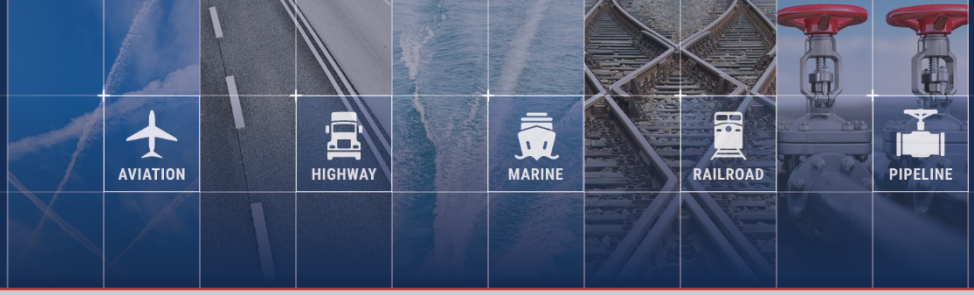

Aviation Investigation Factual Report

Location:	Hancock, Wisconsin	**Accident Number:**	CEN15LA399
Date & Time:	August 26, 2015, 11:30 Local	**Registration:**	N2005C
Aircraft:	Weatherly Aviation Company Inc 620B	**Aircraft Damage:**	Destroyed
Defining Event:	Part(s) separation from AC	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 137: Agricultural		

On August 26, 2015, about 1130 central daylight time, a Weatherly Aircraft Company 620B, N2005C, impacted terrain after the left wing partially separated during an aerial application flight near Hancock, Wisconsin. The pilot was fatally injured, and the airplane was destroyed. The airplane was registered to Agricair Leasing, LLC and operated by Agricair Flying Service, Inc., under the provisions of Title 14 *Code of Federal Regulations* Part 137. Visual meteorological conditions prevailed in the area, and no flight plan was filed for the flight, which originated from the operator's private airstrip near Bancroft, Wisconsin, about 1115.

The only witness to the accident stated that he was working in a field about 1/2 mile from the accident site about 1125 when he heard an aircraft engine that had an unusual sound. The sound stopped and was followed by the sound of breaking trees.

According to the Federal Aviation Administration (FAA) inspector who responded to the accident site, the airplane was performing spray operations from north to south on a potato field about 4.2 miles southeast of Hancock at the time of the accident. The field was surrounded by trees that were about 50-60 ft tall. Three birch trees, about 25-30 ft tall, were located near the edge of the potato field and about 30 yards closer to the planted area of the field than the treed area. The birch trees were in line with a wreckage path that contained the airplane left wing leading edge pieces, trailing edge, and wingtip. There was no evidence that the airplane impacted the birch trees. Postaccident examination revealed damage to the left wing, spray boom, empennage, and fuselage structure consistent with upward and rearward separation of portions of the left wing.

The owner of Agricair Flying Service, Inc. examined the potato field after the accident and believed that the pilot was just starting spray operations at the time of the accident. Another agricultural operator examined the field and believed that the pilot was almost finished with the spray operations.

Pilot Information

Certificate:	Commercial; Flight instructor	**Age:**	37,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Center
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane single-engine	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	February 10, 2015
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	June 6, 2014
Flight Time:	(Estimated) 1045 hours (Total, all aircraft), 420 hours (Total, this make and model), 476 hours (Pilot In Command, all aircraft), 408 hours (Last 90 days, all aircraft), 154 hours (Last 30 days, all aircraft)		

The accident pilot's logbook was examined and, as of January 2, 2015, the logbook indicated 584.1 hours of total flight time in single-engine airplanes. Most of the flights annotated in the logbook were conducted in light general aviation airplanes. In 2011, the pilot only recorded 2 flights for a total of 4.9 hours, in 2013 the pilot only recorded 3 flights for a total of 2.9 hours, and in 2014 the pilot only recorded 6 flights for a total of 6.1 hours.

The pilot began agricultural flight training in April 2015 at Battlefords Airspray, North Battleford, Saskatchewan, Canada. Much of the training was performed in a Gippsland GA200 two-seat agricultural training airplane. The pilot's logbook entries for the GA200 airplane did not indicate dual received flight time for these flights. Seven of the training flights were solo flights in a Piper PA-25-180 or -235 airplanes. On April 28, 2015, an entry in the logbook indicated the pilot had completed agricultural pilot training after completing 26 flights for 41.2 hours. No other flight times were contained in the pilot's logbook.

The pilot began working for Agricair Flying Service in May 2015. The operator provided a desk calendar for May-August 2015 where the pilot annotated his flight time, the number of loads, and the number of acres. A Letter of Competency from the company was contained in the pilot records indicating the accident pilot had satisfactorily completed the knowledge and skills tests for an agricultural pilot under 14 *CFR* Part 137.19 on May 24, 2015 and was qualified to serve as pilot-in-command under the operator's certificate. The last entry on the calendar was on August 23, 2015. As of that date, the pilot had accrued 461.1 hours of agricultural operations, including his agricultural flight training. A majority of this time, 419.9 hours, was accrued in the accident airplane while working for the operator. His minimum recorded flight time on a single day was 0.4 hours and his maximum flight time was 13.6 hours with an average flight time of 5.9 hours. Fourteen days had recorded flight times that exceeded 10 hours. No information was available on the pilot's flight time on the day of the accident or the two preceding days.

National Transportation Safety Board (NTSB) Special Investigation Report on the Safety of Agricultural Aircraft Operations (NTSB/SIR-14/01 PB2014-105983) stated in part, "Compared to the pilots in other [general aviation] sectors, ag operations pilots who were involved in accidents tended to be highly experienced. For 2010, the average total flight time for an ag pilot involved in an accident was about 10,400 hours with about 2,900 hours in aircraft type (NTSB 2012, 54)."

Aircraft and Owner/Operator Information

Aircraft Make:	Weatherly Aviation Company Inc	**Registration:**	N2005C
Model/Series:	620B	**Aircraft Category:**	Airplane
Year of Manufacture:	1993	**Amateur Built:**	
Airworthiness Certificate:	Restricted (Special)	**Serial Number:**	1557
Landing Gear Type:	Tailwheel	**Seats:**	1
Date/Type of Last Inspection:	April 15, 2015 Annual	**Certified Max Gross Wt.:**	4000 lbs
Time Since Last Inspection:	343 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	4811.83 Hrs at time of accident	**Engine Manufacturer:**	Pratt & Whitney
ELT:		**Engine Model/Series:**	R-985 AN-14B
Registered Owner:	Agricair Leasing LLC	**Rated Power:**	450 Horsepower
Operator:	Agricair Flying Service, Inc	**Operating Certificate(s) Held:**	Agricultural aircraft (137)
Operator Does Business As:		**Operator Designator Code:**	J8PG

The accident airplane, serial number (S/N) 1557, was manufactured in 1993 and registered to the operator in June 2014. It was a single-seat, single-engine, low-wing, all-metal airplane with conventional landing gear and was designed for agricultural spraying operations. The airplane was powered by a Pratt & Whitney R985 radial engine which drove a 3-blade tractor propeller.

The Weatherly 620B was certified under FAR 21.25(a) effective February 1, 1965, with policies contained in Civil Aeronautics Manual 8 (CAM 8) Appendix B. The airplane type certificate (TC) ownership was transferred to Weatherly Aircraft Company, Chicago, Illinois, on November 6, 2000. The FAA responsible office for the TC was the Los Angeles Aircraft Certification Office, ANM-100L.

Aircraft Maintenance Information

Maintenance records indicated that the accident airplane was not flown between May 1, 2000, and March 21, 2003. Annual inspections were performed on the airplane each year since manufacture except in 2000, 2001, and 2002. The entries for the annual inspections performed in 2004-2008 and 2010-2012 specifically noted that the wing attach bolts were torqued.

The wing hinge pins were inspected in accordance with Weatherly Service Note No. 15 on July 23, 1996, at a total time of 1,179 hours. A logbook entry on June 19, 2001 indicated that the wing leading edges were removed, stripped, primed, painted, and reinstalled. Two wingtip skins and two wingtip ribs were also replaced at this time. All applicable airworthiness directives were tracked in the maintenance records and had been complied with. The manufacturer's maintenance manual contained limited inspection information in Section XV, Periodic Aircraft Inspections. Step (n) in this section stated, "Remove wing bands and inspect wing hinge fittings." No other information in the manual addressed inspection of the wing hinge brackets.

The most recent inspection was an annual inspection completed on April 15, 2015, at a total airplane and tachometer time of 4,468.9 hours. The logbook entry indicated that the inspection was completed in accordance with 14 *CFR* Part 43, Appendix D, and stated, "Removed all inspection plates & checked structure." The tachometer time at the time of the accident was unknown due to impact damage. The last recorded maintenance logbook entry before the accident was for an oil change on August 22, 2015, at a tachometer time of 4,811.83 hours.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	LSE,656 ft msl	**Distance from Accident Site:**	9 Nautical Miles
Observation Time:	10:53 Local	**Direction from Accident Site:**	180°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	4 knots / None	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	30.2 inches Hg	**Temperature/Dew Point:**	20°C / 11°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Bancroft, WI (PVT)	**Type of Flight Plan Filed:**	None
Destination:	Hancock, WI	**Type of Clearance:**	None
Departure Time:	11:15 Local	**Type of Airspace:**	Class G

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:**	44.098331,-89.591392(est)

The main wreckage was located in a treed area beyond the southern edge of a potato field; portions of the wreckage were found in the southwest corner of the field. The airplane impacted the tops of several large trees before impacting the ground. All the components of the left wing leading edge assembly were located in the field north of the main wreckage site. The left outboard wing fixed trailing edge section and left wingtip assembly were located in the grass between the planted area of the field and the treed area.

Examination revealed that the left center section forward spar lower hinge brackets were fractured

vertically through the pin holes (Figure 1). The pin remained installed through the left wing forward spar lower hinge brackets with the fractured ends of the center section brackets captured by the pin. All the remaining spar attach points on the left and right wings were intact. The left wing spars, interspar structure, and skins were recovered at the main wreckage site with varying amounts of damage. The left wing leading edge, left wing tip and left fixed trailing edge section separated during the accident sequence and were recovered in the field. There was mechanical damage and deformation noted on the left wing and center section upper spar caps adjacent to the forward spar attach point. The damage was consistent with the outboard wing having rotated up more than 120º with respect to the center wing. The left wing rear spar was fractured through the outboard wing hinge bracket holes even though the brackets remained intact. The left wing structure was crushed downward between the spars and curled upward with yellow paint transfer noted on the internal wing ribs. The left aileron control tubes and left wing spray bar displayed significant upward deformation.

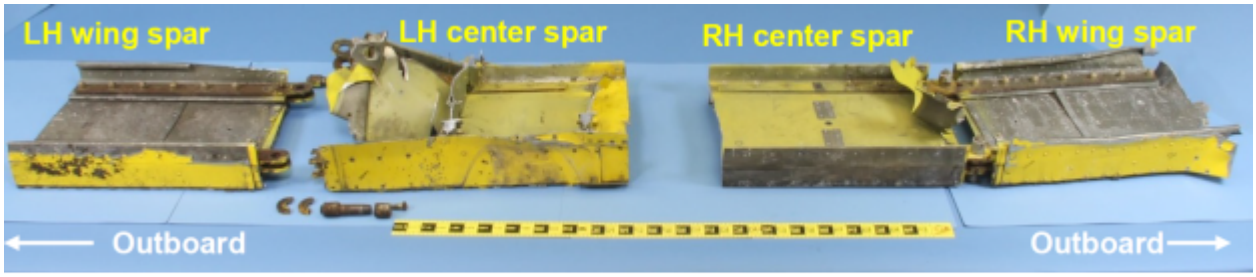

Figure: The sections of the left and right forward wing spar assembly sections, viewed aft looking forward angled from below, as received. The figure shows the separated pieces of the left center section forward spar lower hinge brackets, which are placed at the bottom of the left wing spar and left center section spar for the photo.

Medical and Pathological Information

The Fond du Lac County Medical Examiner, Fond du Lac, Wisconsin conducted an autopsy of the pilot. The autopsy stated that the cause of death was multiple blunt force injuries.

The FAA Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicological testing on specimens from the pilot. Testing was negative for ethanol, carbon monoxide, and all tested-for drugs.

Tests and Research

The wing forward spar attach points were removed from the accident airplane wreckage and sent to the NTSB Materials Laboratory for examination.

NTSB Materials Laboratory Examination of N2005C

The left center section forward spar lower forward hinge bracket exhibited a visible, flat, thumbnail-shaped crack containing crack arrest marks consistent with progressive fracture, which was determined to be fatigue. The crack arrest marks emanated from the aft corner of the pin hole. The fatigue crack measured 0.15 inch on the aft (inside) face, 0.19 inch along the pin hole, and 0.24 inch deep from the crack initiation corner. Examination of the crack in a scanning electron microscope revealed fatigue striations. The areas outside of the fatigue crack exhibited dimple rupture, consistent with subsequent overstress fracture.

A closer view of the initiation site revealed a small corrosion pit containing non-conductive deposits. Examination of the rest of the pin hole found multiple features consistent with corrosion pits along the surface, as well as shallow circumferential gouging. The upper side of the lower forward hinge bracket revealed a small flat region, absent shear lips, in the aft corner, as well as microscopic thumbnail cracks. These small fatigue cracks exhibited striations and ratchet marks consistent with multiple crack initiation sites on the pin hole surface. Cross-sectional metallographic inspection found corrosion pits on the pin hole surface.

The chemical composition of the lower forward hinge bracket was consistent with Type 4130 alloy steel. Examination of the corrosion products in the pits at the crack initiation sites revealed a material consistent with iron oxide.

The hardness of the lower forward hinge bracket was consistent with a tensile strength for an alloy steel. The microstructure exhibited features consistent with tempered martensite, which was consistent with a microstructure typical of this alloy and hardness.

The lower aft hinge bracket exhibited rough, tortuous fracture features and shear lips consistent with overstress failure; closer examination near the pin hole revealed small fatigue cracks. The lower side of the hinge bracket had small thumbnail cracks present along the pin hole surface. Examination of the larger of the two cracks revealed fatigue striations propagating downward from the pin hole. The crack initiation site contained a small corrosion pit.

The upper side of the aft hinge bracket exhibited small thumbnail-shaped fatigue cracks. One of these cracks was unique from the others examined in this investigation, as the crack initiation site contained an oxide inclusion. Examination of the inclusion using Energy-dispersive X-ray spectroscopy (EDS) found it to be consistent with aluminum oxide. The other, smaller fatigue crack on the upper portion of the aft hinge bracket had been smeared at the crack initiation site.

The discovery of additional microscopic fatigue cracks prompted the inspection of all the other hinge brackets submitted. These brackets were first detached from their respective wing spars, and the paint and primer around the pin holes was removed using a rotary wire brush. The brackets were then examined around the pin hole using magnetic particle inspection (MPI). MPI found small indications inside the pin holes of two of the hinge brackets; the lower forward hinge bracket from the right center

section forward spar and the lower forward hinge bracket from the left wing forward spar. These brackets were back cut and intentionally overstressed (laboratory opened) to reveal any preexisting cracks that might be present. No cracks were found in the right center section forward spar lower forward hinge bracket.

However, opening of the left wing forward spar lower forward hinge bracket revealed multiple fatigue cracks. The largest crack, about 0.03 inch maximum depth, was located on the forward side corner of the pin hole. This crack contained fatigue striations that propagated from a corrosion pit. There were multiple smaller thumbnail-shaped fatigue cracks that initiated at corrosion pits along the pin hole surface.

NTSB Materials Laboratory Examination of N20077

After the accident, the NTSB was notified of another Weatherly 620B airplane, S/N 1558, that had a cracked right wing forward spar lower aft hinge bracket. The right wing forward spar lower forward and aft hinge brackets were removed from the airplane and also sent to the NTSB Materials Laboratory for examination. That airplane had accumulated 4,337 total hours of operation. The center section of the wing was rebuilt due to corrosion in May 2007 at 3,138.9 hours total time. Examination found the right wing forward spar lower aft hinge bracket had fractured through the pin hole. The fractured lower aft hinge bracket was substantially oxidized, exhibiting enough iron oxide (rust) to obscure any fracture features. Both the upper and lower portions of the fractured hinge bracket exhibited crack arrest marks. Further examination of the fracture surfaces revealed fatigue striations. Almost all the fracture surfaces exhibited features consistent with fatigue. A small portion of the lower fracture surface and a smaller portion of the upper fracture surface exhibited dimple rupture features consistent with subsequent overstress failure.

Examination of the aft hinge bracket upper fracture surface revealed ratchet marks, consistent with multiple fatigue crack initiation sites. These crack initiation sites contained features consistent with corrosion pits along the pin hole surface.

The lower forward hinge bracket was inspected using MPI. The inspection revealed a small indication on the lower side. The bracket was back cut and laboratory opened. Both sides exhibited multiple thumbnail-shaped fatigue cracks propagating from corrosion pits on the pin hole surface.

Weatherly Aircraft's Model 620B Outer Wing Fitting Engineering and Failure Analysis Report

At the request of Weatherly Aircraft Company, AvSpec Corporation performed a postaccident engineering and failure analysis of the wing hinge brackets. According to the report, only a static strength evaluation of the wing brackets was performed with no dynamic, gust, or unsymmetrical loads.

The static strength analysis of the wing hinge brackets for the accident airplane was performed based on the known condition of the brackets at the time of the accident. Although there were fatigue cracks noted on all four fracture faces of the center section hinge brackets, the crack on the lower forward face was significantly larger than the others. The total area of cracking on the lower forward face was calculated to be 0.0377 in^2 based on the crack dimensions presented in the NTSB Materials Lab Report. This cracked area represented about 15% of the area of the single hinge bracket, or about 7.5% of the area of

the entire bracket assembly. The static strength of the bracket assembly was calculated assuming that only the largest fatigue crack was present, there was no effect on stress intensity due to the crack, there were no additional loads created due to the unbalanced load sharing, and the crack geometry did not affect the load distribution. The report calculated the static strength of the bracket assembly was reduced about 7.5% in shear-bearing and about 7.7% in tension due to the single fatigue crack.

The report stated that the aerodynamic and inertia loads in the wing brackets were calculated for various g-loads for an airplane operating at a maneuvering speed (Va) of 112 kts and a maximum gross weight (MGW) of 4,000 lb and 6,000 lb. Comparing these results to the calculated reduced static strength of the bracket assembly showed that the accident airplane should have been able to withstand aerodynamic and inertia loads generated by the airplane at +9.22 g vertical at 4,000 lbs MGW and +6.14 g vertical at 6,000 lbs MGW.

A similar analysis was performed for the other Weatherly airplane which was found to have an entire wing lower forward hinge bracket fractured. The intact wing hinge bracket on this airplane also had a small amount of fatigue cracking that was not considered in the analysis. Using the same assumptions, the bracket assembly was calculated to have a 50% reduction in the static strength for both shear-bearing and tension. This airplane should have been able to withstand aerodynamic and inertia loads generated by the airplane at +3.39 g vertical at 6,000 lbs MGW.

NTSB Group Chairman's Engineering Study of N2005C and N20077

The NTSB Airworthiness Group Chairman performed a structural loads study of the wing hinge brackets for both airplanes. The forward spar lower bracket assembly consisted of 4 mostly identical steel hinge brackets that were held together with a pin. The two wing hinge brackets fit inside the two center section hinge brackets with a pin installed through the bore of each bracket to attach the wing to the airplane. The bracket assemblies on the wing and center section are essentially fail-safe at limit load, which means that one bracket can carry the full limit load if the other bracket is failed. The accident airplane had a relatively small fatigue crack in one of the center section hinge brackets and the wing failed, while the other airplane that was provided had a fully cracked wing hinge bracket and had continued to fly with this configuration. The study showed that the design and geometry of the bracket assembly would produce eccentric loading of the remaining center section bracket in the event that the other failed; however, in the event of a wing bracket failure, no eccentric loading was produced in the remaining wing bracket in the event of a failure.

The static strength solution in the Weatherly engineering report did not provide a reliable estimate for the strength of a hinge bracket that was cracked. The crack will induce stress intensities dependent on the size of the crack that serve to reduce the residual strength of the bracket. The accident airplane had a pre-existing fatigue crack in the center section lower forward bracket that would likely have undergone a fast fracture failure at a load level of about 2.7 g based on the calculations in the study. The redistribution of the load into the center section lower aft bracket combined with the eccentric loading due to the geometry would likely cause a static failure of the aft bracket at the same load level.

The other airplane had more extensive fatigue cracking that had failed the wing lower aft hinge bracket. The bracket was failed for an unknown amount of time before its discovery and the airplane had reportedly been operated at gross weights up to 5,800 lbs. The geometry of the bracket assembly does

not allow for eccentric loading of the remaining wing bracket, so only tension loads are produced in the wing brackets. The lack of a wing failure further proves the fail-safe design of the brackets and accentuates the criticality of the eccentric loads on the accident airplane.

Additional Information

Weight and Balance Information

The Weatherly 620B was certified in the restricted category under Federal Aviation Regulations (FAR) 21.25(a) with policies contained in Civil Aeronautics Manual 8 (CAM 8) Appendix B. The airplane was certificated with an MGWof 4,000 lbs. Examination of the Weatherly certification reports showed that the airplane structure was analyzed at this MGW, with some limited analysis at an MGW of 4,800 lbs. Later versions of the airplane flight manual and marketing material from Weatherly contained information and performance charts for an MGW of 5,800 lbs. The guidance in CAM 8 states that there is no MGW established for agricultural aircraft. The operator is permitted to select a gross weight above the certificated MGW provided that the airplane is controllable and operates satisfactorily during a flight test at that weight. The flight test must be documented in the aircraft logbooks and via a Form ACA-337 (Major Repair and Alternation).

The most recent weight and balance report for the accident airplane was dated June 22, 2004, and indicated an MGW of 4,000.0 lbs; given an empty weight of 3,049.29 lbs, the useful load was 950.71 lbs. The empty weight did not include the weights of the pilot, useable fuel, baggage, hopper load, or spray system. The operator estimated that the gross weight of the airplane prior to takeoff on the accident flight was 5,084 lbs. There was no record of a flight check, nor did the maintenance logbook contain an entry noting an increased MGW.

Continued Airworthiness Information

The Weatherly design reports submitted to the FAA for certification were examined. The MGW used for the analyses was 4,800 lbs. The critical element of the wing structure was determined to be an aluminum reinforcement strap installed externally on the lower center section spar cap. A follow-up fatigue evaluation of the forward spar outer wing hinge brackets was performed in 1993 for the Australian authorities. The analysis determined that the factored fatigue life of the hinge brackets was 5,273 hours.

In August 2002, the Civil Aviation Safety Authority of Australia issued Amendment 1 to Airworthiness Directive (AD) W620/1 defining life limits for parts of the Weatherly 620 series wings. The AD established a life limit of 2,500 hours for the wing main spar lower cap assembly and a limit of 5,000 hours for the steel wing attachment brackets. The original AD was issued in November 1992.

On March 25, 2016, the FAA issued AD 2016-07-11, applicable to all Weatherly Aircraft Company 201, 201A, 201B, 201C, 620, 620A, 620B, 620B-TG, and 620TP airplanes as a result of preliminary NTSB investigation findings. The AD required a close visual inspection of the center and outer wing

forward spar lower hinge brackets for cracks and corrosion within 30-days of April 15, 2016. Cracked hinge brackets were required to be replaced and limited corrosion could be repaired. The results of all inspections were required to be reported to the FAA. As of the date of this report, the FAA has obtained information on 37 of the 94 total airplanes affected by this AD. No reports of cracked wing brackets, other than the 2 airplanes discussed in this report, have been received.

As of the writing of this report, Weatherly has manufactured replacement wing and center section hinge brackets for the 620B airplane based on the information from the investigation and the condition of other wing brackets in service. The new brackets are manufactured from 4130 steel. To improve the corrosion resistance of the brackets, the new brackets are cadmium plated. A service bulletin (SB) to provide instructions for inspection and replacement of the wing and center section hinge brackets was developed and incorporated on N20077. Repetitive inspection procedures in the SB call for a yearly corrosion inspection of the hinge brackets with replacement for any discrepancies beyond the limits specified. Procedures in the SB call for a more detailed inspection including removal of the hinge brackets every 5 years. The SB was issued on March 13, 2018. The FAA has indicated that they will make the SB mandatory through the issuance of an AD.

The FAA provided information on the roughly 4,700 restricted category agricultural airplanes on the U.S. registry. Nearly 3,900 of these airplanes include CAM 8 in the certification basis. With only two exceptions (Piper PA-36 and Cessna 188), the in-service maximum weight of these CAM 8 airplanes can be increased by a logbook entry. The FAA maintains that the detrimental effects of overweight operation to include the effect on fatigue life is adequately addressed through AD action once a problem is discovered.

Administrative Information

Investigator In Charge (IIC):	Gallo, Mitchell
Additional Participating Persons:	Paul Sweeney; Federal Aviation Adminstration; MKE FSDO; Milwaukee, WI Robert Poe; Weatherly Aircraft Company; Chicago, IL
Report Date:	April 10, 2018
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=91924