PFR- 26 Title: Sensor Door Axle/Mount Failure

Assembly : THM-AXB-FLT-006 (F3 L)	**SubAssembly :** THM-AXB-MEC-050-14 THM-AXB-MEC-050-15
Component : Sensor Door Axle/Mount	
Originator: Rob Duck	**Organization:** Space Sciences Lab
Phone : 510 643 9234	**Email :** rduck@ssl.berkeley.edu

Failure Occurred During (Check one √)

☐ Functional test √ Qualification test ☐ S/C Integration ☐ Launch operations

Environment when failure occurred:

☐ Ambient ☐ Vibration ☐ Shock ☐ Acoustic
☐ Thermal ☐ Vacuum √ Thermal-Vacuum ☐ EMI/EMC

Problem Description

During the stow procedure for the boom after Thermal Vacuum cold cycle testing, it was noticed that the top ends of the sensor door mount had a hairline fracture and the sensor door axle had a slight bend. All other flight units (SN#: 001,002,003,004,005) have been tested, and inspected and no fracture or yield is present.

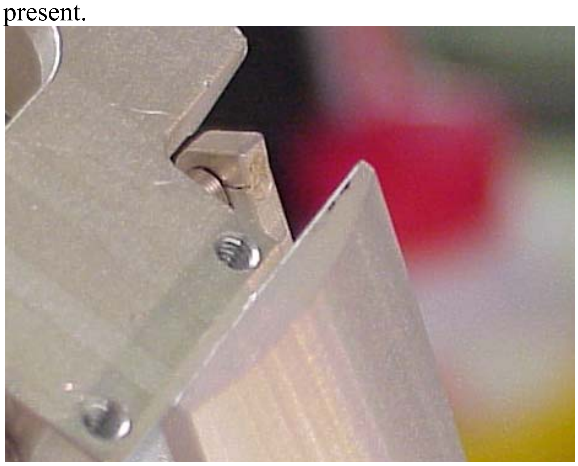

Figure 1. Crack in Door Mount

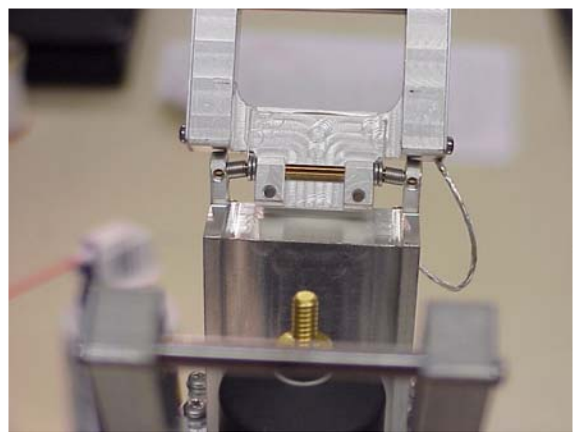

Figure 2. Bent Door Axle

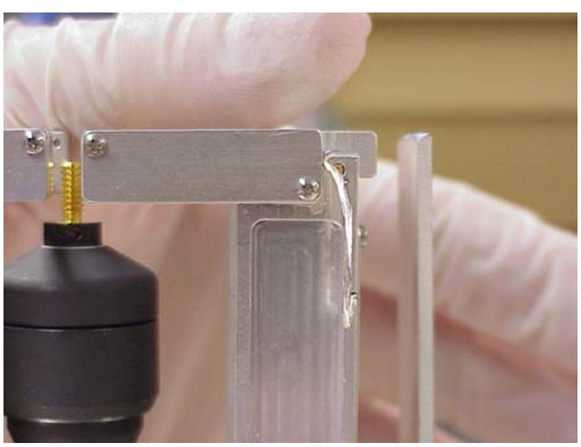

Figure 3. Door post relative to door (latch removed)

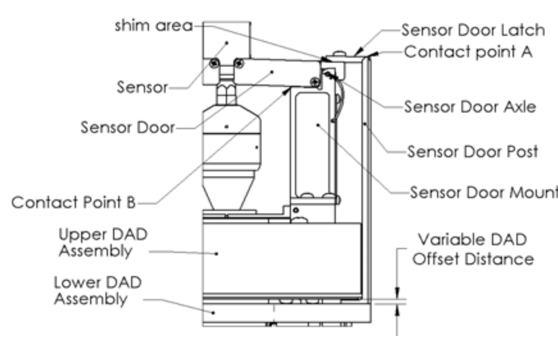

Figure 4. Stowed boom front view.

Analyses Performed to Determine Cause

The boom was inspected visually to determine the cause. The part of the mount that showed the fracture was where the door axles contacted the mount, figure 1. The inside of the mount had the fracture and the axle was bowed up slightly, figure 2. The axle received significant stress resulting in yielding. This stress was also transmitted to the inside of the axle hole on the mount, placing the hole under significant tensile loading and ultimately leading to the yield and fracture of the metal. Thus there was a significant force placed on the door, pulling the axle and causing the failure. There are two possible factors that may have contributed to the failure of the door mounts and axles.

The first was improper stowing of the Frangibolt actuator. During the stow of the actuator prior to cold thermal vacuum, the Frangibolt actuator was positioned improperly relative to the cable bobbin. This was a result of the Frangibolt washer seating in the actuation bolt notch, not on the bobbin itself. When in the notch, the actuation bolt can be torqued properly. When the safety pin is removed, the spring loaded Deploy Assistance Devices ("DAD") pull the actuator towards the bobbin. If the actuator is positioned to the bolt notch, there is approximately 0.125" of gap between the actuator and bobbin. In this case, the pin was pulled and the DAD did jump this distance. When the Frangibolt washer hits the bobbin, the stacer tip piece motion is stopped, causing the upper DAD assembly to stop suddenly. The lower DAD assembly is slowed only by the spring between it and the upper DAD assembly, thus it doesn't stop immediately when the upper DAD stops. This would impart additional forces to the sensor door axle as the lower DAD would push the sensor post into the latch at this instant. The actuator was removed and restowed properly, however the sensor doors were not checked for possible failure after this so the extent of damage that this may have caused is unknown. However, this failure may have added to the cause of failure in the axle and mount.

The second possible cause of failure results from additional interference introduced between the sensor door posts and latches during stow. The design and geometry of the stowed boom configuration was reviewed and it was determined that additional forces can be imparted to the sensor door axle by one of two components, the sensor and/or the door latch. A description follows.

The first component, the sensor, is in contact with the inside end of the sensor door. The contact pin from the sensor door fits into a groove on the sensor holding the sensor in place. If the sensor were forced up, this would force the door open and put stress on the axle in the direction of failure. The sensor assembly weights approximately 23 grams and the only force that pushes on it is the spring force of the stowed small stacer, on the order of 10s of grams. It is unlikely that this caused additional forces on the door axle.

The second source of stress on the door comes from the door latches that are screwed on the doors in the final assembly step of the stow process. As the latches are screwed down, they are hooked onto the sensor door posts (contact point A, figure 4) which apply upward pressure on the latches causing the doors to close down on the mount (contact point B, figure 4). They are designed to apply slight pressure on the door thus holding it in position and keep the sensor from deploying. Both the sensor door mounts and sensor door posts are rigidly fastened to two separate subassemblies of the DAD ("Deploy Assistance Device"). Each of these assemblies, the upper and lower DAD respectively, is spring loaded. Slight variations in the spring forces due to spring manufacturing will result in different offsets between the upper and lower DAD assemblies when compressed and stowed. This creates variations in the position of the door posts relative to the position of the door mounts from boom to boom. The higher the door post relative to the door mount, the greater the interference between the latch and post, and the more stress will be produced on the axle when the latches are screwed down. Thus one boom may produce more stress on the axle in its stowed configuration than another.

In the case of the FLT-006 boom, the combination of the offsets between the mount and post was large enough to generate significant post/latch interference. This interference and the possible impact generated from the errant stowing of the actuator resulted in additional forces at contact points A & B, figure 4. The axle and mount were force to bear this stress and failed.

Corrective Action/ Resolution

Future Booms:

The failure mode of the improper actuator position was known prior to its failure. The procedure will be update in more detail, and a second engineer will inspect this step in the procedure for future flight stows. All previous flight units have been inspected and were all properly stowed.

The interference issue can be removed through shimming the latches. This procedure step was reviewed in the ETU build however during the first several flight builds, it was determined that shimming was not needed as the tolerance build ups were small enough. FLT-006 was the first boom where stack up may have been significant. A straight edge will be placed from sensor door post to sensor door post with the sensor doors in the closed position. The gap between the post and the top of the door will be measured and calibrated for the proper spacing. If this spacing is too large, shims will be placed between the sensor door and sensor door latches, reducing the interference between the latch and post, see shim location on figure 4. The stow procedure will be updated to reflect this new step. This final stow procedure step will be adopted on all booms moving forward.

Previously assembled booms:

All booms have been inspected for possible yield and fracture with no signs of failure. Since all booms have the sensor doors open during I & T testing, the new stow procedural step will be integrated on all booms prior to probe integration when the doors are closed. Thus no rework, nor testing, will be needed on any of the previous booms.

New door mount assemblies have been built for THM-AXB-FLT-006 and will be assembled onto the boom. Since they are the last assembly added during the original boom assembly, the main DAD, stacer, preamp, and cable assemblies are unaffected. FLT-006 has already completed all environmental testing however, it will go through an additional functional deployment to verify that the new 050 sensor door assemblies function properly, a workmanship vibration, and then a final functional deployment test to verify proper operation, at which point the boom testing will be considered complete and ready for science calibration and Suite I&T.

Acceptance:
MAM: Ron Jackson________________________; MSE: Ellen Taylor____________________________

PM: Peter Harvey__________________________; Cog. E: Rob Duck____________________________

Date of Closure____________________