Replica Spacecraft Parts – Bolts and Pupil Masks

What is this document?

Information about the replica bolts and pupil masks, provided by Webb scientists.

'Space-Qualified' fasteners (screws) used on MIRI (JWST)

Information from Martin Black, Optical Engineer at UKATC.

The Webb Campaign have arranged for AstroBoost partners to receive replica bolts alongside normal bolts, so that the differences in quality of workmanship and materials can be examined. A magnifying glass is provided.

What are 'Space-Qualified' fasteners and why do we need them on an assembly bound for space?

- They have to be very strong.
    - Space-bound assemblies are subjected to extremely high vibration loads - particularly during rocket launch!
- They have to be very reliable.
    - We can't easily send up someone to replace one - especially for JWST!
- We have to make sure that they are very tight.
    - We can't have them coming loose during launch - if things fall off during launch; it's a very serious issue!
- They have to hold things together reliably at different temperatures
    - The MIRI instrument operates at 'cryogenic' temperatures (minus 200 ^{o}C & below)
- Because of space and weight restrictions we can't just use bigger 'ordinary' bolts.

How or where did we get 'Space Qualified' screws?

- They had to be very strong.
    - For MIRI we went to a specialist screw supplier and manufacturer.
        - We asked for the screws to be supplied in a very strong steel alloy.
- They had to be very reliable.
    - We asked for more checks from the specialist screw supplier.
        - They carried out a strength test on a sample screw for each size.
        - They inspected the dimensions of a sample screw for each size.
        - They cut through samples of each screw size & examined it under a microscope.
        - They carried out tests on the bar of material used to make the screws.
- We have to make sure they are very tight.
    - We asked the screw supplier to provide a 'low-friction' coating on the screws.
        - This helps to make sure that you get a reliable 'tightness' each time.

We got the screws, what else did we have to do?

- We had to make sure that they were very tight.
    - We calculated the force we needed to hold things together with the screws.
    - We calculated the tightening 'torque' we had to use to get this force.
    - We used a 'calibrated' torque wrench to tighten the screws
        - They could have broken if we had tightened them too much - the 'low-friction' screw coating helped this.
    - Launch vibrations can be very severe and can 'unwind' even tight screws.
        - To be extra sure, we put adhesive on the screw head after tightening.
- They have to hold things together reliably at different temperatures.
    - Screws could be tight when 'warm' but loose when 'cold' (materials shrinking).
    - We calculated this effect and put a washer (special material) under the screw head.
- We ***tested*** all the MIRI assemblies, before we 'delivered' it to the JWST team.
    - For the screws this meant a test to simulate the extreme vibrations at launch.

MIRI pupil mask (courtesy of David Lee)

Information from David Lee, Optical Engineer at UKATC

Astronomers will use the James Webb Space Telescope's Mid-Infrared Instrument MIRI to take pictures, and record the spectrum of, extremely faint astronomical objects. For MIRI to be able to measure the light from faint objects it is important that MIRI only views the light that reaches the instrument through the telescope. Light that reaches the instrument without first passing through the telescope is called stray-light and can ruin the image or spectrum.

It is important that we prevent stray-light by removing it. Both the James Webb Space Telescope and MIRI contain a number of aperture stops, or pupil masks, that only allow the useful scientific light to pass, and block the stray-light. The example pupil mask supplied in this kit is used in MIRI at the entrance to MIRI's medium resolution spectrometer. It has a distinctive shape that exactly matches that of the telescope mirror. This mask only allows through light reflected from the telescope's primary mirror.

The mask was manufactured by precision etching a thin piece of aluminium sheet resulting in a very accurate shape. The aluminium is then treated with a corrosion resistant alochrom coating to keep the part in good condition in the harsh environment of space. Thanks to these stray-light blocking masks MIRI will have a clear view of faint infrared astronomical objects.

AstroBoost Project

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