

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA23FA007

MATERIALS LABORATORY

Factual Report 23-064

August 17, 2023

(This page intentionally left blank)

A. ACCIDENT INFORMATION

Location: East Hampton, New York
Date: October 6, 2022
Vehicle: Seamax Aircraft M-22, N46PD
Investigator: Heidi Kemner, AS-ERA

B. COMPONENTS EXAMINED

Left and right wing strut pieces and wing attachment hardware.

C. EXAMINATION PARTICIPANTS

Specialist Matthew R. Fox, Ph.D.
NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

The accident airplane was a version of the Seamax Aircraft M-22 that had a foldable wing design. When on the ground, the wings could be detached from the upper fuselage and rotated about the wing strut attachment bolts to fold against the fuselage for transportation or storage. The wing struts are structural members that span between the lower right or lower left side of the fuselage at the inboard end of each strut to a point near mid span on the lower side of each wing. In the case of the accident airplane, the right wing separated in flight and was found approximately 770 feet away from the main wreckage site.

A view of the inboard end of the right wing as examined at an airplane salvage facility is shown in figure 1. The inboard attachments for the wing were fractured at the locations indicated in the upper image in figure 1. At the forward attachment location, the lug, made of composite material, was fractured at the inboard lower quadrant. The area above the lug showed deformation consistent with heavy contact from the wing locking latch. At the aft location, the inboard end of the spar tube was bent upward, and the upper portion was fractured away. The pin holes were elongated, and fractures in the tube intersected the holes for the locking pin at a tangent, features consistent with shearing from the pin attachment.

Views of right side of the fuselage at the wing attachment locations are shown in figure 2. The forward end of the wing carrythrough structure was crushed and deformed aft, and the forward transverse tube was rotated clockwise about 90 degrees (as viewed looking inboard) such that the upper side of the tube faced forward. The wing tube that is inserted into the carrythrough structure at the forward attachment location was intact and in place, and a fractured piece of the composite attachment lug was present within the clevis end fitting for the tube. The lock pin that

holds the tube in place was also present and in the locked position. The plate for engaging the locking latch was also intact on the upper side of the carrythrough tube.

At the aft wing attachment location on the right side of the fuselage, the upper half of the outboard end of the carrythrough tube was deformed upward as shown in the lower image in figure 2. The lock pin positioning mechanism was deformed, but the lock pin remained partially engaged in the carrythrough tube.

Overall deformation, witness marks, and fracture patterns for the right wing attachments at the upper side of the fuselage were consistent with the wing bending upward relative to the fuselage with the lock pins and locking latch fully engaged.

The right wing strut was recovered separated from the right wing and fuselage. The strut had separated at the joint at the outboard attachment location and was fractured at the inboard attachment location. At the outboard attachment location shown in figure 3, the attachment bolt was intact, and remnants of metal threads and the red nonmetallic insert from the self-locking nut were present on the bolt threads. The remainder of the nut and washer on the inboard side of the joint were missing. At the inboard end of the right wing strut, the strut was fractured adjacent to the fuselage attachment location as shown in figure 4. The fracture surfaces were on slant planes with deformation consistent with ductile overstress fracture under bending and torsion loads.

On the left wing, the strut remained intact and connected at both the inboard and outboard joints as shown in figures 5 and 6. The strut attachment hardware consisted of a bolted joint with a self-locking nut with a non-metallic insert. Metal washers were located under the bolt head and the nut clamping face and nonmetallic bushings were located between the faying surfaces of the joint.

The bolt with the corresponding fractured nut thread and insert pieces (previously removed from the bolt) and the bushing from the outboard attachment for the right wing strut were initially received at the NTSB Materials Laboratory as shown in the lower image in figure 7. Following an additional examination of the wreckage at the salvage facility, the outboard ends of both struts and attachment hardware from the outboard end of the left wing strut were also collected for further examination. The total collection of parts as received at the NTSB Materials Laboratory are shown in the upper image in figure 7.

The bolt shank and nut threads and mating surfaces in the joint from both outboard attachments were generally covered with a greasy black substance. To facilitate further examination of the thread condition, the nut thread piece from the right strut attachment and the nut from the left strut attachment were cleaned using an ultrasonic cleaner while submerged in a plastic beaker of acetone. The remaining images in the report show the hardware after cleaning.

An overall view of the nut thread piece that was removed from the right wing strut outboard attachment bolt is shown in the upper image in figure 8, where the noncontact side of the nut threads is shown. The orientation of the threads relative to contact with the bolt threads was evident by contact patterns on the opposing thread flanks and by deformation in the thread fracture surfaces around the outside circumference. The thread piece consisted of between 2 to 3 threads as shown in figure 8. The threads closest to the clamping face were deformed such that the surface at the inside diameter rotated toward the clamping face. The thread closest to the clamping face had secondary fractures where pieces of the rotated inside diameter surface were fractured away.

A close view of the contact flanks of two of the threads is shown in the lower image in figure 8. The contact faces had a battered appearance with rounded pits and deformed metal shavings, features consistent with repeated contact loading.

The fracture surfaces around the perimeter were examined using a scanning electron microscope (SEM). The surfaces showed many areas of smearing that obliterated fracture features and other areas where elongated dimple features were observed consistent with ductile overstress fracture in a plane of shear stress. An SEM image of typical fracture features is shown in figure 9.

The nut from the left strut outboard attachment location is shown in figure 10. The nut had 2 to 3 threads between the clamping face and the red nonmetallic locking insert. A closer view of the threads is shown in figure 11. The two threads closest to the clamping face were deformed and twisted with the inside diameter face rotated toward the clamping face. The threads were also partially fractured and displaced axially toward the clamping face. The bolt thread contact flanks as viewed from the other end of the nut are shown in figure 12. The contact flanks had a battered appearance with rounded pits and metal shavings consistent with repeated contact loading.

Following the accident, the Federal Aviation Administration issued Special Airworthiness Information Bulletin (SAIB) 2022-24 on December 23, 2022, where it was recommended that all pertinent Seamax service bulletins be complied with and that repetitive inspections for fastener security of the strut attachment hardware be completed before each flight. On February 23, 2023, Seamax Aircraft issued Service Alert (SA) SA_001_23, which required a one-time inspection of the attachment bolts and nuts at the outboard ends of the left and right struts. In Seamax SA_001_23, the hardware included in the outboard strut attachment is specified as an AN5-10C bolt and an AN364-524 nut.

According to Air Force-Navy (AN) Aeronautical Standard AN364 revision 4 dated July 22, 1969, the standard is inactive for design after March 13, 1957. The AN364 standard was canceled on October 21, 1991, and for self-locking low height

nuts with nonmetallic inserts, was superseded by Military Specification Sheet (MS) MS21083.

According to note 3 in MS21083, revision H, dated September 28, 1993, the MS21083 nuts are intended for shear applications only. Additionally, use of the nuts is subject to limitations of MS33588. According to MS33588, revision E, dated December 28, 1984, self-locking nuts shall not be used "...where loss of the bolt would affect safety of flight unless the threaded parts are held by a positive locking device that requires shearing or rupture of materials before torsional loads would relieve the initial stresses of the assembly." Additionally, self-locking nuts shall not be used "on any externally threaded part that serves as an axis of rotation..." unless the loads acting on the joint do not act to relieve initial stresses or unless the nut is secured with a positive locking device as previously described.

The axial height of the nut as measured using calipers was 0.250 inch, which is the maximum height listed for an AN364-524 nut. The corresponding steel nut with a non-metallic insert, MS21083N5, has a specified height range of 0.235 inch to 0.266 inch.

A flat on one side of the nut was coarse-ground flat while the opposite flat was polished to a 1200-grit finish, and hardness was measured on the polished surface using a Rockwell hardness indenter. The average hardness measured from 3 indentations was 73.0 HR30TW, which corresponds to an estimated tensile strength of 83,000 psi. According to the MS21083 standard, steel nuts should have a minimum yield strength of 70,000 psi.

Submitted by:

Matthew R. Fox, Ph.D.
Chief Technical Advisor - Materials

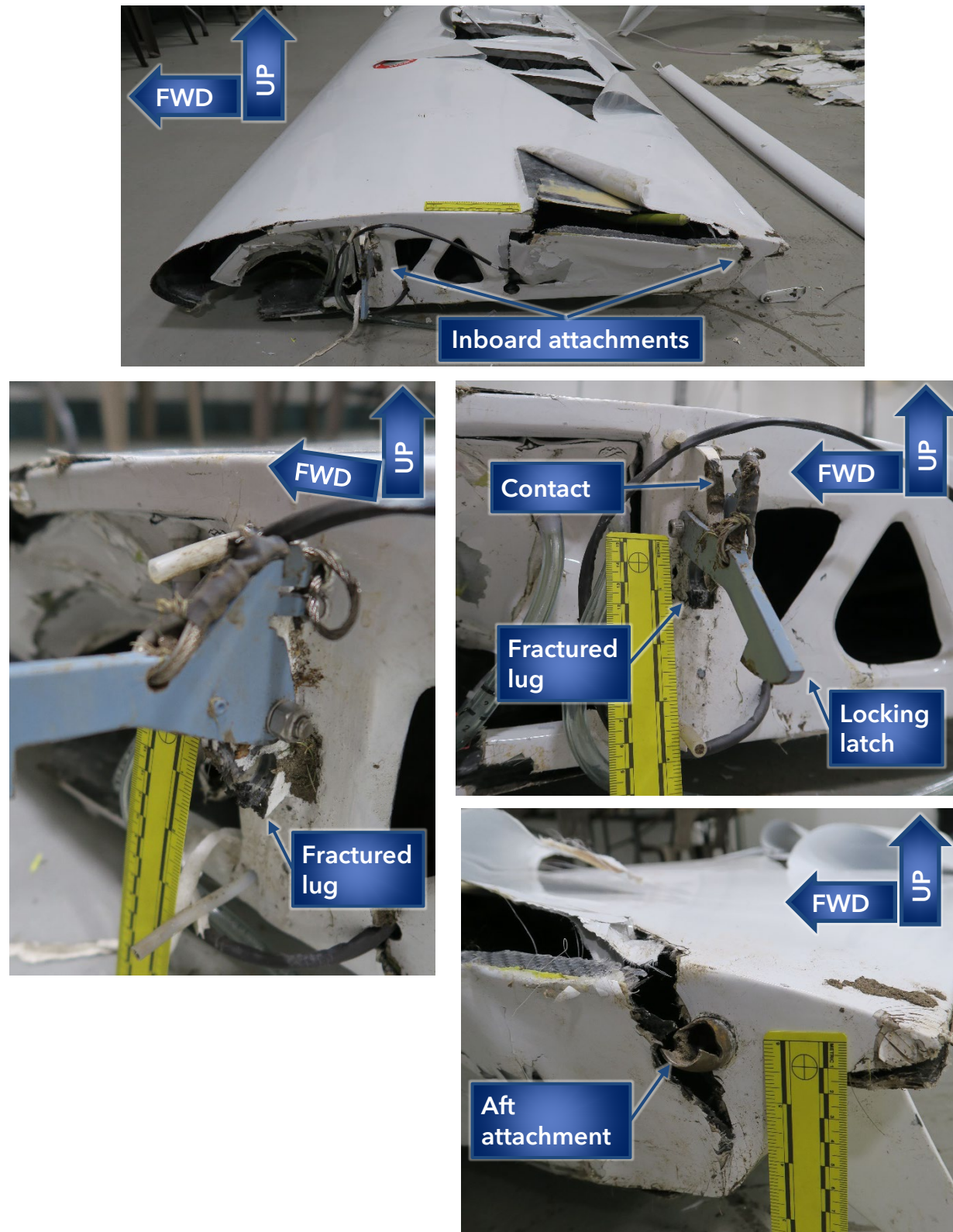


Figure 1. Inboard end of the right wing (upper image) with closer views of the forward (middle left and middle right images) and aft (lower right image) wing to fuselage attachment locations.

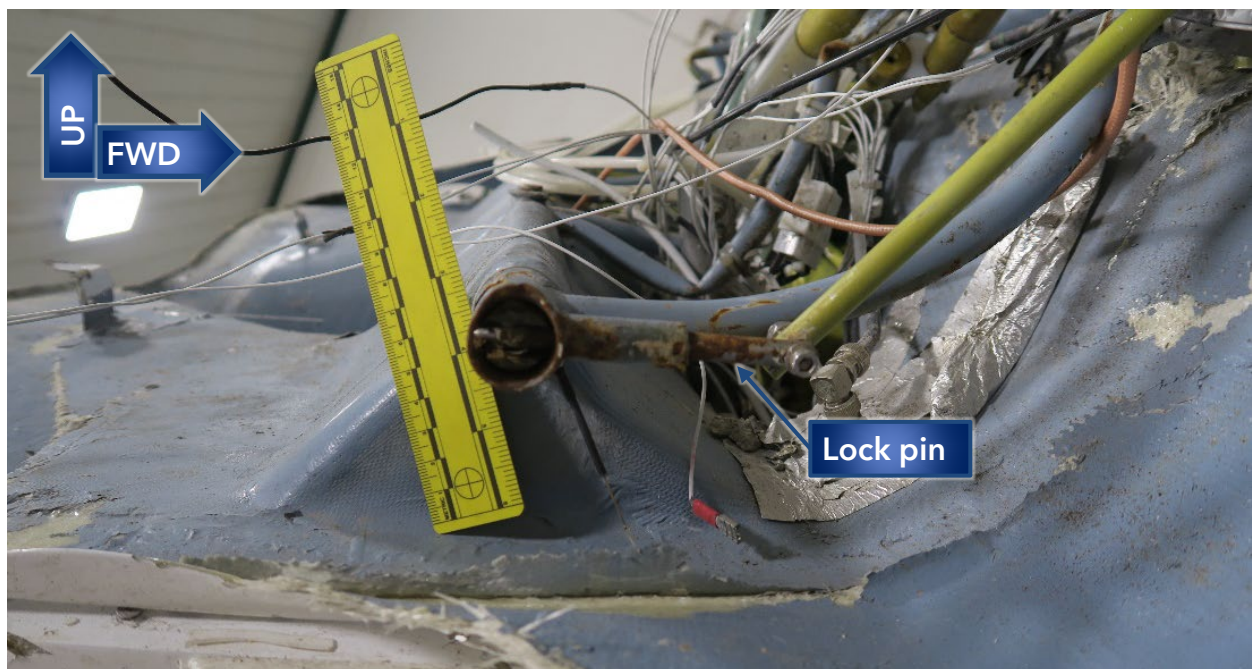
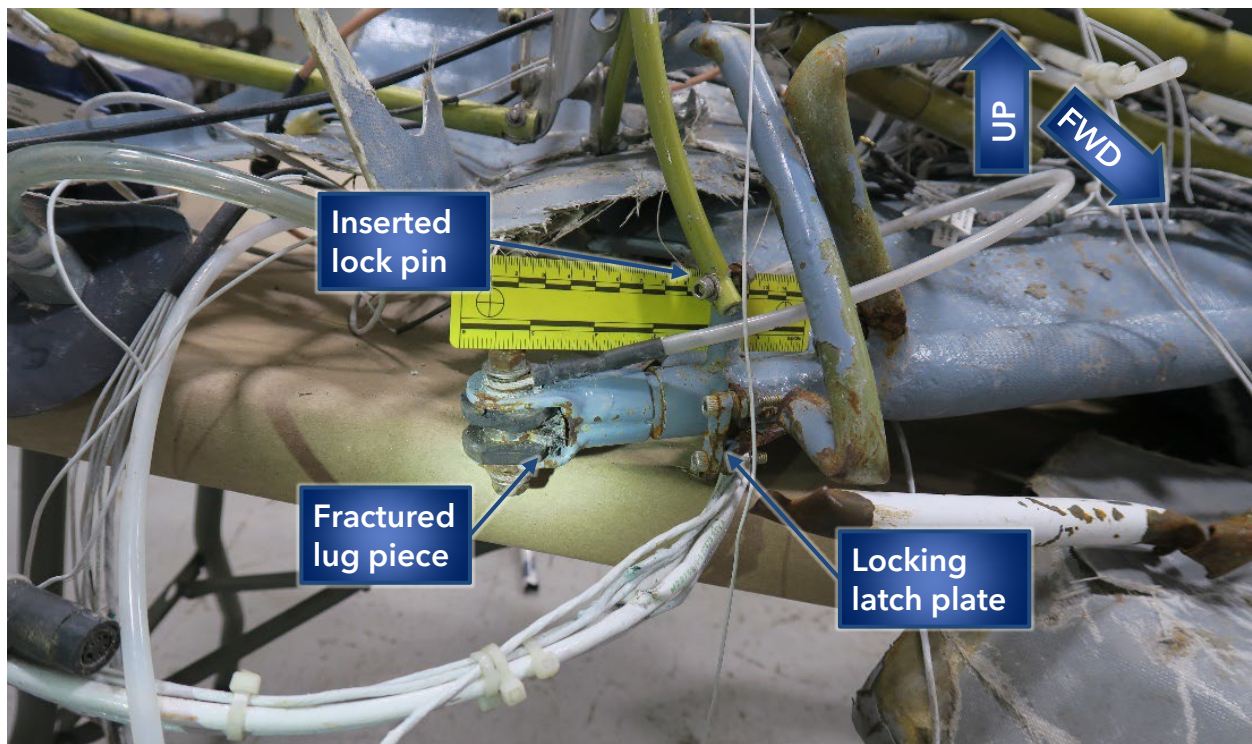


Figure 2. Right side of the fuselage showing the forward (upper image) and aft (lower image) wing attachment locations. The forward attachment location was displaced aft and rotated clockwise approximately 90 degrees such that the upper side faced forward.



Figure 3. Right wing strut outboard attachment location as photographed on scene.



Figure 4. Right wing strut inboard attachment location.



Figure 5. Left wing strut outboard attachment location as photographed on scene.



Figure 6. Left wing strut inboard attachment location as photographed on scene.



Figure 7. Outboard ends of the left and right wing struts with attachment hardware (upper image), and a closer view of the right wing strut outboard attachment hardware (lower image) as received for examination.

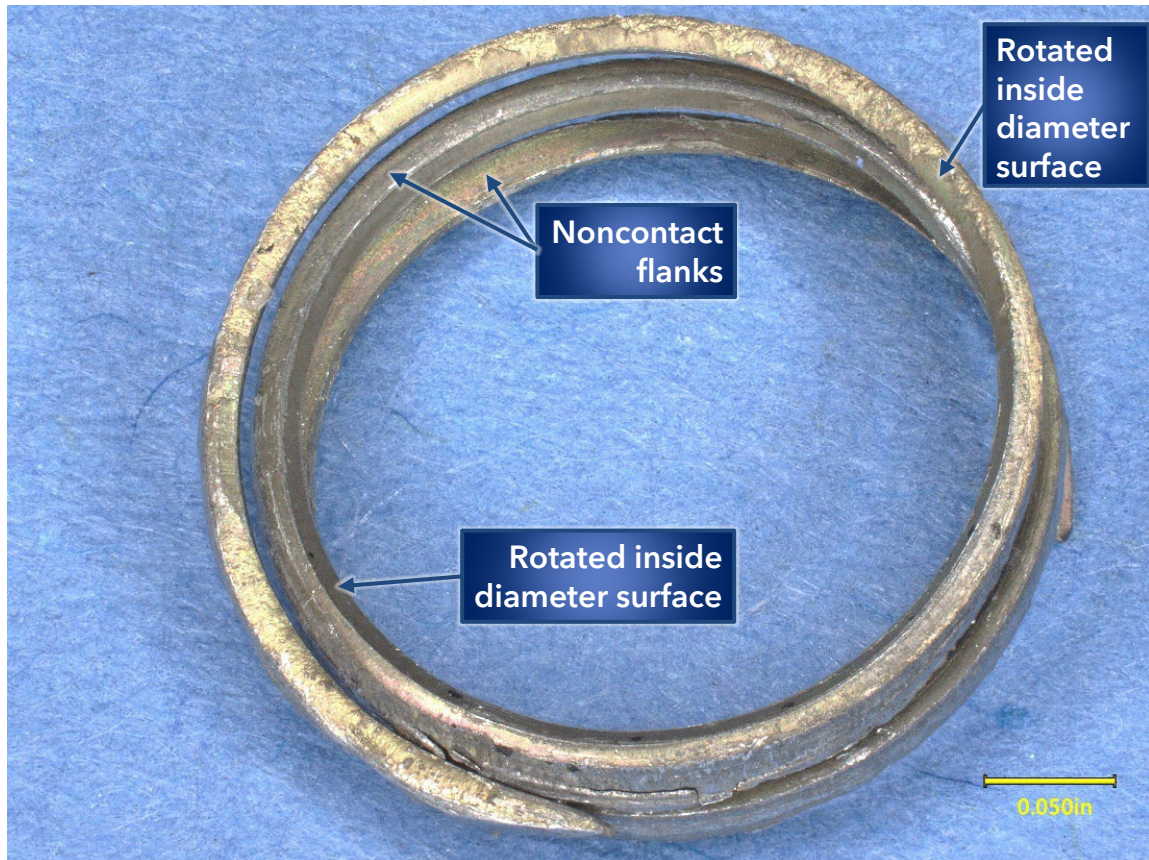


Figure 8. Fractured threads from the right wing strut outboard attachment nut after cleaning (upper image) as viewed looking at the bolt thread noncontact flanks of the nut threads. The lower image shows a close view of the bolt thread contact flanks on the nut thread piece with rough features consistent with repeated contact loading.

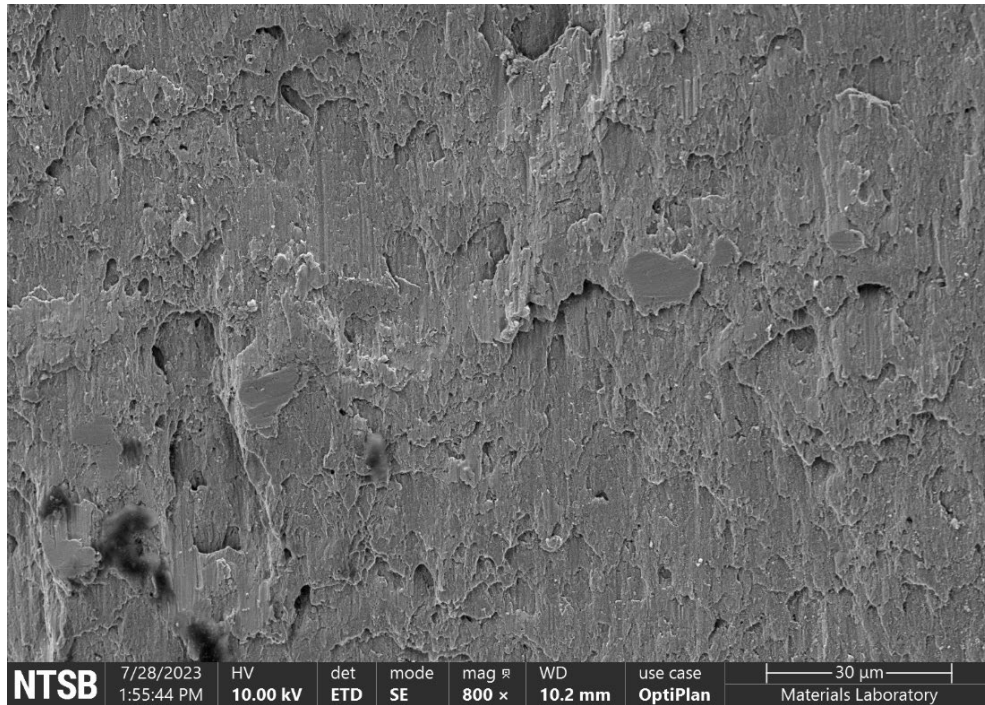


Figure 9. SEM image of typical fracture features for the nut threads showing elongated dimple features consistent with ductile overstress fracture in a plane of shear stress.



Figure 10. Macro photograph of the nut for the left wing strut outboard attachment showing 2 to 3 threads next to the red insert.

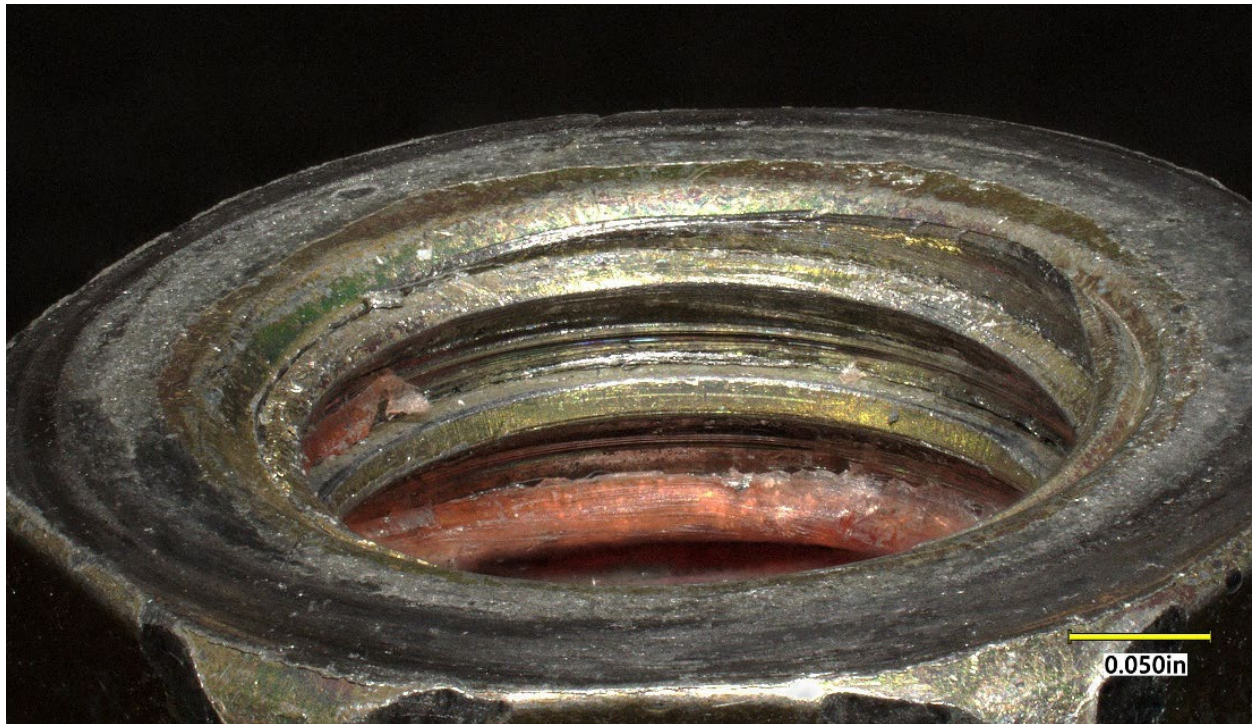


Figure 11. Optical image of the nut for the left wing strut outboard attachment location showing rolled, partially fractured, and displaced threads.

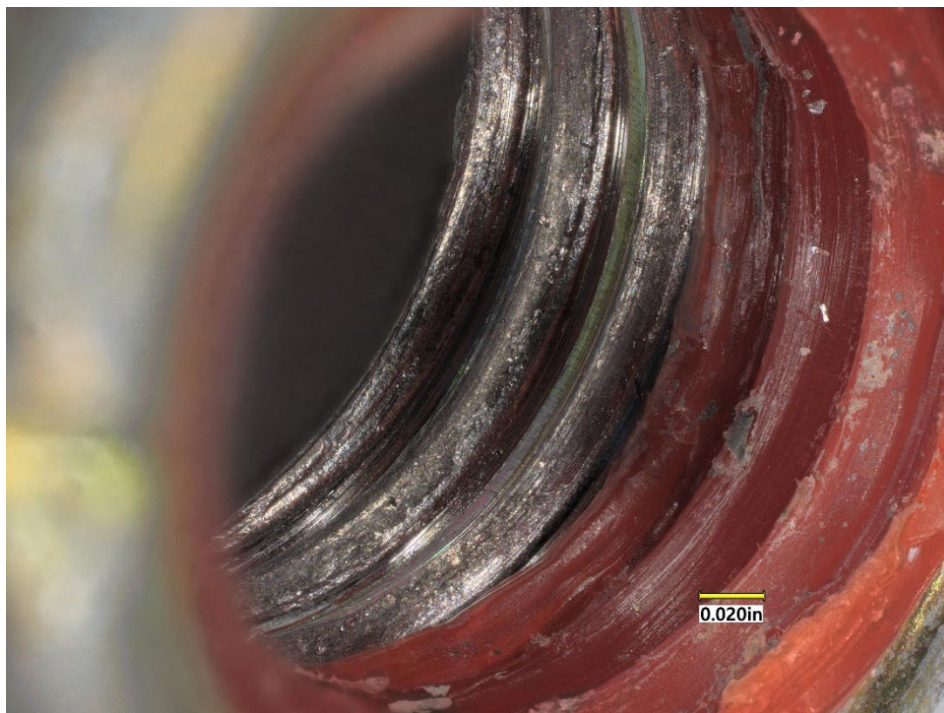


Figure 12. Optical image of the nut for the left wing strut outboard attachment location showing rough features on the bolt thread contact flanks consistent with repeated contact loading.