

Response to the GLAST LAT Tracker Anomaly Resolution Team Report

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Introduction

The tracker team greatly appreciates the efforts of the TART and the detailed and helpful report that they have produced. This document outlines our response to the report and provides, for each of the 12 TART recommendations, the following information, where relevant:

1. Plan for implementation
 - a. Who is responsible
 - b. When complete—intermediate checkpoints
 - c. Decision points
2. Items where the implementation deviates from the TART recommendations and justification for deviation
3. Additional resources needed for implementation
4. Interdependencies with other organizations

We have also included an overall schedule leading up to restarting of flight tray production with the new design.

The goal of the TART's efforts and the focus of the tracker team's response is to get the tracker back into flight production as efficiently as possible. Here we give the milestones and critical steps in this process, which are further detailed in the attached schedule:

Milestones to Returning to Flight Production:

9/17/04 Review of new procedures

9/20/04 Materials available for test articles (etched, primed tiles, trays, wire, compliant pad, ...)

9/23/04 Coupons verified

9/24/04 New drawings and procedures released

10/1/04 Facility modifications at Plyform complete; Manufacturing Readiness Review

10/4/04 Begin flight tray production

Critical Steps to Returning to Flight Production:

The team, guided by the recommendations of the TART, feels that the following steps must be accomplished before the start up of production:

1. Etched and primed tiles with good coupon test results must be produced in sufficient quantity to make trays

2. A clean, controlled work area at Plyform must be set up, and the recommended cleanliness steps of the report must be implemented.
3. The new procedures, process controls, mandatory inspection points, and configuration control must be in place.
4. Test articles 4.1.2 and 4.1.3 as outlined in the TART report must be built and in test.
 - a. Note A: whereas we agree with the importance in testing the compression pad concept, there may be schedule issues that would delay its implementation in the tray production. If it is found to put an unacceptable delay into the schedule, then it will be introduced as a later improvement in the process.
 - b. Note B: It is possible, if the clean area is ready, to start flight production before completing TVAC of the test articles. This would be a deviation from the TART recommendation. However we believe that proceeding at risk is the correct step to take if the production facilities are ready. This possibility is indicated by “Scenario 2” in the schedule.

Recommendation 1: Qualification program: Brez

Sandro Brez will be responsible for implementation of this plan, which will follow the recommendations of the TART, as specified in Section 4.2 of their report, with no deviations. The test articles will be fabricated by Plyform according to the flight tray-panel fabrication processes and procedures. Our goal is to produce these articles in the flight-fabrication assembly line once that line will have been upgraded as recommended by the TART and defined below. The first decision point will be a production readiness review for flight articles, currently scheduled for 10/1. The first 6 flight tray panels (4 thin converter and 2 thick converter) will comprise the set of qualification units. Flight tray panel production will continue during the qualification testing. A second decision point will be an okay to proceed with integrating MCMs and ladders onto panels. That can occur only after successful thermal-vacuum testing and thermal cycling (through at least 4 cycles) of the qualification units. We anticipate that the qualification units will also become flight trays following inspection after the final thermal cycles.

The resources needed to implement this program exist already at INFN Pisa (thermal chamber) and INFN Roma-II (thermal-vacuum chamber). The test procedures already exist and need to be modified only according to the qualification temperature limits and number of cycles.

Recommendation 2: Tungsten surface preparation: Brez

We intend to follow the TART recommendation to etch and prime the tungsten tiles. To that end, we will develop and test the procedure in two locations in parallel (both organizations are new to the Tracker program):

1. NASA GSFC will etch and prime at least enough tiles to outfit a tower. They will verify the process by bonding and testing coupons, and in addition they will supply coupon-sized tiles to Plyform to be bonded and tested there. They will start with the TART recommended procedure and will tweak it as needed to obtain good results.

2. Plyform will contract with the same company in Turin that prepared the tungsten for the Agile project. That company will clean and etch the tiles and then ship them to Plyform in clean vacuum-sealed bags. Plyform will inspect them (including a water-break test) and then prime them according to the TART recommendation.

We do not foresee making significant deviations from the TART recommendations. The TART recipe is only a starting point, and GSFC will use their expertise to optimize it. The Turin company has their own etch process, which should give the same results (removal of some tungsten, leaving a clean surface). The biggest deviation in that case will be a delay of a week or two between etching and priming. That will be necessary, as the company in Turin cannot do the priming. However, the vacuum-sealed bags will prevent contamination of the etched surfaces.

Plyform will do the following set of coupons for T-peel and conductivity tests:

Description	Cure
3 Thin W (GSFC process) with Kapton	1 day at room temperature
3 Thin W (GFSC process) with Kapton	1 day at room temperature, 1 day at 40C
3 Thin W (Turin process) with Kapton	1 day at room temperature, 1 day at 40 C
Conductivity tests with primed W and wires	1 day at room temperature, 1 day at 40 C

Decision points:

1. Success or failure of the surface treatment will be decided based on peel tests of coupons, on about 9/20/04. The peel strength should be as good as or better than was obtained with the best grit-blasted coupons.
2. A decision as to which process to use will be made based on comparison of the peel strengths, on about 9/20/04. If both are suitable, according to the criterion specified above, and not significantly different in strength, then both sets of tiles can be used. In that case, a decision on which process to continue with will be based on cost, schedule, availability, efficiency and reliability.

The drawings for the tiles (LAT-DS-00791 and LAT-DS-00792) will be updated and released with complete specifications and bill-of-materials for the cleaning, etching, and priming of the tiles by 9/24/04.

Recommendation 3: Bias Circuit preparation: Foglia

A new procedure for preparing the bias circuits prior to bonding will be written by INFN as outlined in the TART report. There will be no deviation from the recommended procedure. All new materials (Scotch Brite pads and a visual reference for process verification) will be provided to Plyform on 9/10/04. Plyform already has the necessary solvents and cleaning materials.

Specifications for the new procedure have been provided to Plyform as of 9/10/04, and the final procedure is to be released by 9/17/04.

Recommendation 4: Tungsten Bonding: Bagagli

A new procedure for preparing the tungsten prior to bonding will be developed as outlined in the TART report to avoid contamination with mold release in sequential bonding steps. We believe that discarding the sand-blasted, curved thin tungsten tiles, in favor of the new etched and primed tiles, together with the recommended cleaning procedures, should address this issue.

The TART has suggested the use of a thin sheet of polyethylene between tiles and the vacuum fixture for the thin tiles. This suggestion has been explored experimentally, and is cannot be employed on either heavy and mid-tray type fixtures.

Plyform has identified a potential issue with bonding to the adhesive between tiles, which results from the bonding of the tile to the face sheet. In the past they abraded the entire tray surface, including that cured adhesive. The process will have to be different with the primed. This issue is being explored with INFN.

A draft procedure will be developed with Plyform, with the final procedure to be released by 9/17/04.

Recommendation 5: Preparation of Adhesive: Foglia

A new degassing procedure for preparing the adhesive prior to bonding will be developed as outlined in the TART report. A new vacuum bell jar, reserved for the use of the GLAST program, will be purchased by Plyform for this use and will be delivered and in use by 9/17/04.

We will explore with Plyform to see whether they already have an internal procedure document consistent with our needs. If not, then a draft procedure will be provided to us with the final procedure to be released by 9/17/04. We intend to use a procedure consistent with that recommended in the TART report.

Recommendation 6: Grounding of Tungsten tiles: Brez

The TART has suggested that stainless steel or equivalent wires, 50 microns in diameter, be used to ensure the grounding of the tiles to the carbon face sheet.

- Candidate wire samples will be provided to INFN by SLAC, arriving 9/13/04.
- Other candidate wire samples will be found by INFN directly

Coupons will be prepared at Plyform and Goddard to test the conductivity of the carbon face sheet to the tungsten with the wires embedded in the epoxy. Coupon test results will be available 9/20/04. The primer, BR-127, is known to be nonconducting. If the wires do not make a low enough impedance path between the carbon face sheet and the primed tungsten (tens of megohms is low enough), a process of preparing and protecting the tungsten surface that does not use primer will be considered and extra test articles may be prepared. The team will consider the option of not grounding the W tiles.

In parallel, the conducting primer, BR-127ESD, is being ordered by SLAC and shipped to INFN as soon as possible for future studies.

Recommendation 7: Process cleanliness: Bagagli

All of the process cleanliness steps outlined in the TART report will be implemented at Plyform, including the use of a clean tent inside the clean room for exclusive GLAST

use. Riccardo Bagagli will develop the procedures and ensure that the steps outlined in the TART report are followed. Plyform has committed to provide the new clean facility by 10/4/04. Earlier availability is being explored. Note that most of the improvements, but not the tent, will be available for assembly of the test articles.

The process control steps outlined in the TART report will be implemented. The T-peel samples will be built as per Plyform standard practice (specimen cured at room temperature for 24 hours) and without control over adhesive thickness to be able to compare with previous T-peel tests on sandblasted samples. Initially 6 samples will be built:

- 3 samples cured for 24 hours at room temperature (reference)
- 3 samples cured for 24 hours at room temperature and then cured for another 24 hours at 40C.

In production, the T-peel and Shore D hardness by ASTM D2240-91 tests will be implemented in the production process as a control. The hardness test may not be immediately available, however, as Plyform will have to acquire special tools in order to implement it.

Recommendation 8: Quality assurance and configuration control: Foglia

Giovanni Foglia will work with Plyform to provide more aggressive oversight of the manufacturing process. The guidelines suggested in the TART report of a formal change control process will be implemented. INFN will define a set of MIP's:

- Tile conditions before usage
- Kapton conditions before bonding
- Glue conditions before usage

These will be used to ensure quality control during the process. INFN QA will also survey the etching vendor in Turin, including the packaging of the tiles for shipping. The first batch will be delivered on 9/13/04 before the survey can be completed. Those tiles will be inspected at Plyform by INFN, including a water break test and checking of the package integrity.

Recommendation 9: Non-use of grit blasted tungsten: Brez

The grit-blasted thin tiles have been removed from the production flow and quarantined at Plyform. The thick tungsten tiles that have been grit blasted will be etched and primed before use, according to the process of Recommendation 2. They were not distorted by the grit blasting.

INFN will have to order new thin tungsten tiles to replace the 2 towers' worth already grit blasted, but this is not urgent.

Recommendation 10: Bond joint compression: Bagagli

A material suitable for the bond joint compression will be located and ordered by SLAC (Drell/Johnson) and shipped to INFN. In addition, INFN and Plyform will look for a suitable material in Italy. The procedure for introducing the pad into the tray fabrication will be developed by Riccardo Bagagli. If the procedure has a good chance of success, then a test article will be developed per 4.1.3 of the TART report. Bagagli will develop a

draft procedure that will be released at the time of the fabrication of the test article. A final procedure will be released in advance of the assembly of the qualification model.

If a suitable pad and procedure cannot be obtained soon enough, we will proceed with test articles and qualification without the pad. In parallel, then, we will work on improving the bond joint compression and introduce a suitable improvement into the flight production as soon as it can be tested and qualified.

Recommendation 11: Alternate bond cure protocol: Brez

An alternate protocol for curing the epoxy will be developed as suggested in the TART report. This alternate protocol (1 day at 35C followed by 1 day at room temperature) will be used on coupons in parallel with the normal cure protocol (7 days at room temperature followed) in coupon tests performed at Plyform. If successful in producing some significant improvement in peel strength, then one tray (test article) will be prepared using this protocol and tested as per 4.1.4 of the TART report.

This recommendation may be useful in the process flow, but it will not determine success or failure of the bonding process and therefore will be studied at lower priority and considered as a process improvement at a later date.

Recommendation 12: Examine bonding integrity of the EM tower: Brez

The Tracker team will remove the top tray from the EM tower and examine it. This tray is particularly relevant, because it used the flight-design bias circuit and is outfitted with thin tungsten. (The only other tray to use the flight-design bias circuits was the bottom tray, and it has no tungsten.) However, like all EM trays, the top tray does have silicon mounted over the bias circuit. The examination will be visual, plus an ESPI (holographic) test to try to detect any large-scale delamination below the silicon. The ESPI test will require painting the silicon black. Note that the Tracker team is preparing to ship this long-overdue EM tower to SLAC I&T, so we want to avoid destructive analysis at this time.