gallons of fuel on the morning of June 7, 2014. Both wing fuel tanks were also topped off. The fuel receipt showed that a total of 136 gallons of fuel was added to the airplane before the accident flight.

Witnesses and the pilot's emails indicated that the pilot was having autopilot problems with the airplane. The pilot wrote an email dated June 6, 2014, to the hangar owner in Bend, Oregon, which stated, "I am in town since Thursday and working on the plane. One problem solved, the next showing up. Right now the autopilot tries to kill me. Flying straight and level high speed my electric trim buddy pushes or pulls all of a sudden. Very bad feeling, even worse that the auto-trim is on his side. I will meet RDD in Redmond early in the morning, begging for help."

The owner of RDD (an aviation maintenance facility) in Redmond, Oregon, stated that he received a phone call from the pilot concerning the problems he was having with the autopilot. The accident pilot flew the airplane to Redmond about 0730 on June 6, 2014. The pilot indicated that the airplane was experiencing violent pitch ups. RDD diagnosed the problem as an auto-trim reverse sensing which caused the nose to trim up or down which was backward from what was required. The fix took less than 20 minutes. All that was required was to flip a switch on the auto-trim module. After the work was completed, the accident pilot flew back to Bend, Oregon. The pilot did not tell the owner of RDD that he was going to fly to DLH on the same day. The owner of RDD stated that he received a text message from the accident pilot later that night that stated that the autopilot was working much better.

The accident pilot wrote an email dated June 6, 2014, at 7:00 PM to the hangar owner in Bend, Oregon, which stated, "I took a chance today to start the ferry flight. Right now I am in Duluth, MN. Tomorrow aiming for Goose Bay. I have still my back seat in your hangar. Probably will fly next spring or I find another way to pick it up asap."

The airplane which seated four was made of primarily of composite materials and had a maximum gross weight of 3,800 pounds. The estimated weight and balance of the aircraft indicated that the aircraft takeoff weight on the accident flight was 4,309 lbs., which was 509 lbs. over the maximum gross weight of the aircraft. The estimated center of gravity (CG) of the aircraft was 93.2, which was within the CG range of the aircraft of flight stations 86.5 - 94.5.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	DLH,1428 ft msl	**Distance from Accident Site:**	8 Nautical Miles
Observation Time:	11:22 Local	**Direction from Accident Site:**	95°
Lowest Cloud Condition:	Few / 300 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	Broken / 1000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	9 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	140°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.05 inches Hg	**Temperature/Dew Point:**	11°C / 10°C
Precipitation and Obscuration:			
Departure Point:	Duluth, MN (DLH)	**Type of Flight Plan Filed:**	IFR
Destination:	(CYYR)	**Type of Clearance:**	IFR
Departure Time:	11:16 Local	**Type of Airspace:**	

At 1102, the surface weather observation at DLH was: wind 080 at 4 kts; 10 miles visibility; scattered clouds 700 feet; overcast ceiling 2,500 feet; temperature 12 degrees C; dew point 9 degrees C; altimeter 30.06 inches of mercury.

At 1122, the surface weather observation at DLH was: wind 140 at 9 kts; 10 miles visibility; scattered clouds 300 feet; broken ceiling 1,000 feet; overcast ceiling 2,700 feet; temperature 11 degrees C; dew point 10 degrees C; altimeter 30.06 inches of mercury; ceiling variable 700 feet to 1,100 feet.

At 1132, the surface weather observation at DLH was: wind 120 at 6 kts; 10 miles visibility; ceiling 300 feet broken; overcast 1,000 feet; temperature 11 degrees C; dew point 10 degrees C; altimeter 30.07 inches of mercury.

A National Transportation Safety Board (NTSB) weather specialist reported that computer modeling of weather data indicated that clouds were likely from the surface through at least 32,000 feet above mean sea level (msl), with icing conditions likely starting at 10,000 feet msl and above at the time of the accident. The winds aloft from 3,000 to 6,000 feet were between 12 to 18 kts from the northeast.

Airport Information

Airport:	Duluth International Airport KDLH	**Runway Surface Type:**	
Airport Elevation:	1428 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	46.882221,-91.918891

The airplane wreckage was recovered from Lake Superior on June 23, 2014, and relocated to a St. Louis County maintenance facility located in Duluth, Minnesota, for examination. The wings, horizontal stabilizer, and much of the composite fuselage structure of the airplane were not recovered; as such, flight control continuity could not be verified. The engine, propeller, landing gear, cockpit instrument panel, instruments, cabin floor structure, seats, interior pieces, vertical stabilizer, rudder, and various aircraft parts were recovered and examined.

The engine was removed from the remaining airframe and a cursory inspection of the engine was performed. The engine and propeller were shipped to the GE Aviation Czech (GEAC) factory in Prague, Czech Republic, for examination. The propeller was transferred to the Avia factory facility in Prague, Czech Republic, for a teardown examination.

An Avidyne Flight Max Integra Multi-function display (MFD) and two Chelton IDUs were sent to the NTSB Vehicle Recorders division for examination.

The rudder bellcrank, the rudder spherical bearings, and a section of the lower rudder were sent to the NTSB Materials laboratory for examination.

The rudder trim was found in a right rudder trim position with about 1/2 inch deflection. The electric rudder servo motor was tested by using a 9-volt dc power source. It exhibited full travel when power was applied.

Medical and Pathological Information

An autopsy of the pilot was conducted on June 10, 2014, at the University of Minnesota School of Medicine in Duluth, Minnesota. The "Cause of Death" was noted as the "result of multiple severe impact injuries." A Forensic Toxicology Fatal Accident Report was prepared by the FAA Civil Aerospace Medical Institute. The results were negative for carbon monoxide and ethanol. The toxicological report indicated that 0.146 (ug/ml, ug/g) diphenhydramine was detected in the blood (cavity).

Diphenhydramine is a sedating antihistamine used to treat allergies and as a sleep aid. It is available over the counter under various names including Benadryl and Unisom. Diphenhydramine carries the following warning: may impair mental and/or physical ability required for the performance of potentially hazardous tasks (e.g., driving, operating heavy machinery). The therapeutic range for the

drug is 0.0250 to 0.1120 ug/ml.

The pilot's FAA medical certification examination did not identify any medical concerns or natural disease. His autopsy identified mild cardiomegaly with left ventricular enlargement and mild coronary atherosclerosis, but no evidence of heart muscle damage or other natural disease. Toxicology testing detected diphenhydramine in cavity blood at 0.146 ug/ml.

Tests and Research

On August 19, 2014, the engine and propeller were examined under NTSB oversight in Prague, Czech Republic. The engine examination revealed that the power turbine was intact; however the hub was rotationally scored on both faces. The leading edges of all the blades were rotationally scored and bent aft. The gas generator turbine was intact and the blade tips were circumferentially scored with metal transfer evident on the convex sides of the tip, consistent with contact against the gas generator turbine shroud. Additionally, there were randomly distributed bright shiny flakes deposited on the convex side of some of the blades, which is consistent with a metal spray condition. The compressor rotor, consisting of two axial compressors and one centrifugal impeller was intact. The axial compressor blades were intact and the tips were circumferentially scored consistent with contact against their respective shroud elements. The impeller vanes were rotationally scored, consistent with contact against the impeller shroud. The compressor and impeller shrouds exhibited rotational scoring.

The propeller examination revealed that the Nos. 1 and 2 blades were bent aft at the mid-span to a bend angle of about 90 degrees, with no evidence of blade twisting. The No. 3 blade had a slight bend with no evidence of blade twisting deformation. The No. 1 piston guide was slightly dented at a location which indicated that the blade pitch at impact was 15 degrees, a low angle corresponding to the hydraulic low pitch stop. This, in turn, corresponded to a low power setting of the engine.

The NTSB Materials laboratory examined the rudder bellcrank, the rudder spherical bearings, and a section of the lower rudder and vertical stabilizer bulkhead. The examination revealed that the rudder bellcrank was comprised of a left arm and a right arm. On each arm, there were attachment points for a control cable input and a rod output. There were two holes in the vertical stabilizer bulkhead that allowed the rods to connect to the forward rudder spar via an attachment fitting. The right and left rods were fractured. Pieces of the right and left rods were attached to the rudder and a piece of the right rod was attached to the bellcrank. By contrast, there was no corresponding piece of the left rod attached to the bellcrank. A closer examination of the right rod fracture surfaces revealed that they did not match; indicating that the right rod had fractured in two or more locations and an intermediate section had been separated and was not recovered. An examination of the bellcrank revealed a deformation mark on the forward portion of the right arm in the vicinity of the bellcrank stop.

The left and right rod fracture surfaces were visually examined using a stereomicroscope. The fracture surface on the left rod piece attached to the rudder consisted of inclined slant fractures, and no apparent out-of-plane deformation, consistent with a tensile overstress fracture. The right rod had collapsed near each fracture. The initially circular tube cross sections had deformed by elongating in one direction and collapsing in the other direction. The rod end at the forward end of the right rod (attached to the

bellcrank via a rod end bearing) was bent. The features were consistent with overload by compressive buckling.

The NTSB Vehicle Recorders laboratory examined the Avidyne FlightMax Entegra MFD removable compact flash card. While the compact flash card successfully read, it did not contain any recorded information. Avidyne confirmed that the Entegra does not record any information when installed in an experimental, turbine aircraft.

The NTSB Vehicle Records laboratory examined the accident pilot's Nokia C5 cell phone that was found in the airplane wreckage. The Nokia cell phone turned on, but the screen was damaged and no further recovery attempts were attempted.

Two Chelton IDUs were recovered from the accident aircraft and sent the NTSB Vehicle Records laboratory for examination. The units sustained minor impact and water damage. The units integrate multiple primary flight instruments including airspeed, altitude, electronic compass, turn rate, bank angle, pitch angle, vertical speed, and an optional slip/skid ball. They can also function as a navigation and engine display. They may integrate with external components, including a GPS/Air Data/AHRS. Units are typically installed in pairs, providing PFD and MFD capabilities.
The units are capable of recording a log of aircraft parameters at a rate of 1 sample per second to an internal PCMCIA card. The parameters recorded depend upon installation and include primary flight instrument data, GPS position data, AHRS data, and engine data.

The current log file "LOG00.DAT," was retrieved from the download of each Chelton IDU unit. The "LOG00.DAT" file from the unit with serial number 292 contained recorded data on June 7, 2014 between 16:00:16 universal coordinated time (UTC) and 16:20:53 UTC. The file recorded primary flight instrument data, GPS position data, AHRS data, and engine data. There were about 20 additional log files of prior flights, four of which were recorded on June 6, 2014. For the accident flight, 5 hours were subtracted from UTC to convert to CDT.

The data showed that the aircraft departed from KDLH, climbed towards Lake Superior with intermediate level offs, exhibited fluctuations in pitch, speed, and roll, and then descended rapidly and crashed into Lake Superior. The maximum altitude attained was 6,607 ft with an indicated airspeed (IAS) of 94 kts, which was the minimum recorded IAS after the initial departure climb. Thereafter, the IAS increased and the aircraft descended, reaching a maximum recorded IAS of 262 kts about 6 seconds before the end of the recording.

On the prior flight from Bend, Oregon, to Duluth, Minnesota, the day before the accident, the roll, heading, and course each oscillated about +/-10 degrees for about an hour in cruise flight. See the NTSB Vehicle Recorder Division's report "Electronic Devices" in the docket material associated with this investigation for further details.

The NTSB's Vehicle Performance Division conducted an airplane performance study which described the accident airplane ground track, altitude, and speed, as well as the timing of select radio communication between ATC and N86NW, including estimates of airplane pitch, roll, and heading derived from radar, as well as airplane and engine data recovered from the Chelton IDUs. The study compared the data derived from radar and the Chelton IDU's log data. The Chelton log data is the data

being displayed to the pilot on the PFD.

The study indicated that during two periods about 30 seconds in length during the accident flight (the first centered around 16:17:40 and the second at16:19:50) the radar-derived airspeed exceeded the airspeed recorded in the log file by 10 to 20 kts. During approximately the same time frame, the radar-derived bank angle exceeded the bank recorded in the log file by as much as 25 degrees (i.e., more right-wing-down). Additionally, the recorded log data bank angle is different than the heading shown by the radar data. During the first 30 second period centered at 16:17:40, the log data shows little or no bank, while the heading derived from radar data showed the airplane turning to the south/right.

The other notable difference in the comparison was between the heading derived from radar and that recorded in the log file. For nearly two minutes, early in the flight, the log file heading was 20 degrees to 25 degrees more airplane-nose-left than that estimated from radar. From 16:19:20 until the end of the data the log file heading was upwards of 45 degrees more airplane-nose-right than that estimated from radar.

The Chelton log files recorded the groundspeed, wind speed, and wind direction during the flight. During the climb to 6,600 ft msl, the wind speed varied between 5 and 88 kts. Wind direction in the log varied counterclockwise from 360 degrees to 203 degrees, and then back (clockwise) to 338 degrees. It then continued clockwise from 338 degrees to 247 degrees when the data ended. This represented over a 360 degree change in wind direction (i.e., 203 degrees clockwise to 247 degrees) in less than three minutes. See the NTSB Vehicle Performance Division's report "Airplane Performance Study" in the docket material associated with this investigation for further details.

The airplane was equipped with a Crossbow 500 Attitude Heading Reference System (AHRS) interfaced with the Chelton IDU. The Crossbow 500 is a nine-axis measurement system that combines linear accelerometers, rotational rate sensors, and magnetometers. It uses the angular rate sensors to integrate over the rotational motion and find the actual pitch, roll, and yaw angles. It uses the accelerometers to correct for rate sensor drift in the vertical angles (pitch and roll); and uses magnetometers to correct for rate sensor drift in the yaw angle. According to the manufacturer (MEMSIC, Inc.) the Crossbow 500 was manufactured as a TSO'd (technical standard order) device requiring proper installation and calibration procedures. The Crossbow 500 was located near the 208 bulkhead. The magnetometer (which senses the earth's magnetic lines of flux and converts it to a heading and provides the heading information to the AHRS) was located in the empennage near the horizontal stabilizer. A magnetometer is sensitive to magnetic interference and can be influenced by ferrous metals like AN bolts, control rod ends, any 4130 steel, seat belts, unshielded electrical wires, and antenna cables. There was no indication in the maintenance logbooks that the AHRS and magnetometer had been recalibrated after it had been initially calibrated during the manufacture of the airplane.

Administrative Information

Investigator In Charge (IIC):	Silliman, James
Additional Participating Persons:	Kevin Morris; FAA Minneapolis FSDO; Minneapolis , MN Robert Wolstenholme; Lancair Int; Redmond, CA Sam Farminga; GE Aviation; Cincinnati, OH Robert DuRall; Genesys Aerosystems; Mineral Wells, TX Masoud Beheshti; Memsic; Milpitas, CA
Original Publish Date:	November 19, 2015
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=89387