

NATIONAL TRANSPORTATION SAFETY BOARD

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



July 13, 2022

MATERIALS LABORATORY FACTUAL REPORT

Report No. 22-047

A. ACCIDENT INFORMATION

Place : Dardanelle, California
Date : August 25, 2018
Vehicle : Bell 212, N512TA
NTSB No. : WPR18LA242
Investigator : Fabian Salazar, ASI – WPR

B. COMPONENTS EXAMINED

Pieces of a Bell 212 main rotor blade spar.

C. DETAILS OF THE EXAMINATION

Pieces of a Bell 212 main rotor blade spar were submitted to the NTSB Materials Laboratory for examination as shown in figures 1 – 3. The pieces had been cut chordwise prior to shipping. The approximate origin of each piece is indicated on the photo shown in figure 4, which was taken at the crash site. The piece shown in figure 1 was closest to the root end of the blade. The adjoining pieces are shown in figures 2 (2 pieces) and 3 (1 piece), respectively. The lengths of the pieces, starting at the root end and as measured by a tape measure along the leading edge, were approximately 42.8 inch, 46.2 inch, 9.5 inch, and 47.2 inch, respectively. The blade kerf, measured on a dead-end cut, was approximately 0.1 inch (1/8 inch). Including the width of the cuts, the pieces spanned a length of approximately 146.0 inch (12.17 ft). For comparison, the rotor diameter is listed as approximately 48 ft. The trailing edge and much of the blade afterbody had separated from the D-spar as described below.

The construction of the spar to afterbody transition can be seen in figure 5. Upper and lower aluminum skins lapped and were bonded to the upper and lower surfaces of the spar. The skins extended aft forming the upper and lower surfaces of the afterbody. The interior of the afterbody was filled with a hexagonal aluminum honeycomb core. The skins and core were bonded using a film adhesive (red color in figure 5) and a layer of the adhesive also appeared to have been applied to the aft face of the spar. A yellow-green foaming adhesive was applied at the interface between the core and the spar aft face. As seen in figure 5 the foam formed elongated structures that conformed to the structure of the honeycomb core. The foam structures were cracked along 45° angles relative to the spanwise direction and in some regions the foam exhibited cohesive separations near the interface with the underlying red adhesive layer.

The spar exhibited an upward bend, as shown in figures 1b, 2b, 3b, and 4, and an aft bend, as shown in figure 3a. On-scene images of the trailing edge and afterbody are shown in figures 6a and 6b. The upper surface, shown in figure 6a did not exhibit any apparent large-scale skin wrinkling or bend buckling. The trailing edge exhibited a severe localized bend near the root, as seen in figure 6b, but the remainder of the trailing edge appeared to exhibit comparatively minimal bending and/or deformation elsewhere.

Near the root end of the blade, the afterbody had separated along the edges of skin doublers that extended past the aft face of the spar on the upper and lower surfaces, as indicated in figure 1a. Moving outboard along the blade, the width of the doublers gradually decreased until they intersected the aft face of the spar, at which point the afterbody separation ran along or adjacent to the aft face of the spar instead. Examination of the on-scene photo shown in figure 6b indicated that inboard of the root end piece, the afterbody separation continued to follow the edges of the doublers. As a result, the separation turned in the aft direction as it approached the root of the blade and then turned outboard again as it approached the trailing edge before finally arresting, as indicated by the red arrows in the figure. A branching fracture, indicated by the blue arrows in figure 6b, ran across the doublers, through the afterbody along a curved path, and ended when it reached the root end of the blade.

The upper and lower skin fractures and afterbody separations were examined by eye and with the aid of a stereomicroscope. On the root end piece there was a region spanning from approximately 6.5 inch to 27.2 inch¹ where the honeycomb core had fractured across the cell walls at approximately 45° angles starting near the upper surface, as shown in figure 7 and indicated in figure 1b. The honeycomb separation then progressed downward toward the lower surface before arresting. A second separation through the honeycomb was observed starting at the lower surface that progressed upward until it intersected the separation that had started from the upper surface. Further outboard, there was a region spanning from approximately 38.4 inch to 66.2 inch that exhibited cohesive fractures of the foam adhesive along the lower spar edge, as indicated in figures 1b and 2b. As the fracture progressed toward the upper surface the separation switched to tearing of the honeycomb core cell walls. A region with similar features but starting from the upper spar edge, also indicated in figure 2b, was observed from approximately 66.2 inch to 80.5 inch.

The upper and lower skin fractures from the root end section to the 80-inch mark were examined with the aid of a stereomicroscope. Most of the fractures were similar to that shown in figure 8 which was taken along the lower skin approximately 40.0 inch from the root end section. The fracture surfaces were inclined at 45° angles to the skin surface and had comparatively coarse features that were consistent with overstress fractures. One minor variation was a region of lower skin fracture from approximately 66.2 inch to 80.5 inch (see figure 2b) that, while still consistent with overstress fracture, had progressed aft into the afterbody and exhibited additional features of tearing, bending deformation, and peel separation.

¹ All distances are measured and calculated from the root end section based on the piece lengths and approximate kerf width.

Continuing outboard, from approximately 80.5 inch to 100.0 inch, the lower aluminum skin continued to fracture in line with the lower edge of the spar and exhibited features consistent with tensile overstress, as previously described and as seen in figures 5 and 9. Outboard of that point, the lower skin fracture transitioned slightly aft, approximately 0.19 inch to 0.25 inch into the afterbody, and began to exhibit peeling, bending, and tearing features. Starting in this region and continuing outboard, the attached remnants of the honeycomb were flattened against the aft face of the spar, folding over in the outboard direction. From approximately 99.0 inch to 108.0 inch (the first 9 inches of the outboard piece in figure 3) red adhesive was observed smeared on the honeycomb walls, as shown in figure 10a. Several of the honeycomb walls were lifted with tweezers to see if adhesive was present beneath any of the folds, but no such indications were found, as shown for two locations shown in figure 10b.

The upper skin, starting at approximately 80.5 inch and continuing to approximately 112.8 inch, exhibited alternating plastic bending/buckling and chordwise tearing features, as seen in figures 5 and 9, along with peeling separation between the skin and the honeycomb core that increased in length as the separation proceeded outboard. A large impact to the spar was observed along the lower spar edge at approximately 129 inch, as indicated in figure 11. Outboard of this point both upper and lower skins had separated through the afterbody approximately 0.19 inch to 0.25 inch from the aft face of the spar and both upper and lower skins were bent inward, lying flat against the spar's aft face. Further outboard, as seen in figure 4, the fracture moved further into the afterbody and toward final separation.

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Sr. Materials Engineer

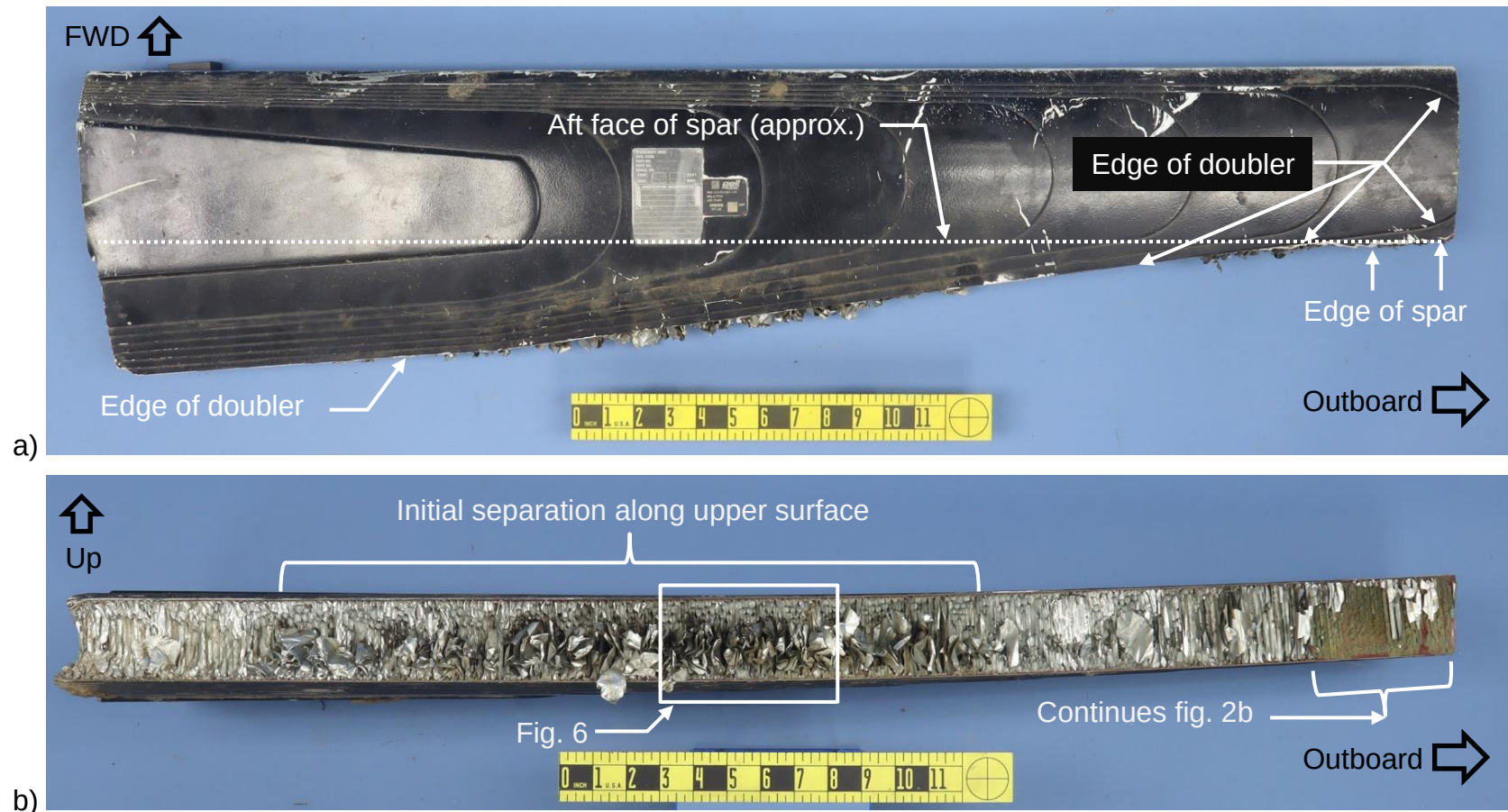


Figure 1: Piece of blade spar at root end: a) view from top looking down and b) view from aft looking forward.

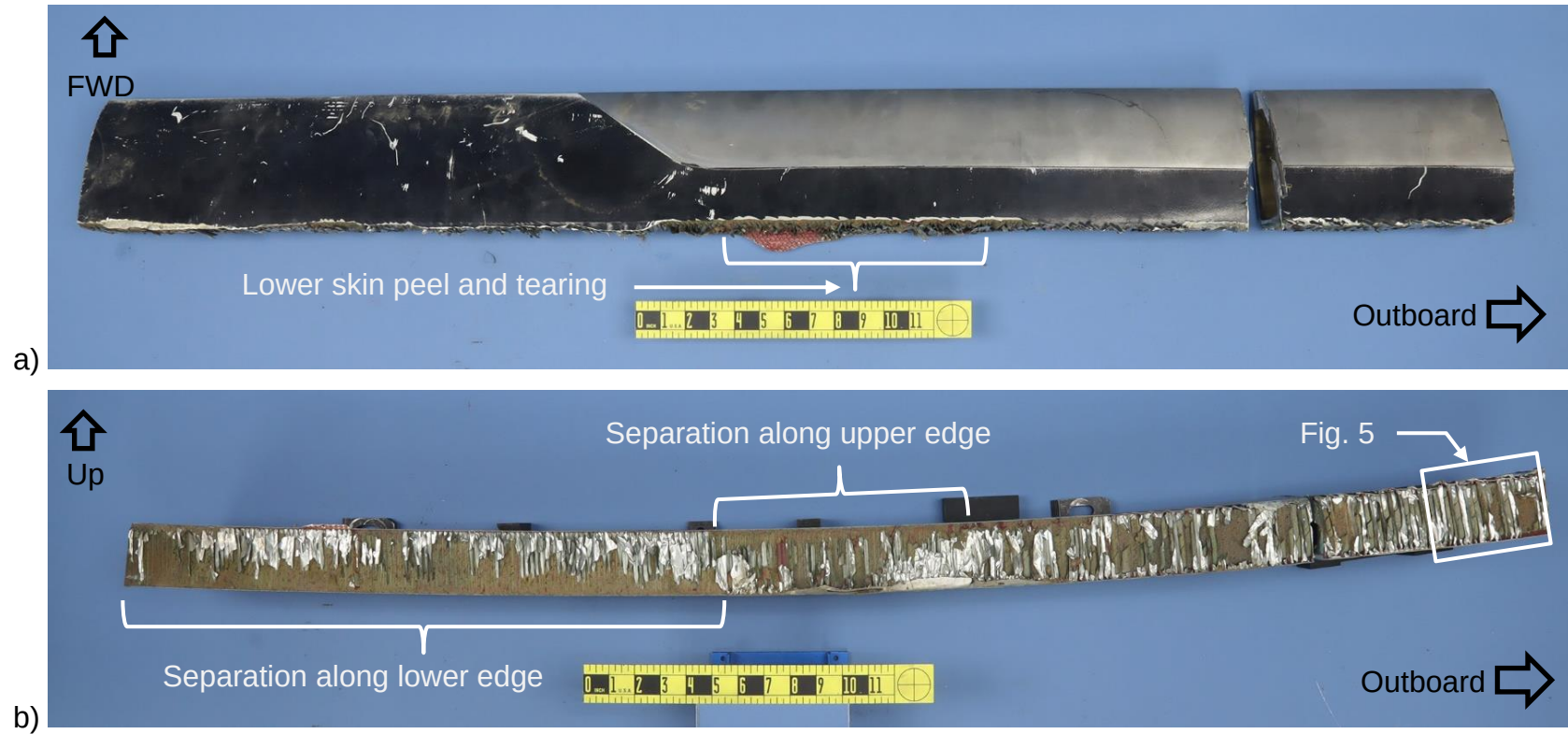


Figure 2: Middle blade spar pieces: a) view from top looking down and b) view from aft looking forward.

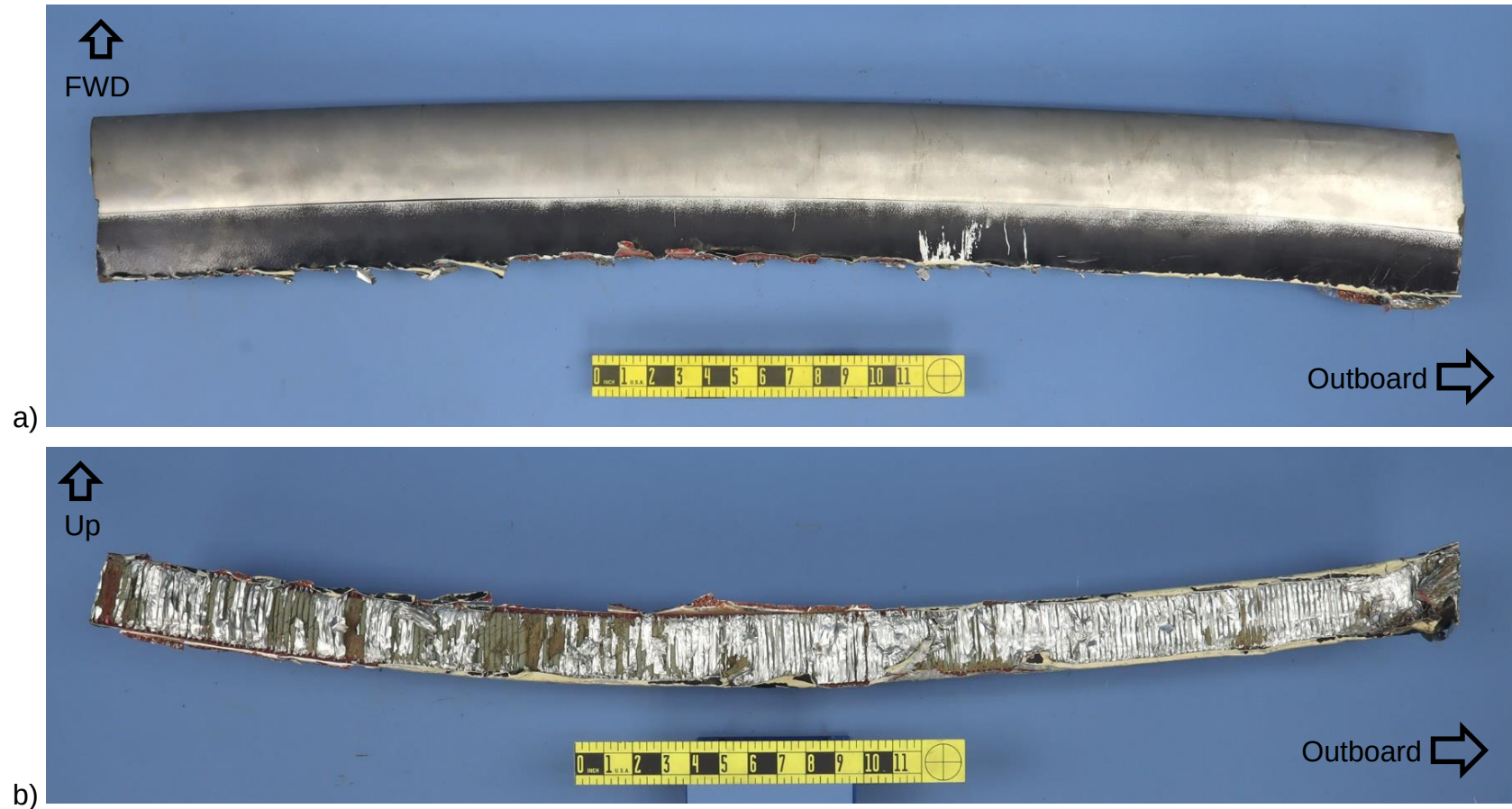


Figure 3: Outer blade spar piece: a) view from top looking down and b) view from aft looking forward.

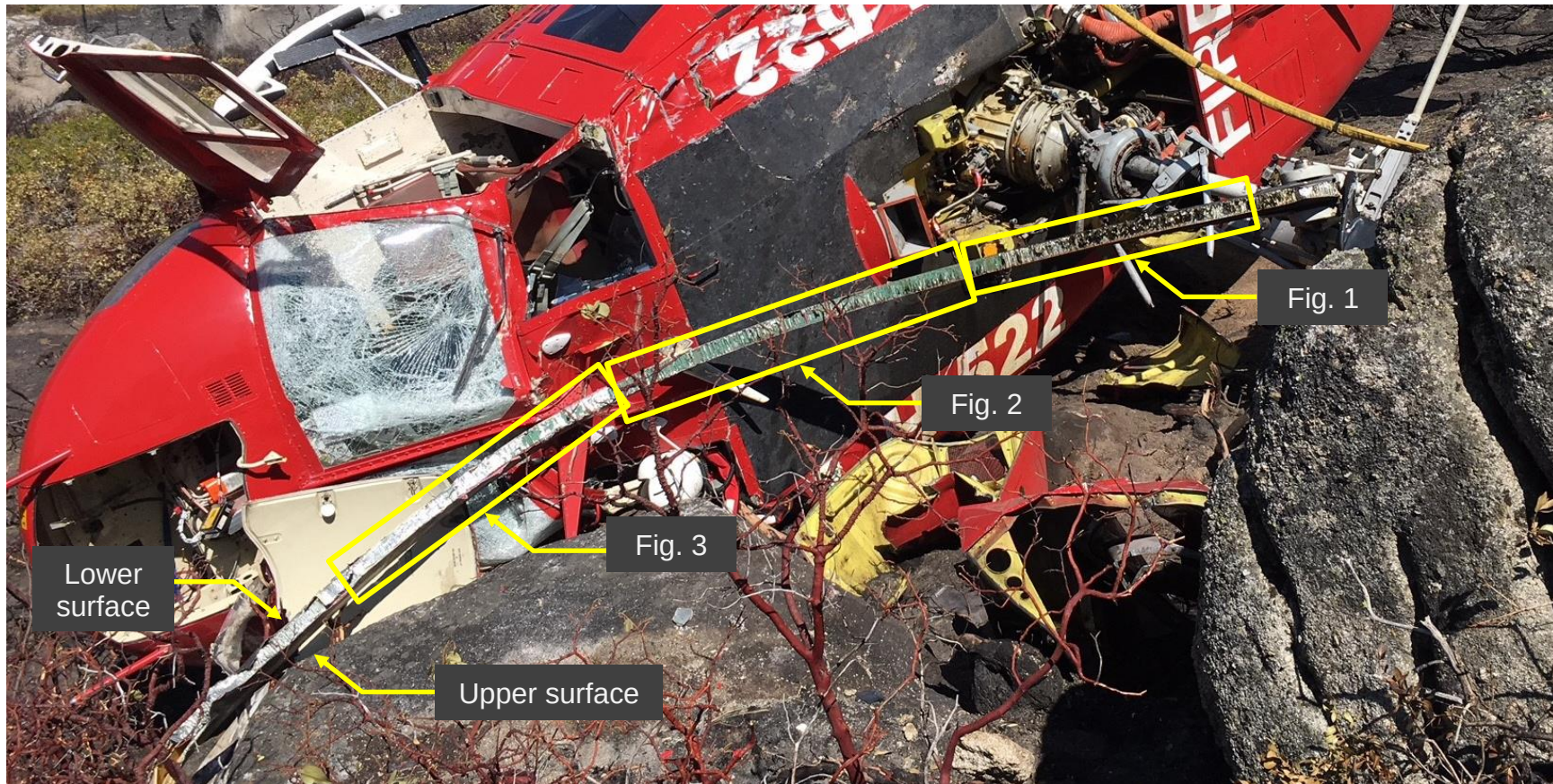


Figure 4: Photo taken at the crash site, with the rotor blade piece locations indicated by the yellow rectangles.



Figure 5: Image of the main rotor blade spar aft face shown the construction of the spar to afterbody transition as well as skin bending/buckling and tearing features along the upper skin.
See figure 2b for location information.



Figure 6: Images of the main rotor blade afterbody at the crash site: a) image showing the afterbody upper surface and b) image showing the root end of the blade with the upper surface visible in the background and lower surface visible in the foreground. The afterbody did not appear to exhibit the same upward bending as the spar.

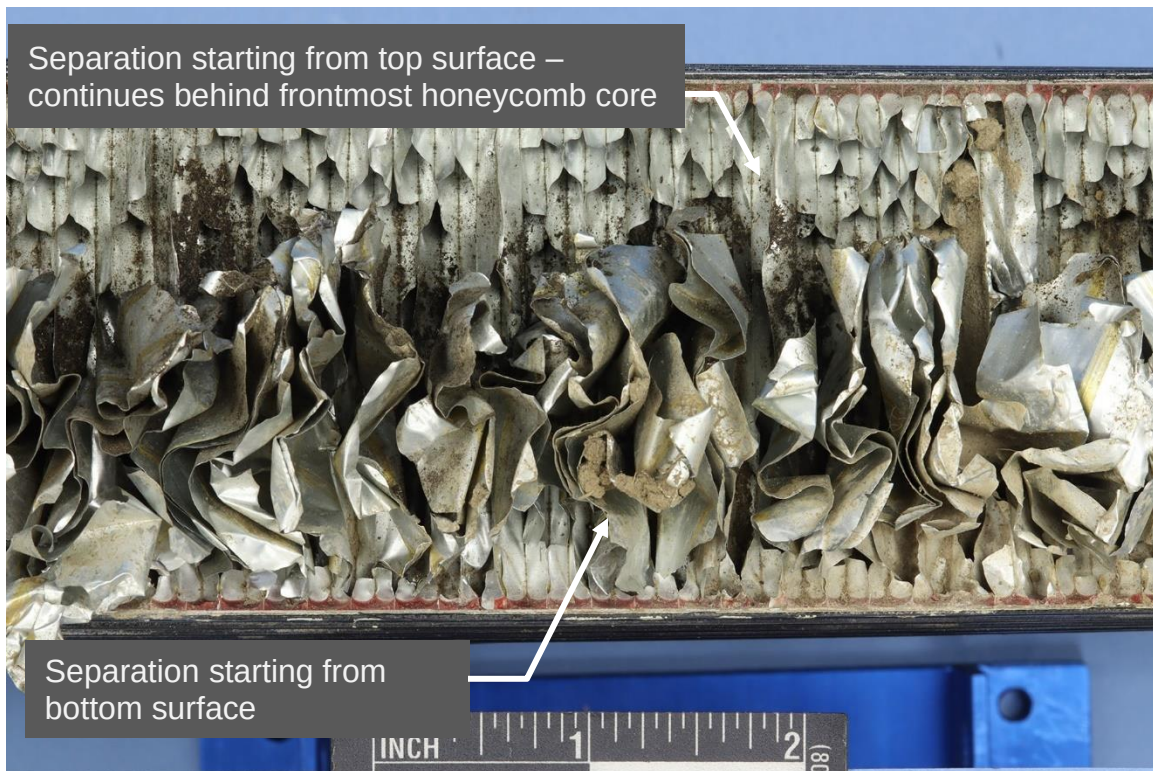


Figure 7: Image of the skin and honeycomb separation in the root end section. The skin fractures followed the edge of upper and lower skin doublers. See figure 1b for location information.

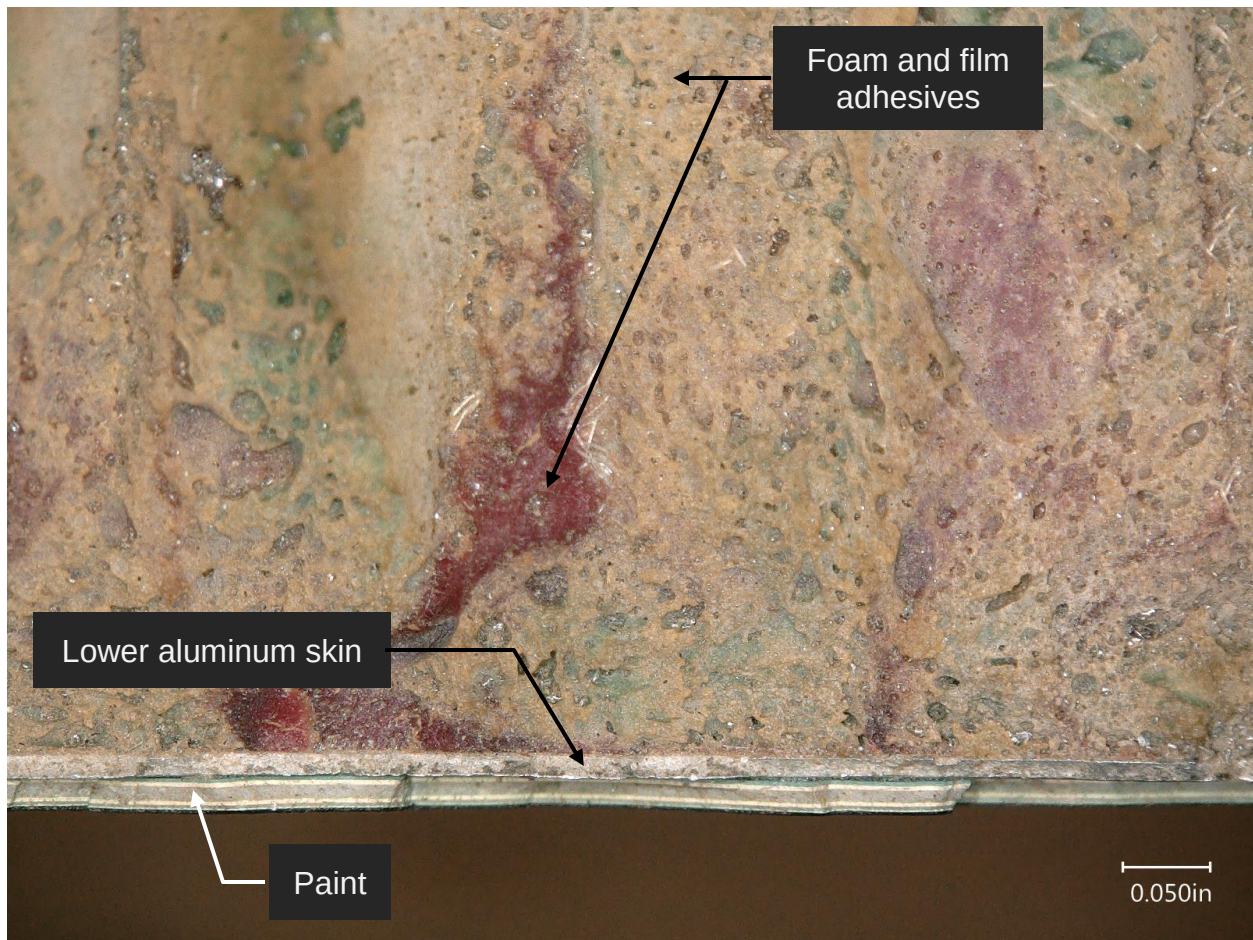


Figure 8: Image showing typical tensile overstress fracture of the lower skin.

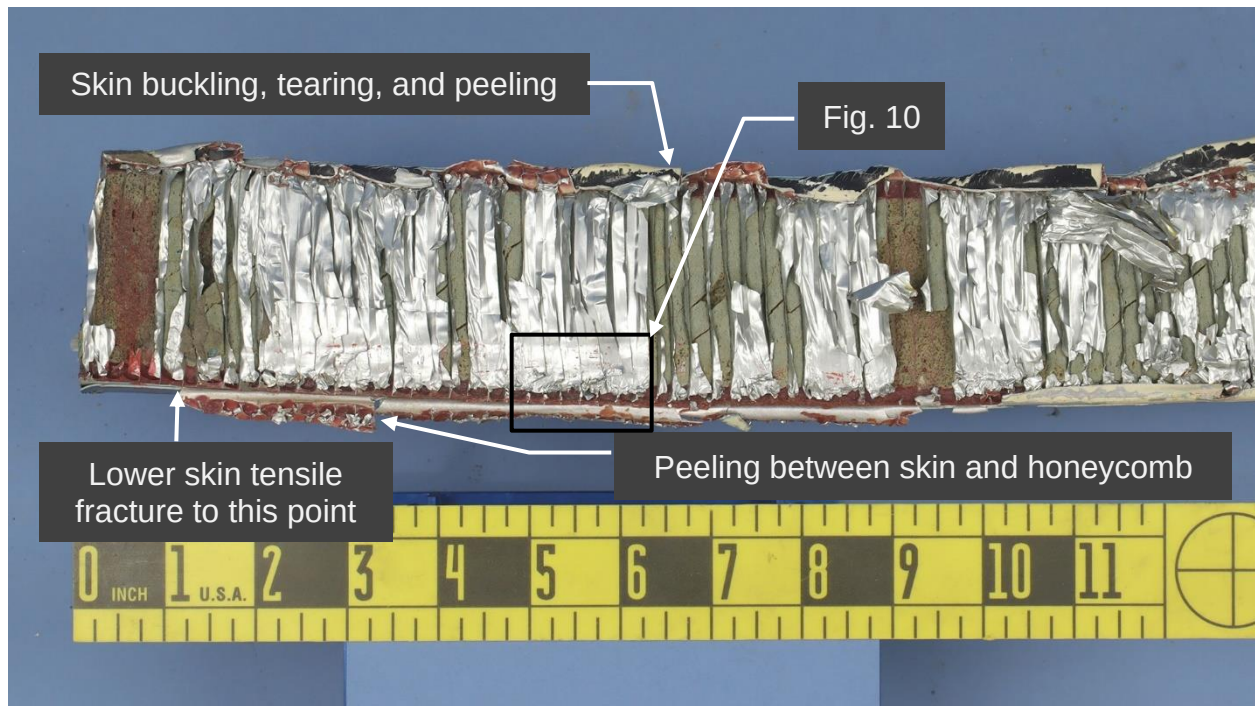


Figure 9: Image showing flattening of honeycomb, tearing, and peeling of upper and lower skins. The image is taken at the inboard end of the outer section, shown in figure 3b.



Figure 10: Images of the flattened honeycomb core : a) image showing smeared red adhesive on the cell walls and b) two of the cell wall lifted showing no adhesive under the folds.

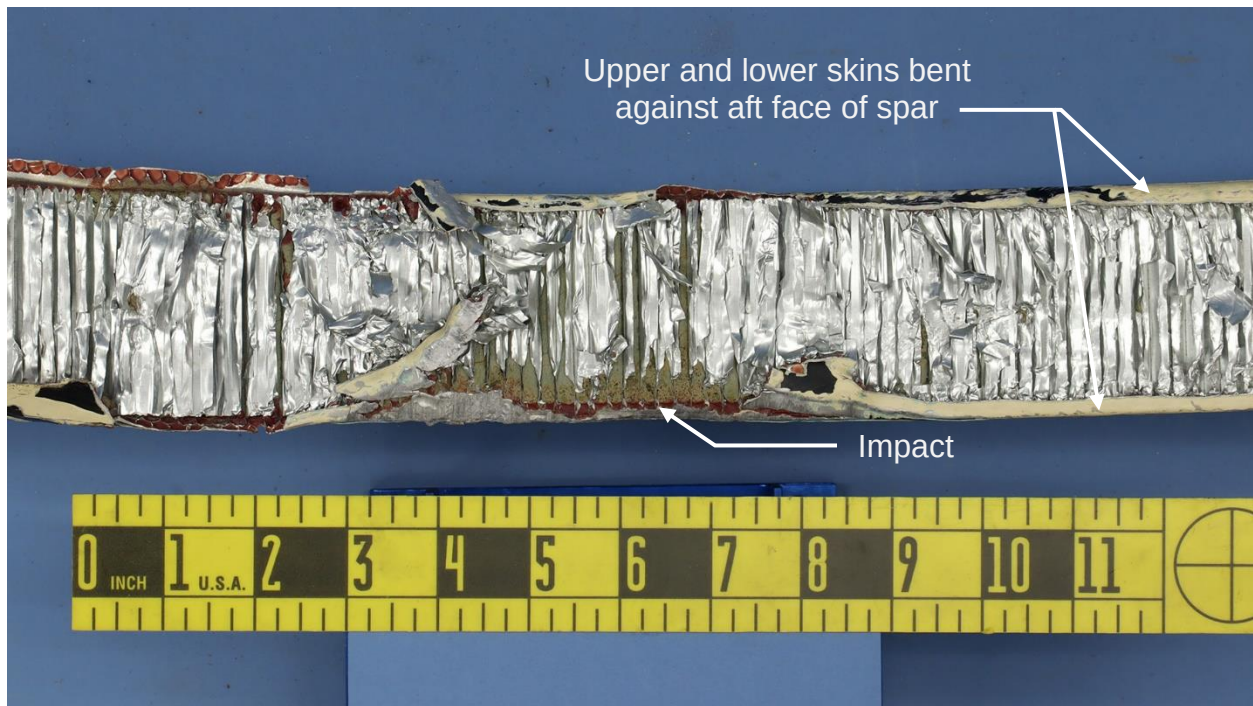


Figure 11: Image of outer spar pieces showing impact to the lower surface and the bending and folding of the upper and lower skins against the aft face of the spar.