Aviation Investigation Final Report

Location:	Brunswick, North Carolina	**Accident Number:**	ERA16LA209
Date & Time:	June 10, 2016, 09:00 Local	**Registration:**	N2283M
Aircraft:	WSK PZL MIELEC M 18A	**Aircraft Damage:**	Destroyed
Defining Event:	Aircraft structural failure	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 137: Agricultural		

Analysis

The experimental, restricted-category airplane impacted wooded terrain after a separation of the right wing during an aerial application flight. The right wing separated under normal loading conditions due to extensive pre-existing fatigue cracking in the right outboard wing forward spar lower fitting as the result of corrosion in the hole bores. In addition, the outboard half of the right aileron separated during the accident sequence due to fatigue cracking in the right outboard aileron bracket.

Examination revealed evidence of moderate to severe corrosion throughout the airplane. Given the amount of fatigue cracking and the individual crack features of the spar fitting, it is likely that the cracking was present for an extended period of time before the final separation and also likely would have been visible during previous inspections. Maintenance records indicated that the airplane received an annual inspection about 6 months before the accident and inspection of the wing fittings in accordance with a Federal Aviation Administration airworthiness directive; however, these inspections failed to detect the pending failure of the right wing, indicating that they were performed inadequately or improperly. The maintenance records also indicated that the wing fittings on the accident airplane had been replaced on three occasions in the 15 years before the accident, indicating that proper cleaning and corrosion prevention procedures were not being performed.

The airplane was operated over its certificated maximum gross weight on the accident flight and likely had been operated overweight for much of its lifetime. About 11 years before the accident, the airplane was outfitted with a larger hopper, increasing its capacity from 660 gallons to 800 gallons. While the increased hopper volume is beneficial for operation with lower-density solid or dry chemicals, it could easily be loaded with up to twice the certificated weight of liquid chemicals. Although the manufacturer published provisions for increasing the operating weight of the airplane, it required that the airframe service life limit of 10,000 hours be reduced by a factor of 1.35. Review of maintenance records indicated that not only did the operator not apply any service life limit factors to account for the overweight operation but that a reduction in overall airframe time was annotated several years before the accident; this reduction could not be reconciled based on the information presented in the records. Given the lack of information about its operating history, the actual service life of the airplane could not be

determined; however, it is likely that the airplane was close to or had exceeded its service life, particularly given the overweight operation. Although the failed wing fittings had not accumulated the service life limit due to their replacement, the corrosion found throughout the airplane and its routine overweight operation would have reduced the true service life of the fittings.

In addition to the increased airframe stress imposed by continuous overweight operation, the airplane was modified to install a turbine engine many years before the accident. The engine conversion likely caused more severe flight loads than accounted for in the design of the original radial piston engine-equipped airplane, further rendering the manufacturer-published service limits inadequate.

Probable Cause and Findings

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

The failure of the right wing due to a fatigue fracture of the right outboard wing forward spar lower fitting. Contributing to the accident was the routine operation of the airplane over its certificated maximum gross weight and the operator's improper or inadequate maintenance practices, which failed to apply a service life factor to the airplane to account for its overweight operation and also failed to detect the extensive corrosion throughout the airplane.

Findings

Aircraft	Attach fittings (on wing) - Fatigue/wear/corrosion
Personnel issues	Scheduled/routine maintenance - Maintenance personnel
Organizational issues	Oversight of maintenance - Operator
Organizational issues	Oversight of operation - Operator
Aircraft	Maximum weight - Capability exceeded
Aircraft	(general) - Fatigue/wear/corrosion

Factual Information

History of Flight

Maneuvering-low-alt flying	Aircraft structural failure (Defining event)
Maneuvering-low-alt flying	Part(s) separation from AC
Uncontrolled descent	Collision with terr/obj (non-CFIT)

HISTORY OF FLIGHT

On June 10, 2016, about 0900 eastern daylight time, an experimental WSK PZL MIELEC M-18A, N2283M, was destroyed following an inflight separation of the right wing while maneuvering near Brunswick, North Carolina. The commercial pilot was fatally injured. Visual meteorological conditions prevailed, and no flight plan was filed for the aerial application flight, which was operated by Canam Aviators Inc., under the provisions of Title 14 *Code of Federal Regulations* Part 137. The flight originated from Bear Pen Airstrip (NC43), Supply, North Carolina, around 0845.

According to ground personnel, the airplane departed with a full load of fertilizer and 45 minutes of fuel with 30 minutes of reserve fuel. After 1 hour passed and the airplane did not return to the airport, ground personnel called 911 to report the airplane missing. The airplane was subsequently located in a wooded area.

PERSONNEL INFORMATION

According to Federal Aviation Administration (FAA) records, the pilot held a commercial pilot certificate with ratings for airplane single-engine land, airplane multiengine land, instrument airplane, and rotorcraft-helicopter. He also held an FAA second-class medical certificate, which was issued on May 13, 2016. At the time of the medical examination, the pilot reported 30,576 total hours of flight experience. The pilot's logbook was not recovered.

AIRCRAFT INFORMATION

The airplane was manufactured in 1994 and imported to the US, where it was issued a special airworthiness certificate in the restricted category. The accident operator purchased the airplane in 2003.

The most recent annual inspection was performed on January 15, 2016, at 8,567.9 hours total time in service. All of the inspection and maintenance entries from October 17, 2012, to the time of the accident were performed by the same company and mechanic. There were four annual inspections completed in this timeframe, and all entries specified that the inspections were conducted in accordance with the M-18 Service Manual. There was no specific information to indicate which of the published inspections from the manual were performed.

The airplane wing is composed of three sections; the center section and the right and left outboard sections. The outboard wing sections are connected to the center wing at three points each: two on the forward spar and one on the aft spar. The center section contains clevis fittings at the forward spar upper and lower spar caps and a clevis fitting at the aft spar. Corresponding lug fittings on the outboard wing sections fit into the center wing clevis fittings. The forward spar connections use an expansion mandrel installed through the bores of the center wing clevis and wing lug fittings. The aft spar connection uses a bolt installed through the bores of the center wing clevis and wing lug fittings.

An FAA inspector estimated that the takeoff weight was about 11,787 lbs, using an airplane empty weight of 5,975 lbs, chemical weight of 4,940 lbs (800 gallons), a fuel weight of 692 lbs (1.5 hours), and a pilot weight of 180 lbs.

AIRPLANE MODIFICATION AND MAINTENANCE HISTORY

The type certificate for the PZL M-18A was approved by the FAA in September 1987. The maximum weight was 9,260 lbs with a maximum hopper weight of 3,300 lbs regardless of the hopper capacity.

The original engine was removed from the accident airplane in April 1996 and replaced with a Honeywell TPE 331 turbine engine driving a Hartzell 3-blade, constant speed, reversing and feathering propeller in accordance with STC SA09039SC. Geared servo tabs were installed on the ailerons, elevators, and rudder in accordance with STC SA09063SC as part of the engine conversion. At the time of the modification, the airplane had accrued 997.0 hours total time in service. The airplane was again modified in January 2005, in accordance with STC SA09039SC, to install a different Honeywell TPE331 turbine engine driving a Hartzell 5-blade constant-speed reversing and feathering propeller. The airplane had accrued 5,153.7 hours total time in service at the time of this modification. The maximum weight approved as part of the STC was 9,260 lbs with the spray bar installed and 8,800 lbs with the spreader installed. A modified hopper was also installed at this time, which increased the hopper capacity to 800 gallons.

A logbook entry at an airframe time of 6,389.0 hours on June 21, 2006, indicated that the service life of the airplane was increased to 10,000 hours by incorporation of a manufacturer service bulletin. An entry on October 9, 2009, adjusted the total time in service of the airframe from 7,630 hours to 6,147 hours. The explanation provided in the entry indicated that the hour meter installed was recording incorrectly. On February 20, 2014, at an airframe time of 8,042.0 hours, a logbook entry documented the replacement of both left lower wing attach fittings and expanding mandrel in accordance with SB E/02.170/2000. On July 2, 2015, a logbook entry documented the replacement of the wing center section with a used serviceable unit with an estimated total time of 7,460 hours; the airframe time was 8,562.9 hours.

WRECKAGE AND IMPACT INFORMATION

Examination of the wreckage by an FAA inspector revealed that the debris path was oriented from south to north. The wreckage area was compact except for the right wing and one propeller blade, which were located about 125 ft east of the main wreckage. The airplane impacted in a nose-down attitude of about 60°. The left wing was located on top of the engine and separated from the fuselage. The fuselage, cockpit, and hopper were found 10 ft north of the initial impact point. The remainder of the empennage

was found 20 ft north of the cockpit. Small pieces of debris were found within a 50-ft radius of the initial impact point.

Further examination of the airplane by an NTSB investigator revealed that the right outboard wing forward spar lower fitting was fractured. Additionally, the right outboard aileron attach bracket was fractured, and visible cracks were evident on the right center and inboard aileron attach brackets. The fractured wing fitting, a fractured wing fitting attach bolt, and all three aileron attach brackets were sent to the NTSB Materials Laboratory Division in Washington, D.C. for analysis.

ADDITIONAL INFORMATION

Metallurgical Examination

The right outboard wing forward spar lower fitting fractured through the upper and lower arms in the areas indicated by arrows in figure 1. Each arm contained six vertical bolt holes used to attach the fitting to the outboard wing forward spar. The fracture in the upper arm intersected the inboard vertical bolt hole, and the fracture in the lower arm intersected the second vertical bolt hole from the inboard end. Bench binocular microscope of the fractured arms revealed all the fracture faces contained fatigue cracks that emanated from the bore of the holes on diametrically opposite sides of each hole, in the areas indicated by brackets "O" in figure 1.

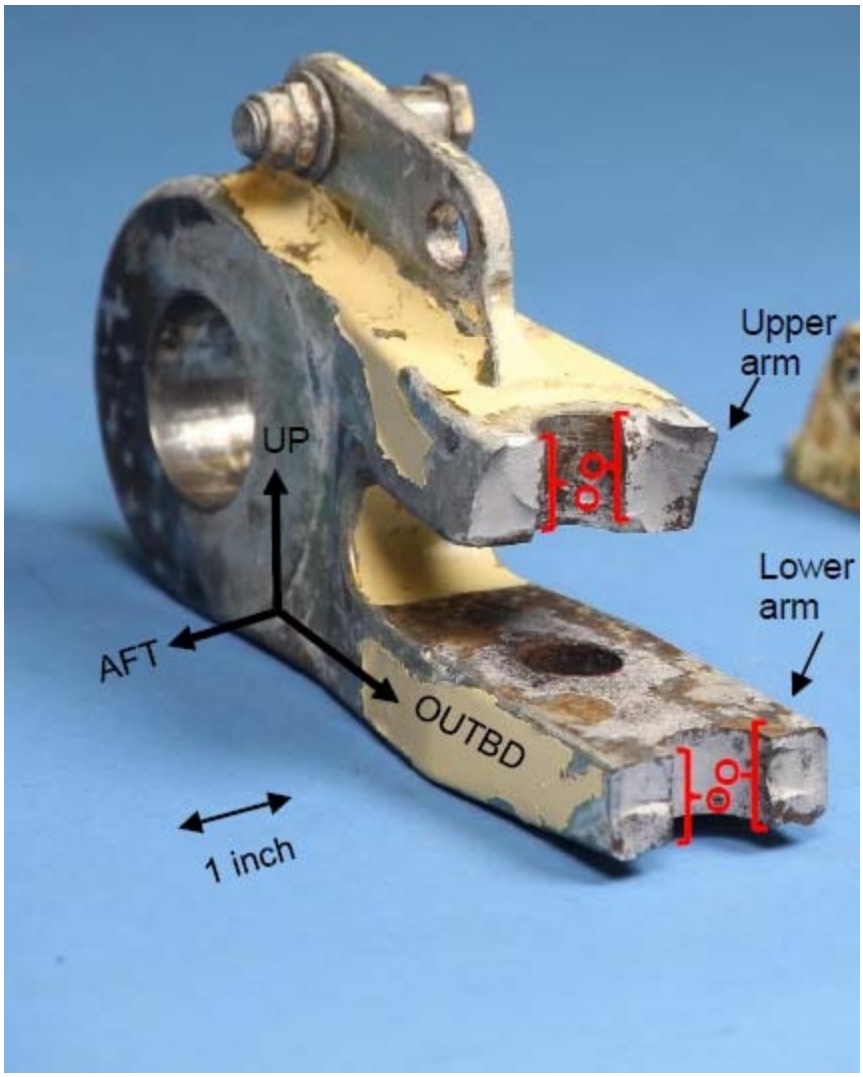

Figure 1. Right outboard wing forward spar, lower fitting.

Figure 2 shows a photograph of the lower arm fracture faces. The fatigue cracks in the lower arms initiated from multiple origins along the entire length of the bolt hole, in the areas indicated by brackets "O" in figure 2. Most of the fatigue crack origins were associated with corrosion pitting in the bore. Fatigue propagation on each side of the hole was through a 90% of the thickness and terminated in the areas indicated by dashed lines in figure 2.

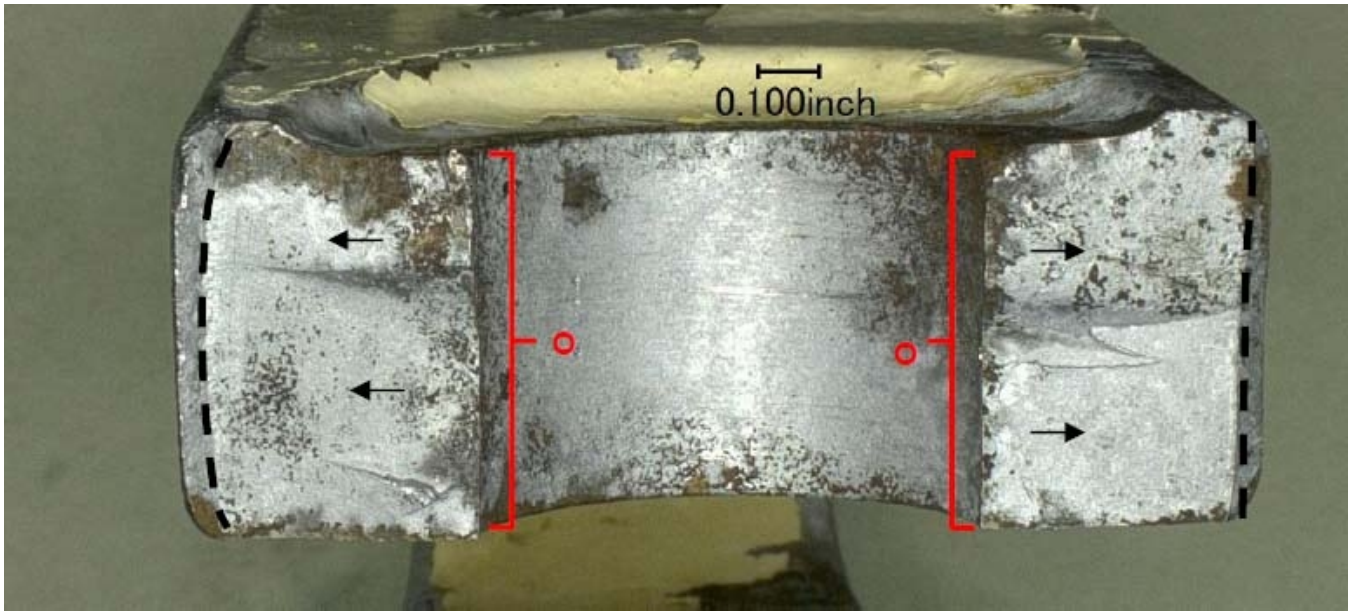

Figure 2. Right outboard wing forward spar, Lower fitting, Lower arm.

Figure 3 shows a photograph of the upper arm fracture faces. The upper arm fractures contained similar fatigue cracks with the exception that the fatigue cracks initiated from multiple origins near the lower portion of the bolt hole. Most of the fatigue crack origins were associated with corrosion pitting in the bore. The fatigue cracks in the upper arms exhibited better defined fatigue fracture features than those on the lower arms.

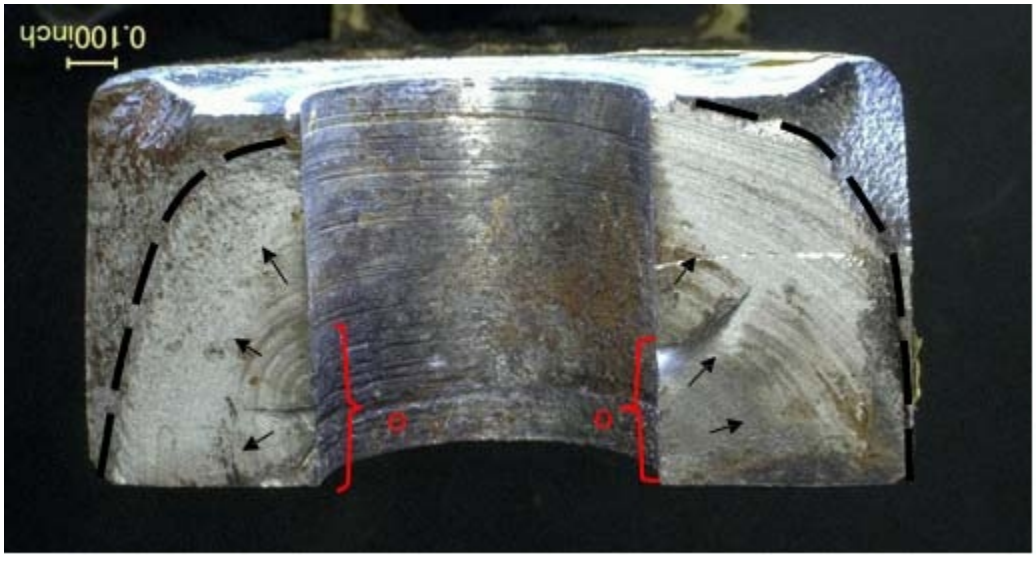

Figure 3. Right outboard wing forward spar, lower fitting, upper arm.

The fractured bolt examined was installed through the third vertical bolt hole in the right outboard wing forward spar lower fitting. The fracture intersected the root thread portion of the bolt. The fracture face of the bolt contained fatigue cracks that emanated from multiple origins all around the root portion.

Fatigue propagation was toward the center of the bolt and extended through about 95% of the bolt cross section.

Figure 4 shows a photograph of the right outboard aileron attach bracket, which contained a circumferential fracture in the main tube portion, near the location where the two upper arms were welded to the main tube. The fracture intersected the aft edges of the welds at the base of the two arms, indicated by arrows "X" in figures 4. Bench binocular microscope examination of the forward face of the main tube fracture revealed multiple fatigue cracks that emanated from the outer surface of the main tube at the aft edges of the welds. Fatigue propagation was through about 50% of the thickness and extended around about 30% of the tube circumference. Corrosion was noted on the outboard tube surface.

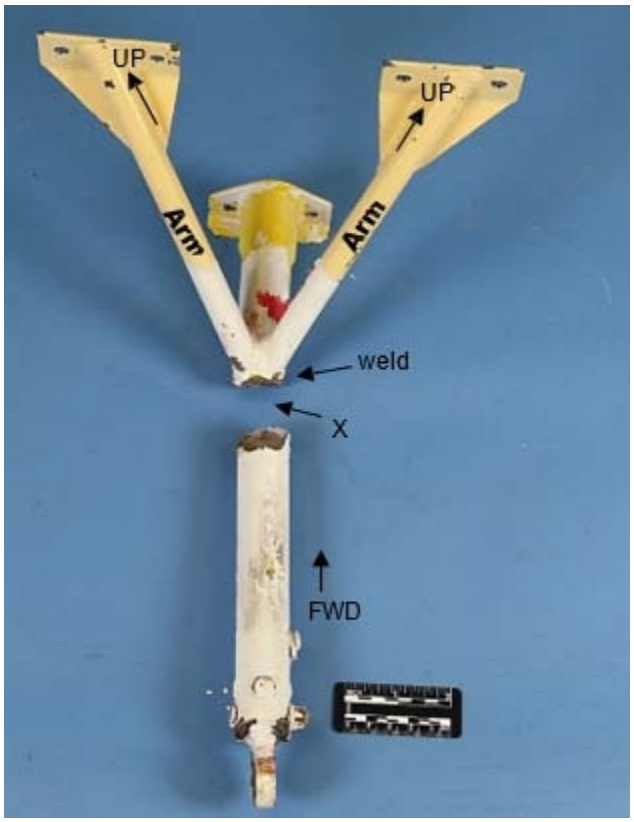

Figure 4. Right outboard aileron attach bracket.

The right center and inboard aileron attach brackets were intact, but both brackets contained visible cracks in the white paint layer where the two upper arms were welded to the main tube. The paint was removed with a commercial paint stripper from the weld areas of the intact brackets. Bench binocular microscope examination of both intact brackets after paint stripping revealed the presence of corrosion and intermittent cracks on the outer surface of the welds in the same respective location as the fracture on the outboard bracket. The cracks were not opened, but examination of the inner face of the main tube portion for both intact brackets revealed the intermittent cracks did not extend through the thickness.

Manufacturer Information

The PZL M18 Description and Service Manual provides procedures for maintaining and inspecting the airplane, including procedures for corrosion prevention and control; particular emphasis was placed on the cleaning of the airplane, with the statement that "regular and thorough cleaning of both the interior and exterior of the aircraft is a major part of corrosion control." The instructions for cleaning included the statement, "particular attention should be given to wing fittings." In addition, the manual provides instructions for non-destructive inspection of airframe structural fittings, with specific details for the wing fittings and anti-corrosion protection of the wing fittings. The manual also includes a maintenance schedule that contains procedures for verifying inspections every 3,000 flight hours, and periodic inspections at 50, 100 and 500 flight hours. The manual calls for a mandatory annual inspection within the scope of the 500-hour inspection and special verifying inspections each 3,000 hours of operation.

According to the PZL M18 Aircraft Repair Manual, the airframe has a service life of 10,000 flight hours. The left aft center-wing-to-fuselage attach fitting has a service life of 3,000 flight hours. The manual also defines an "Airframe Service Life in Overload Version." The original airframe service life was calculated for a takeoff weight of 10,340 lbs. There are procedures to increase the takeoff weight to 11,700 lbs, which, according to the manual, "causes higher fatigue wear and drop of service life by 1.35 times." For all operations performed above the standard weight of 10,340 lbs, the operator should multiply the flight hours by 1.35 to obtain the proper flight hours for calculating the service life of the airplane.

The manufacturer issued Service Bulletin (SB) E/02.159/97 in 1997 to provide instructions for corrosion protection of the outboard wing forward spar fittings as a result of findings on four airplanes that were operated in Greece. The bulletin provides instructions for inspection of the fitting arms where they attach to the forward spar, removal of any corrosion within limits, and protection of the fittings by application of a corrosion inhibiting compound. The bulletin also provides instructions for adding an inspection panel in the lower leading edge of the outboard wing to improve access to the outboard wing forward spar fittings. The accident airplane did not have the inspection panel specified by this SB.

The manufacturer issued SB E/02.170/2000 in August 2000 to provide instructions for inspection of the wing attach joints as a result of two accidents in the United States. The accidents were caused by corrosion in the lower wing attach fittings that resulted in fatigue cracking and failure of a fitting lug. The SB provides instructions for inspection of the wing fittings for corrosion in the lug bore and on the exterior surface of the fittings, repair of minor corrosion, inspection for ovalization of the lug holes, and magnetic particle inspection of the fitting lugs for cracks. The procedures do not require removal of the outboard wings but do require removal of the expansion mandrels. Procedures are also provided for replacement of the wing fittings, if necessary, with the recommendation that both left and right pairs of lower wing fittings should be replaced, even if only one pair has damage beyond limits. There are no specific procedures for inspection of the vertical holes where the fittings attach to the spar. The provisions of this SB were subsequently mandated by airworthiness directive (AD) 2000-18-12. The manufacturer issued Service Letter M18/034/2016 in February 2016 with instructions that only the magnetic particle inspection method is applicable for the SB and suggesting that the wings be removed from the airplane to better perform the inspection.

In January 2001, the manufacturer issued SB E/02.172/2001 to provide guidelines for increasing the service life of the airframe up to 10,000 flight hours for airplanes S/N 1Z001-01 through S/N 1Z028-01, which included the accident airplane. The SB instructed operators to perform the 3,000-hour special inspection in the Service Manual with particular attention paid to incorporation of all applicable

mandatory bulletins on the airplane and corrosion, cracks and wear in the outboard wing-to-center wing attach fittings.

There are two published Airplane Flight Manuals (AFM) for the airplane: a European Aviation Safety Agency (EASA)-approved version for those airplanes operating outside the United States, and an FAA-approved version. The EASA-approved AFM is used by other airworthiness authorities around the world, and provides for the operation of the airplane at increased gross weights up to 11,700 lbs, with the stipulation that a service life factor of 1.35 be applied for those flights above 10,340 lbs.

The FAA-approved AFM specifies that the airplane is certificated in the restricted category for agricultural operations and dispensing fire-fighting materials. The limitations specify a maximum takeoff and landing weight of 9,260 lbs, a maximum hopper load of 3,300 lbs, a never exceed speed of 151 knots, a maximum cruising speed of 124 knots, maneuvering load factors of +3.4g and -1.4g, and prohibits operational flights with a person in the mechanic's seat. The FAA AFM does not specify a service life factor since the airplane is certificated at a gross weight of 9,260 lbs.

FAA Information

In September 2000, the FAA issued Airworthiness Directive (AD) 2000-18-12 to address corrosion and cracking of the wing attach fittings on all PZL M-18, M-18A, and M-18B airplanes as a result of two wing separation accidents. The AD required that operators inspect the center wing-to-outboard wing attach joints for cracks in the lugs, corrosion in the main holes, and ovalization of the main holes every 1 year or 500 hours time in service (whichever occurs first), repair corrosion and apply anti-corrosion protection, replace the wing attach joints as necessary, and eliminate any ovalization of the wing main joint holes. The AD specified that the inspection of the main holes must be done using magnetic particle methods and all other procedures were to be in accordance with manufacturer SB E/02.170/2000. The procedures published in the SB and AD were focused on the main attach lug and clevis on the wing fittings and did not specifically address the vertical bolt holes where the fittings attached to the wing or center section forward spar.

The AD was first complied with on the accident airplane on January 9, 2001, at an airframe total time of 4,195.7 hours. The records indicated that the left and right forward spar, lower wing attach fittings on the outboard wings, and the center section were replaced with new fittings as a result of the inspection, along with the wing straps and the left aft center-wing-to-fuselage attach fitting. The upper fittings were found to be serviceable. SB E/02.170/2000 was also complied with. The most recent AD inspection of the wing fittings was performed in January 2016, at an airframe total time of 8,567.9 hours, with no discrepancies noted.

FAA Advisory Circular (AC) 23-13A provides guidance on the fatigue, fail-safe, and damage tolerance evaluation of metallic structure for normal, utility, acrobatic, and commuter category airplanes. Section 1-6 of the AC is applicable for alterations, modifications, or changes to the design and states, "Changes to the operational characteristics that may be important for fatigue include higher design airspeeds or higher average speed. They also include changes to the maximum allowable weight and center of gravity envelope, changes to the average weight and center of gravity location, and engine or propeller changes." Further, the section discusses a comparative fatigue analysis that should be performed when a modifier does not have access to the data from a manufacturer.

The manufacturer was not able to supply any information on the modification of the M-18A airplane by installation of a turbine engine, including any changes to the flight loads, fatigue spectrum, or reliability data. They were aware that there are STC provisions for the modification, but were not consulted for the modification by the STC holders.

Australian Transport Safety Bureau Investigation

The Australian Transport Safety Bureau (ATSB) investigated an accident involving a PZL Mielec M-18A airplane that suffered an in-flight failure of the left wing in October 2013. The details of the investigation can be found in ATSB Report AO-2013-187. The airplane was equipped with a TPE331 turbine engine. They determined that there was fatigue cracking that initiated due to corrosion pitting in the bore of the left outboard wing forward spar lower fitting attach lug. The fatigue cracking was only present on one leg of the lug and comprised about 19% of the total cross-sectional area of the fractured lug. The ATSB used 25 hours of recorded data from the accident airplane to develop a maneuver load spectrum for comparison with the manufacturer's design load spectrum and the FAA load spectrum for agricultural operations published in AC 23-13A. Analysis of the load spectrums showed that "the negative acceleration fraction spectrum correlated well with the other reference spectra, falling between the FAA and aircraft manufacturer's spectra" and "other than at low acceleration fractions, the positive acceleration fraction spectrum was significantly greater than both the FAA and aircraft manufacturer's spectra." The manufacturer calculated the effect of the derived spectrum, flight time, and operating speed on the airplane's fatigue life and found that the fatigue life could be reduced by a factor of as much as 3.85.

Additionally, the ATSB found that the airplane had been operated at higher speeds than assumed by the manufacturer and at weights above the certificated maximum gross weight, that the flight loads imposed on the airplane were more severe than assumed during design, and that the service life factors were not appropriately applied for these operations. This resulted in greater fatigue damage than anticipated by the manufacturer, rendering the service life limits and inspection intervals inadequate for the operation of the airplane.

Pilot Information

Certificate:	Commercial	**Age:**	57,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Single
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	3-point
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane single-engine; Instrument airplane	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	May 13, 2016
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	(Estimated) 30576 hours (Total, all aircraft), 99999 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	WSK PZL MIELEC	**Registration:**	N2283M
Model/Series:	M 18A B	**Aircraft Category:**	Airplane
Year of Manufacture:	1994	**Amateur Built:**	
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	1Z024-25
Landing Gear Type:	Tailwheel	**Seats:**	1
Date/Type of Last Inspection:	January 15, 2016 Annual	**Certified Max Gross Wt.:**	9260 lbs
Time Since Last Inspection:	350 Hrs	**Engines:**	1 Turbo prop
Airframe Total Time:	8567.9 Hrs as of last inspection	**Engine Manufacturer:**	Honeywell
ELT:	Not installed	**Engine Model/Series:**	TPE 331-11UA-
Registered Owner:	CANAM AVIATORS INC	**Rated Power:**	940 Horsepower
Operator:	CANAM AVIATORS INC	**Operating Certificate(s) Held:**	Agricultural aircraft (137)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KSUT,25 ft msl	**Distance from Accident Site:**	18 Nautical Miles
Observation Time:	08:50 Local	**Direction from Accident Site:**	132°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	6 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	310°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.1 inches Hg	**Temperature/Dew Point:**	26°C / 21°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Supply, NC (NC43)	**Type of Flight Plan Filed:**	None
Destination:	Supply, NC (NC43)	**Type of Clearance:**	None
Departure Time:	08:45 Local	**Type of Airspace:**	Class E

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:**	34.127498,-78.339721

Administrative Information

Investigator In Charge (IIC):	Boggs, Daniel
Additional Participating Persons:	Clyde McCullough; FAA; Greensboro, NC Tomasz Makowski; State Commission Aircraft Accident Investigation; Warsaw Janusz Pietruszka; PZL Mielec; Mielec
Original Publish Date:	April 17, 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=93360