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Document Title **Plan to Strengthen and Test the Tracker-Module Flexure Mount**		

Gamma Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Plan to Strengthen and Test the Tracker-Module Flexure Mount

1. PURPOSE

As described in LAT-TD-00793, there were two structural failures in the first random-vibration test of the pre-engineering-model Tracker prototype tower module:

1. The fasteners attaching the tower sidewalls to the bottom tray backed out during transverse-axis random vibration.
2. In one of the corners the carbon-carbon closeout pieces vertical cracks formed from the closeout lower edge up to the flexure-mount insert.

Design modifications were implemented to correct the first problem and were proved in a follow-on test described in the same document. An as-yet-unspecified secondary locking mechanism has always been intended for the sidewall fasteners in the flight modules, which will add a further safety margin.

The violent motion that took place after the sidewall fasteners backed out may have aggravated the second problem. However, our working assumption is that there is not enough margin of strength in the carbon-carbon material surrounding the corner-flexure mounting inserts.

2. ANALYSIS PLAN AND PRELIMINARY RESULTS

The post-mortem analysis presented in LAT-TD-00793 shows that while there is a margin of 8.5 around the corner-flexure mounting inserts with respect to quasi-static launch loads, the margin for qualification-level (12.3 g rms) transverse-axis random vibration is –6%. The flexure mounts in the middle of each closeout side suffered no damage in full qualification level random vibration *even after failure of all four corner mounts.* There clearly is a drastic difference in stress concentration about those mounts compared with the corner mounts. That can be qualitatively understood by noting that the side flexure has two bolts holding its mounting bracket tight against the closeout in a single plane. This prevents any significant hoop stress from rising around the inserts holding those brackets in the case that the closeout frame distorts during random vibration. There may be a stress riser at each end of the bracket as the tray distorts, but it evidently is not severe (and there is a lot of material in those regions).

On the other hand, each corner flexure has only a single bolt into each of two perpendicular closeouts, and the span of the bracket parallel to the sides is relatively short. Therefore, as the tray distorts, causing the angle of the corner to deviate from 90º, the stress falls upon the bolt and its aluminum insert as they work to maintain parallelism between the closeout sides and the bracket. The resulting hoop stress in the insert puts the rather thin region of carbon-carbon between the insert and closeout edge in tension. The region failed in tension during the test.

3. PRELIMINARILY PROPOSED MODIFICATIONS

We propose to implement a set of design modifications similar to those discussed in LAT-TD-00793. In summary, they are the following:

1. Remove the light-weighting pockets from the closeout walls of the bottom tray panel, to avoid stress concentrations.

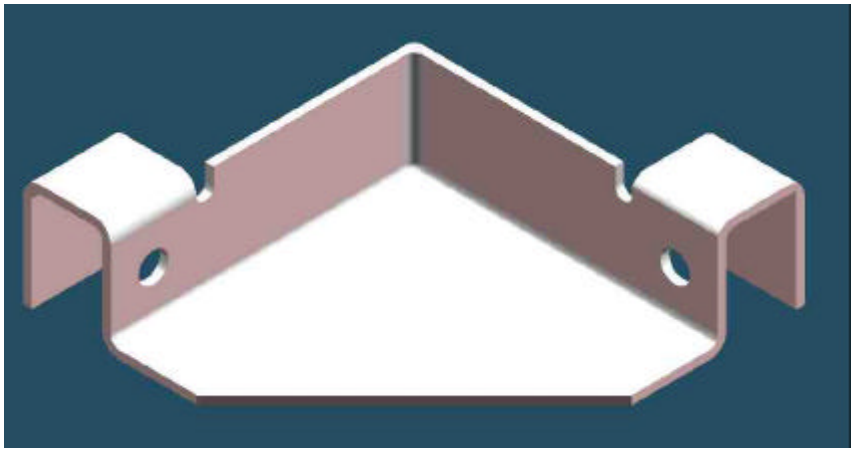

Figure 1. Corner clevis concept.

2. Increase the height of the bottom tray panel closeout by up to 5 mm (TBD). The extra material will be added to the bottom edge of the tray, with no change to the upper honeycomb-panel section.
3. Two options being discussed for reinforcing the flexure attachment:
   a. Replace the flexure fasteners with bonded joints, using a clevis-type joint similar to the wraparound gusset illustrated in LAT-TD-00793 (see Figure 1. Each one-piece clevis would include the mount for the flexure blade. It would wrap around the bottom of the tray but would be recessed in the bottom and outside edged of the closeout, in order not to change the flush mounting scheme for the sidewalls and the grid. A master tool will be designed and built for bonding of the clevises, to ensure accurate location in all tracker modules. This bonded-clevis scheme would be used for all 8 flexures.
   b. Reinforce the corners on the inside of the closeout with a bonded gusset and greatly increase the size of the insert head on the outside of the closeout, as

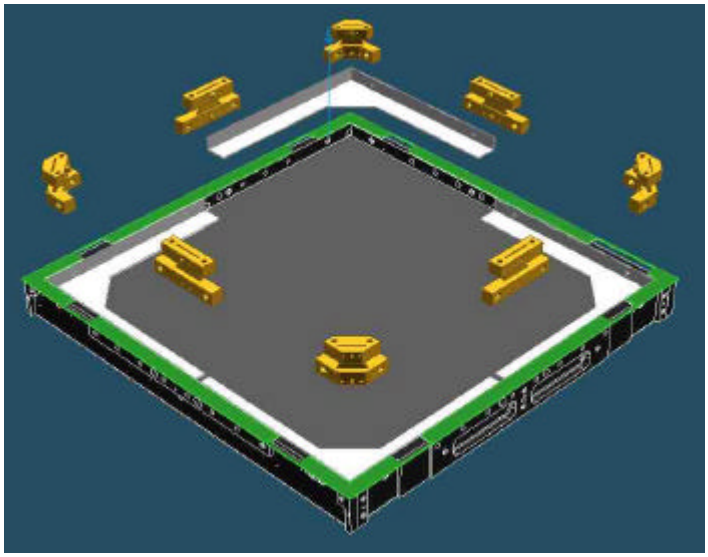

Figure 2. Extended corner-gusset scheme.

illustrated in LAT-TD-00793. The gusset might go as far from the corner as the center flexure, as illustrated in Figure 2. In this case the inserts themselves would probably be steel, instead of aluminum.

4. As suggested by Lou Fontano of GSFC, we propose to replace the polymeric thermal gasket by a metallic gasket made of beryllium-copper. It would be bonded to the inner face of the closeout frame and bent over the bottom edge, such that it gets compressed against the aluminum grid.

The new bottom tray design will not undergo random vibration testing in a tower-module prior to engineering-model fabrication and testing. However, a series of coupon and load tests described below will be used to ensure that the joint is sufficiently strong to guarantee success in the engineering-model vibration and environmental tests.

4. ANALYSIS

The design modifications will be checked by FEA and hand calculations, and the results will be compared with the previous design. Internal loads will be recovered from the FEM and used to calculate stresses around the clevis joints. The results will be compared with allowable stress specifications obtained from coupon testing.

5. COUPON TEST PLANS

5.1 Material Tests

Allowed tensile stress has already been obtained by testing of carbon-carbon coupons. However, allowable shear stress has not been determined. GSFC engineers recommended shear testing of coupons, so we will do that for the Alcomp carbon-carbon material.

5.2 Corner-Joint Tests

A series of load tests will be conducted for applicable failure mechanisms on bottom-tray flexure-mount coupons:

1. The existing design, with the fastener-mounted flexure.
2. The existing design, but with the increased closeout height and without the pockets in the closeouts.
3. The new design, with bonded clevises or bonded gusset plus large-headed insert.

Corner-joint coupons will also be thermal cycled, and the load tests will be repeated on coupons after thermal cycling.

5.3 Test Tray

A second bottom tray will be fabricated alongside the engineering model tray using material that we already have in hand. Due to a shortage of material on the relevant time scale of sufficient thickness, the outside bosses on this tray will have to be shimmed. However, they are not relevant to the flexure joint. This extra tray will be subjected to load testing to understand the margins in the design before assembling and testing the engineering-model tower-module.

6. BOND-JOINT PROOF TESTING

We also propose to add to the fabrication procedure for the bottom tray panels a proof test of the clevis-closeout (or gusset-closeout) adhesive bond to 3 standard deviations above the expected random-vibration loads. This would be done prior to mounting detectors and electronics onto the tray. The goal will be to check the workmanship in the bonding process.

This proof testing will first be carried out on the engineering-model bottom tray panel. In the case of the bonded-clevis option, for example, a test fixture will be made to apply static equivalent loads at the tracker-module center-of-gravity and transfer them to the bottom tray via the sidewall fasteners, with the tray mounted on a "grid" by its flexures. This will test all 8 flexure mounts simultaneously.

7. SCHEDULE

An MS Project schedule is shown on the last page. The goal of this schedule is to keep the engineering-model fabrication on track. In any case, we have to wait until August 20 to start cutting the carbon-carbon closeouts for the bottom and top trays because of the recent screw-up that occurred in machining the parts in Italy (the large pieces for the top and bottom trays were used instead for regular-tray closeouts). Replacement material is on order from Alcomp (which by chance gives us the opportunity to add the 5 mm to the bottom-tray closeout height) and will be available in late August when our Italian colleagues return from vacation. At that time we want to have the closeout design finalized. Therefore, analysis and coupon testing should be completed before then. The schedule shown here meets that requirement.