

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



November 9, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-065

A. ACCIDENT INFORMATION

Place : Glendale, Arizona
Date : November 4, 2020
Vehicle : Remos Aircraft GMBH Flugzeugbau GX, N87GX
NTSB No. : WPR21LA037
Investigator : Michael Hicks, ASI-WPR

B. COMPONENTS EXAMINED

Carry-through spar, fractured into three pieces.

C. DETAILS OF THE EXAMINATION

A carry-through spar, fractured into three pieces was submitted to the NTSB Materials Laboratory for examination, as shown in figures 1a and b. The spar consisted of a middle section that was composed of an upper cap, lower cap, and web with circular holes in it, as well as two end-sections used to attach left and right main landing gear (MLG) strut tubes to the carry-through. The lower cap was fractured at the left end of the middle section and the upper cap was fractured at both ends. Three of nine web ligaments (the material between the holes) were fractured in one location, while the remaining six, toward the right side of the spar, were fractured in multiple locations and those ligaments were missing. The spar was visibly bent at the transition from the middle section to the right MLG attachment sleeve section, such that the attachment arm had rotated counterclockwise (up) relative to the rest of the spar.

The upper and lower spar cap fracture surfaces were examined with the aid of a stereomicroscope and all surfaces exhibited a rough granular appearance, consistent with overstress fractures. The upper and lower cap fractures on the left side of the spar are shown in figure 2. The fractures intersected the top and bottom of the leftmost hole in the web (12 o'clock and 6 o'clock positions). As the fractures entered the upper and lower caps, they progressed along paths oriented approximately 45° to the longitudinal axis of the spar. The upper cap also exhibited slight upward bending deformation.

The ligament fractures in the spar web were examined for indications of fatigue but none were found. Instead, the ligaments typically exhibited an initial "V-shaped" fracture profile with a rough fracture morphology, which transitioned to a rubbed appearance at the point of final fracture that was also accompanied by an increase in the web thickness (plastic bulge) and a shear lip at the adjacent hole edge (plastic hinge). Figure 3 shows

the direction of crack growth and separation for the web ligaments. The web ligament fractures near the upper cap proceeded across each ligament from left to right and the fractures near the lower cap proceeded from right to left. The features were consistent with overstress due to a leftward shear displacement of the upper spar cap relative to the lower cap.

Taken together, the observed features were consistent with an initial failure at the left side of the spar due to upward bending followed by upward plastic bending of the right attachment arm.

Additional examination of the carry-through revealed a crack at its right end in the sleeve used to secure the right MLG strut tube. An image of the crack is shown in figure 4a (also see figure 1 for reference). The crack ran along the edge of a lug through which a bolt was inserted and used to clamp the sleeve around the strut tube. The crack extended approximately 1.5 inch in the longitudinal direction and through the thickness of the sleeve. The sleeve was sectioned using a water-cooled abrasive saw in accordance with standard laboratory practices and the crack was opened for examination, as shown in figure 4b. As seen in the figure, the surface was clean and did not exhibit any notable dirt or debris. The fracture was then examined using a scanning electron microscope and the surface exhibited ductile dimples in all locations examined, consistent with an overstress fracture.

An engineering drawing provided by the manufacturer indicated that at the time the spar was manufactured, it was made from aluminum alloy 7075 in the T6 temper (7075-T6). There was no mechanical property data listed on the original drawing. The current revision of the drawing (R3) listed additional acceptable alloys and minimum yield strength and tensile strength requirements of 435 MPa (63 ksi) and 505 MPa (73 ksi), respectively. According to the ASM Metals Handbook Desk Edition (ASM International, 1998), typical yield strength and tensile strength values for 7075-T6 are 490 MPa (71 ksi) and 570 MPa (83 ksi), respectively.

The heat treatment and the hardness of the spar material were evaluated using a conductivity meter and hardness tester, respectively. Material property data from AMSH6088C (MIL-H-6088) (SAE, 2000), indicated that 7075-T6 has a typical conductivity range of 30.5 – 36.0 %IACS (International Annealed Copper Standard) and minimum hardness of 84 HRB (Rockwell B Hardness). The conductivity values for the spar material, measured twice, were 29.8 %IACS and 30.7 %IACS. The hardness was measured three times in accordance with ASTM E18 – 20 (ASTM, 2020). The resulting values were 89.1 HRB, 89.4 HRB, and 89.6 HRB.

D. REFERENCES

ASM International (1998). "Metals Handbook Desk Edition," ASM International, Materials Park, OH.

ASTM (2020). "ASTM E18-20, Standard Test Methods for Rockwell Hardness of Metallic Materials," ASTM International, West Conshohocken, PA.

SAE (2000). "AMSH6088C – Heat Treatment of Aluminum Alloys, 2000-07-01," SAE International, Warrendale, PA.

Donald Kramer, Ph.D.
Sr. Materials Engineer

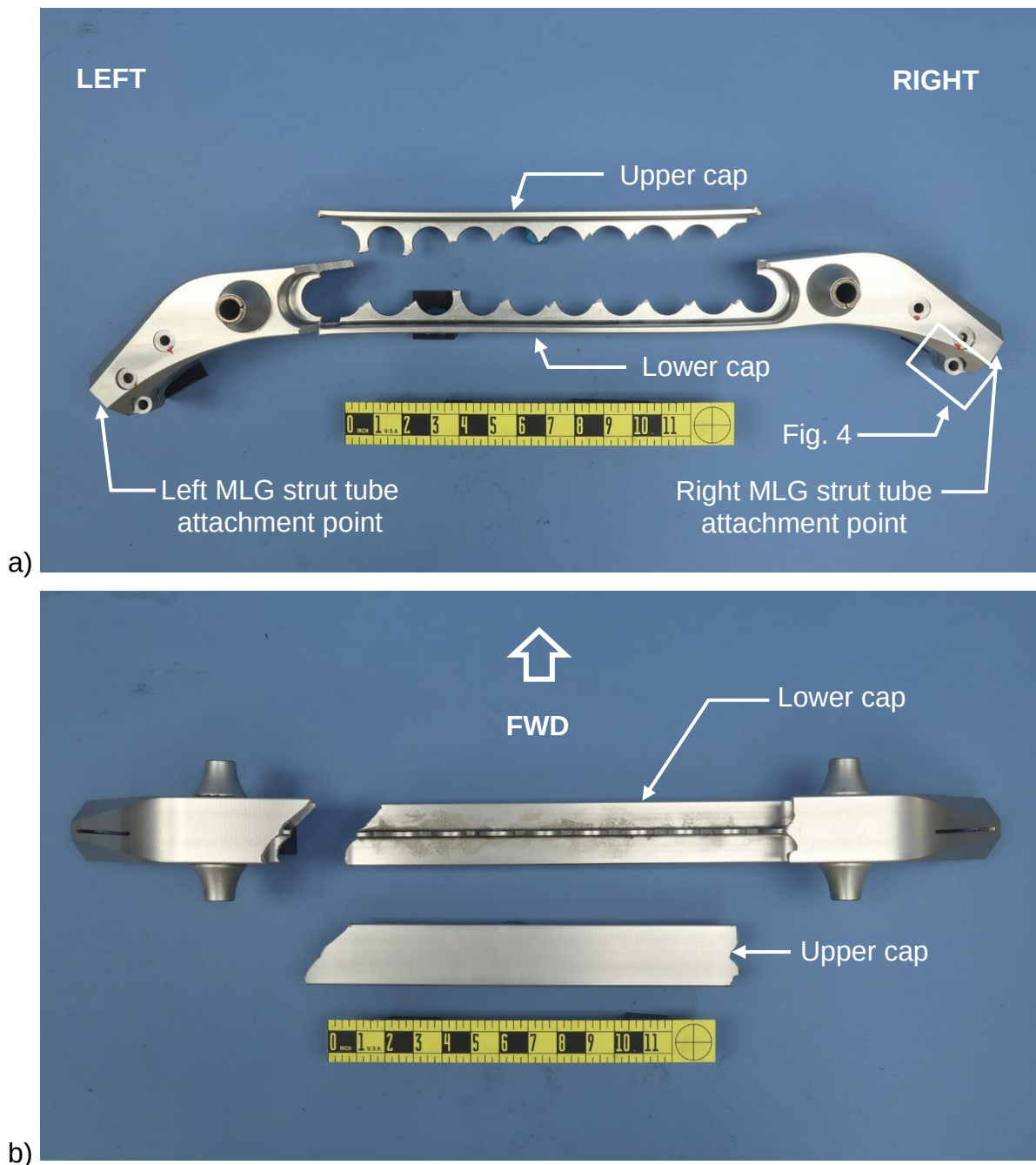


Figure 1: Images of the fractured carry-through: a) viewed from the aft direction looking forward and b) viewed from the top looking down.

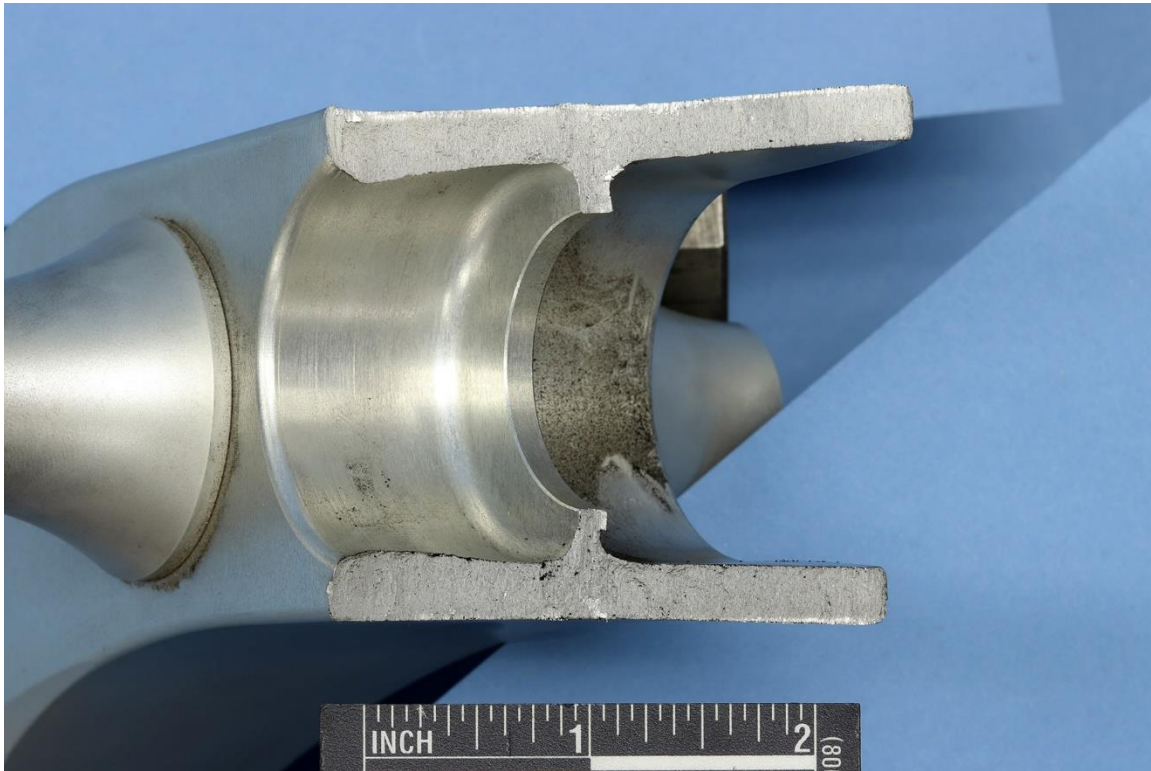


Figure 2: Image of the fracture surfaces on the left side of the carry-through. The fractures exhibited a rough granular appearance, consistent with an overstress fracture.

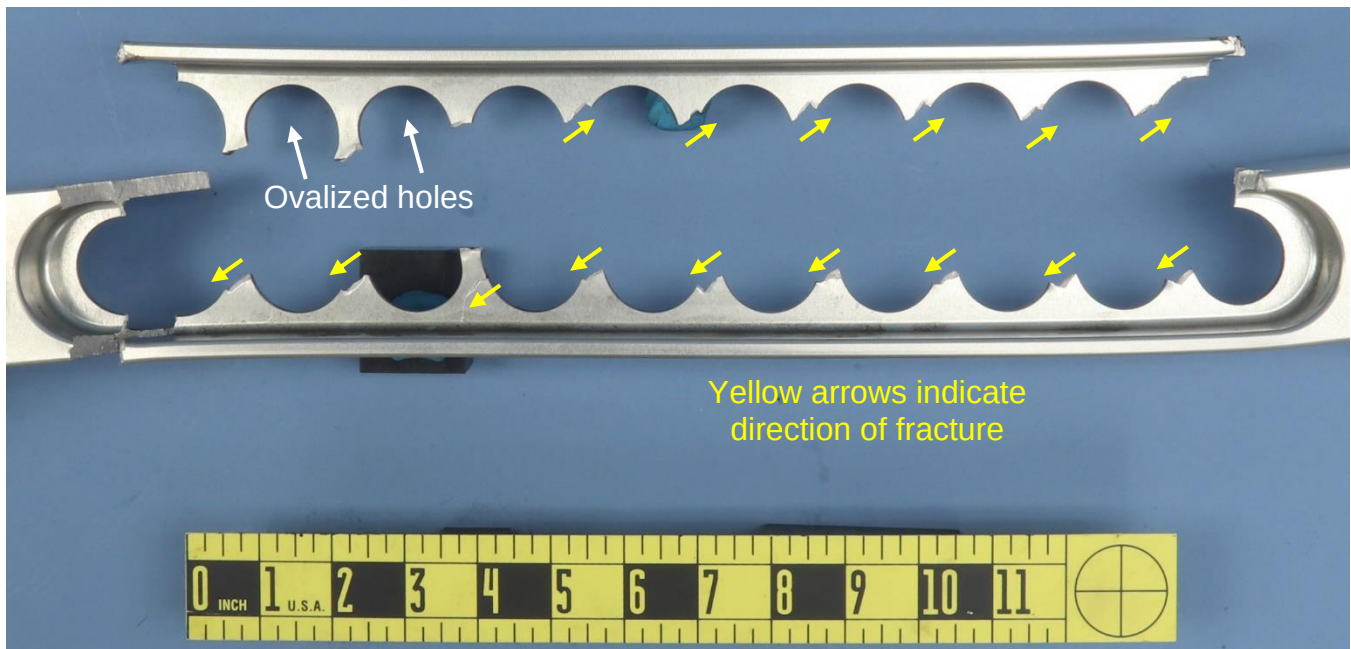


Figure 3: Image of the carry-through spar center section with arrows indicating the direction of crack growth through the web ligaments.

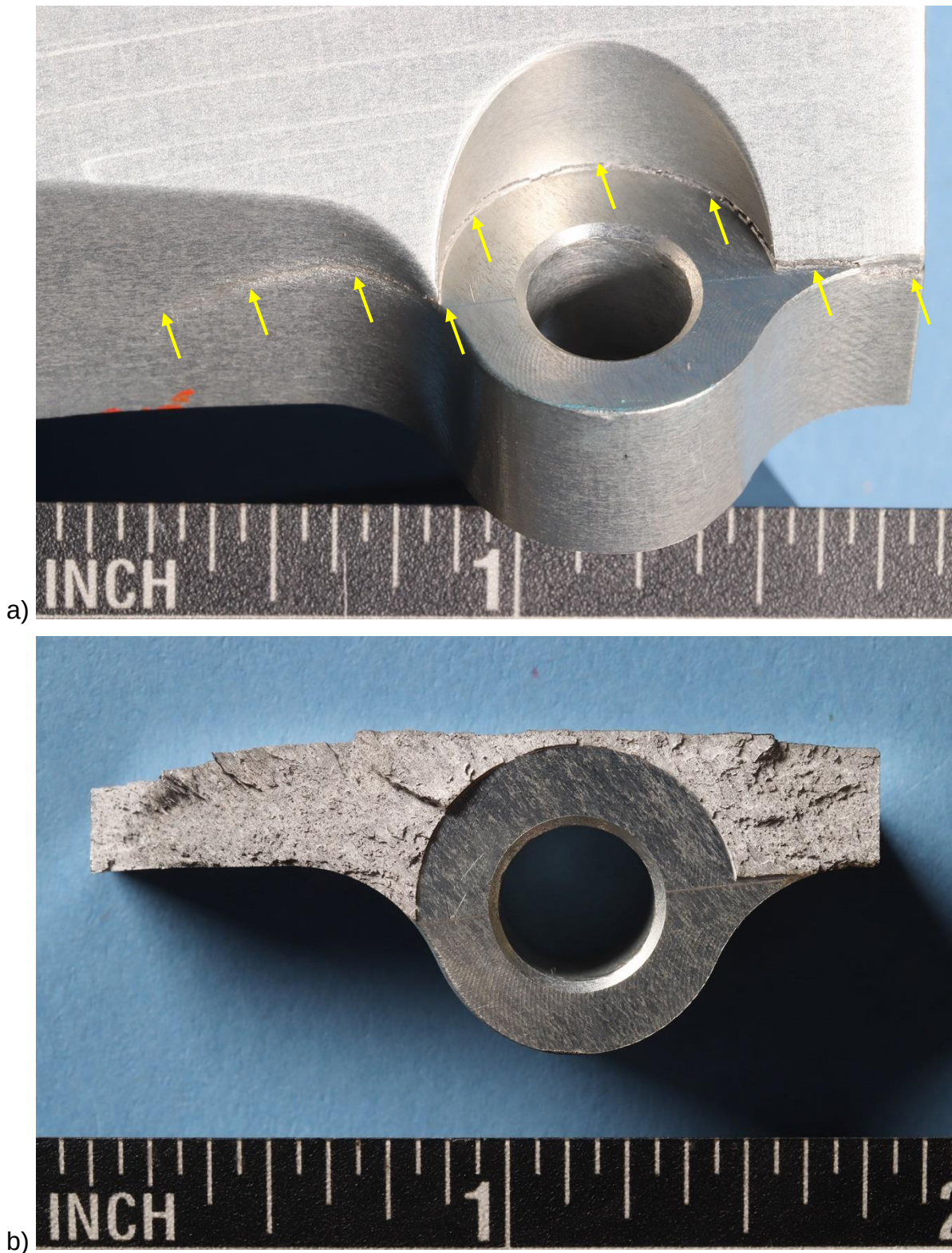


Figure 4: a) Image of the right main landing gear strut tube attachment sleeve showing a longitudinal crack near the clamping lug, as indicated by yellow arrows and b) image of the fracture surface after the crack was broken open.