



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

June 16, 2023

Attachment 1. Accidents with Lower Strength Restraint Failures

SURVIVAL FACTORS

1.0 Completed Accidents

1.1 SEA96LA114

On June 7, 1996, at approximately 0530 mountain daylight time, a Cessna T188C, N4970J, operated by Lemmon Flying Service of Roundup, Montana, collided with terrain approximately 20 miles northeast of Roundup during a 14 CFR 137 agricultural aerial application flight. The single-seat restricted-category agricultural airplane was destroyed, and its commercial pilot suffered serious injuries.

Postaccident examination of the airframe revealed that the pilot's upper torso harness attach ring broke during the accident sequence (see figure 1). The seat and seat belts were documented as being checked during the aircraft's last annual inspection, performed on April 5, 1996, at 1,226.7 hours AFTT. The operator reported an AFTT of 1,336 hours at the time of the accident. Photographs of the fractured part showed that the two fracture faces were on a 45-degree plane to the direction of load on the part. The fractures were through two legs of the triangle, along a line parallel to the third leg (which anchors the harness strap.) The attach ring bolts to the airframe at the apex of the triangle, opposite the third leg. A photograph of the manufacture tag sewn to the seat belt indicated that the belt assembly had a rated strength of 1,500 pounds and conformed to FAA Technical Standard Order (TSO) C22f. The tag indicated that the belt was manufactured by Aero Fabricators of Lyons, Wisconsin, on January 4, 1993. FAA Advisory Circular (AC) 20-36S indicates that Aero Fabricators holds a TSO-C22f authorization to manufacture safety belts.

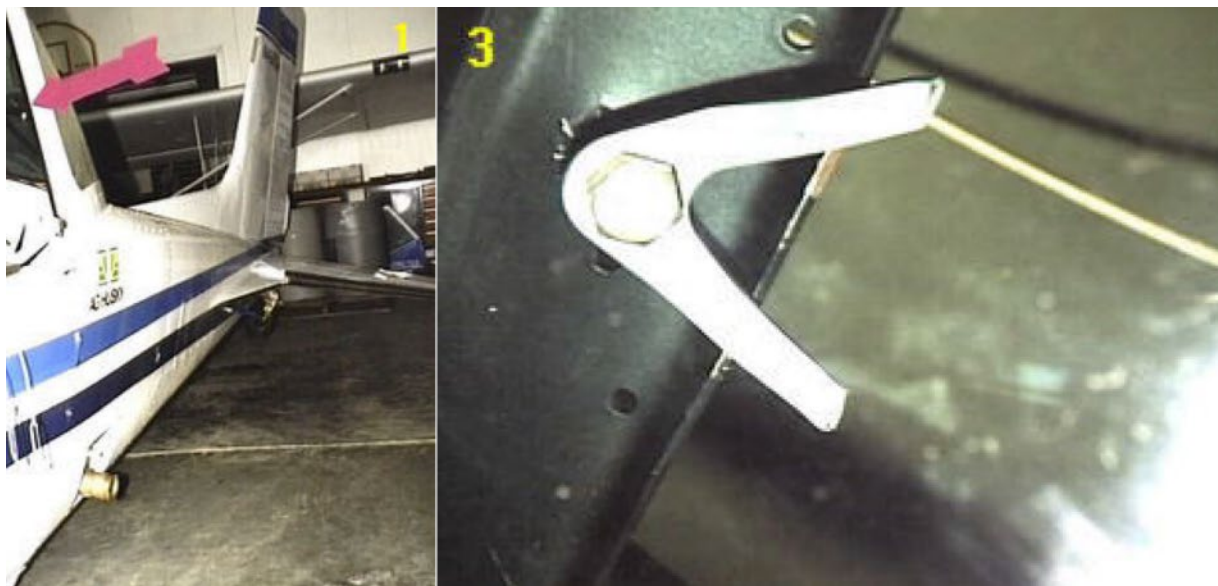


Figure 1. Cessna T188C, N4970J, pilot seat upper torso harness attachment point and bracket.

1.2 CHI99LA258

On July 24, 1999, at 1830 central daylight time, an Air Tractor 401B, N6006A, operated by Bakke Flying Service, received substantial damage on impact with terrain while spraying a potato field located approximately 2 miles north of McCanna, North Dakota. The pilot sustained serious injuries.

The left upper torso harness was found separated following the accident. The upper torso harness was removed and sent to the National Transportation Safety Board's (NTSB's) Materials Laboratory for examination. The NTSB's Material Report stated. "...Generally the harness appeared to be of uniform coloration...". Three sections of the harness were removed and delivered to an independent testing laboratory for tensile testing. The test results for the three sections indicated ultimate loads of 4,920 lbs, 4,760 lbs, 4,670 lbs. The test report also stated, "...In all three cases the failure initiated in the harness adjacent to the double 'X' stitching .. A test certificate ... indicated that a harness, part number 500702-403, was tested on April 13, 1989 for Air Tractor. It had a rated strength of 1,500 pounds and failed at 3,300 pounds when an end fitting broke. Testing was reported as in compliance with TSO-C22e (NAS 802), single occupancy." The separated ends of the left upper torso harness had, "...numerous individual filaments protruding from the surface almost obscuring the pattern of the strands..." The area containing the protruding filaments extended approximately one inch below the separated ends above which was the harnesses adjusting roller. Areas along the separated ends exhibited "horsetailing". According to the Materials Laboratory Factual Report, "...Horsetailing" is a product of the material properties and the differences in the energy stored during separation."

1.3 CHI00FA170

On June 23, 2000, about 2030 central daylight time, an Aeronca 7AC, N81681, sustained substantial damage on impact with terrain west of the approach end of runway 12 (4,098 feet by 75 feet, dry asphalt) at Airlake Airport (LVN), near Lakeville, Minnesota (see figure 2). The commercial rated front seat pilot was fatally injured and the commercial rated rear seat occupant was seriously injured.



Figure 2. Aeronca 7AC, N81681 at the accident site in Lakeville, MN.

An aluminum-colored seat belt end from the rear seat was found detached from the fastener that secured it. That fitting's hole was found deformed and a section was torn in the radius area about that hole (see figure 3).



Figure 3. Photograph of rear seat belt attachment hardware failure.

1.4 ANC05FA070

On April 30, 2005, about 1715 Alaska daylight time, a tundra tire equipped F-19 Taylorcraft, N3691T, sustained substantial damage following a loss of engine power and loss of control during the takeoff/initial climb from runway 36 at the Chena

Marina Airpark, Fairbanks, Alaska (see figure 4). The commercial certificated pilot was fatally injured which was attributed to multiple blunt force trauma according to the autopsy, including left rib fracture, laceration of the aorta, inferior vena cava, and pericardium. The sole, pilot-rated passenger, received serious injuries.



Figure 4. Taylorcraft F-19, N3691T, at the accident site in Fairbanks, AK.

Postaccident examination of the airframe revealed that the pilot's TSOC22f upper torso harness failed at the point where the single anchor, or tail strap, attached to the V-shaped upper torso restraint straps (see figure 5). The passenger received serious injuries and was hospitalized for several weeks. Her upper torso restraint system did not fail.



Figure 5. Picture showing intact right side passenger harness, and left side pilot failed upper torso harness.

The pilot's and passenger's upper torso harnesses were sent to the NTSB Materials Laboratory for testing and failure analysis. The report notes, in part, that the pilot's harness failed at the stitching where the anchor strap was sewn to the junction of the upper torso restraints. The webbing material was tensile tested to failure, albeit without the ability to test the box stitching at the attachment point. The material was found to fail at 3,840 pounds, exceeding the minimum of 2,250 pounds as specified in Technical Service Order C22f for webbing material, which was applicable when the harnesses were reportedly purchased. A test was also performed on the passenger's harness. The webbing material again failed at a strength exceeding the minimum requirements, but the box stitching joint failed at 995 pounds, significantly below the minimum of 1,500 pounds.

1.5 LAX06LA036

On November 15, 2005, at 1540 Pacific standard time, a Ryan Aeronautical ST3KR (Ryan PT22) airplane, N56038, impacted terrain following a loss of control while maneuvering near Lincoln, California (see figure 5). The airline transport pilot, who was the owner of the airplane, operated it under the provisions of 14 CFR Part 91 as a personal flight. The pilot, who was the sole occupant, received serious injuries, and the airplane sustained substantial damage.



Figure 6. Ryan Aeronautical ST3KR, N56038, at the accident site in Lincoln, CA.

Postaccident examination revealed that the stitching of the pilot's TSO C22f upper torso harnesses was torn from the restraint attach webbing. Examination of the belt revealed it was manufactured on March 19, 1999, by Aero Fabricators of Lyons, Wisconsin. The data tag on the belt indicated that the rated strength of the assembly was 1,500 pounds.

1.6 CHI08FA196

On July 21, 2008, about 1030 central daylight time, a Czech Aircraft Works Sport Cruiser, N602CF, sustained substantial damage when it impacted terrain near Cushing Field (0C8), Newark, Illinois (see figure 6). The sport pilot received fatal injuries.



Figure 7. Czech Sport Cruiser, N602CF, at the accident site in Newark, IL.

Postaccident examination of the airframe revealed that the pilot's TSO C22f upper torso harness revealed that the single strap of the upper torso harness that attached the harness to the rear cabin bulkhead was separated from the upper torso harness yoke where it was stitched to the right and left upper torso straps. The stitching had failed at the attach point (see figure 8). The pilot's and co-pilot's seat belt and upper torso harness assemblies were removed from the airplane and sent to the NTSB's Materials Laboratory for examination. The pilot's harness was in four pieces. The pilot's seat belt portion of the harness had been cut in two locations during the on-site recovery. The co-pilot's harness was intact.

Two exemplar harness sets (labeled EX1 and EX2) were obtained for the purpose of examination and destructive testing. In order to determine the strength of the sewing pattern at the yoke (where the pilot's harness failed) the exemplar harnesses EX1 and EX2 were subjected to tensile testing. For comparison, the sewing location at the rear fitting of the harness was also tested. The tensile test revealed that the EX1 harness yoke failure occurred at a load of 1,458 pounds, and the rear location failure occurred at a load of 3,384 pounds. The EX2 harness yoke failure occurred at a load of 1,456 pounds, and the rear location failure occurred at a load of 3,375 pounds.



Figure 8. Upper torso harnesses and seat belts.

Although there was intrusion into the cockpit and some buckling of the forward portions of the aircraft into the occupied space, the physical evidence appears to indicate that the deformation stopped forward of the base of the control stick. In addition, the upper torso harness failed at the stitching indicating that the harness was under load, which likely would not have been the case if the control stick were impacting the pilot's upper body. The control stick may have been displaced aft but likely not to the extent to impact the pilot if his restraint system were intact. The severity of the crash, the intrusion into the cockpit and the pilot's age may still have resulted in injuries severe enough to result in a fatality.

1.7 WPR10LA119

On January 25, 2010, about 1521 Pacific standard time, a Czech Aircraft Works Sportcruiser airplane, N243SC, was substantially damaged during a forced landing following a loss of engine power in cruise flight near La Quinta, California (see figure 9). The airplane was registered to Desert West Aviation, Palm Springs, California, and operated by the pilot under the provisions of Title 14 Code of Federal Regulations Part 91. The airline transport pilot and pilot-rated passenger sustained serious injuries.



Figure 9. Czech Sport Cruiser, N243SC, at the salvage facility in La Quinta, CA.

Postaccident examination of the airframe revealed that the left seat restraints remained attached to the airframe via all mounts. However, the left and right upper torso restraints were found separated from the single strap that originated from the aft mount (see figure 9). The area of separation appeared was reportedly not cut by first responders or aircraft recovery personnel. The separation of the left and right upper torso straps appeared to be pulled away from the aft strap. Remains of threads and stitching patterns remained in all three straps. The right seat restraint was intact and remained attached to the airframe via all mounts. The left and right upper torso straps remained attached to the aft strap. The area of where all three straps were stitched together exhibited a slight amount of separation.



Figure 10. Left seat place with restraints, (right) view of separation point for the restraints.

1.8 WPR11LA317

On July 8, 2011, about 1721 mountain daylight time, a Schweizer SGS2-32, N591CC, sustained substantial damage when it impacted terrain during takeoff initial climb following a practice low altitude rope release near the Ferndale Airport (53U),

Bigfork, Montana (see figure 10). The airline transport rated pilot sustained fatal injuries and the airplane transport rated pilot examiner sustained serious injuries.



Figure 11. Schweitzer, N591CC at the accident site in Bigfork, MT.

Postaccident examination of the airframe revealed that both TSO C22f upper torso restraints were separated. The front seat upper torso restraint was found separated through the fabric webbings above the chest adjusters (see figure 12) with no stitching or fitting attachments were apparent in the area. The rear upper torso restraint was found separated at the stitched webbing where the upper torso restraint straps connected to two straps which connected to the tubular metal support beam. The inside edges of the straps were slightly frayed. The separations were consistent with tensile overstress of both sides with no indications of cutting or sharp edges at the separation locations.



Figure 12. Schweitzer N591CC front seat upper torso harness and attachment point.

1.9 CEN12LA601

On September 1, 2012, approximately 0830 eastern daylight time, an Aeronca 7AC single-engine airplane, N82383, sustained substantial damage when it impacted terrain following a loss of control during initial takeoff climb from the Brighton Airport (45G), Brighton, Michigan (see figure 12). The private pilot sustained serious injuries, and the passenger sustained fatal injuries.



Figure 13. Aeronca Champ, N82383, accident site in Brighton, MI.

Postaccident examination of the airframe revealed that the pilot's upper torso harness failed during the accident (see figure 14). Material examination of the upper torso harness webbing and stitching showed that they failed due to an overload event. The occupants' injuries suggest that both occupants were using the four-point upper torso harnesses at the time of the accident and were exposed to strong deceleration forces. If the pilot's upper torso harness had not failed, he likely would not have suffered the brain injury he received, which caused permanent disability. However, it is possible that an intact upper torso harness could have led to more severe chest, abdominal, or cervical injuries.



Figure 14. Aeronca N82383 pilot's upper torso harness as found in airplane.

1.10 WPR13FA138

On March 3, 2013, about 1558 mountain standard time, a Cessna 172M airplane, N5129R, impacted trees and snow-covered mountainous terrain nautical miles east northeast of Saratoga, Wyoming (see figure 14). The pilot was fatally injured, and the airplane sustained substantial damage. The airplane was registered to and operated by the pilot under the provisions of 14 Code of Federal Regulations Part 91, as a cross-country flight. Visual meteorological conditions prevailed for the flight, which operated on a visual flight rules (VFR) flight plan. The flight originated from Bryce Canyon Airport, Bryce Canyon, Utah, at about 1223.



Figure 15. Cessna 172, N5129R, accident site in Saratoga, WY.

During the on-scene wreckage documentation, the NTSB observed that the pilot's TSO C22f upper torso harness had failed during the accident, with failure of the threading at the 'Y' junction (see figure 16). The pilot restraint was manufactured by Aero Fabricators (Model number H-702) and installed on the accident airplane on February 9, 2003. The date of manufacturing stamp on the upper torso harness restraint was smeared and was illegible. The upper torso harness label stated the restraint system had a "rated strength of assembly [of] 1500 pounds."



Figure 16. Cessna 172 N5129R pilot's upper torso harness.

In this case, the upper torso portion of the pilot's safety harness failed during the crash sequence, allowing his chest significant additional forward excursion. As a result, his chest interacted with the yoke and caused the overload failure of the control column. This interaction is most likely the cause of his sternal fracture, as well as his lung, mediastinal, and cardiac contusions. In addition, it allowed his face to impact either the yoke or the dashboard. If the upper torso harness had not failed, the pilot may have suffered superficial contusions to his chest wall (safety belt marks) and perhaps some rib fractures, but it is unlikely that he would have significantly impacted the yoke or suffered significant internal chest injuries.

Without the upper torso harness failure, at the end of the crash sequence this would have been an otherwise generally healthy 63-year-old man with a lower leg fracture along with contusions, lacerations and abrasions. Although cold, windy, and overcast, it was still daylight. Even in the frigid conditions, given the clothing and equipment the pilot had available, such an individual would have been expected to use self-rescue and survival techniques such as sheltering in the aircraft or building some type of shelter and lighting a fire. Without the chest injuries, the pilot would have been very likely to survive the 45-hour interval until the crash scene was identified and he was then rescued.

1.11 ERA16LA200

On June 1, 2016, about 0854 eastern daylight time, an Aeronca 7AC, N83547, was substantially damaged when it was involved in an accident near Toughkenamon, Pennsylvania. The student pilot and flight instructor sustained minor injuries. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 instructional flight.



Figure 17. Aeronca 7AC, N83547, at accident site in Toughkenamon, PA.

During the on-scene wreckage documentation, the NTSB observed that the rear seat upper torso harness assembly pulled loose from its mounting location. Examination of the rear seat upper torso harness assembly revealed that it was not bolted, fastened, or positively secured to the airplane's tubular structure but was instead clamped over two, 5/8-inch-diameter tubes with upper and lower triangular attachment brackets just forward of where the tubes intersected with the top longeron. Examination of the attachment brackets revealed that, during the impact sequence, the bracket assembly likely either mechanically pulled or slid over the airplane's structural tubing. It was noted that the back seat occupant was more seriously injured than the front seat occupant, whose upper torso harness did not separate from the structure. On the basis of this evidence, it is likely that the detachment of the rear upper torso harness assembly contributed to the instructor's injuries because it allowed him to strike the front seatback and his control stick.

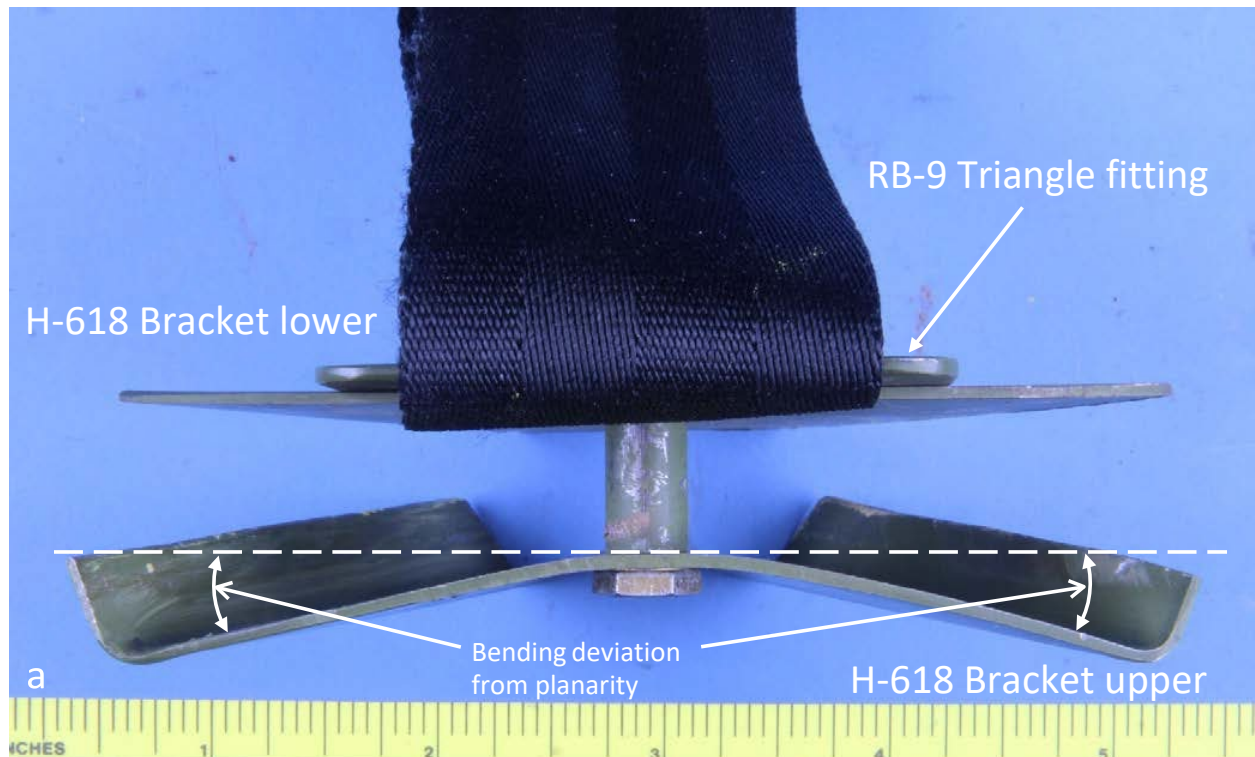


Figure 18. Edge views of the rear attach hardware assembly showing permanent bending deformation in the upper bracket.

1.12 ERA18FA141

On May 5, 2018, about 0905 eastern daylight time, an Aeronca 7AC, N84396, was substantially damaged when it was involved in an accident near Randall Airport, Middletown, New York (see figure 19). The pilot was fatally injured, and the flight instructor was seriously injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 instructional flight.



Figure 19. Aeronca 7AC, N84396, accident site in Middletown, NY.

During the on-scene wreckage documentation, the NTSB observed that the rear seat upper torso harness anchor was found separated from the airframe tubes to which it was clamped (see figure 20). The anchor components were intact, but the upper bracket was bent upward on both sides. Examination of the anchor components revealed sliding marks on the brackets consistent with sliding forward asymmetrically along the airframe tubes, which were oriented triangularly such that they were farther apart looking forward. The harness buckle attachment arms that connected the two upper torso harness straps to the buckle were bent. The right harness buckle arm was bent more than the left harness buckle arm, consistent with asymmetrical loading. The webbing components and stitching of the upper torso harness remained intact. The center bolt, which clamped the brackets together, was found installed upside down (with the bolt head facing up instead of the nut facing up) and, according to the installation specifications, was missing a washer.

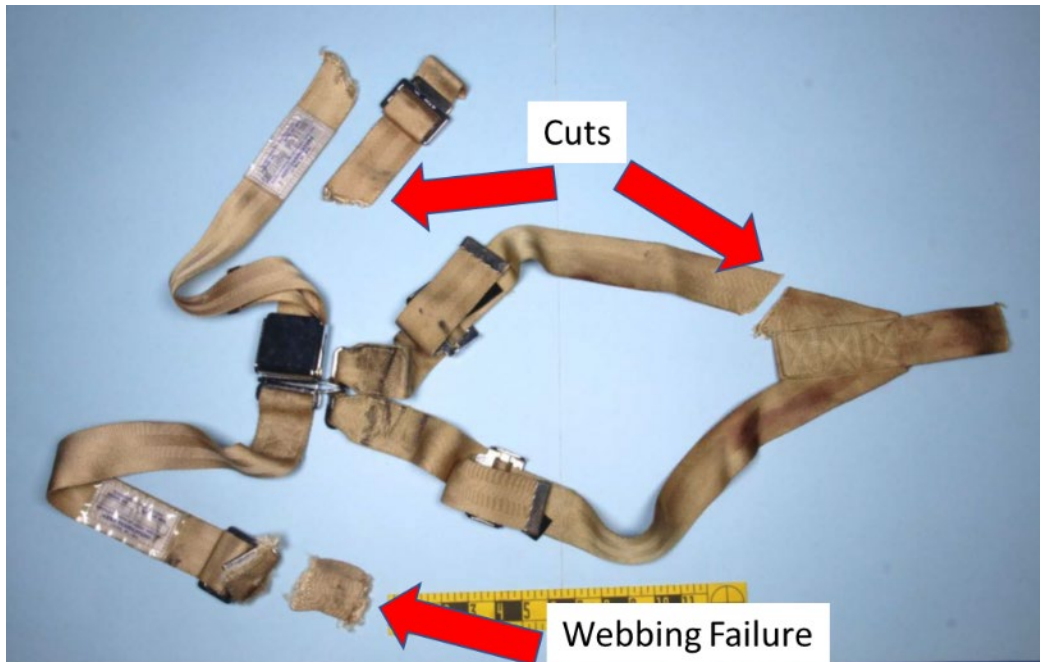


Figure 20. Front seat belt assembly with webbing failure and cuts noted.

The front seat left-side lap belt webbing was separated in two places near its attach point (see figure 21). Examination of the fracture surfaces revealed damage consistent with overload.



Figure 21. Rear seat belt assembly

2.0 Accidents Still being Investigated¹

2.1 ANC22FA066

On August 11, 2022, at 1152 Alaska daylight time, a Piper PA-12 airplane, N3937M, was substantially damaged when it was involved in an accident near the Marsh Fork Canning River, about 40 nautical miles (nm) northwest of Arctic Village, Alaska (see figure 22). The pilot was fatally injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.



Figure 22. Piper PA-12 N3937M, accident site near Marsh Fork Canning River, AK.

During the on-scene wreckage documentation, the NTSB observed that the pilot's upper torso harness had failed during the accident, with failure of the threading at the 'Y' junction (see figure 23).

¹ Information in this section is based on the preliminary reports and photos provided by the IICs.



Figure 23. Piper PA-12 N3937M pilot's upper torso harness.

2.2 CEN23LA101

On February 4, 2023, about 1630 central standard time, a Bellanca Aircraft 7ACA, N9111L, was substantially damaged when it was involved in an accident near Bayport, Minnesota (see figure 24). The pilot sustained minor injuries. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight. The flight originated from Lake Elmo Airport, Lake Elmo, MN, at about 1330.



Figure 24. Bellanca Aircraft 7ACA, N9111L, at the accident site in Bayport, MN.

During the on-scene wreckage documentation, with separation of the threading at the 'Y' junction (see figure 25). The pilot seat had a label that read Model number 11-702-300, date of manufacture of December 15, 2017. The upper torso harness label stated the restraint system was an FAA-Parts Manufacturer Approval (PMA) part with a "rated strength of assembly [of] 1500 pounds."



Figure 25. Bellanca Aircraft 7ACA, N9111L, pilot's upper torso harness.

2.3 ERA23FA200

On April 18, 2023, at 1820 eastern daylight time, a Cessna 172N, N734GB, was substantially damaged when it was involved in an accident near Madison County Airport (UYF), London, Ohio (see figure 26). The flight instructor and student pilot were fatally injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 instructional flight.



Figure 26. Cessna 172 Skyhawk, N734GB, at the accident site in London, OH.

During the on-scene wreckage documentation, separation of the threading at the connection to the airframe of the upper torso restraint was noted (see figure 27). Both restraints had labels that read Model number R, date of repair of January 21, 2022. They further read "rated strength of assembly [of] 1500 pounds, Aero Fabricators, Lyons, WI, USA."



Figure 27. Cessna 172 Skyhawk, N734GB, front seat upper torso harnesses failed stitching.

2.4 CEN23FA248

On June 21, 2023, at 0714 central daylight time, an Aeronca 7CCM airplane, N308ED, was substantially damaged when it was involved in an accident near Duluth, Minnesota (see figure 28). The pilot and passenger were fatally injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.



Figure 28. Aeronca 7CCM, N308ED, at the accident site in Duluth, MN.

During the on-scene wreckage documentation, separation of the threading at the connection to the airframe of the upper torso restraint was noted (see figure 29). The pilot and passenger's restraints had a label on the upper torso restraint that read "Model Number H-702-300, Date of Manufacturing Nov 13, 2009." They both further read "rated strength of assembly [of] 1500 pounds, Aero Fabricators, Lyons, WI, USA."



Figure 29. Photograph of the upper torso restraint failure.