

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



DCA22MA193

MATERIALS LABORATORY

Factual Report 23-022 Elevator

March 30, 2023

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A. ACCIDENT INFORMATION

Location: Freeland, WA
Date: September 4, 2022
Vehicle: de Havilland Aircraft DHC-3 Otter, N725TH
Investigator: Clinton Crookshanks

B. COMPONENTS EXAMINED

Right and left elevators from de Havilland Aircraft DHC-3 Otter.

C. EXAMINATION PARTICIPANTS

A group examination of the submitted pieces was held between January 10 and 12, 2023 at the Safety Board’s Materials Laboratory, Washington, D.C. Follow-up work continued and was completed after departure of the group members:

- | | |
|-------------|---|
| Group Chair | Frank Zakar NTSB Washington, DC |
| Member | Edward Komarnicki NTSB Washington, DC |
| Member | Clint Crookshanks NTSB Aurora, CO |
| Member | Luke Walker FAA Washington, DC |
| Member | Dennis Pollard DeHavilland Aircraft of Canada Limited Calgary, Alberta, Canada |
| Member | Mina Nourmansouri DeHavilland Aircraft of Canada Limited Toronto, Ontario, Canada |

D. DETAILS OF THE EXAMINATION

Figures 1 through 4 show photographs of the as-received right and left elevator assemblies. The name plate at the inboard end of the left elevator indicated the airplane type was "DHC3"; serial number "FW-296"; drawing number "C3-TE-1-111"; ISS: "C"; date of manufacture was "11-7-58"; and was inspected by "CCF 30".

1.0 Right Elevator

The right elevator was mostly intact but damaged. The right elevator servo tab was intact and remained installed. The two servo tab actuating rods remained attached to the tab at the aft ends and were fractured through the forward rod ends about 22 inches forward of the aft attach points. A section of the inboard root rib about 12 inches long was torn from the right elevator. The center and outboard bearing blocks remained attached to the right elevator forward spar. The center bearing was separated, and the outboard bearing remained installed.

2.0 Left Elevator

The left elevator was mostly intact but damaged. The left elevator trim tab was intact and remained installed. The trim tab control rod remained attached at the forward and aft ends but was fractured about 6 inches aft of the forward end. The center and outboard bearing blocks remained attached to the left elevator forward spar with the bearings installed. The hinge pin and outboard horizontal stabilizer hinge block remained installed in the outboard elevator bearing. The lower surface of the left elevator contained approximately a 4.9 inches by 4.4 inches repair patch that was located approximately 6 inches from the inboard end and approximately 7 inches from the front spar. The upper surface of the left elevator contained a repair doubler (approximately 11.5 inches long by 1.5 inches wide) coincident with the attach area of the inboard end of the auxiliary spar.

Examination of the left elevator assembly revealed the inboard end of the auxiliary spar contained three cracks (see figures 5 through 9). The three cracks were arbitrarily referred to as cracks "1", "2", and "3". Cracks "1" and "3" were located in the same area that contained a 2-inch long repair doubler (installed at the inboard end on the forward face of the auxiliary spar). Crack "1" extended from the inboard tooling hole to the inboard end of the auxiliary spar. The length of crack "1" measured approximately 0.8 inches. Crack "2" extended nearly vertically through the entire cross section of the auxiliary spar about 4 inches from the inboard end. Crack

"3" intersected a rivet hole on the top flange of the auxiliary spar. The total length of crack "3" measured approximately 1 inch.

Each crack had two fracture faces. At least one fracture face of each crack was examined by bench binocular microscope and scanning electron microscope (SEM), after the fracture faces were cut out of the spar. The cut areas are indicated by dashed lines in figures 6 through 9. Other views of the inboard end of the auxiliary spar are shown in figures 10 and 11. The excised fracture faces were ultrasonically cleaned with Alconox, a commercial detergent.

SEM examination of the outboard fracture face of crack "1" revealed the majority of the fracture face contained mechanical damage that resulted from relative movement between mating fracture faces. Isolated areas of the fracture face at the inboard end contained evidence of crack arrest fracture features, typical of fatigue cracking, that emanated from the aft side of the auxiliary spar. Typical fatigue striations are shown in figure 12. The origin of the fatigue cracking was obliterated due to mechanical damage.

SEM examination of the inboard fracture face of crack "2" revealed evidence of micro-void coalescence typical of overstress separation, with no evidence of fatigue cracking.

SEM examination of the forward fracture face of crack "3" revealed the majority of the fracture face contained mechanical damage that resulted from relative movement between mating fracture faces and exhibited evidence of dirt on the fracture face. The fracture face was further cleaned with a chromic acid solution that removed dirt and debris from the fracture face.¹ Isolated areas of the fracture face at the inboard end contained evidence of crack arrest fracture features, typical of fatigue cracking, that emanated from the upper side of the auxiliary spar. Typical fatigue striations are shown in figure 13. The origin of the fatigue cracking was obliterated due to mechanical damage.

The outboard end of the auxiliary spar was disassembled (de-riveted) from the left elevator to expose all surfaces of the auxiliary spar. The remaining portion of the auxiliary spar contained no evidence of cracks.

On October 4, 2022, the Federal Aviation Administration issued an Emergency Airworthiness Directive (AD) 2022-21-51 that required operators and owners of DHC-

¹ Cleaned by immersion in a chromic acid solution prescribed in American Society for Testing and Standards (ASTM) G1 for cleaning aluminum alloys.

3 airplanes to inspect the left elevator assembly in the area of the inboard end of the auxiliary spar for cracks, corrosion, and previous repair. If any cracks, corrosion beyond Level 1, or previous repair is found during any inspection required by the AD, before further flight, replacement of the left-hand elevator auxiliary spar was required. Fatigue cracks "1" and "3" and a repair doubler were located in the area that required inspection by the AD though the AD was not effective at the time of the accident.

Fractures outside of the two fatigue cracks exhibited rough texture on slant planes typical of overstress separation.

2.1 Balance Weight for the Left Elevator

The inboard end of the left elevator contained two balance weights that were attached to an arm that extended from the elevator (see figures 14 and 15). One weight was attached to the inboard side of the arm and another was attached the outboard side of the arm. The inboard weight was stamped part number "C3-TE-15 13A" and stamped "12 OZ", where "OZ" indicated weight in ounces. The outboard weight for the accident elevator was stamped part number "C3-TE-15 15A" and stamped "11.2 OZ". The white paint was missing (had peeled off) from the forward inboard side of the inboard balance weight. Impact marks from the balance weights were found on the upper surface of the elevator (see figure 16). An exemplar balance weight was placed above the impact marks. The upper surface of the elevator contained what appeared to be at least four adjoining impact marks that corresponded to the outline of the bottom side of the exemplar balance weight.

2.2 Control rod bellcrank

The left elevator tab control rod bellcrank from the forward inboard end of the elevator (see figure 5) was removed. The upper arm of the bellcrank contained a fracture that intersected two rivets (see figure 17). The fracture faces were ultrasonically cleaned in Alconox, a commercial detergent. Bench binocular microscope examination of the fracture faces on the arm portion revealed coarse fracture features on slant planes consistent with overstress separation, with no evidence of fatigue cracking.

Submitted by:

Frank Zakar
Senior Metallurgist



Figure 1. As-received right hand right elevator assembly showing the upper surface.



Figure 2. As-received right elevator assembly showing the lower surface.

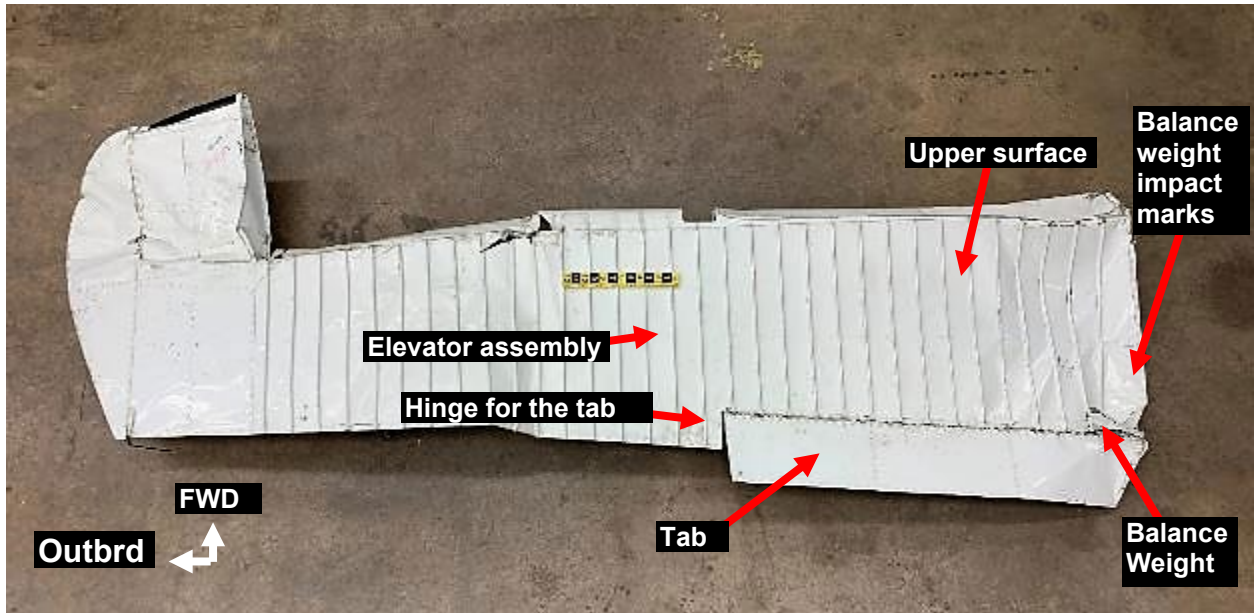


Figure 3. As-received left elevator assembly showing the upper surface. Close-up view of impact marks are shown in figure 16.

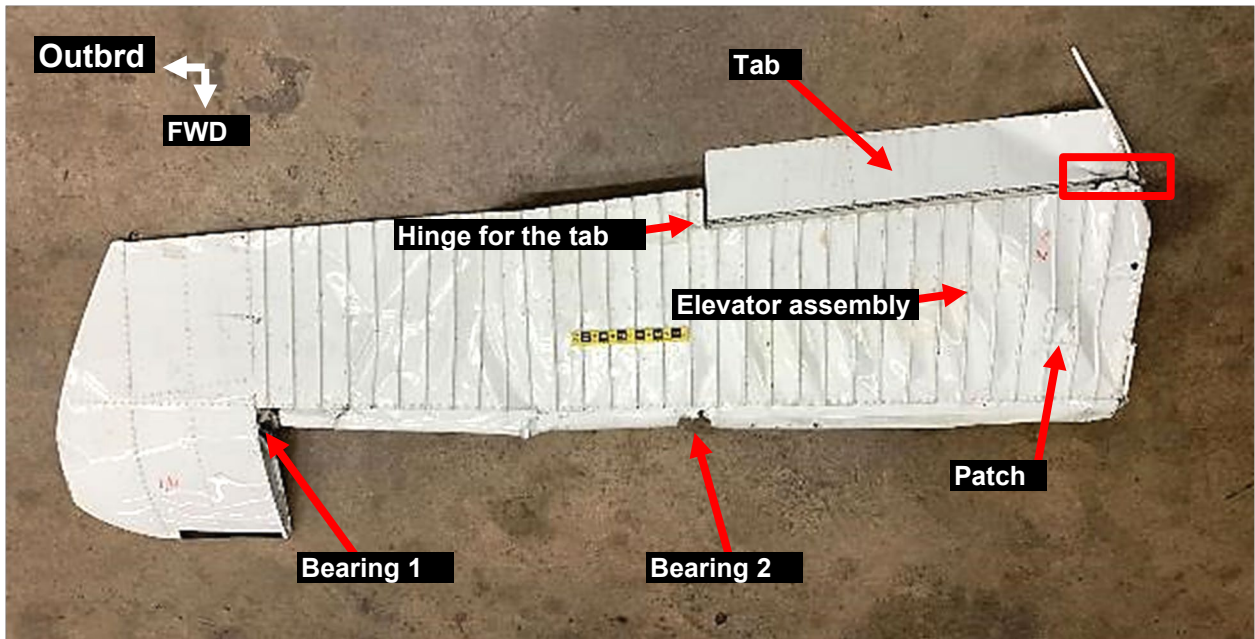


Figure 4. As-received left elevator assembly showing the lower surface. Three cracks were found at the inboard end of the auxiliary spar in the area enclosed by the red square.

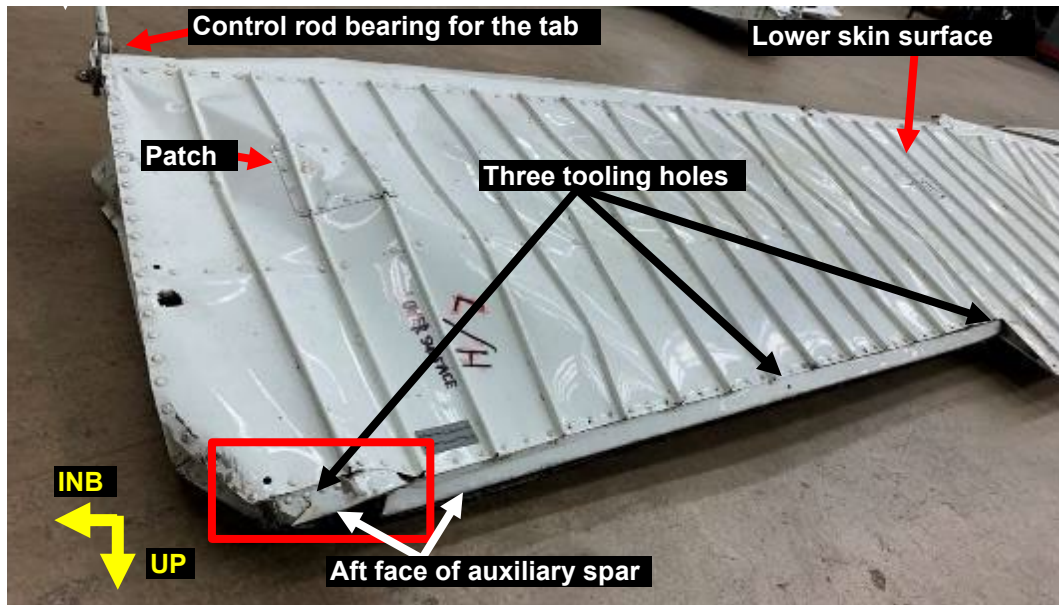


Figure 5. Inboard end of the auxiliary spar for the left elevator that contained three cracks (shown after the tab was disassembled from the elevator). The 3 cracks were found in the area enclosed by a red box.

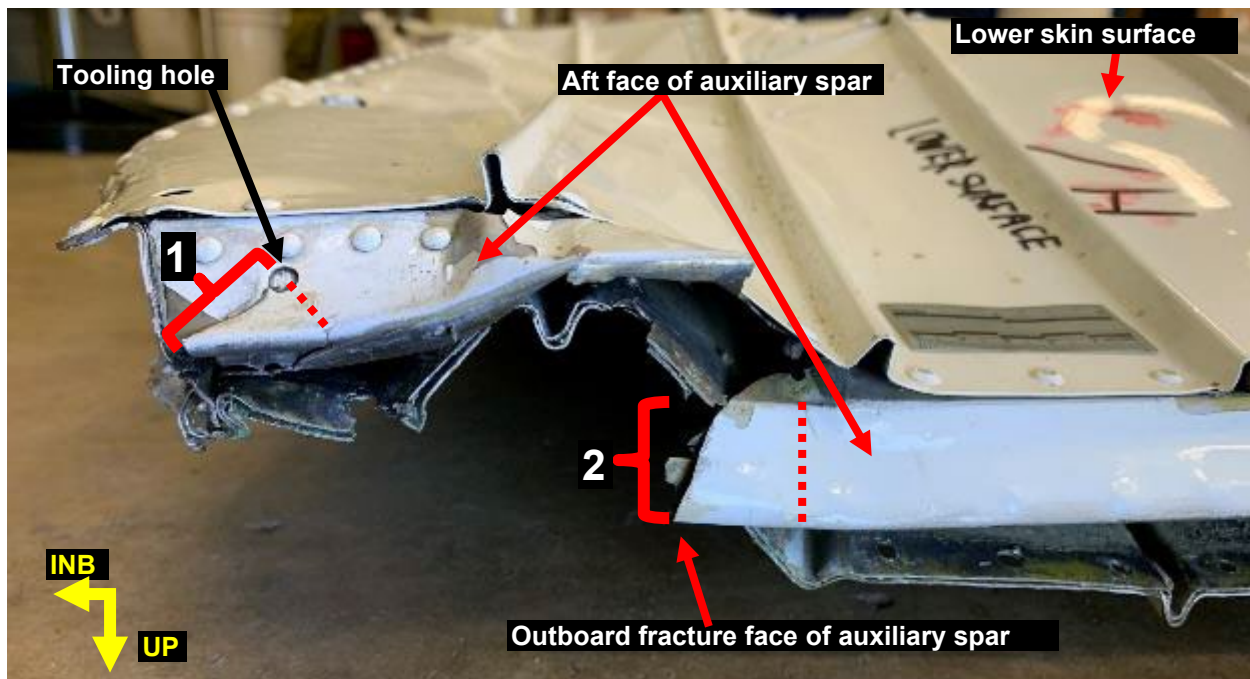


Figure 6. View looking forward at the auxiliary spar for the left elevator, shown after the tab was disassembled. Cracks "1" and "2" are shown.

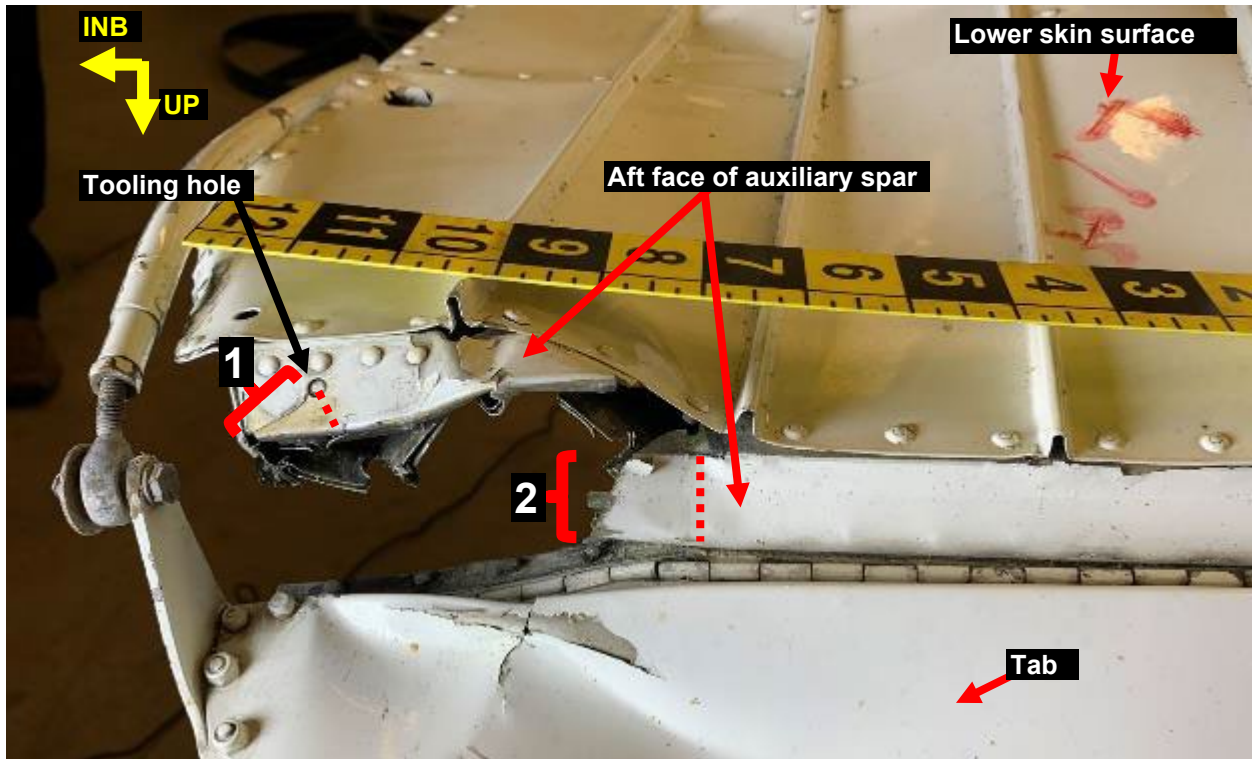


Figure 7. Another view looking forward at the auxiliary spar of the left elevator prior to removing the tab.

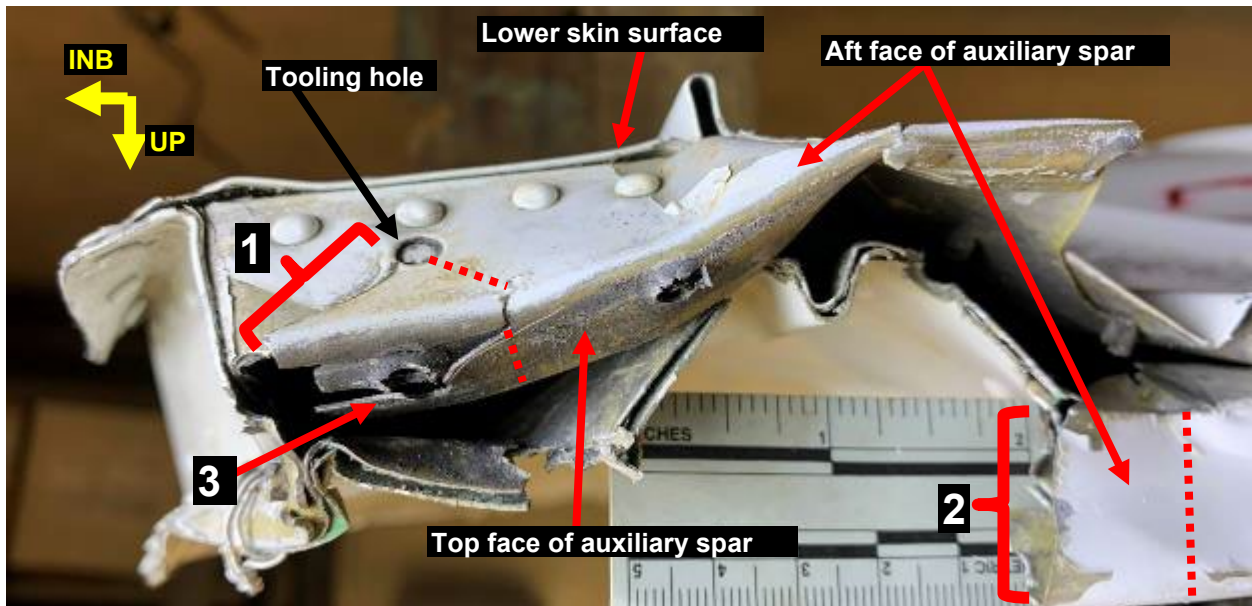


Figure 8. Another view looking forward at the auxiliary spar for the left elevator, after the tab was removed, showing cracks "1", "2" and "3".

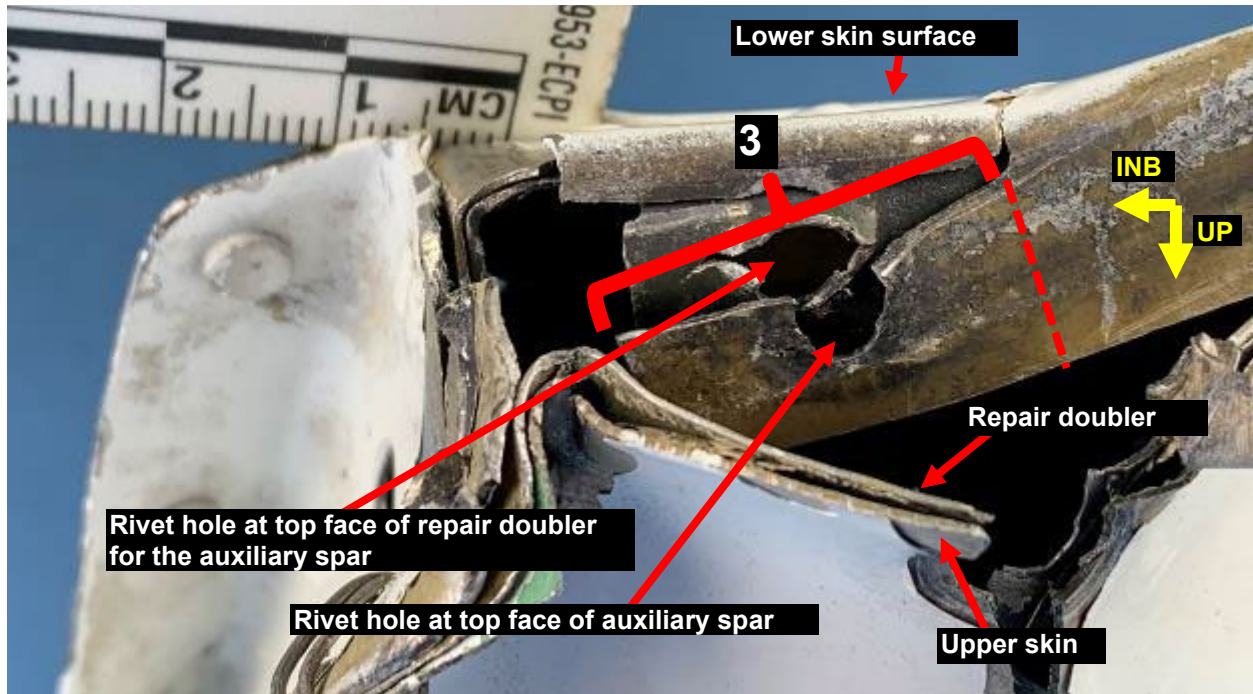


Figure 9. Another view looking forward at the auxiliary spar for the left elevator, after the tab was removed.

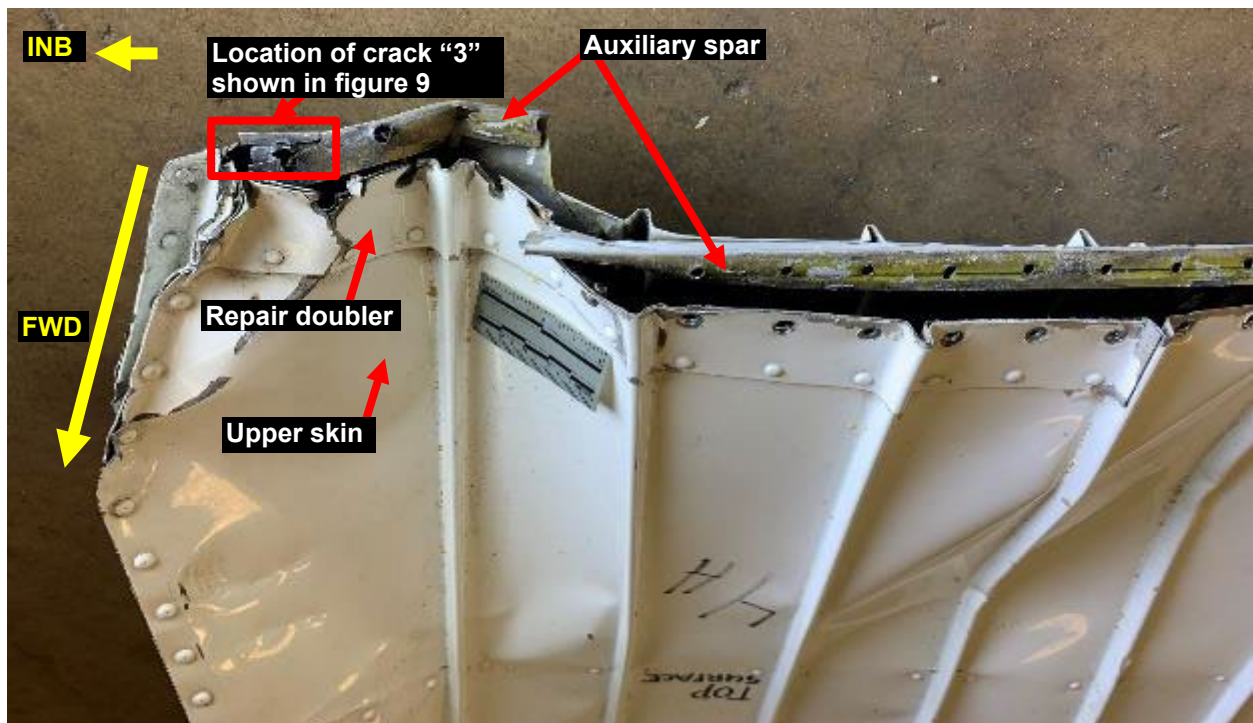


Figure 10. View looking forward and up at the auxiliary spar for the left elevator, after the tab was removed, showing a repair doubler at the inboard end.

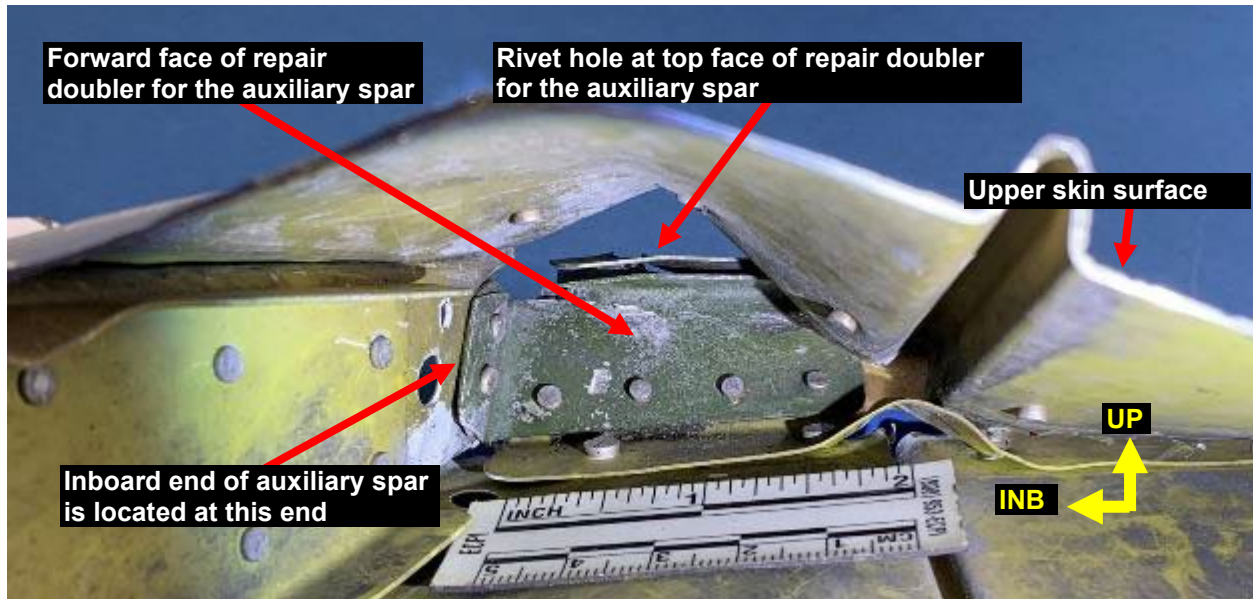


Figure 11. View looking aft at the inboard end of the auxiliary spar after the tab was disassembled showing a repair doubler in the area that coincided with fatigue cracks "1" and "2".

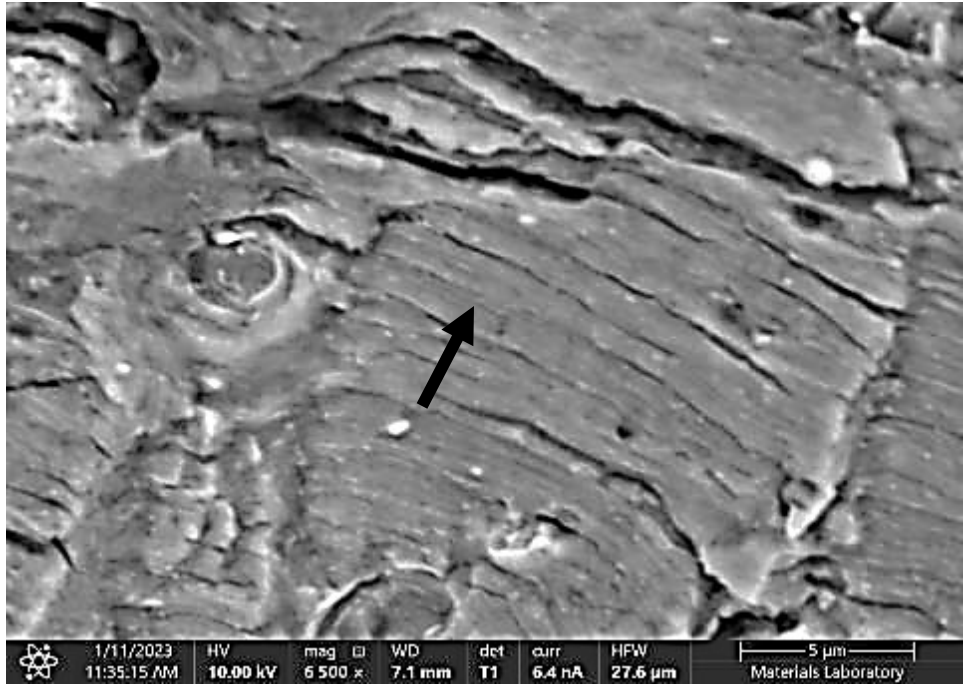


Figure 12. SEM image of fatigue cracking on the fracture face of crack "1". Arrow indicates general direction of fatigue crack propagation.

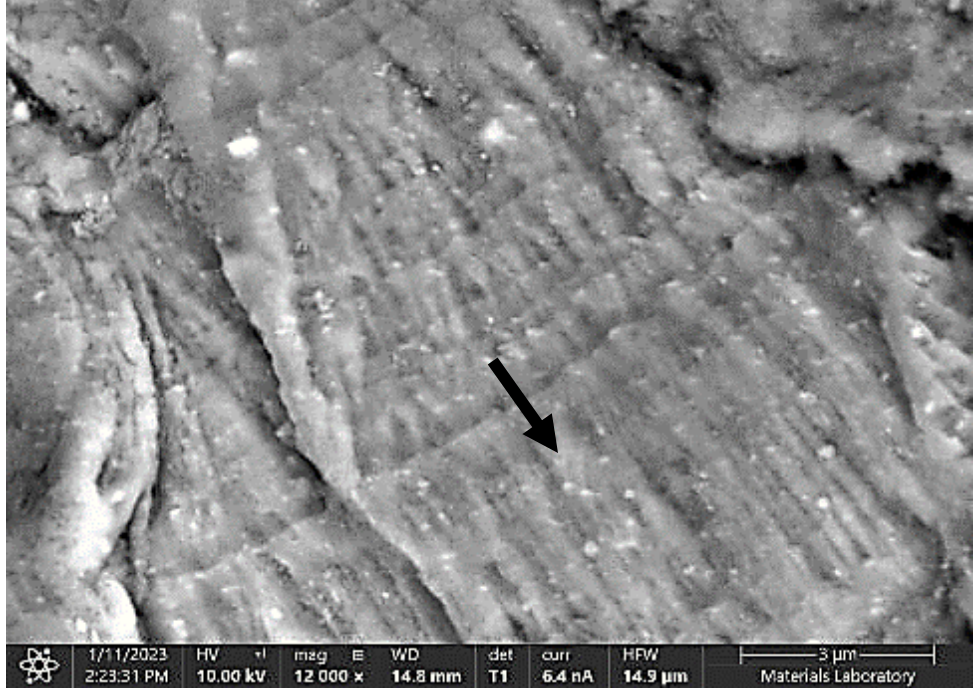


Figure 13. SEM image of fatigue cracking on the fracture face of crack "3". Arrow indicates general direction of fatigue crack propagation.

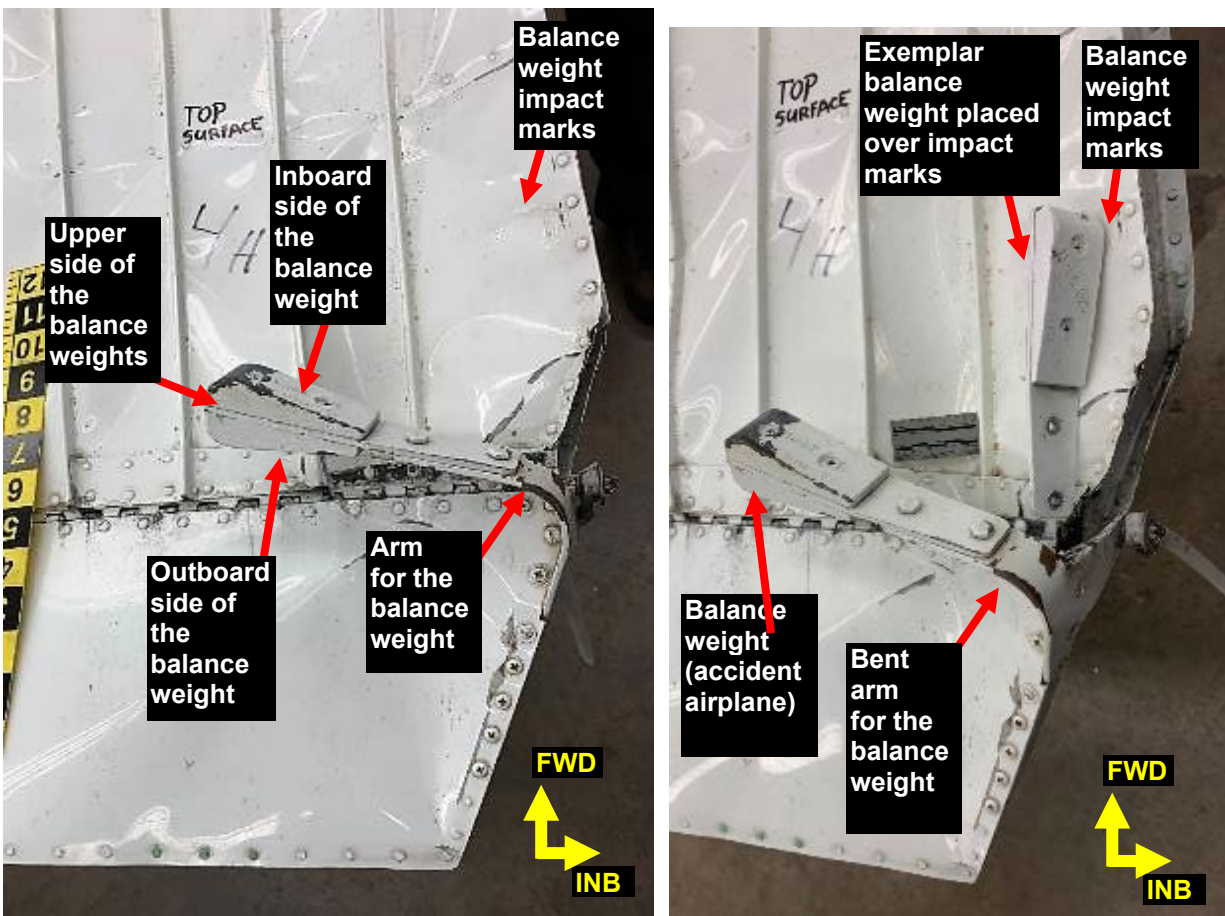


Figure 14. View of the upper inboard surface of the left elevator showing the inward bent arm and attached weight from the accident airplane (left side of page); and an exemplar balance weight that was placed on top of the impact marks (right side of page). The outline of the impact marks resembled the outline of the exemplar balance weight (see figures 15 and 16).



Figure 15. View of the lower side of the balance weights from the accident airplane.

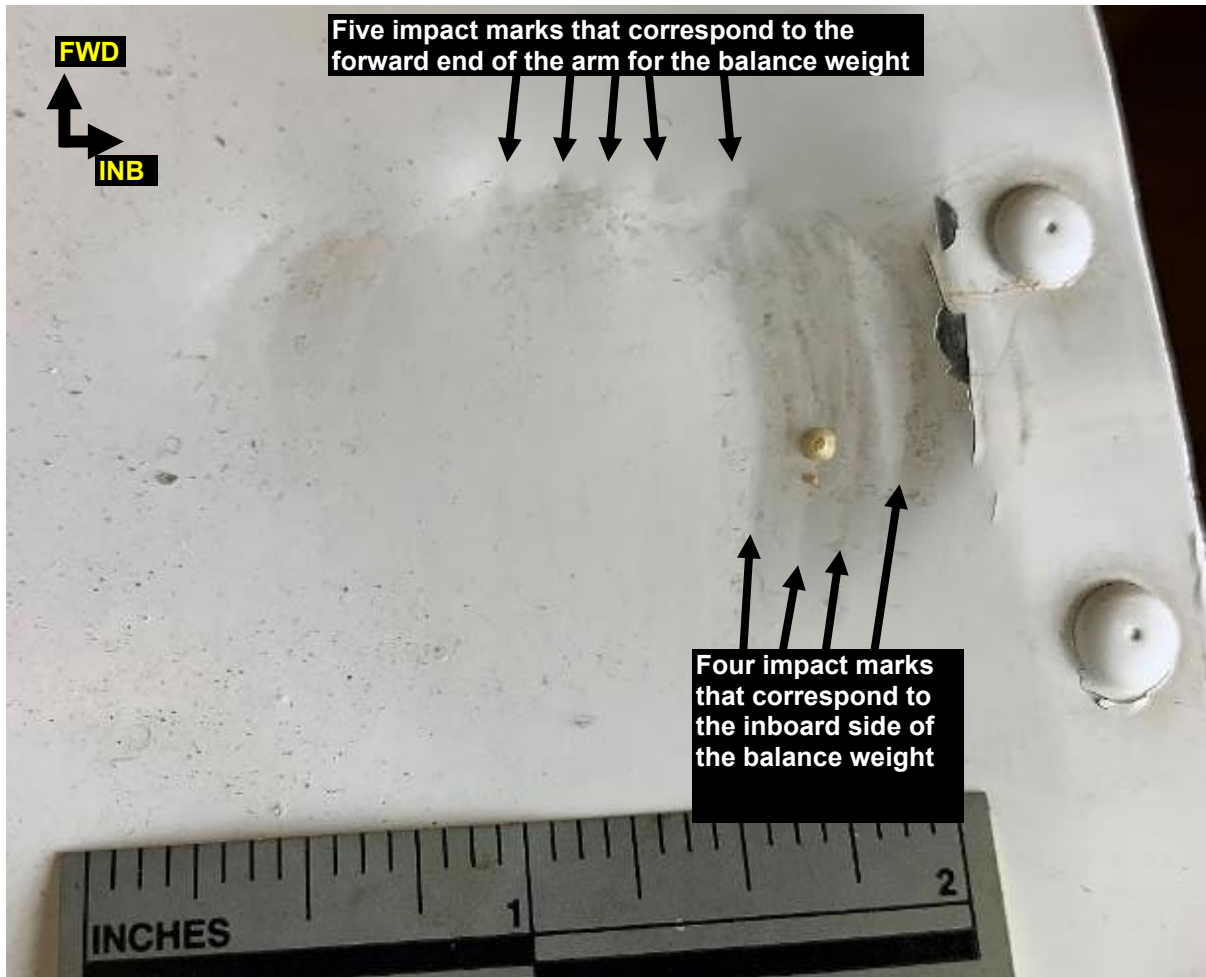


Figure 16. Close-up view of impact marks found at the upper face at the inboard end of the left elevator that resembled the outline of the exemplar balance weight.

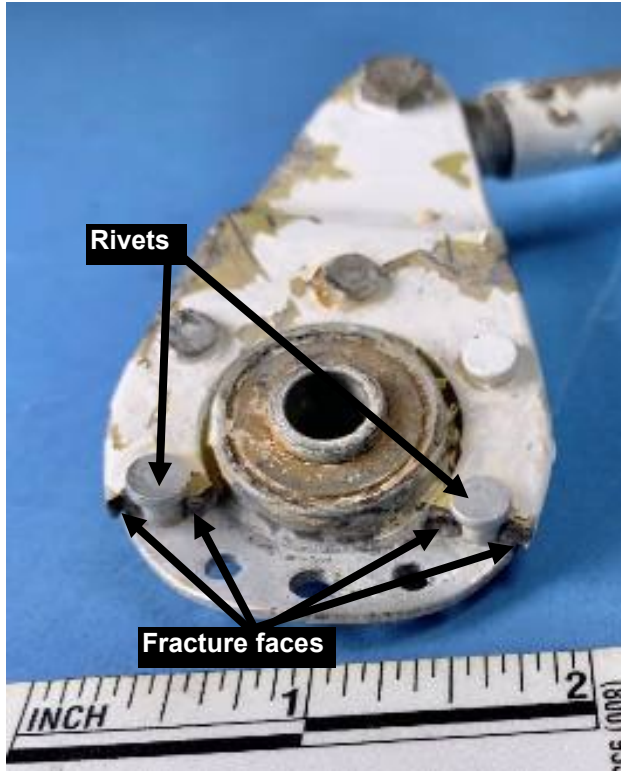


Figure 17. Control rod bellcrank that was disassembled from the forward inboard end of the tab for the left elevator.