

NATIONAL TRANSPORTATION SAFETY BOARD

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



June 15, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-042

A. ACCIDENT INFORMATION

Place : Leesburg, Virginia
Date : January 19, 2021
Vehicle : American AA-5, N5880L
NTSB No. : ERA21LA106
Investigator : Timothy W. Monville, AS-ERA

B. COMPONENTS EXAMINED

Left and right horizontal stabilizers, elevators, and elevator trim tabs from the accident airplane and exemplar left and right horizontal stabilizers from another airplane of the same make and model.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted horizontal stabilizers, elevators, and elevator trim tabs from the accident airplane is shown as-received in figure 1. The elevators and trim tabs were received disassembled from the horizontal stabilizers, and the tip assembly had been removed from the outboard end of the right elevator. The aft spars were fractured near mid span on both the left and right horizontal stabilizers. The outboard rib on the left horizontal stabilizer was fractured as shown in figure 2, and the fractured piece was missing. The outboard bearing support bracket for the left elevator was missing along with the fractured rib piece. The outboard bearing support bracket associated with the right elevator was disassembled from the outboard rib of the right horizontal stabilizer and was included with the submitted components. White-colored oxides covered much of the interior surfaces of each of the components. Drain holes in the lower skins of the horizontal stabilizers were open and free of debris.

As assembled on the airplane, the elevators rotate about torque tubes supported at two locations on each elevator. At the inboard end of each elevator torque tube, the tube is supported by a bearing support bracket attached to the aft side of the horizontal stabilizer spar connector (see figure 1). At the outboard end of each elevator torque tube, the tube is supported by a bearing support bracket attached to the outboard face of the outboard rib on the horizontal stabilizer assembly. The attachment location on the right outboard rib and the corresponding bearing support bracket are shown in figures 3 and 4, respectively. As assembled, each outboard elevator bearing support bracket is attached with two threaded fasteners that are threaded into nut plates riveted to the interior surface of the outboard rib.

1. Horizontal Stabilizers

The aft spars on the horizontal stabilizers were fractured at approximately left station 19 to 20 and right station 14¹ as shown in figures 5 and 6. On the left horizontal stabilizer aft spar, the upper flange was fractured at left station 19 and buckled and cracked at left station 14.75, and the lower flange was buckled and fractured at left station 20. On the right horizontal stabilizer aft spar, the lower flange was buckled and the upper flange was slightly buckled near the fracture at right station 14. The lower flange was also buckled and cracked at right station 17. The upper and lower skins around each aft spar damage area also showed buckling deformation.

Bondline separations were observed between the aft spar and the upper skin on the left horizontal stabilizer along 1.5 inches from the inboard end and between left stations 13 to 21.5. The aft spar was separated from the lower skin at the bondline between left stations 16.75 to 27.5. On the right horizontal stabilizer, a 5-inch separation was observed between the upper skin and the aft spar where the skin was buckled outboard of the spar fracture. The lower skin was disbonded from the aft spar along the entire length of the spar outboard of the outboard rivet for the spar connector. Additionally, a rivet at the outboard end of the bondline had pulled through the lower skin.

Bondline separations were also observed between the ribs and the skins on both horizontal stabilizers. On the left horizontal stabilizer, bondline separations were observed between the inboard rib and the skin extending 3 inches aft from the leading edge at the upper bondline (see figure 7) and 13 inches forward from the aft edge at the lower bondline. The middle rib for the left horizontal stabilizer was also separated from the lower skin. At the outboard rib, the upper skin was bowed upward at the bondline, and the rib was separated from the upper skin extending 8 inches forward from the aft spar. The lower bondline for the outboard rib was separated extending 7.5 inches forward from the aft spar. The skin at the leading edge was also deformed, and 0.5-inch-long bondline separations were observed extending from the leading edge of the outboard rib along the upper and lower flanges.

On the right horizontal stabilizer, bondline separations were observed between the inboard rib and the upper skin extending 2.5 inches aft from the leading edge and 14 inches forward from the trailing edge. Additional separations were observed between the inboard rib and the lower skin extending 0.75 inches aft from the leading edge and along a 2.5-inch-long segment in a damaged area near the forward fuselage attachment flange.

At the outboard rib for the right horizontal stabilizer, bonds with the upper and lower skins were separated extending 4.5 inches and 2.75 inches forward from the aft spar, respectively. The leading edge was deformed aft, and the lower skin was buckled and separated from the outboard rib extending 1.25 inches aft from the rib leading edge.

¹ The station is the horizontal distance from the airplane centerline measured in inches.

In order to more closely examine cracks and fractures in the outboard ribs, portions of the outboard ends of the horizontal stabilizer were cut from the remainder of the assemblies as shown in figures 8 and 9. As shown in figure 8, the outboard rib for the left horizontal stabilizer was fractured adjacent to the aft spar and through the aft lightening hole. The fractures intersecting the aft lightening hole extended from cutouts in the upper and lower flanges associated with a bend in the rib web. A vertical crack also extended from the upper side of the rib through approximately half the rib aft of the forward lightening hole.

On the fractures intersecting the aft lightening hole, rough fracture features with out-of-plane bending deformation were observed, features consistent with ductile overstress fracture. The upper flange was bent downward relative to the rib web, and the adjacent fracture in the web was bent outward near the lightening hole. On the lower side of the fracture aft of the lightening hole, the lower flange was bent upward, and the adjacent web fracture was bent downward and outboard. At the aft end of the outboard rib, the aft flange and a triangular-shaped piece remained attached to the aft spar. The forward tip of the triangular piece was bent inboard, and contact marks were observed on the outboard face. A portion of the lower aft side of the triangular piece was curled up and aft with associated contact marks on the inboard face, consistent with contact with the lower nut plate. A vertical crack extended upward along the bend between the aft flange and the triangular-shaped web piece to approximately the middle of the web.

The aft piece of the left horizontal stabilizer outboard rib was cut from the remainder of the aft spar to facilitate an examination of the fracture surfaces using a scanning electron microscope (SEM). The sectioned piece was immersed in acetone and cleaned using an ultrasonic cleaner. SEM imaging of the fracture surfaces showed dimple features consistent with ductile overstress fracture (see figure 10).

The outboard piece cut from the right horizontal stabilizer is shown in figure 9. Cracks extended into the outboard rib web from the cutouts in the upper and lower flanges aft of the aft lightening hole as shown in figure 9. Additionally, cracks extended upward from rivets for the lower bearing support attachment nut plate, also indicated in figure 9. A portion of the outboard rib web between the lower nut plate and the lower flange was fractured and missing.

Angled cuts were made using a handheld grinding wheel to cut from the aft lightening hole to the crack tips aft of the lightening hole, and a vertical cut was made along the bend between the web and the aft flange to expose the vertical cracks aft of the aft lightening hole. Then a horizontal cut was made through the web starting at the aft end and intersecting the crack extending upward from the forward nut plate rivet.

Rough fracture features approximately perpendicular to the web plane were observed on the web fracture below the lower nut plate and on the crack extending upward from the forward rivet. The fracture features were further examined using the SEM, and results showed relatively coarse striations intermixed with dimple features, features consistent with cyclic overstress loading. Figure 11 shows cyclic overstress

features from the horizontal fracture below the lower nut plate. Similar fracture features were also observed on the crack extending upward from the forward rivet.

The fracture extending from the cutout in the upper flange of the outboard rib had slant angles extending into the web, consistent with ductile overstress fracture. The fracture on the lower flange was heavily damaged with out-of-plane deformation consistent with post-fracture recontact between the fracture surfaces. The features associated with the crack extending upward into the web from the lower flange was examined using an SEM, and elongated dimples consistent with ductile overstress fracture were observed, and most of the fracture features on the lower flange were obliterated by post-fracture contact. However, an area with intact fracture features near the bend between the flange and the web had relatively coarse striations intermixed with dimple features, consistent with cyclic overstress.

2. Elevators and Trim Tabs

The elevators were largely intact. Tip assembly damage was observed on the inboard side of the left elevator tip consistent with contact with the horizontal stabilizer, and both elevators had contact damage near mid span corresponding to contact with the fractured horizontal stabilizer aft spars.

Views of the inboard and outboard ends of the left elevator trim tab are shown in figures 12 and 13. The inboard rib remained attached to the trim control arm but was separated from the upper skin and the vertical and lower horizontal portions of the lower skin. Pieces of the upper and lower skin were fractured and missing, and the entire area showed evidence of post-fracture contact. The bondline at the trailing edge of the trim tab was separated from the inboard end out to the rivet at the outboard end shown in figure 13. The rivet hole at the inboard end of the lower skin was enlarged and broken out to the edge (see figure 12). Dark deposits were observed on the bondline surfaces as indicated in figure 12 near the inboard end between 1.75 inches and 20 inches from the inboard end. A sample of the dark deposits was collected onto a carbon-coated stub and examined using energy dispersive x-ray spectroscopy. The EDS spectra for the deposits typically showed high peaks of aluminum, oxygen, carbon, and silicon with smaller peaks of sodium, magnesium, silicon, phosphorus, sulfur, chlorine, potassium, calcium, titanium, and iron.

Views of the inboard and outboard ends of the right elevator trim tab are shown in figures 14 and 15. The inboard rib remained attached to the trim control arm but was separated from the upper skin and the vertical and lower horizontal portions of the lower skin. The entire inboard end of the upper skin was missing, and portions of the lower skin were also fractured and missing. Marks consistent with post-fracture contact between the inboard rib and the lower skin were observed. The bondline at the trailing edge of the trim tab was separated from the inboard end out to within 3 inches of the outboard end, and dark deposits were observed on the bondline surfaces along most of the disbanded length. The interior surface of the lower skin forward of the inboard rivet hole appeared darkened and rubbed consistent with movement between the upper and lower skins near the rivet location. Fretting damage was also observed around the inboard rivet hole on

the lower surface of the lower skin consistent with movement between the lower skin and the inboard rivet buck tail. Bubbled or missing paint consistent with corrosion was observed at the trailing edge, and several areas appeared to have been repainted as indicated in figures 14 and 15.

3. Exemplar Horizontal Stabilizer

Horizontal stabilizers from another American AA-5 airplane were submitted for nondestructive examination. An overall view of the lower side of the horizontal stabilizers is shown in figure 16. The horizontal stabilizers were connected by the rear spar connector and by a temporary wood support piece at the forward fuselage connection flanges. Interior surfaces were partially covered with white oxides.

On the lower skin shown in figure 16, the outboard drain hole in the right horizontal stabilizer and the inboard drain hole on the left horizontal stabilizer were blocked with debris. Bubbled and missing paint was observed on the lower skin along most of the trailing edge as shown in figures 17 and 18. On the left horizontal stabilizer, 7 flush-head rivets (including 1 original rivet) were observed at the outboard end of the bondline between the upper skin and the aft spar, and 21 rivets (including 1 original rivet) were observed at the outboard end of the bondline between the lower skin and the aft spar, consistent with a riveted repair of the bondlines.

A quarter was used to tap the upper and lower skins along bondlines with the inboard and outboard ribs. The edges were also inspected visually for cracks indicating bondline separations.

At bondlines between the outboard rib and skins for the left horizontal stabilizer, a 6.5-inch-long crack was observed at the aft end of the upper bondline, and a 1.75-inch-long crack was observed at the aft end of the lower bondline as shown in figure 19. A dull tapping sound was heard on the upper skin along the bondline to the outboard rib between 2 and 5 inches away from the aft spar.

At bondlines between the inboard rib and skins for the left horizontal stabilizer, 9-inch-long cracks were observed at the aft ends of the upper and lower bondlines, and a 2-inch-long crack was observed at the lower bondline between 15.5 inches and 17.5 inches away from the aft end. A dull tapping sound was heard on the upper skin along the bondline to the outboard rib up to 13 inches away from the aft spar, and on the lower bondline up to 6.5 inches from the aft spar and between 15.5 and 17.5 inches away from the aft spar.

At bondlines between the inboard rib and skins for the right horizontal stabilizer, a 1.5-inch crack was observed at the aft end of the upper bondline, which also corresponded to an area with a dull tapping sound on the upper skin.

At the bondlines between the outboard rib and skins for the right horizontal stabilizer, a 3.25-inch-long crack was observed at the aft end of the upper bondline as shown in figure 20, and a 3.625-inch-long crack was observed at the lower bondline from

5.5 inches to 9.125 inches away from the aft end. Additionally, a 0.75-inch-long crack was observed at the forward end of the lower bondline. Although sealant appeared to be missing from at the aft two inches of the lower bondline, the bondline did not appear to be separated. A dull tapping sound was heard along the bondlines to the outboard rib between 1.5 and 2.5 inches away from the aft spar on the upper skin and between 6 and 8 inches away from the aft spar on the lower skin.

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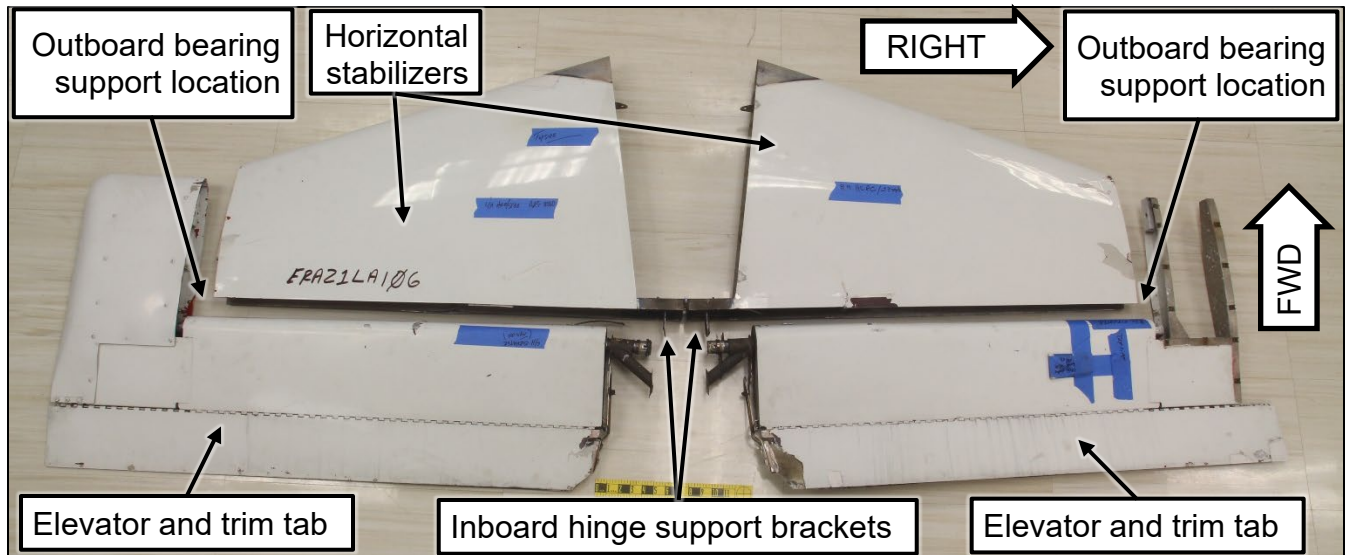


Figure 1. Overall view of the submitted horizontal stabilizer, elevator, and elevator trim tab assemblies from the accident airplane as received.

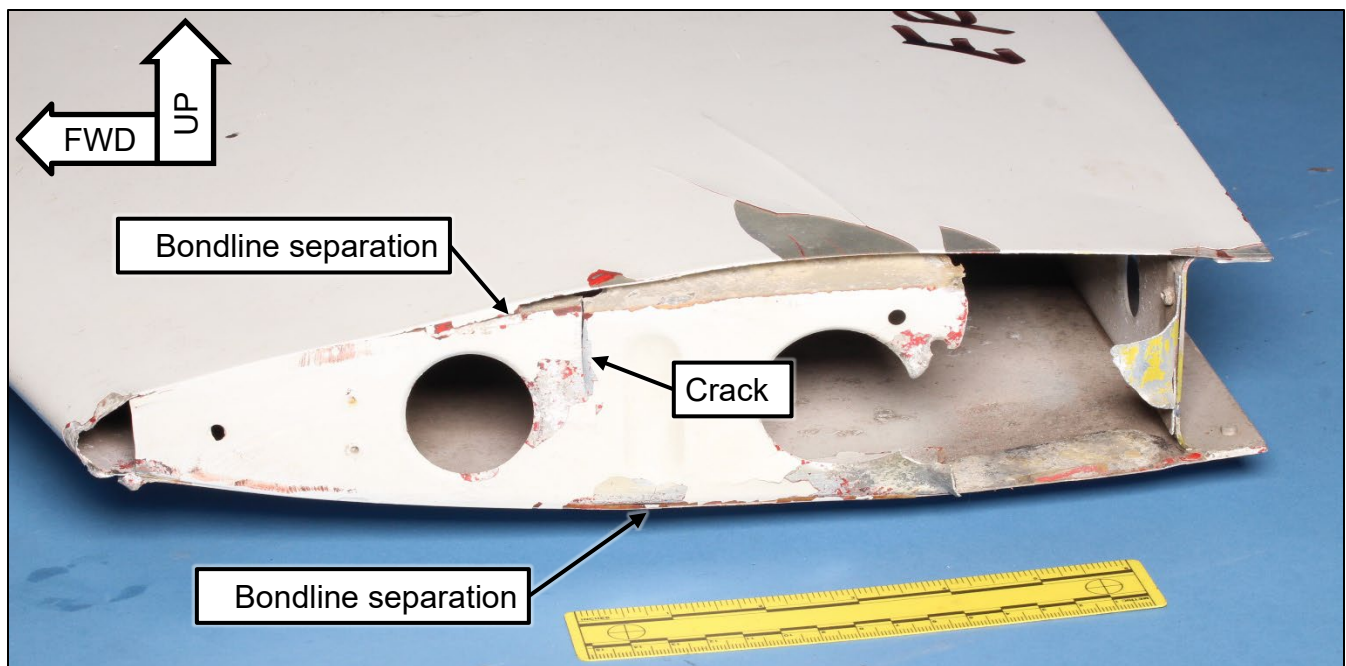


Figure 2. Left end of the horizontal stabilizer assembly showing the fractured and cracked outboard rib.

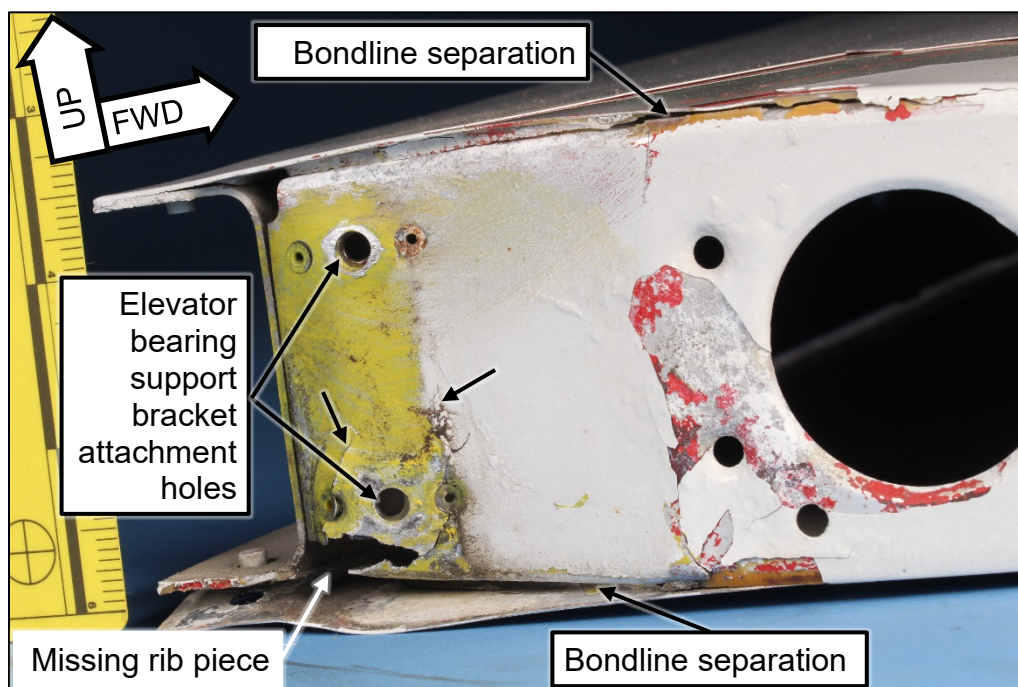


Figure 3. Right end of the horizontal stabilizer assembly showing the aft end of the outboard rib. Unlabeled arrows point to cracks extending upward from rivet holes associated with the lower nut plate for the outboard elevator bearing support bracket attachment.

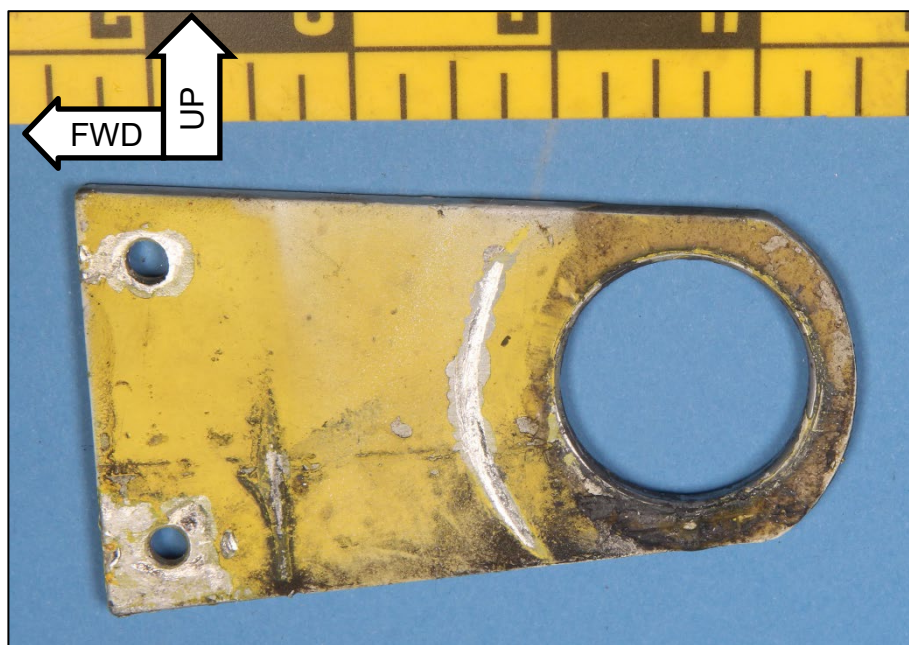


Figure 4. Right elevator outboard bearing support bracket.

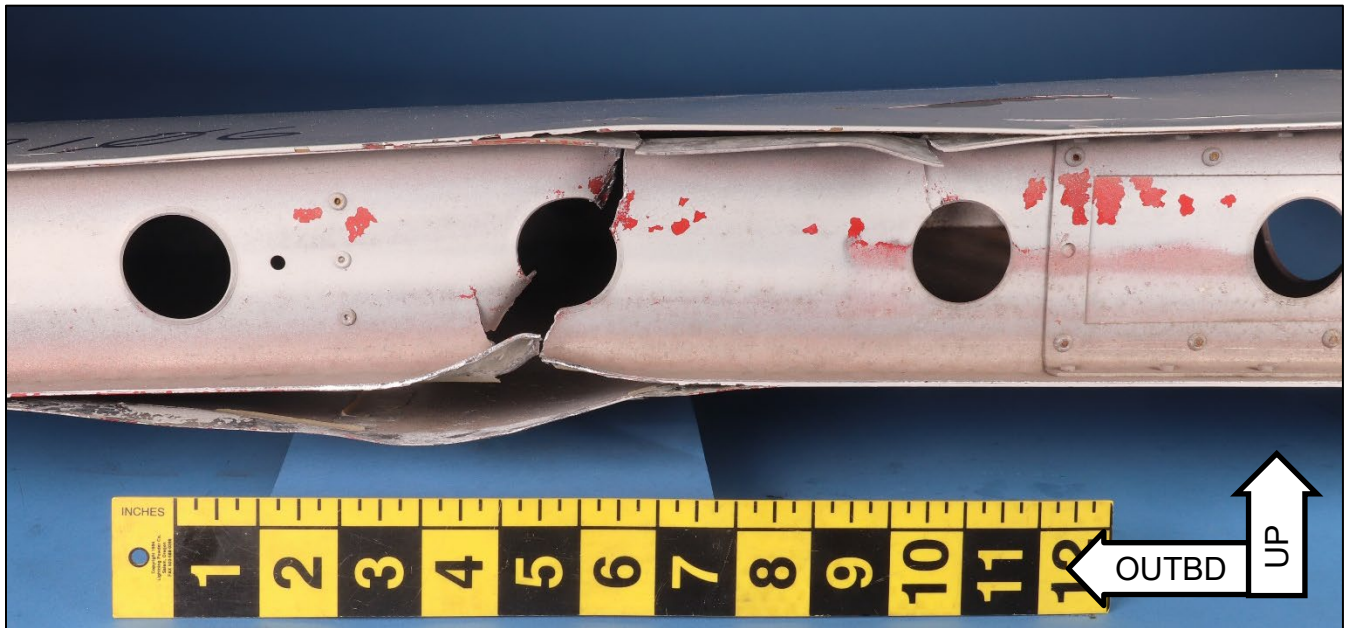


Figure 5. Fractured and buckled aft spar on the left horizontal stabilizer.

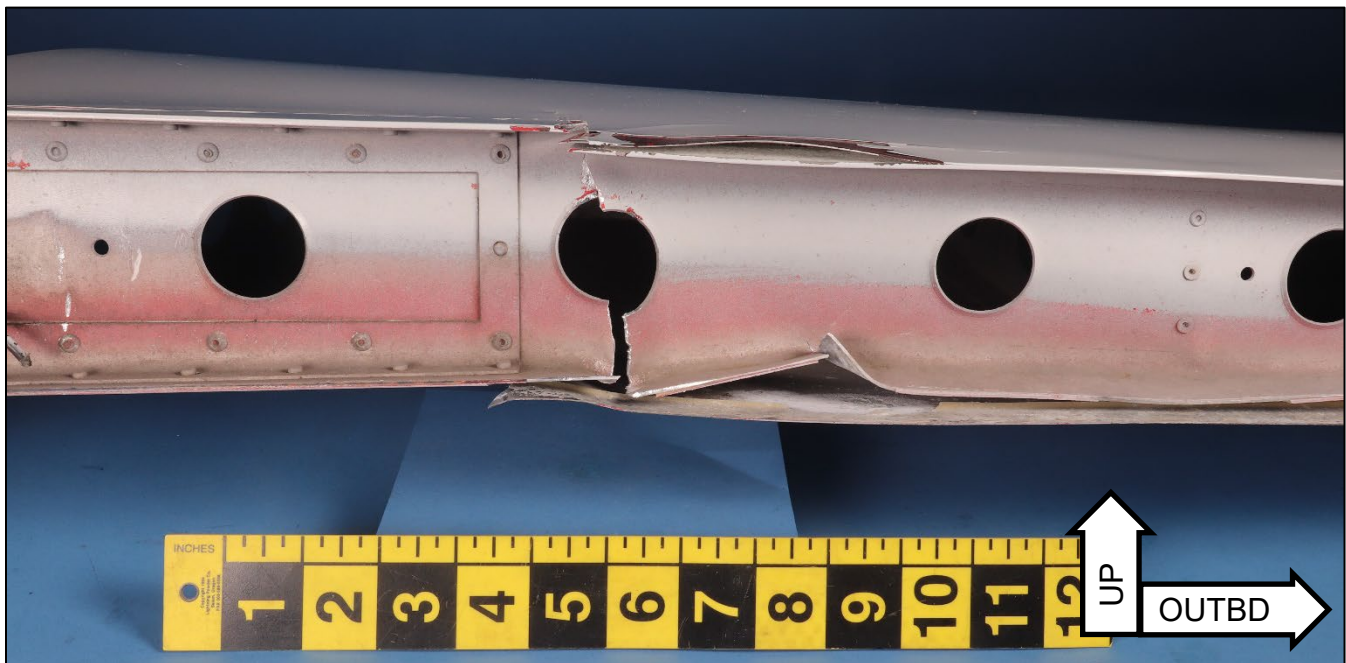


Figure 6. Fractured and buckled aft spar on the right horizontal stabilizer.

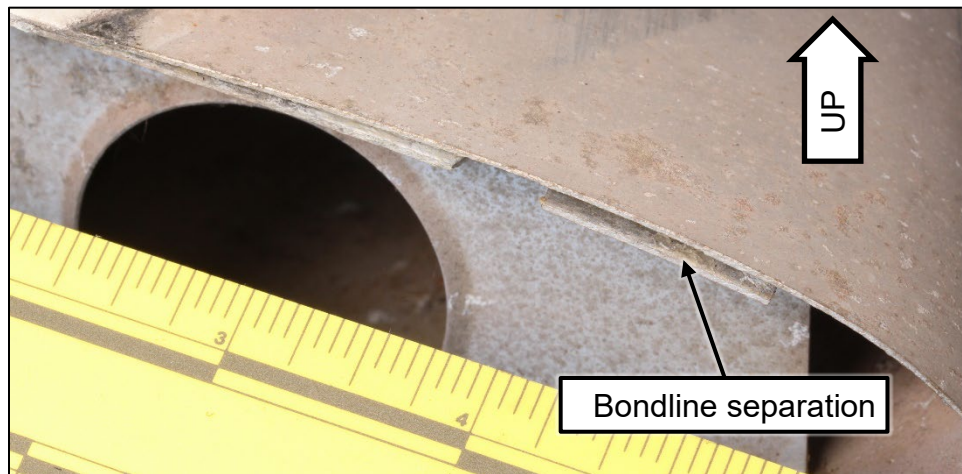


Figure 7. Bondline separation between the inboard rib flange and the upper skin on the left horizontal stabilizer at the forward end of the rib.

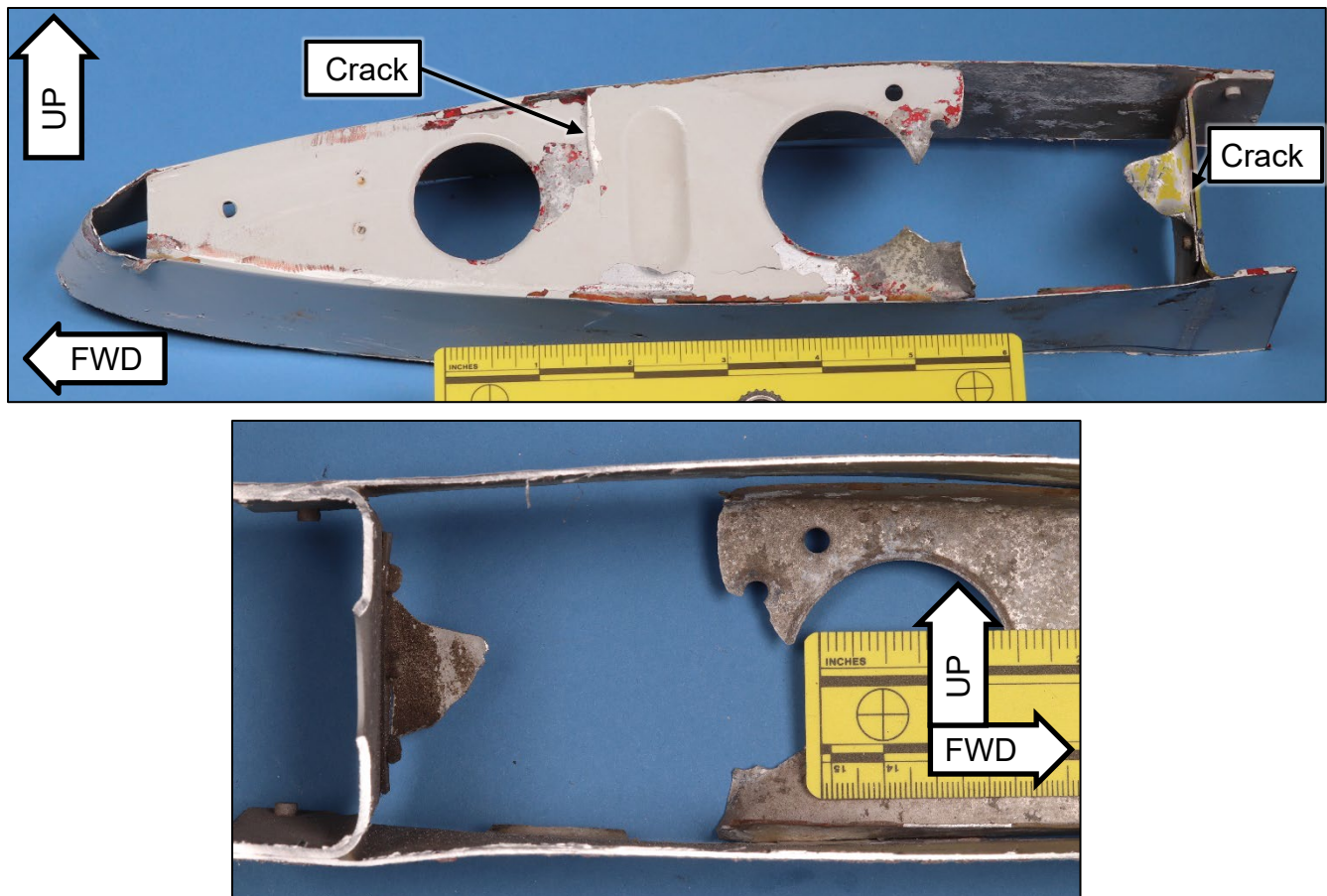


Figure 8. Outboard piece of the left horizontal stabilizer after it was cut from the rest of the assembly showing the outboard face (upper image) and the inboard face (lower image) of the fractured outboard rib.

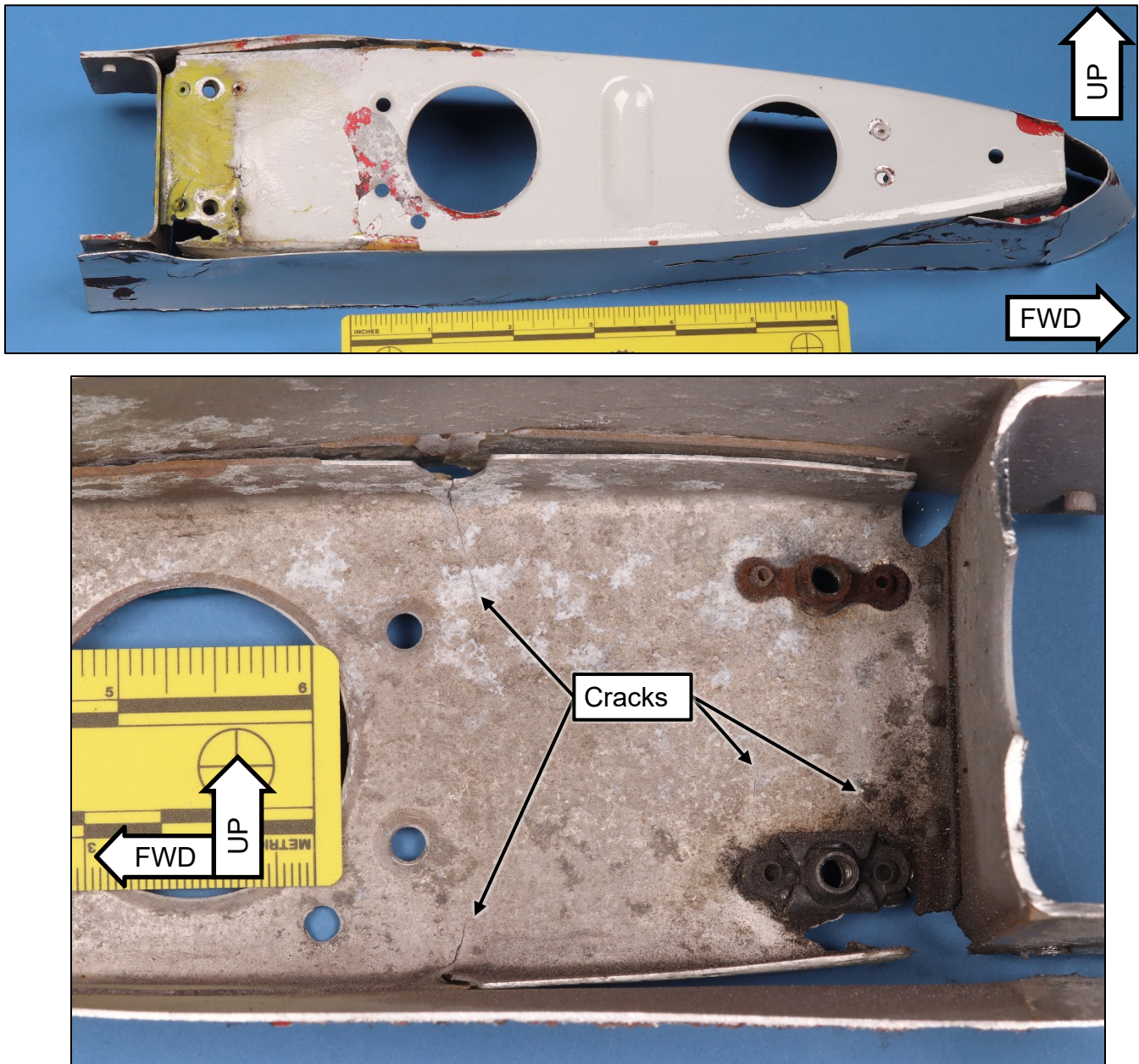


Figure 9. Outboard piece of the right horizontal stabilizer after it was cut from the rest of the assembly showing the outboard face (upper image) and the inboard face (lower image) of the cracked outboard rib.

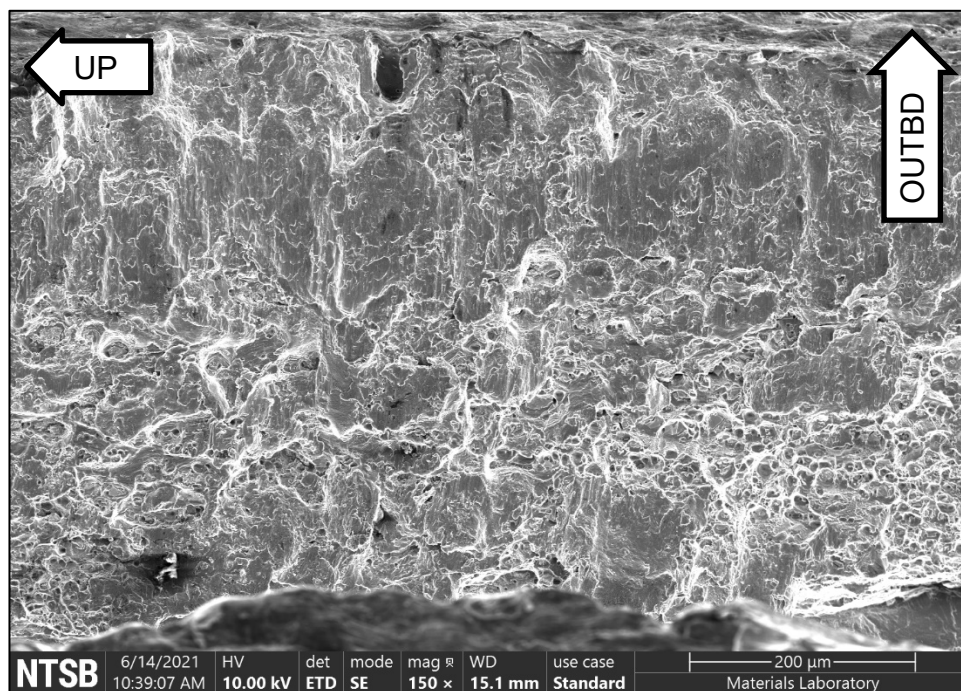


Figure 10. SEM image of typical dimple features observed on fractures at the aft end of the left horizontal stabilizer outboard rib.

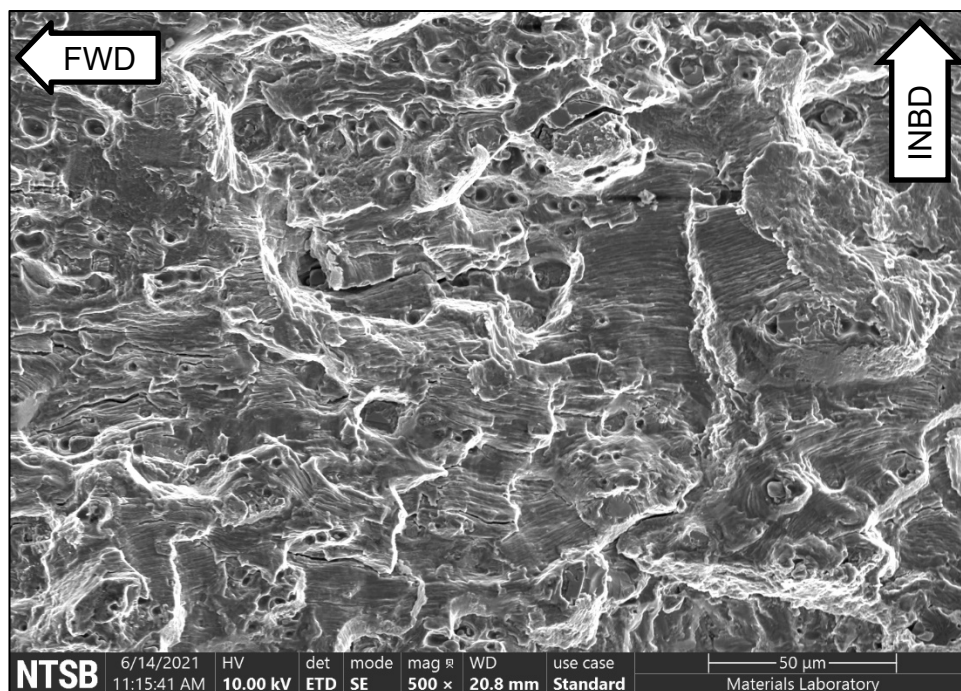


Figure 11. SEM image of coarse striations with dimple features observed on fractures at the aft end of the right horizontal stabilizer outboard rib.

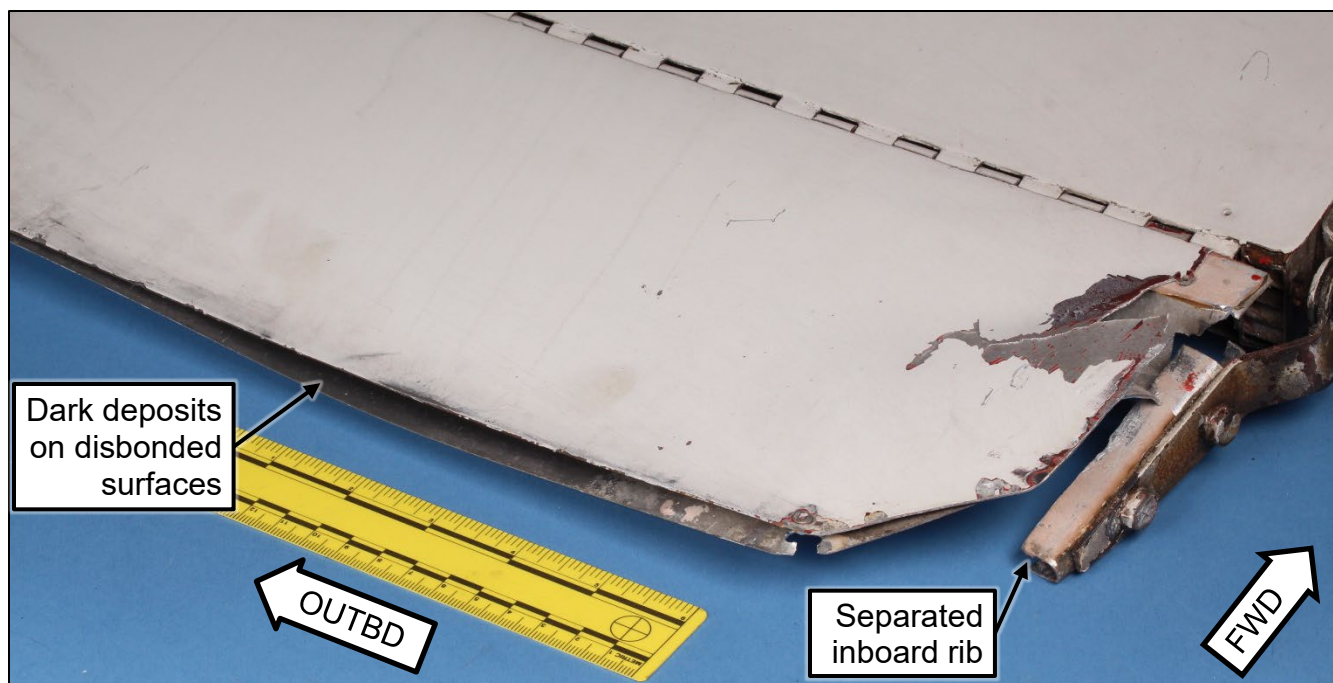


Figure 12. Inboard end of the left elevator trim tab showing separations at the bondlines and cracks and fractures in the spar and skin at the inboard rib.



Figure 13. Outboard end of the left elevator trim tab showing bondline separation, corrosion, and bubbled paint along the trailing edge.

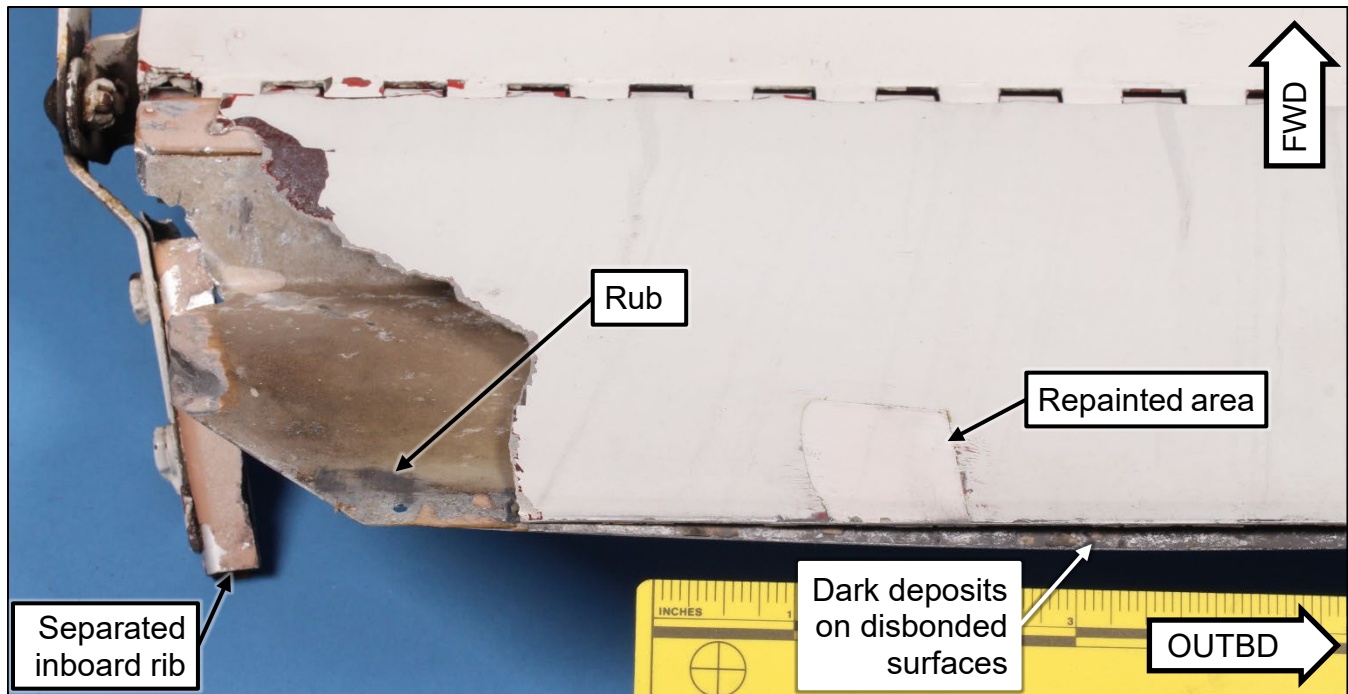


Figure 14. Inboard end of the right elevator trim tab showing separations at the bondlines, cracks and fractures in the spar and skin at the separated inboard rib, and an area that appeared repainted.

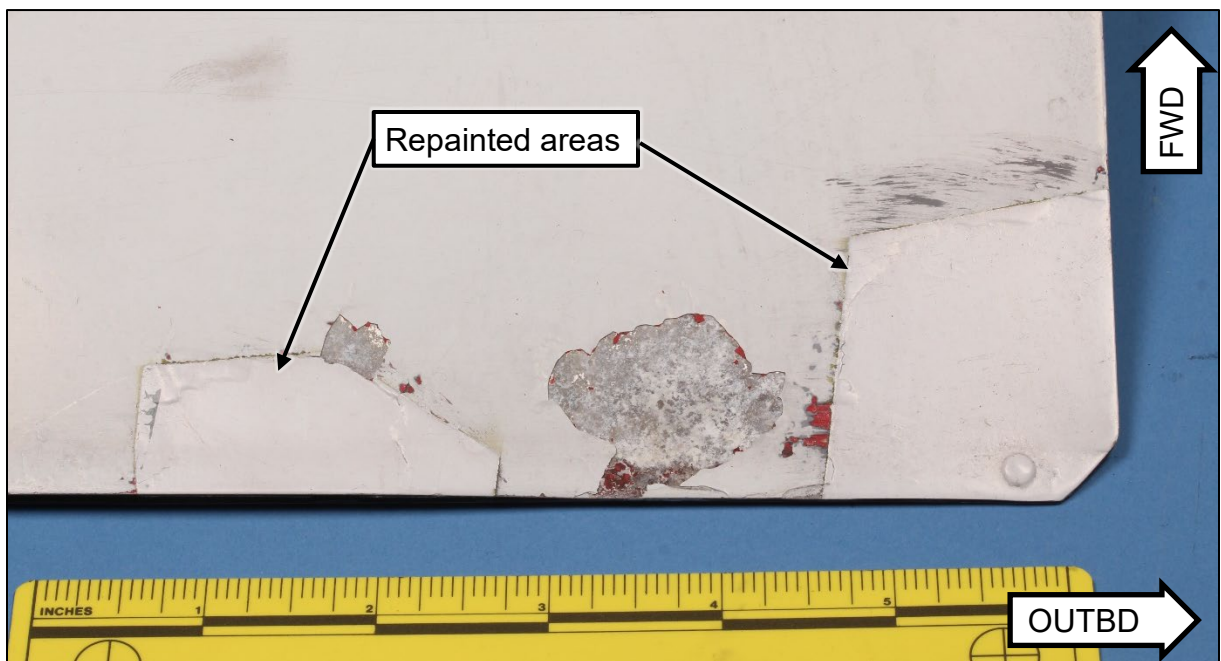


Figure 15. Outboard end of the left elevator trim tab showing corrosion and bubbled paint along the trailing edge and two areas that appeared repainted.

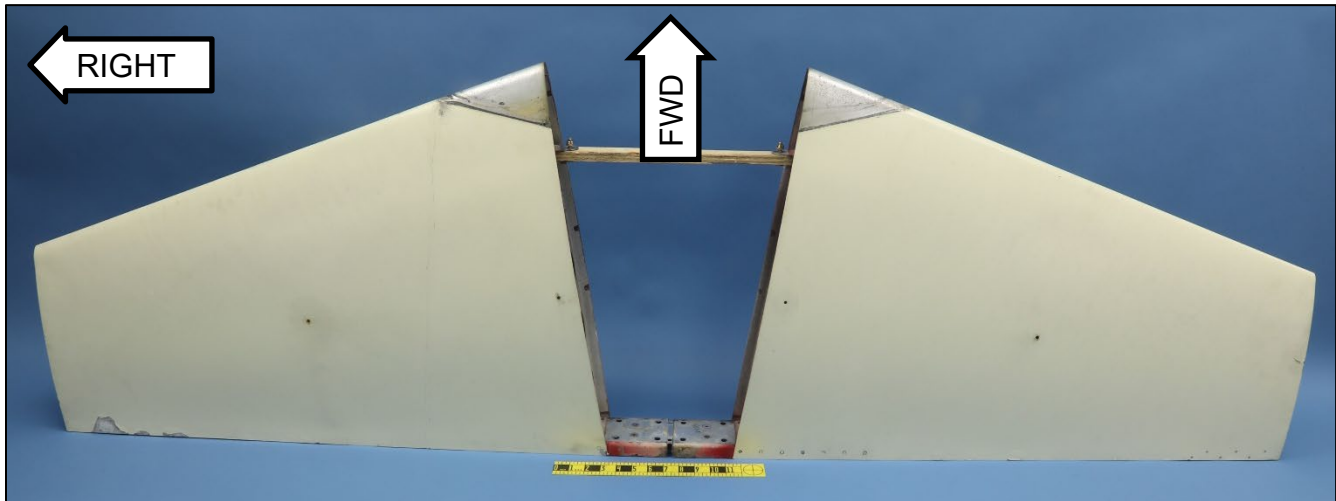


Figure 16. Lower surface of an exemplar horizontal stabilizer from another American AA-5 airplane as-received for nondestructive examination.



Figure 17. Outboard end of the exemplar right horizontal stabilizer showing corrosion with bubbled and missing paint on the lower skin at the trailing edge.



Figure 18. Trailing edge of the exemplar right horizontal stabilizer showing indications of corrosion with bubbled paint at the trailing edge of the lower skin near mid span.

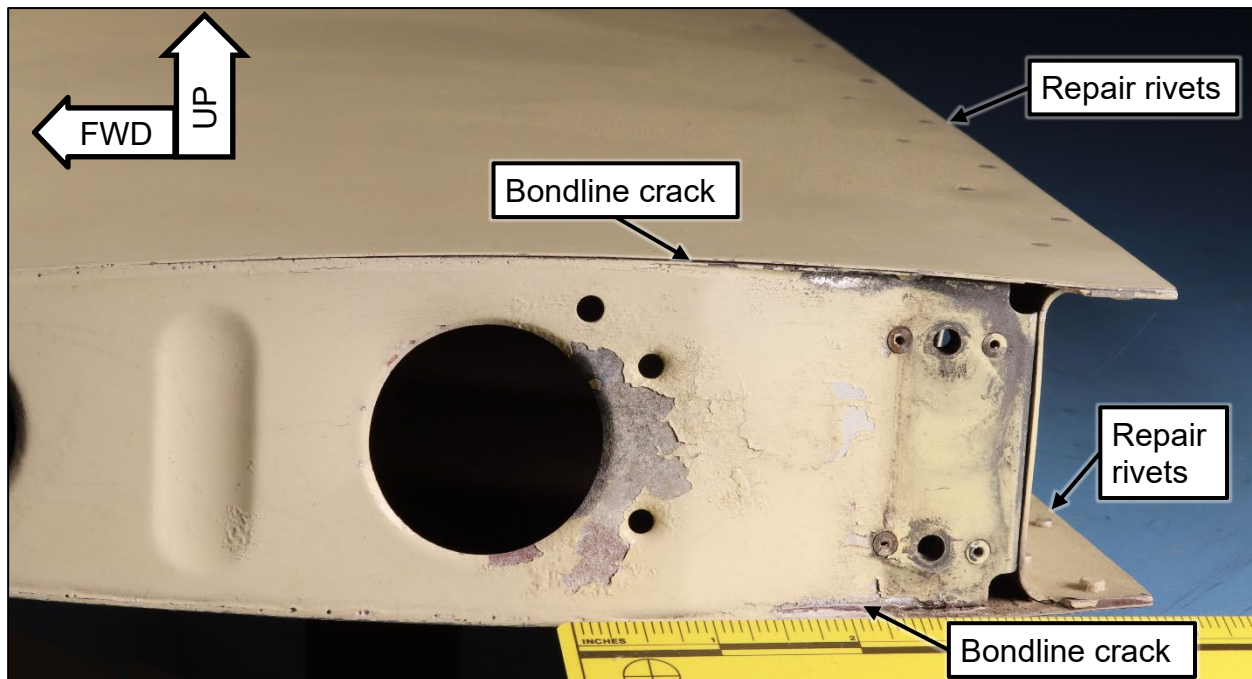


Figure 19. Outboard end of the exemplar left horizontal stabilizer showing cracks indicating bondline separations between the outboard rib flanges and the upper and lower skins.

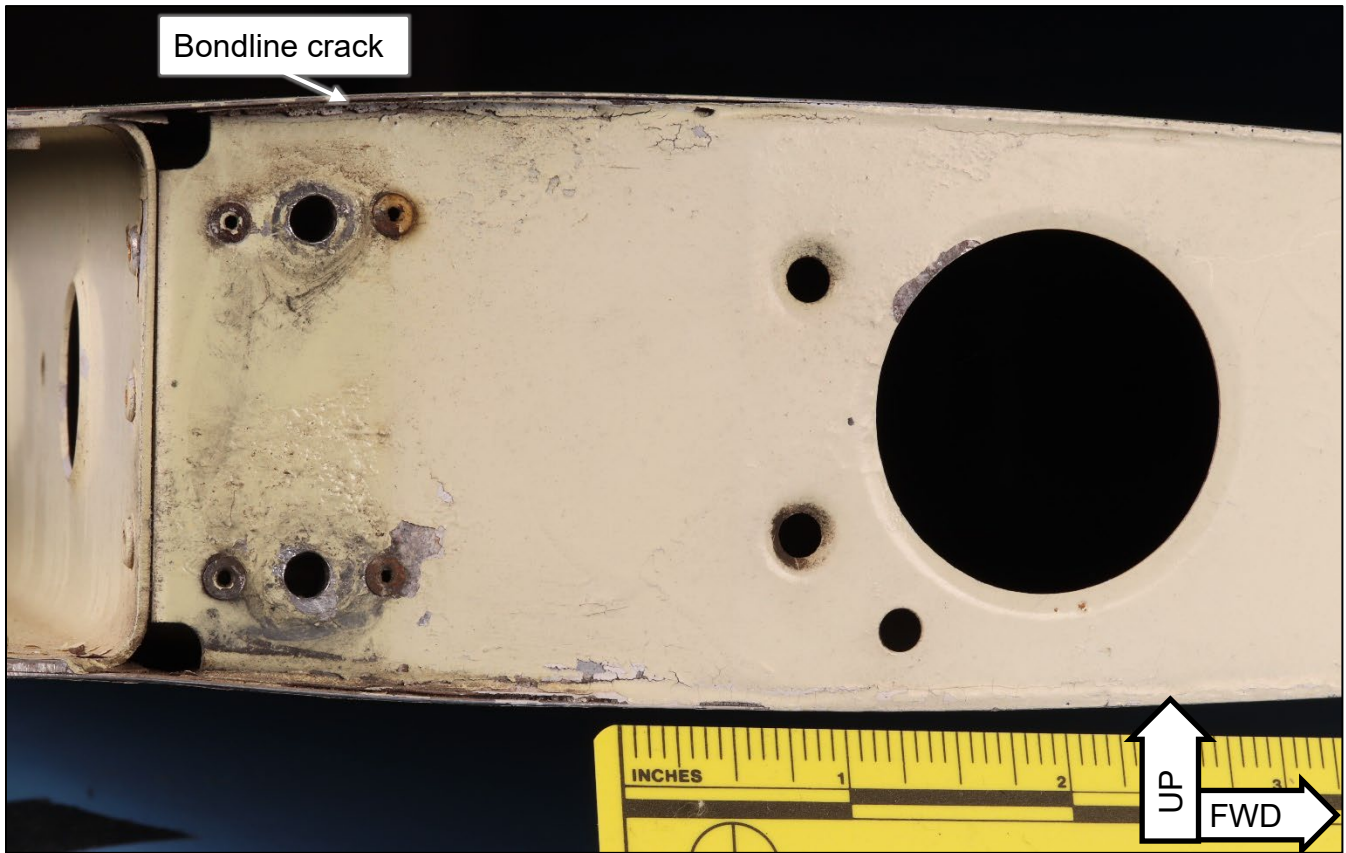


Figure 20. Outboard end of the exemplar right horizontal stabilizer showing cracks indicating bondline separations between the outboard rib flanges and the upper and lower skins.