

NATIONAL TRANSPORTATION SAFETY BOARD

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



August 4, 2016

MATERIALS LABORATORY FACTUAL REPORT

Report No. 16-064

A. ACCIDENT INFORMATION

Place : Wake, Virginia
Date : January 14, 2016
Vehicle : Flightstar II
NTSB No. : ERA16FA089
Investigator : Aaron McCarter, AS-ERA

B. COMPONENTS EXAMINED

Forward and aft spar pieces from the left wing.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 1 as received in the materials laboratory. The forward spar is shown in 3 pieces in the upper portion of the image, and the aft spar is shown at the lower side of the image. The forward and aft spars had a tubular cross-section that was bisected with a vertical web, appearing like back-to-back "D" channels. Portions of the chordwise brace tubes were attached to the spars and were labeled A to C from inboard to outboard. The forward spar had been cut in 3 locations and was also bent and fractured. Also attached to the front spar, the fitting for attaching brace tube B, the fitting for attaching the strut, and chordwise brace tube C had been cut. The aft spar was bent but intact and had been cut at the outboard end of the submitted piece.

Photographs from on-scene and the reconstruction were provided by the IIC and were reviewed in conjunction with the laboratory examination. Several of the photographs are shown in figures 2 through 4. In figure 2, the reconstruction of the left wing is shown with pieces placed in their approximate relative positions. Chordwise brace tubes A, B, and C are labeled as shown in figure 2. Two wing struts, also labeled in figure 2, attached to the lower sides of the forward and aft spars at the location corresponding to chordwise brace tube C. Additional support tubes connected the middle of the struts to the lower sides of the spars at the location corresponding to chordwise brace tube B.

The wings had been modified from the as-manufactured condition. Modifications included adding an aluminum leading edge strip (shown labeled in figures 2 and 3), different skin material, different wing profile, and riveted rib attachments to the spars.

The inboard piece of the forward spar shown in figure 1 had been cut at each end, and the cut at the outboard end of the inboard piece mated to the inboard end of the middle piece. The spar cross-section was pinched with contact marks adjacent to the cut ends, consistent with cutting by a scissor-like action. The outboard ends of the outboard piece of the forward spar and the outboard end of the aft spar were cut without deformation consistent with a saw cut.

A segment of chordwise brace tube A remained attached to the forward spar. The end of the tube was fractured with uniform wall thinning and fracture on a slant plane, features consistent with ductile overstress fracture under tensile load.

The forward spar had mating fracture surfaces between the outboard end of the middle piece and the inboard end of the outboard piece. The fracture was located 27 inches inboard of chordwise brace tube C. The fracture features showed buckling deformation at the upper aft side of the spar and curving deformation on the forward face consistent with the outboard end of the spar displacing upward and aft relative to the fracture location.

The forward spar was bent at a location between 21.5 inches and 29 inches outboard of chordwise brace tube C. The overall deformation of the spar was consistent with the outboard end moving forward and up relative to the bend. Two distinct creases were noted within the inside radius of the bend spaced 5 inches apart. In photos, the leading edge aluminum strip appeared wrinkled in the area corresponding to the location of the bend in the forward spar (see figure 3).

The aft spar included pieces of chordwise brace tubes A and B. Chordwise brace tube A was deformed outboard, and the end was pinched consistent with a scissor-like shear cut. The bracket attaching brace tube B was twisted consistent with the brace tube rotating counterclockwise (as viewed looking forward) relative to the aft spar. The slotted end of brace tube B was also deformed with bulging of the slotted area and flaring of the forward end, features consistent with bending deformation with the forward end of the tube piece moving aft relative to the aft spar attachment. A brace cable was missing at the aft side of the attachment fitting, but the eye shield remained in place. The eye fitting was cracked and deformed with cable wire impressions on the surface, consistent with high tensile loads on the cable.

The aft spar was bent outboard of brace tube B, and the overall deformation was consistent with the outboard end displacing forward relative to the bend. The tube wall was dented inward locally at the bend, consistent with impact with another object.

Ribs had been attached to the spars at locations along the span of the forward and aft spars. A view of ribs still attached to the right wing as viewed on-scene is shown in figure 4. The ribs consisted of curved tubes forming an approximately symmetric airfoil with plastic attachment fittings inserted at each end of each tube. The fittings were then riveted to the upper and lower sides of the spars. A close view of one

of an attachment fitting on the left wing where the rib tube had separated from the barbed end of the attachment fitting is shown in figure 5.

The condition of the rib attachment locations were examined visually on the forward and aft spars, upper and lower attachments, and results of the examination are documented in tables 1 and 2. The rib locations, each consisting of an upper and lower tube, were numbered sequentially from the inboard end of the wing with an "R" prefix before the number for reference in the first column in tables 1 and 2, and the spanwise location relative to features on the spar are noted in the second column. The forward spar pieces had rib attachment locations for the inboard 10 ribs as listed in table 1, and the aft spar had attachment locations for the inboard 4 ribs as listed in table 2. As described in the third column in tables 1 and 2, some of the locations had a hole with no remnant of the rivet or attachment fitting, while other locations showed an intact rivet and attachment fitting (as in figure 5). In some cases, a remnant of a sheared rivet was present within the hole in the spar, such as the case shown in figure 6. At a few locations, the attachment fitting was fractured.

Table 1. Rib Attachments at the Forward Spar

Rib attachment	Spanwise Location	Condition of the Attachment
R1 Upper	Near inboard end	Rivet and fitting missing.
R1 Lower	Near inboard end	Rivet and fitting intact.
R2 Upper	Near chordwise brace A	Rivet and fitting missing.
R2 Lower	Near chordwise brace A	Rivet and fitting intact.
R3 Upper	At inboard end of middle piece	Rivet and fitting missing.
R3 Lower	At inboard end of middle piece	Rivet and fitting intact, but aft side of rivet head is folded over itself.
R4 Upper	Between fracture and chordwise brace B	Rivet and fitting missing.
R4 Lower	Between fracture and chordwise brace B	Rivet and fitting intact.
R5 Upper	Between fracture and chordwise brace B	Rivet and fitting missing.
R5 Lower	Between fracture and chordwise brace B	Rivet and fitting intact.
R6 Upper	Near inboard end of outboard piece	Rivet and fitting intact, but relatively loose attachment.
R6 Lower	Near inboard end of outboard piece	Rivet and fitting intact.
R7 Upper	Inboard of chordwise brace C	Rivet and fitting intact, but relatively loose attachment.
R7 Lower	Inboard of chordwise brace C	Rivet intact, fitting fractured consistent with upward bending.
R8 Upper	Between chordwise brace C and bend	Rivet sheared consistent with fitting moving forward relative to spar. Fitting missing.
R8 Lower	Between chordwise brace C and bend	Rivet sheared consistent with fitting moving forward relative to spar. Fitting missing.
R9 Upper	At inboard end of bend	Fitting fractured through rivet hole consistent with bending where the rib moved outboard relative to the attachment location. Forward and upper surfaces of the fitting piece appeared rubbed.
R9 Lower	At inboard end of bend	Fitting fracture with smeared features consistent with fracture under compression loads.
R10 Upper	Outboard of bend	Fitting fracture through the attachment hole with abrasion on the leading edge. Fracture consistent with tension load combined with rib moving outboard relative to the attachment.
R10 Lower	Outboard of bend	Rivet and fitting intact, but relatively loose attachment.

Table 2. Rib Attachments at the Aft Spar

Rib attachment	Spanwise Location	Condition of the Attachment
R1 Upper	Near inboard end	Rivet and fitting missing.
R1 Lower	Near inboard end	Rivet and fitting missing.
R2 Upper	Near chordwise brace A	Rivet sheared consistent with fitting moving aft relative to spar. Fitting missing.
R2 Lower	Near chordwise brace A	Rivet and fitting missing.
R3 Upper	Inboard of chordwise brace B	Rivet sheared consistent with fitting moving aft relative to spar. Fitting missing.
R3 Lower	Inboard of chordwise brace B	Rivet and fitting missing.
R4 Upper	At the bend in the aft spar	Rivet and fitting missing.
R4 Lower	At the bend in the aft spar	Rivet and fitting missing.

Matthew R. Fox
Senior Materials Engineer

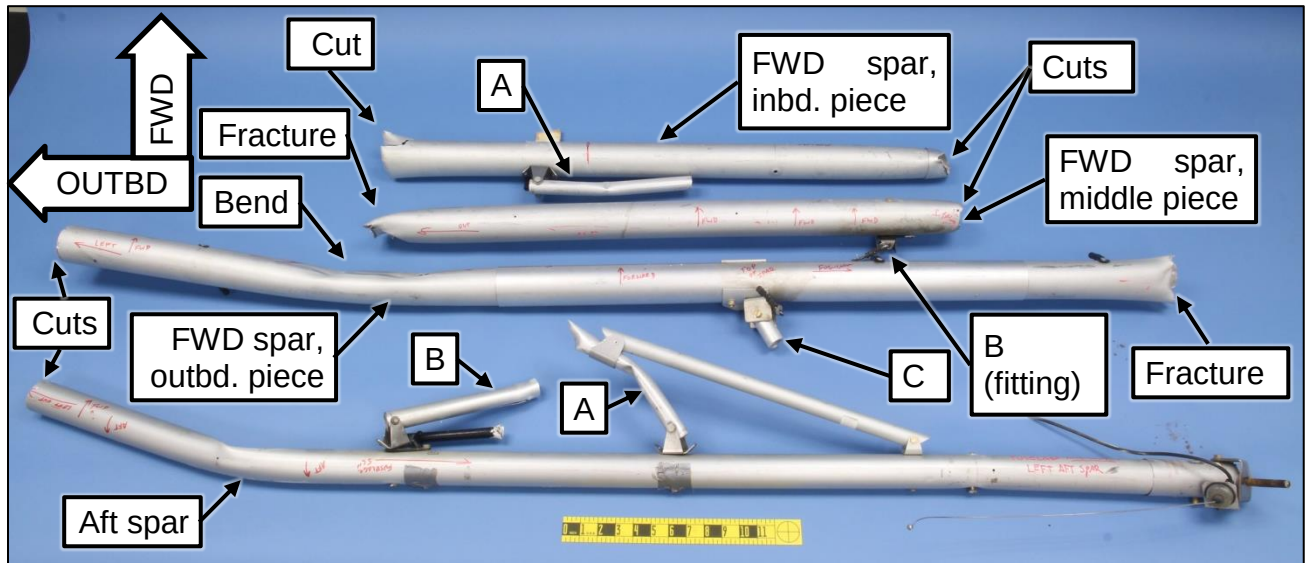


Figure 1. Overall view of the submitted forward and aft spar pieces from the left wing with attached chordwise brace tubes labeled A, B, and C as viewed looking at the upper surfaces.

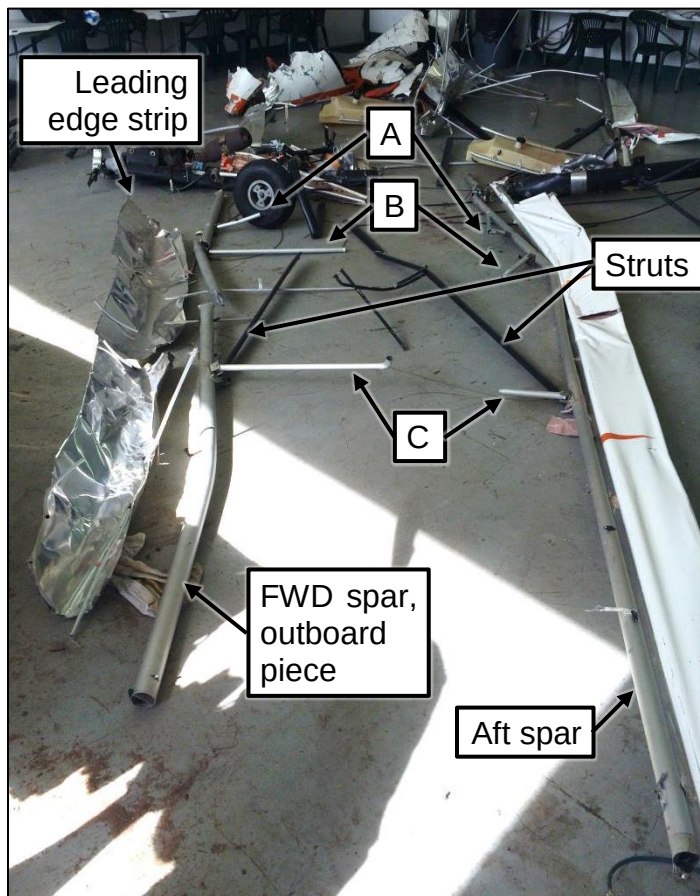


Figure 2. Overall view of the reconstructed left wing pieces including the aluminum leading edge strip.



Figure 3. Left wing skin and leading edge strip as viewed on-scene.

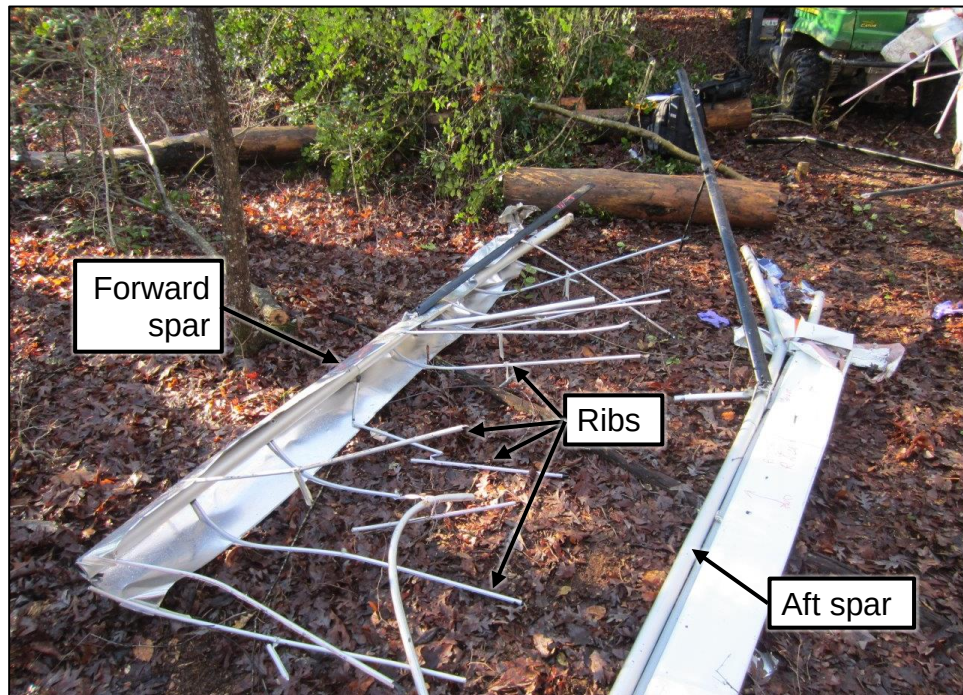


Figure 4. Overall view of the right wing showing the leading edge strip and ribs (several are labeled) attached to the forward spar.

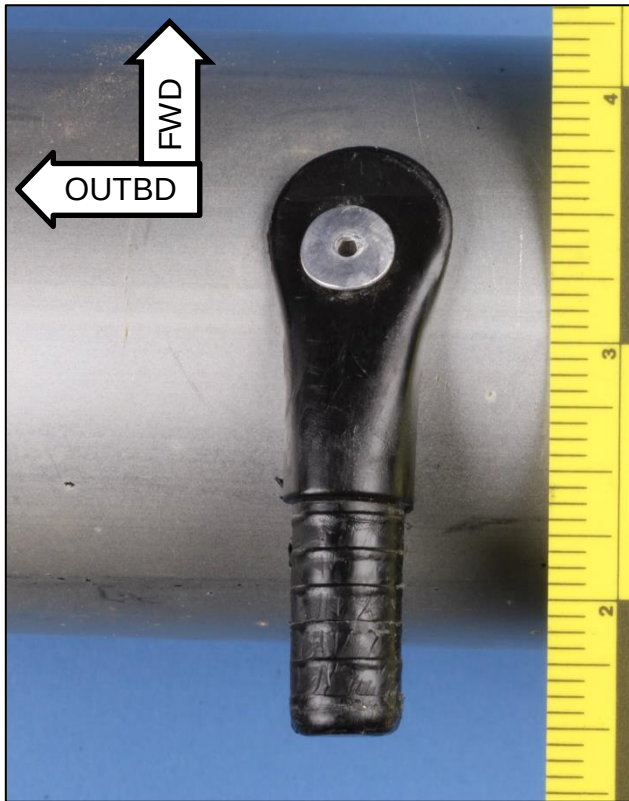


Figure 5. Rib attachment fitting on the forward spar inboard of chordwise brace tube C.

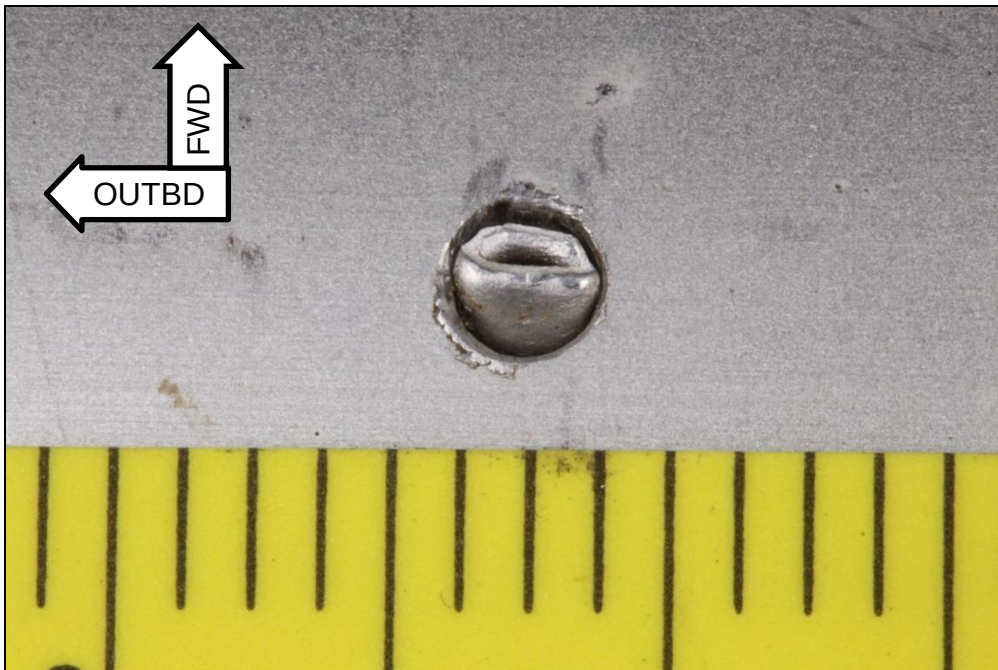


Figure 6. Sheared rivet for the rib attachment fitting on the forward spar outboard of chordwise brace tube C.