

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



CEN23FA204

MATERIALS LABORATORY

Factual Report 23-077

May 23, 2024

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A. ACCIDENT INFORMATION

Location: Lyndonville, New York
Date: May 28, 2023
Vehicle: Luce Buttercup, N18263
Investigator: Mitchell Gallo, AS-CEN

B. COMPONENTS EXAMINED

Wings, lift struts, elevator horns

C. EXAMINATION PARTICIPANTS

Specialist	Michael Meadows National Transportation Safety Board Washington, District of Columbia
Group Chair / IIC	Mitchell Gallo National Transportation Safety Board Washington, District of Columbia
Specialist	Pocholo Cruz National Transportation Safety Board Washington, District of Columbia

D. DETAILS OF THE EXAMINATION

The NTSB materials laboratory received components from an accident involving an experimental aircraft model, Luce Buttercup (N18263). According to the preliminary accident report, both wings were found separated from the main wreckage approximately 0.25 mile behind in the flight path.

Pieces of the recovered aircraft, including the wings, lift struts, horizontal stabilizer, elevator, and fractured propeller were recovered and send to the NTSB Materials Laboratory (Washington, District of Columbia) for examination.

The general construction of each wing consisted of a wooden ribbed structure supported by two wooden spars (main/forward and rear) spanning the length of the wing. A steel spar connector bracket was bolted through the root of each spar which attached to steel wing attachment brackets welded to the fuselage frame, a welded steel tubular structure. At approximately mid span on each spar, two strut brackets were bolted through the main and rear spar faces where the lift struts attached on the underside of the wing. A steel tube compression strut spanned between the rear facing strut bracket on the main spar and the forward facing strut bracket on the rear spar of each wing. The four lift struts (front and rear on the left and right sides) were

assemblies consisting of airfoil-shaped steel tubes and a wooden insert with formed and welded attachment fittings that extended from bolted connections at the strut brackets to bolted connections at the wing strut fittings (strut stubs) which were welded to respective locations on the lower fuselage structure. The rear lift struts were fitted with an adjustable fork and barrel set to adjust the strut length during final assembly.¹ Figure 1 shows a photo of the constructed accident vehicle with locations of the wing spars, lift struts, and structural connections indicated for the right wing, which mirrors the left wing construction.

The right wing was found separated from the fuselage as shown in the left image of figure 2. The wing attachment brackets, circled in red, were fractured from the fuselage connection and retained at the main and rear spar roots where the bolted connections to the spar connector brackets were intact. The right rear spar was fractured through the location of the strut brackets as shown looking outboard in figure 3 bound by the red bracket. The fracture surface extended from the upper spar surface at the inboard end to the lower-aft spar surface at the outboard end and exhibited predominantly shear mode fracture features along the grain flow. This was consistent with predominantly torsion loading during fracture.

The left wing was found separated from the fuselage as shown in the right image of figure 2. The main spar wing attachment bracket, circled in red, was fractured from the fuselage connection and retained at the main spar root where the bolted connection to the spar connector bracket was intact. The left main spar was fractured approximately 44 inches from the root end, just outboard of the leading edge pivot arm, as shown looking inboard in figure 4. The fracture surface closer to the rear surface of the main spar was relatively flat, consistent with compressive fracture, whereas the fracture surface closer to the front surface of the main spar was more splintered, consistent with tensile fracture. This was consistent with predominantly aft bending loading during fracture.

The left rear spar was fractured at the rear wing strut bracket connection as shown looking outboard in figure 5. The fracture surface was more splintered along the upper and forward edges of the left rear spar (tensile regions) with four flatter (compressive) regions 1.) at the wing strut bracket hole, 2.) at the outboard end of the rear gusset plate remnant, 3.) inboard of where Rib 6 was attached, and 4.) outboard of where Rib 6 was attached, which stepped down outboard towards the lower rear corner of the spar and are indicated by red arrows. This was consistent with predominantly downward and aft bending loading during fracture.

A portion of the left rear spar root approximately 37 inches long, shown in figure 6, was found in the main wreckage debris field partially attached to the

¹ General construction details were derived from Luce Air (Brockport, New York) drawings titled Wittman's Buttercup dated 05/26/2002 and revised 06/26/2014.

fuselage structure, as circled in red and shown more closely in figure 10. The spar connector bracket was observed still bolted to the spar root. Pieces of the left rear spar, approximately 28 inches long, which mated to the root section were fractured transversely from the spar root as shown in figure 6. This smaller piece of spar was also fractured along the longitudinal and tangential grain orientation plane at approximately mid-spar height as shown looking along the left rear spar at the transverse fracture location in figure 7. The fracture along the longitudinal-tangential grain orientation plane extended inboard along the spar as indicated by the yellow bracket. The location and orientation of this longitudinal-tangential spar fracture was consistent with torsional loading and a shear fracture mode.

The right and left rear spar dimensions were measured to be approximately 2.9 inches along the front face, 2.7 inches along the rear face, and 1.25 inches thick. The left main spar dimensions were measured to be approximately 4.75 inches along the front face, 4.9 inches along the rear face, and 1.0 inch thick.

The wing attachment brackets were fractured and separated from the fuselage structure at three of the four attachment locations as shown in figures 8 - 10. The bolted connections were still intact, with the fractured portion of the wing attachment bracket retained by the respective spar connector bracket. Deformation of the fractured wing attachment brackets were consistent with upward torsional loading prior to separation as indicated by the white arrows in figures 8 and 9. Closer views of the left rear spar and wing attachment bracket are shown in figure 10 from the lower surface (left) and the upper surface (right). Partial fractures in the fuselage structure were observed near the wing attachment bracket as indicated by red arrows and this section of the left spar root was recovered from the main wreckage site, away from the wing wreckage site.

The inboard end of all four lift struts were still bolted to their respective wing strut fitting, which were all still partially attached to the fuselage structure in the main wreckage debris field. The inboard ends of the left and right front struts are shown looking forward in figure 11 and shows intact bolted connections between the struts and strut fittings and generally downward bending deformation at the connections. The front right strut was fractured approximately 41 inches away from the attachment point to the wing strut fitting as shown looking inboard in figure 12 (right). Shear lip features and deformation/buckling direction as indicated by white arrows were consistent with torsional overstress separation. A fractured wooden insert was observed inside the strut tube. The front left strut was fractured and deformed approximately 36.5 inches away from the attachment point to the wing strut fitting as shown looking inboard in figure 12 (left). The upper surface was compressed inward and the lower surface was buckled. Shear lip features and deformation direction as indicated by white arrows were consistent with predominantly upward bending and tensile overstress separation. The outboard piece of the front left strut was also buckled upward approximately 19.5 inches from the outboard fracture at the wing

attachment fitting location as shown looking forward in figure 13. A waxy black material transfer mark was observed on the upper surface of the strut spanning the buckled area.

The front lift struts were also fractured at the attachment point to the main spar strut brackets. The portions of the front lift struts where the formed and welded end fittings were bolted to the wing strut brackets were retained by the main spar wing strut brackets at the wing debris site. The wing strut brackets were still bolted through the main spars. Figure 14 shows the left and right main spar strut brackets on the underside of the respective wing. The right forward strut remnant is shown as retained by the strut brackets and the left strut remnant had been disassembled in this image for closer examination. and the left forward strut remnant removed for closer examination. The main spar strut brackets were deformed in a manner consistent with wing nose-up torsional loading prior to strut separation. The fractured pieces of both front struts retained by the wing strut brackets are shown after disassembly with the associated attachment hardware in figure 15. Representative locations of the wing strut brackets are indicated by yellow dashed lines. The left front strut attachment measured approximately 1.25 inches wide between the wing strut brackets and the right front strut attachment measured approximately 1.35 inches wide. The engineering drawing specified a width of 1-3/8 (1.375) inches at this location. Two washers, each approximately 0.062 inch thick, were observed between the left front wing strut brackets and the strut upon disassembly as shown in figure 15. The mating fracture surfaces of the forward struts are shown in figure 16. Shear lip features were observed along the fractured strut and welded patch and were deformed in the direction indicated by the white arrows. Separation was consistent with torsional overstress.

The outboard end of the fractured left front strut was examined more closely as shown looking outboard in figure 17. The bracketed area is shown more closely in the right image. A relatively flat crack was observed extending through the weld from the weld face in the area indicated by the yellow dashed line. Scanning electron microscope (SEM) images of this region are shown in figure 18 with the flat crack region bounded by yellow dashed lines. Above this region, dimpled fracture features were observed, consistent with overstress separation. A closer view of the flatter fracture region is shown in the right image. Faint fracture features which resembled fatigue striations were observed at higher magnification and are oriented horizontally in this image, typical examples indicated by yellow arrows, and the general direction of fracture from bottom to top.

Figure 19 shows SEM images of the fractured welds near the outboard end of the left lift strut. Some weld porosity was observed as indicated by black arrows in the left image with the largest observed pore being approximately 0.04 inch by 0.02 inch. Fractured weld material adjacent to the pores exhibited dimpled fracture features consistent with overstress separation.

The rear lift struts were generally bent downward along the span as shown in figure 20, with a greater degree of bending deformation observed on the left rear strut. The rear struts were still attached to their respective wing strut brackets with pieces of the fractured rear spar retained between the brackets as shown more closely in figure 21. The bolts which secured the brackets to the rear spars were retained by the brackets. The rear wing strut brackets were deformed in a manner consistent with aft bending loading prior to spar fracture. Figure 22 shows the forward facing rear wing strut brackets at the location where the compression strut attached. Local deformation of the bracket was observed in the areas indicated as well as separated, torn, and deformed material consistent with ductile tensile overstress separation of the compression strut from the strut brackets.

The right horizontal stabilizer was reportedly found at a location between the wing wreckage and the main wreckage debris fields. The right horizontal stabilizer support bar was fractured approximately 8.5 inches from the inboard edge of the horizontal stabilizer as shown in the left image of figure 23. The fractured end of the bar was bent slightly aft and downward, and the fracture surface exhibited shear lip features, consistent with bending or torsional loading and tensile overstress separation of steel tubular structures. The forward end of the horizontal stabilizer attached to a bracket which was welded to the steel frame. A portion of the bracket was retained by the right horizontal stabilizer and was deformed away from the inboard side of horizontal stabilizer. The right elevator remained attached to the horizontal stabilizer and was fractured at the connection to the elevator horn, shown in the right image. Secondary cracks were observed where the elevator tube attached to the elevator horn as indicated by red arrows.

One blade of the recovered propeller was fractured near the hub as shown from the forward and aft sides in figure 24. The logo for Prince Aircraft Company (Whitehouse, Ohio) was observed on one side of the intact blade and the construction was consistent with a wooden core with a woven carbon fiber reinforced polymeric outer layer. The numbers "8203" and "54" were molded into the hub as shown in the upper central image. The distance from the center of the hub to the end of the intact blade was approximately 35 inches, consistent with a 70-inch propeller diameter. The engineering drawing specified a 66-55 propeller with a O-200 (100 horsepower) engine model.

Submitted by:

Michael Meadows
Materials Engineer



Figure 1. Photograph of the as-built aircraft prior to the accident. Source: Wittman Buttercup Facebook page post from June 7, 2020.



Figure 2. On-scene photographs showing right wing (left image) and left wing (right image). Retained wing attachment brackets are circled in red.

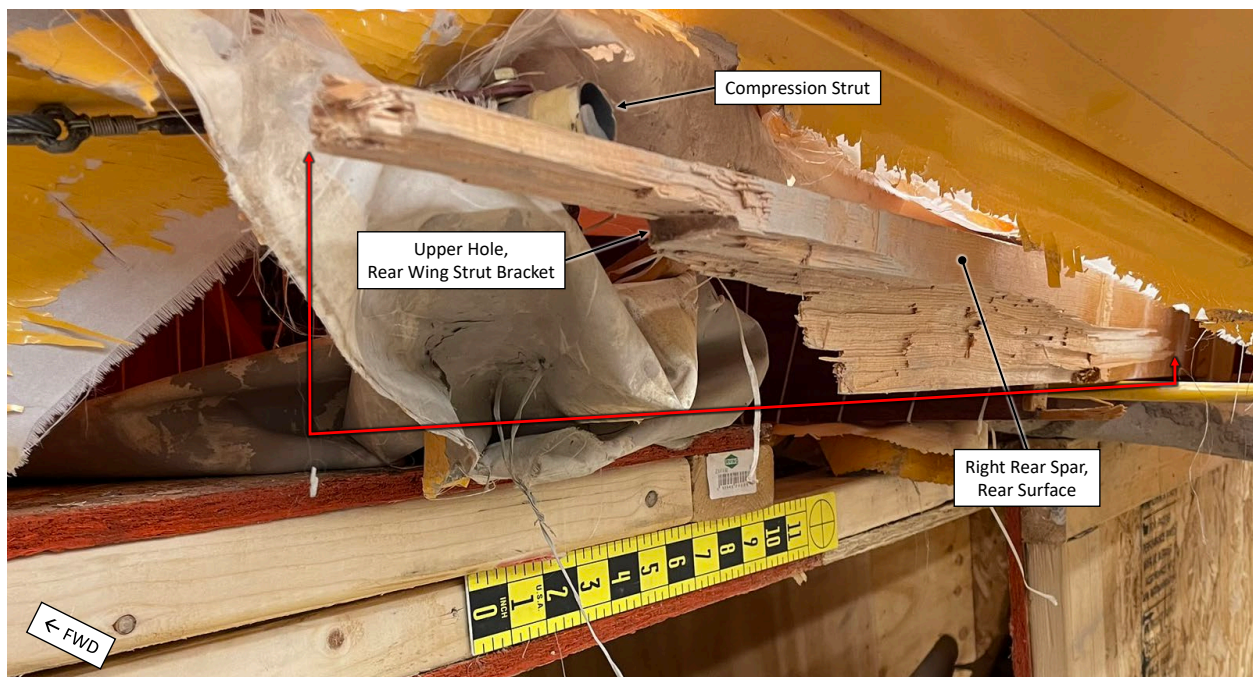


Figure 3. Photograph looking outboard along the fractured right rear wing spar.

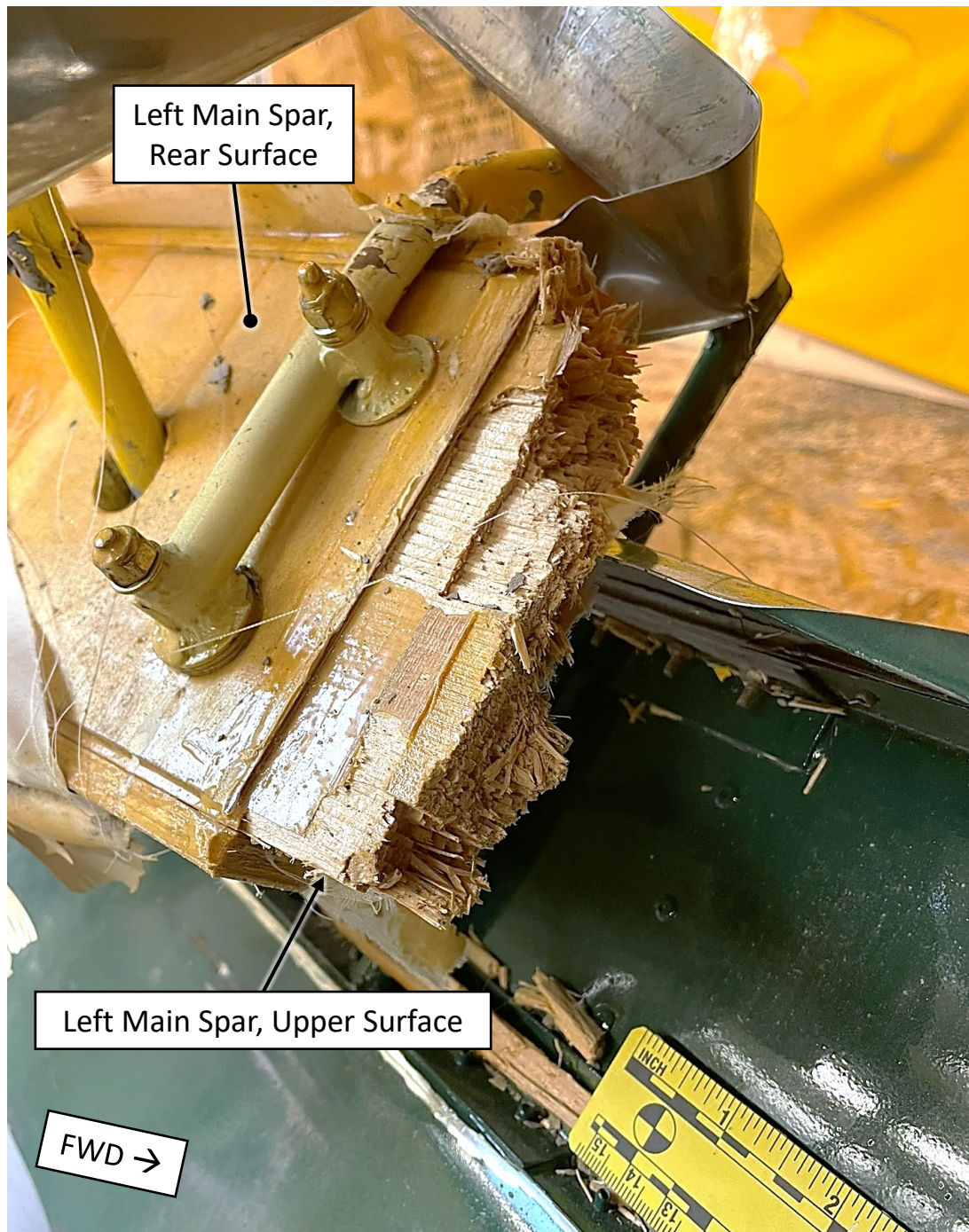


Figure 4. Photograph looking inboard along the fractured left main wing spar.

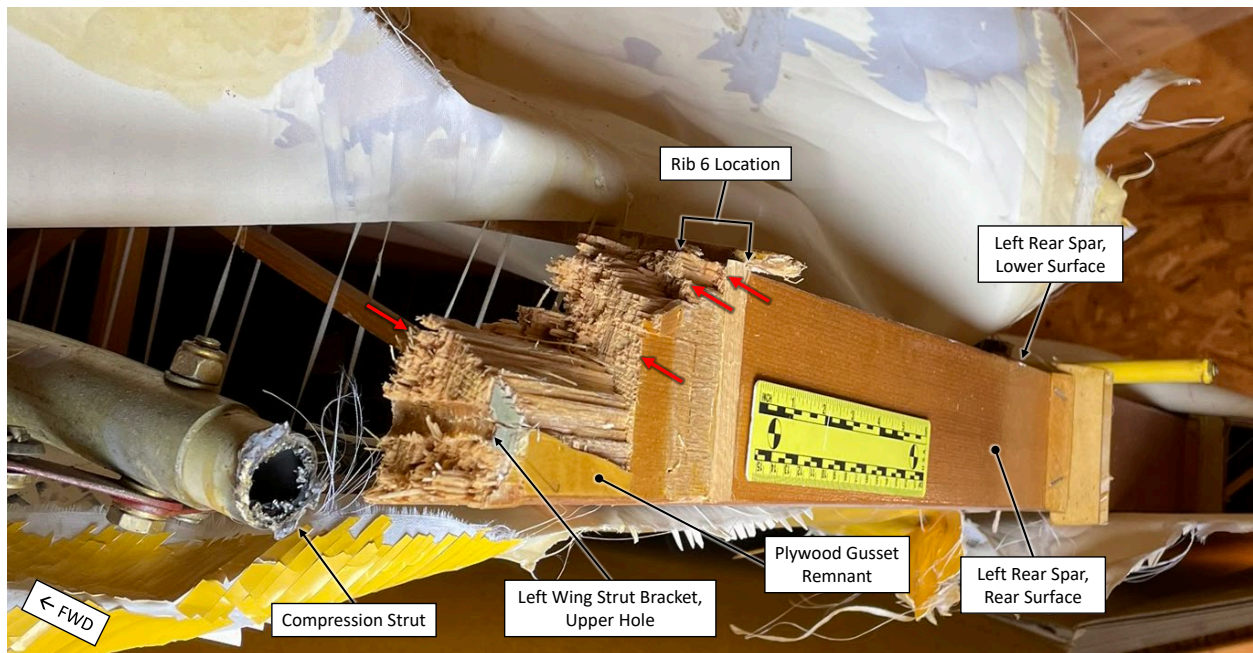


Figure 5. Photograph looking outboard along the fractured left rear wing spar.

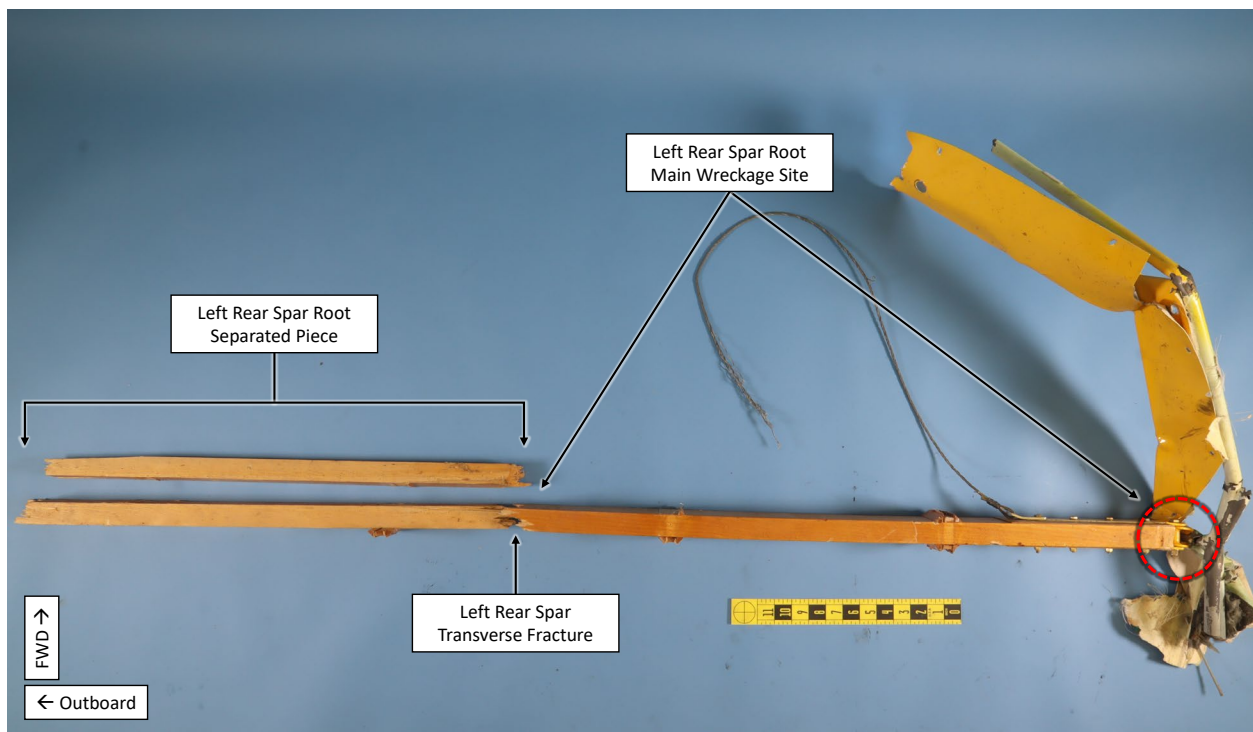


Figure 6. Photograph of the inboard portion of the left rear wing spar.

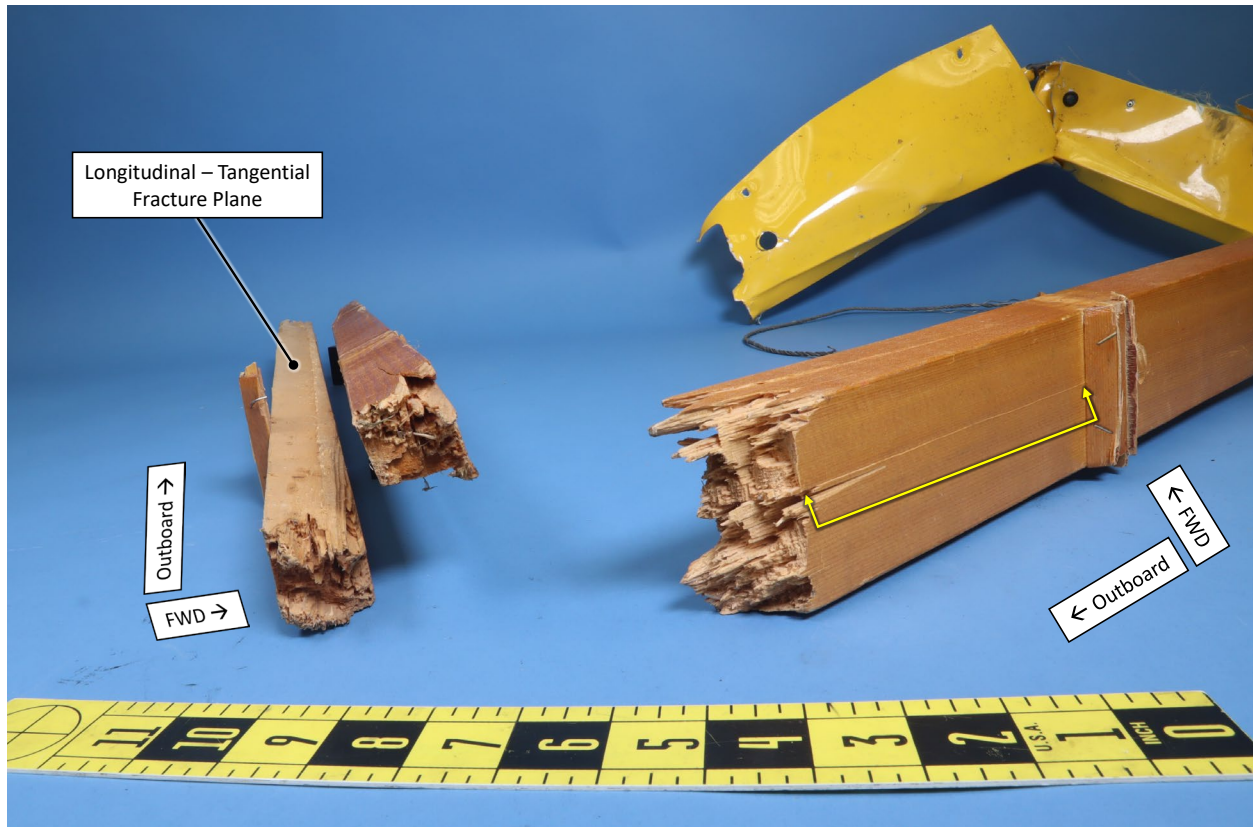


Figure 7. Photograph of the transverse fracture location observed on the left rear wing spar.

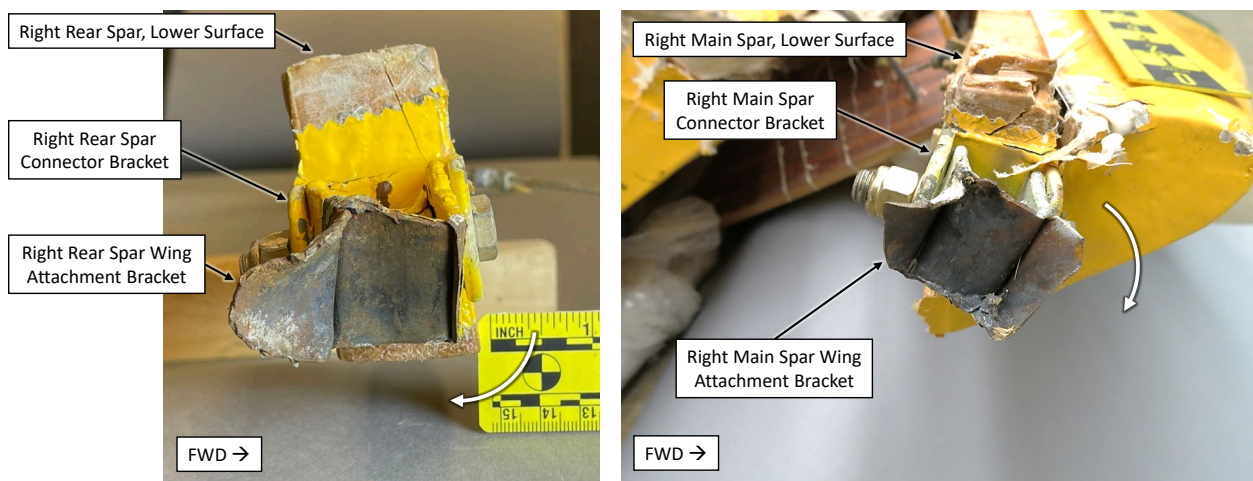


Figure 8. Photograph of the fractured wing attachment brackets from the right wing.

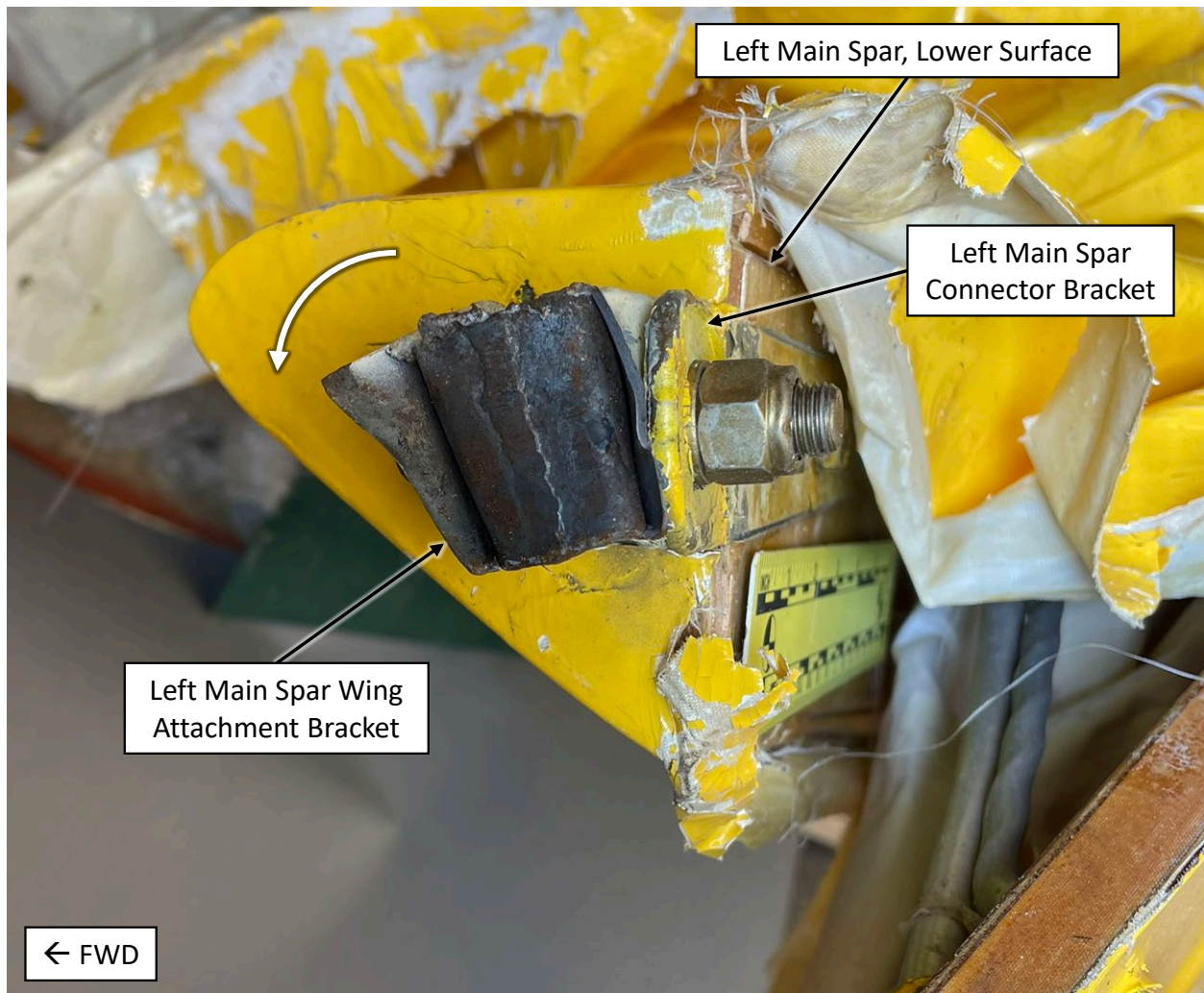


Figure 9. Photograph of the fractured wing attachment bracket from the left main wing spar.

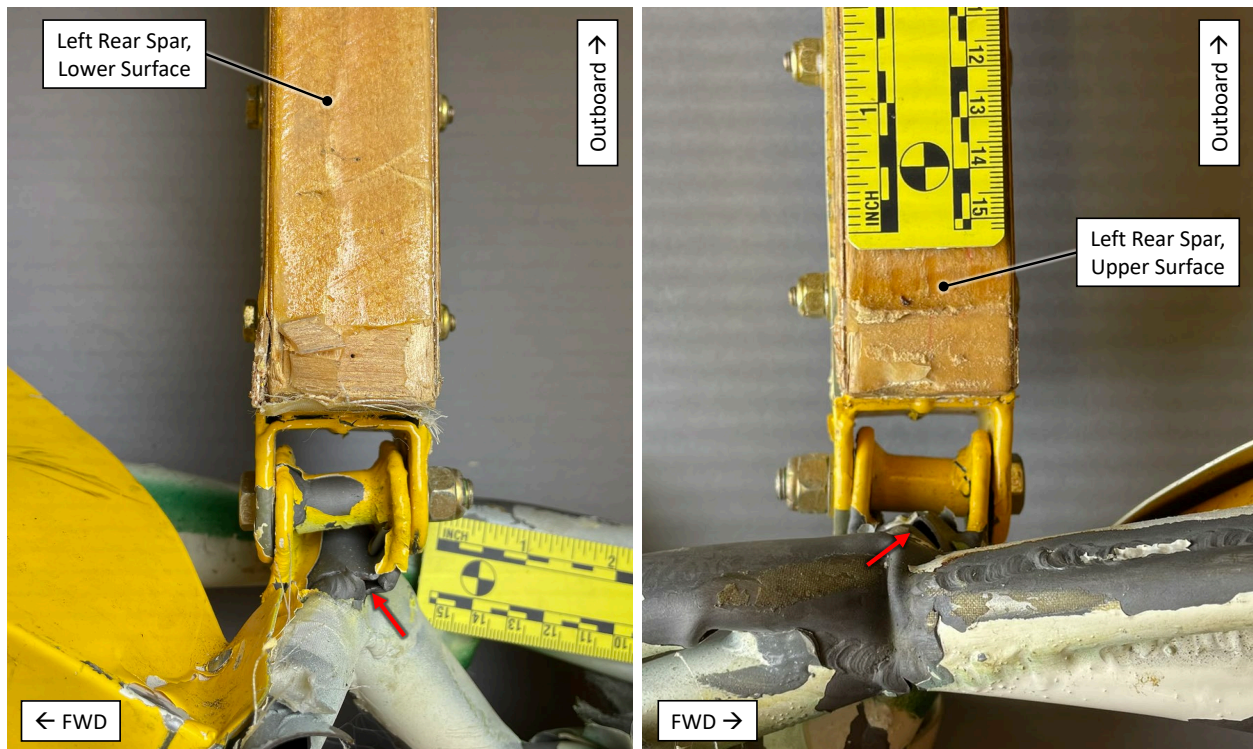


Figure 10. Photographs of the wing attachment bracket from the left rear wing spar still partially connected to the fuselage frame.

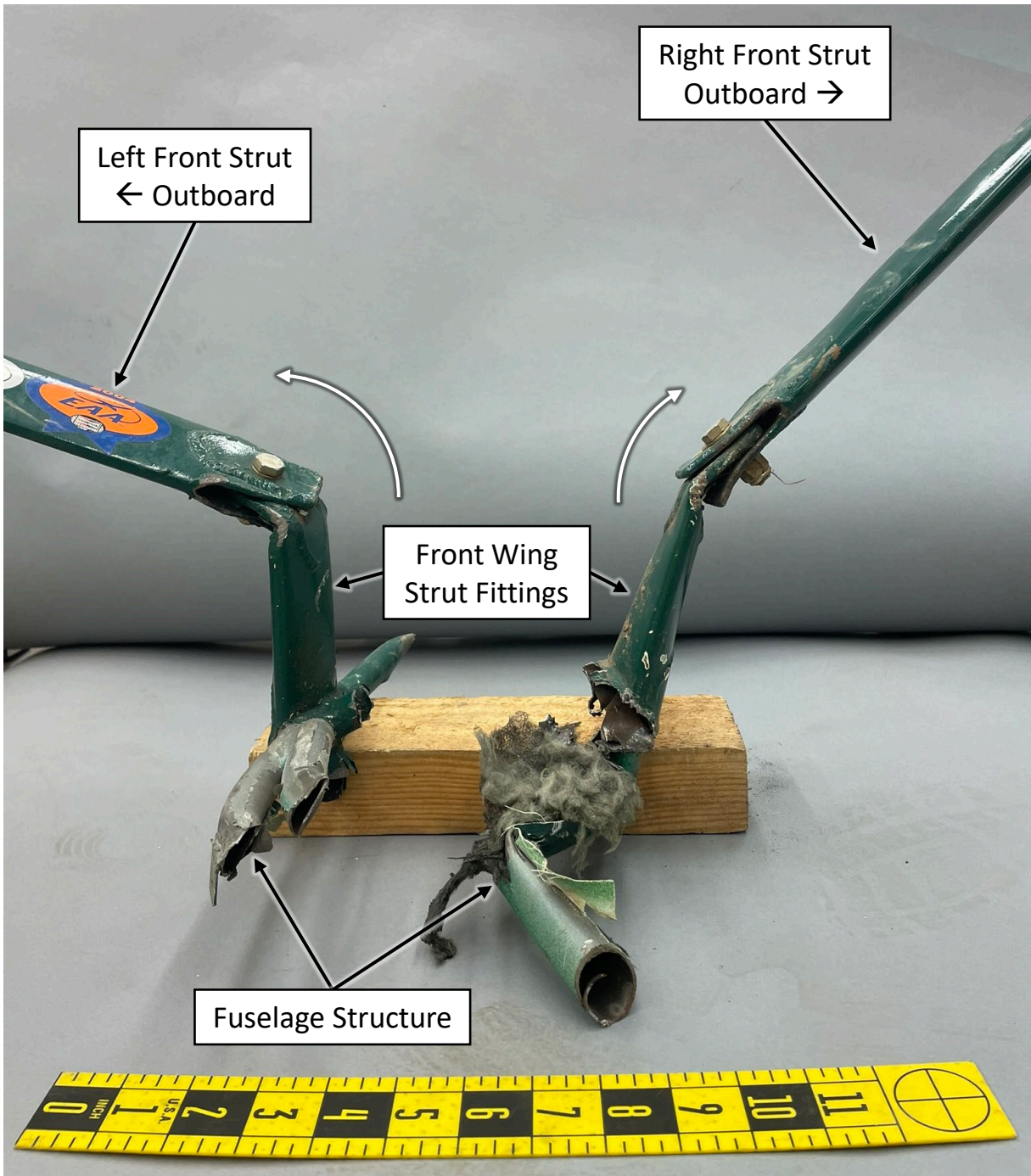


Figure 11. Photographs of the front wing strut fittings.

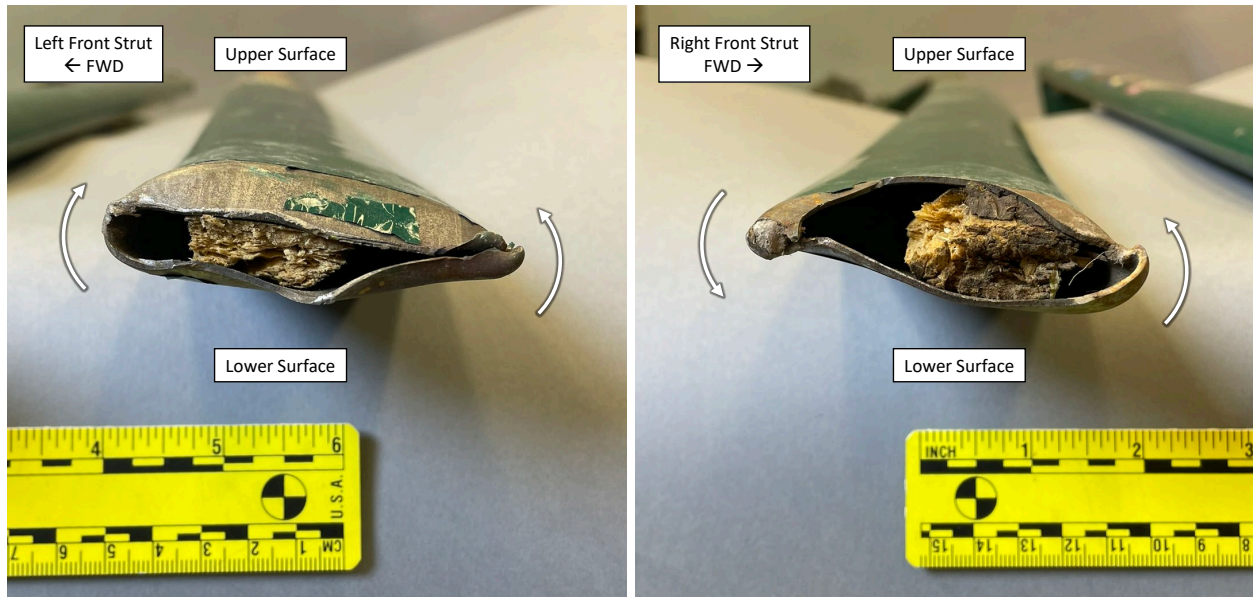


Figure 12. Photographs looking inboard along the front wing struts at the inboard fracture locations.



Figure 13. Photograph of the outboard end of the fractured left front wing strut. A black material transfer mark was observed on the upper surface spanning the region which was buckled upward.

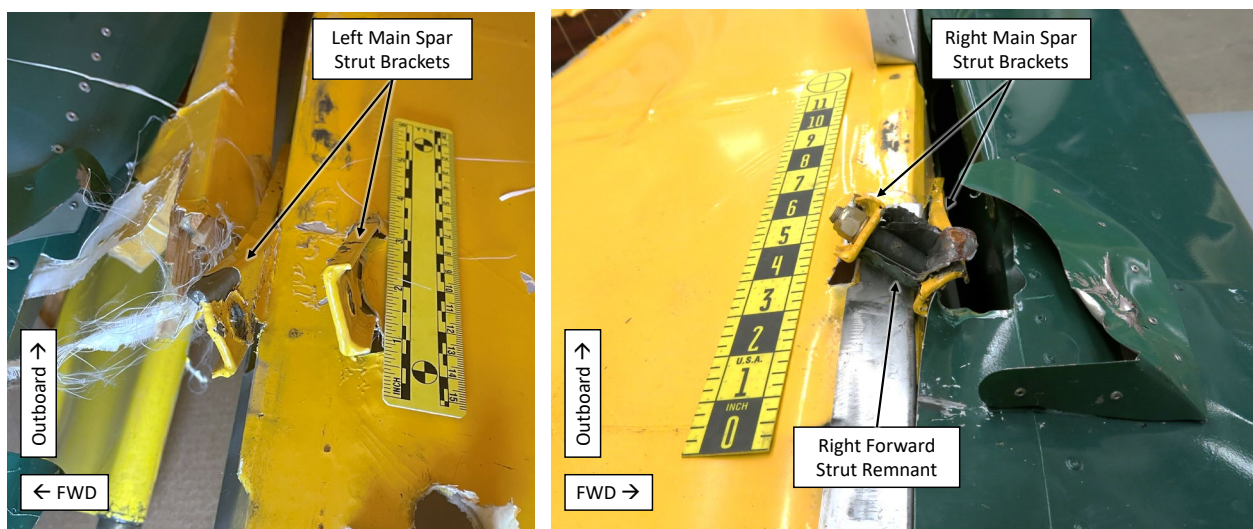


Figure 14. Photographs of the deformed front strut brackets on the underside of each wing.

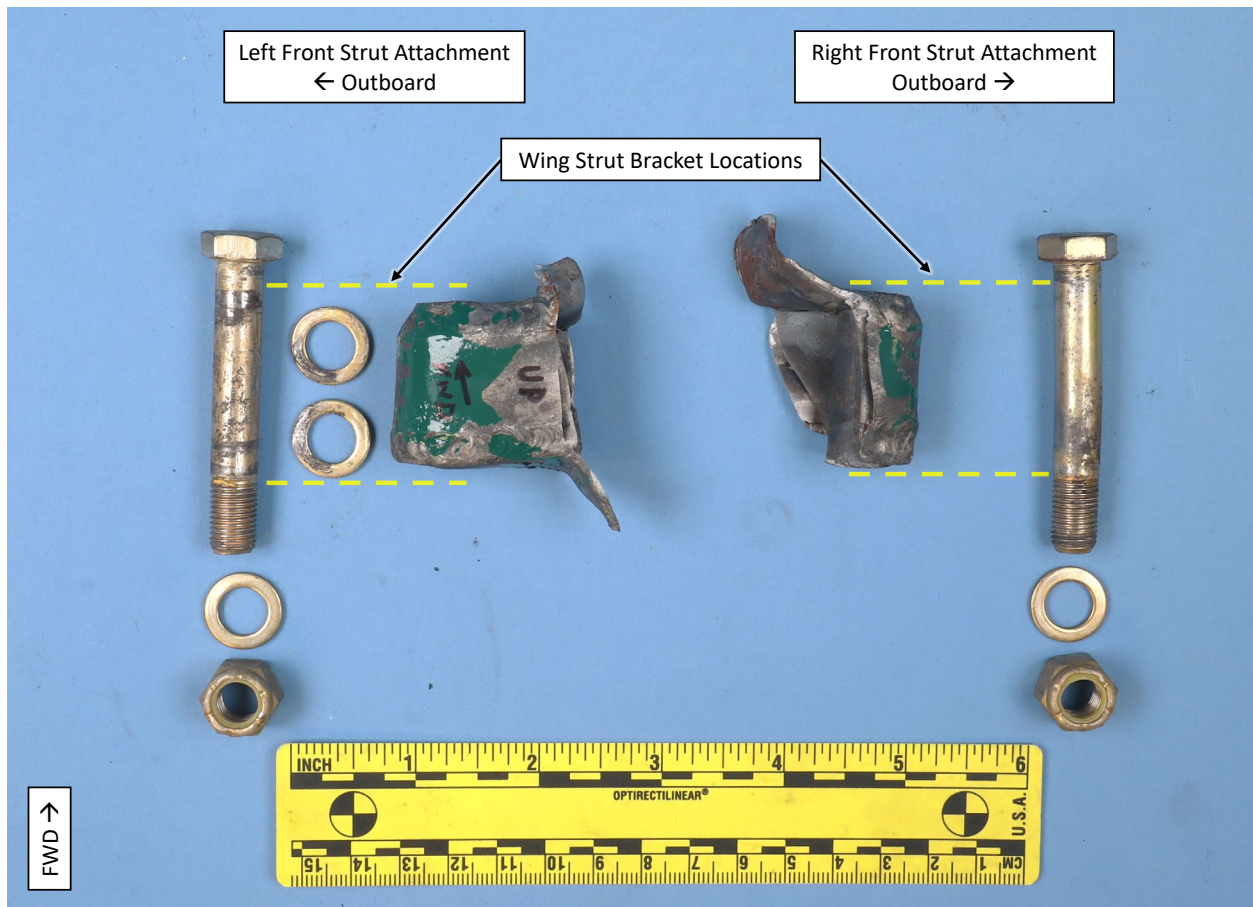


Figure 15. Photograph of the outboard ends of each fractured front strut and attachment hardware which was disassembled. Yellow dashed lines are representative of the strut bracket locations.

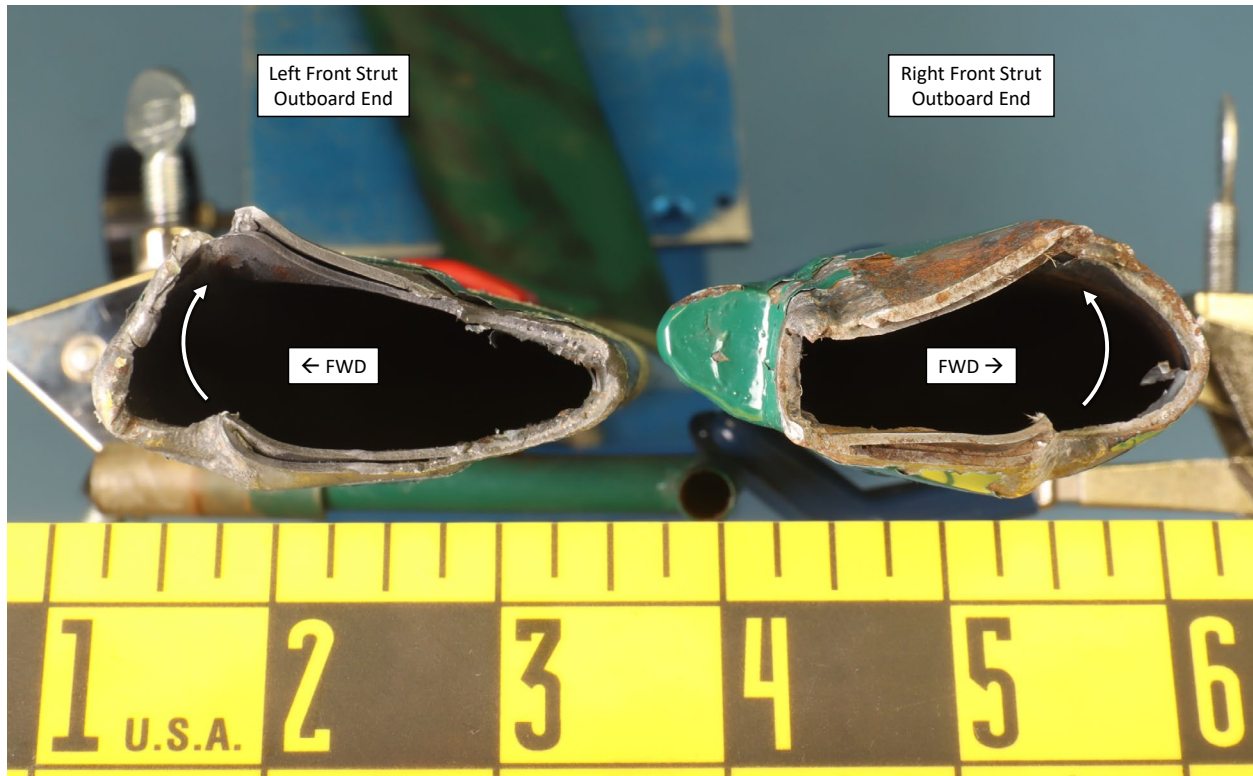


Figure 16. Photograph showing the mating fracture surfaces of the front struts shown in the previous figure.

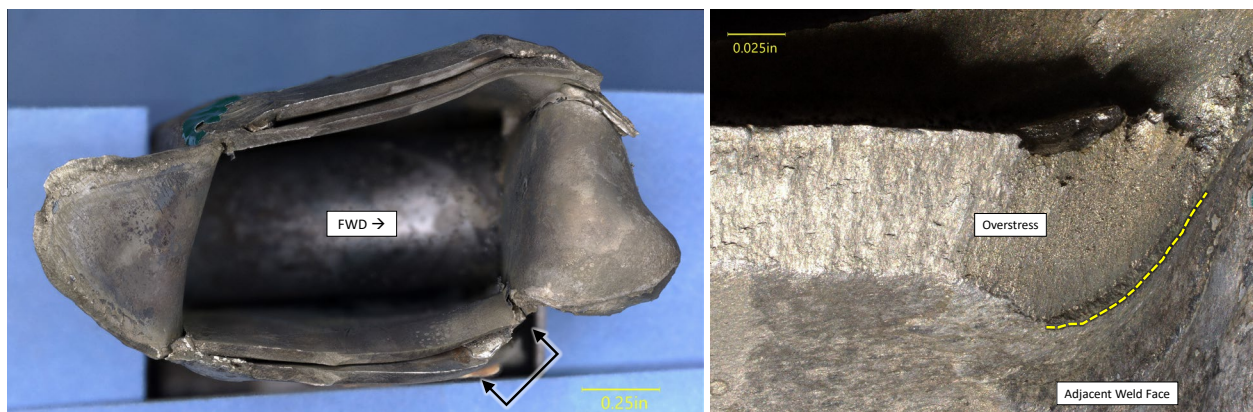


Figure 17. Digital microscope images of the left front strut fracture location near the strut bracket connection. A closer view of the bracketed region is shown on the right. A relatively flat crack was observed extending through the weld from the weld face in the area indicated by the yellow dashed line.

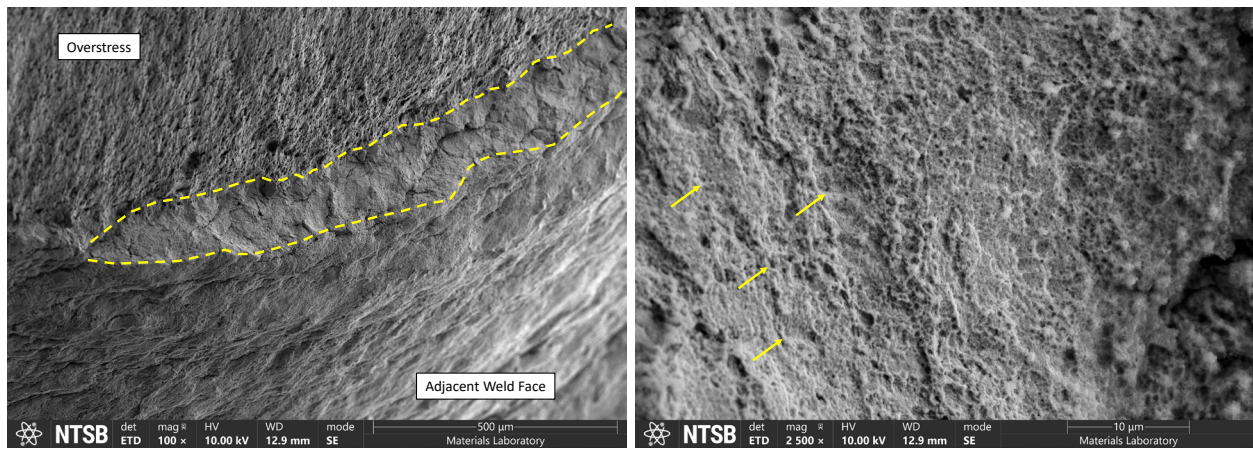


Figure 18. Scanning electron microscope images of the relatively flat fracture region identified in the previous figure. Faint horizontal features resembling fatigue striations are indicated by yellow arrows with the crack growth direction from bottom to top in this image.

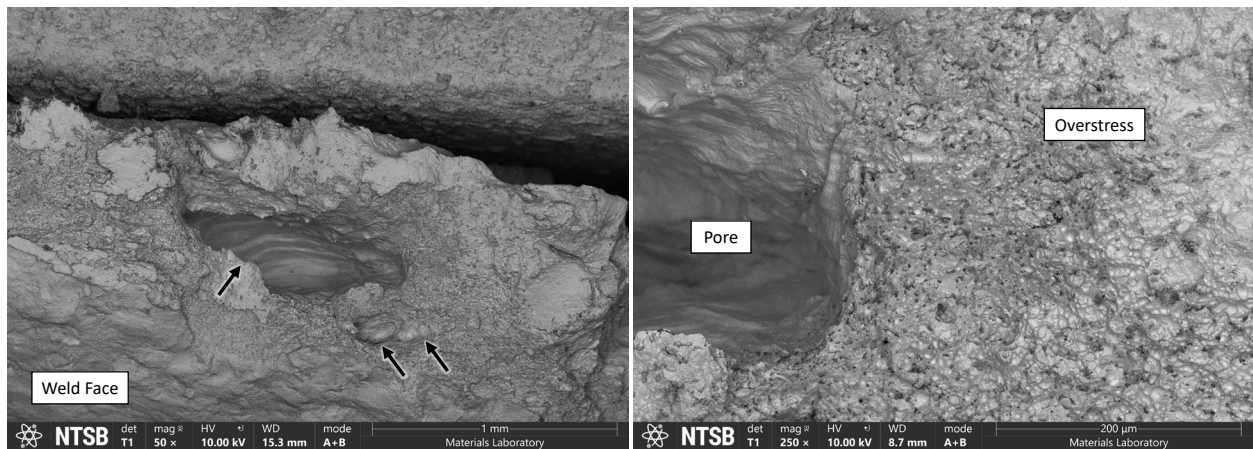


Figure 19. Scanning electron microscope images of fractured weld material from the left front strut fracture surface near the strut bracket connection showing weld porosity.

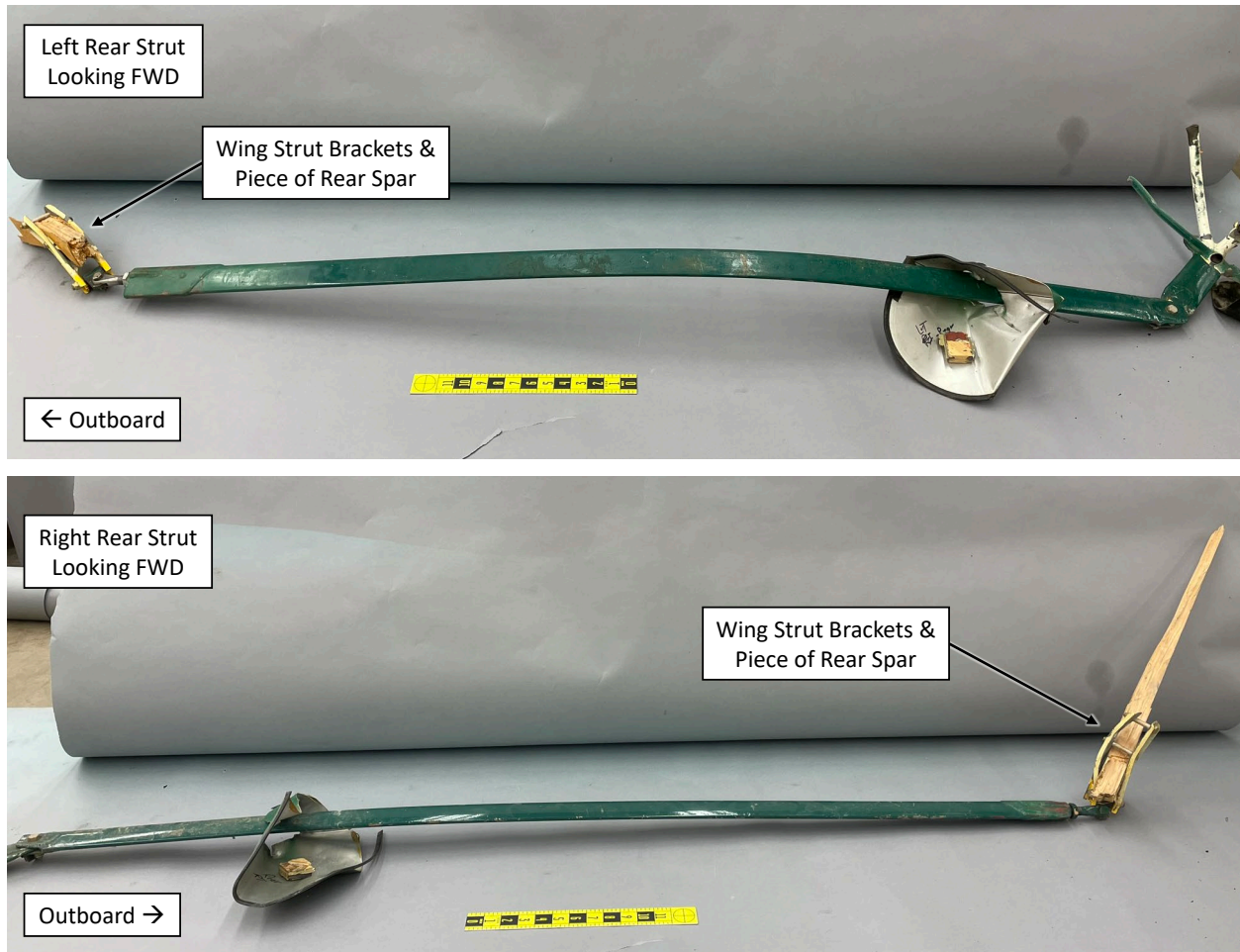


Figure 20. Photographs of the rear strut brackets as viewed looking forward showing generally downward bending deformation.



Figure 21. Photographs of the rear strut brackets as viewed looking down showing torsional bending deformation and pieces of retained rear spar.

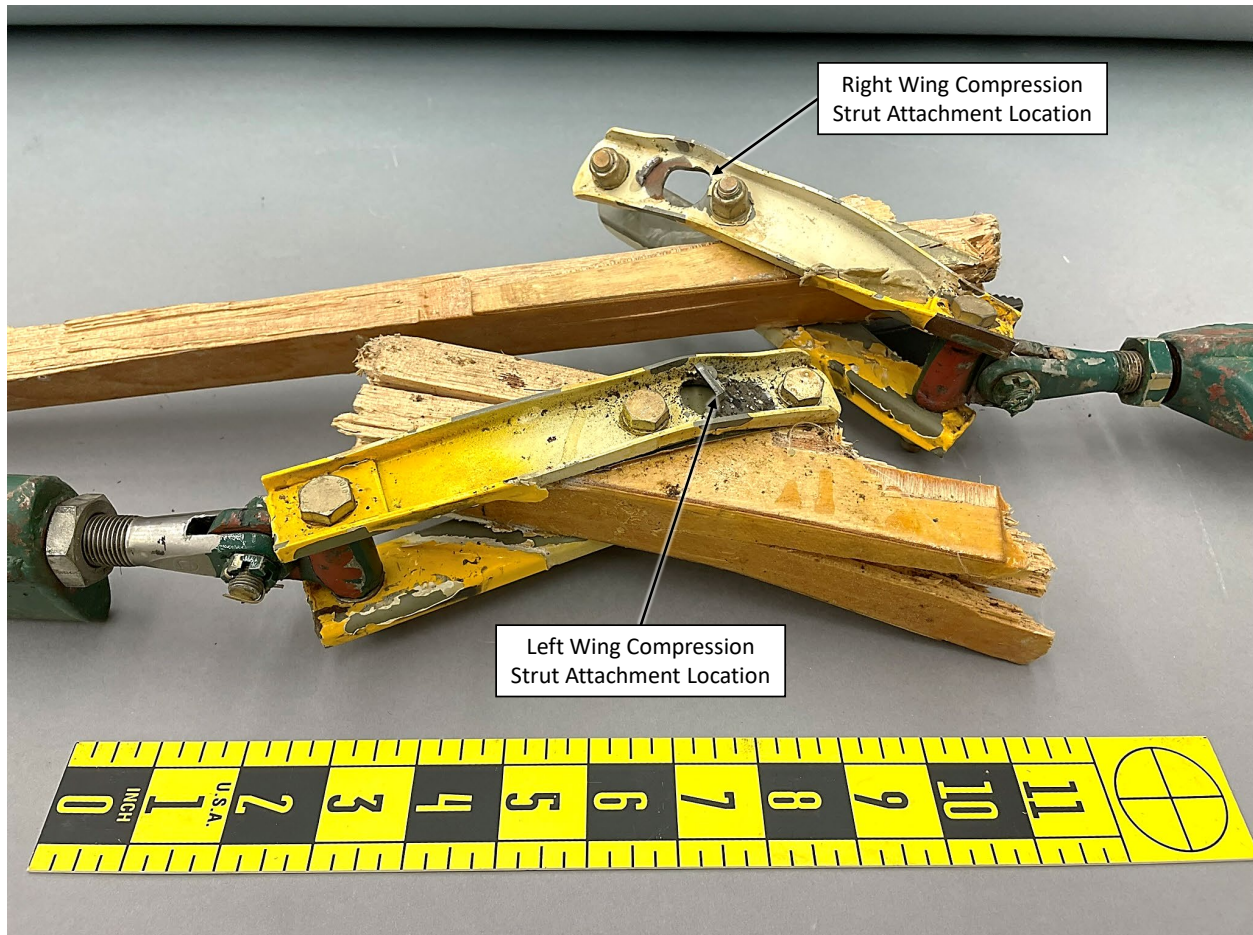


Figure 22. Photograph of the forward sides of the rear strut brackets with compression strut attachment locations identified where local deformation and separated/torn material was observed.



Figure 23. Photographs of the separated right horizontal stabilizer (left) and fractured right elevator horn attachment location (right).



Figure 24. Photographs of the fractured propeller.