GLAST Large Area Telescope:

Tracker Subsystem WBS 4.1.4

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Recent Accomplishments

- **EM Thermal-Vacuum Test Completion**
  - **Thermal balances tests completed March 12**
  - **Test De-Briefing meeting in Bari March 23, 24**

EM tower inside thermal isolation box

Recent Accomplishments

- **Thermal Balance Results**
  - 7 cases were run:
    - 20°C: 8W and 12W power
    - 0°C: 8W, 10W, and 12W power
    - –15°C: 10W and 12W power
  - Good correlation with the model
  - No design or workmanship problems found in the EM Tracker
- **Sidewall Fabrication**
  - Detailed prepreg specifications were worked out with help from Swales, and prepreg procurement has begun.
  - The sidewall drawings have been completed and reviewed by the new engineering team and are in release.
  - A draft fabrication specification was written.

Recent Accomplishments

- **Start of Flight Tray Fabrication**
  - Follow-up production readiness review was held in February at Plyform.
  - About 20 bare panels have been fabricated, which are now ready for ESPI testing next week, followed by bonding of converter foils and bias circuits.
- **Start of Flight MCM Fabrication**

Working on getting some photos together.

  - The preproduction completed with good results, including numerous small lessons learned to improve the flight fabrication.
  - Production began March 24, after a >3-week delay in getting the PO negotiated between SLAC and Teledyne.
  - Our full-time LAT QE is working at Teledyne
  - The first MCMs are expected to start coming off the production line about April 14.
- **Flex-Circuit Cable Design**
  - The Tracker solid model was improved, and a lot of rigorous work went into ensuring that this critical interface will work mechanically.
  - Non-flight cable designs were submitted for EGSE.
  - The first flight-cable design is within a couple of days of being ready for fabrication.

Recent Accomplishments

- **Tracker-Grid Interface Design**
  - Drawings for the bottom tray and flexures were completed.
  - Drawings of new bottom-tray assembly fixtures were completed and are in fabrication.
  - Machining of titanium flexures and bottom-tray M55J/CC closeouts is in progress.
  - The static-test fixture was shipped to Italy, and a SLAC/Hytec team will go there in mid April to help make the test system operational.
  - Interface hardware were detailed, and a plan is in work to qualify the interface design.
  - A thorough analysis of the tolerance stackup in the Tracker-Grid interface was completed and a new plan devised for tower alignment.
    - CMM measurement of the completed tower and the flexure interface bolt holes.
    - Analysis of the measurements to demonstrate that the tower can be placed within its stay-clear by adjustment of the dual eccentric cones.
    - Calculation of the cone orientation needed for tower integration.
    - This process is complex enough to require a dedicated engineer at SLAC.

Open Issues

- **Verification of the Tracker-Grid Interface Design**
  - Plan to do strength testing on mocked up joints, with an Instron.
  - Qualification-level static testing on the first bottom tray, as well as workmanship testing on all bottom trays.
  - A second vibration test of the EM tower, using the new interface.
- **Completion of the Flex-Circuit Cable Design**
  - Completion of the design took far longer than expected, due to issues with mechanical interfaces.
  - Final layouts are by now well in progress, but the production schedule is now critical.
- **EMI/EMC Test Plan**
  - No provisions are in place to execute any such tests in Italy.
  - A plan needs to be put into place for what to do with regard to such tests at SLAC after Tracker delivery.

Technical Risks

- **Validation of the Tracker-Grid interface.**
  - Fabrication of flight hardware has to proceed at risk in parallel with the validation work.
  - The Tracker alignment plan is fairly complex and untried, but necessary in order to meet the tight requirements (2.5mm between towers) given the tower fabrication tolerance that can be achieved with existing tooling.
- **Environmental testing of the MCM/SSD interface.**
  - EM and pre-EM thermal and thermal-vacuum testing did not exercise the final interface between MCMs and SSDs (encapsulated wire bonds).
- **MCM and ASIC Qualification Testing**
  - Flight MCM production is proceeding at risk in parallel with completion of the qualification testing.
  - Some environmental testing has been completed, however:
    - 5 MCMs went through 220 thermal cycles (–30°C to 85°C) without any degradation.
    - 2 MCMs have also been vacuum tested.

Schedule Slips Since Rebaseline

- **MCM Flight Production Startup**
  - The PRR was completed only slightly late, Feb. 10, with hope of getting production started within a week or two, after resolving some issues:
    - Teledyne needed to test offset wire bonding, to ensure that rework can be accomplished to Mil Spec.
    - SLAC was still scrambling to get sufficient quantities of some parts:
      - Omnetics connectors with the shell bonding problem fixed.
      - Machined PWBs from panels with tested coupons.
    - Last detailed changes of drawings and procedures had to be incorporated, signed off, and released at SLAC & Teledyne.
    - We discovered that 2 adhesives in use at Teledyne were not degassed.
    - Price negotiations had to be finalized with Teledyne.
  - We believed we were ready to go Feb. 24, after a meeting in which we agreed on a total cost, including SLAC purchasing.
  - From that point it took *4 weeks* to get a PO in place that SLAC purchasing and Teledyne agreed to, despite the fact that we had purchasing fully involved in these preparations since last September. The main sticking points derived from the fact that the build will cross the fiscal year boundary. The total cost did not change since the Feb 24 agreement.
  - Teledyne did not do any work on flight hardware during this time, not even unpacking and kitting of the parts, so we lost a month of schedule.

Schedule Slips Since Rebaseline

- **Bottom-Tray Design and Fabrication**
  - The EM tower vibration test revealed inadequacies in the design for fastening the tower to the Grid, when the bolts started backing out during vibration.
  - The process of redesigning this interface, carried out by a new mechanical design team, quickly uncovered additional issues that could make integration of 16 towers into the Grid impossible.
  - The project decided that the joints should be redesigned to have nearly zero slippage during vibration and to have built-in adjustment capability to take out machining and assembly tolerances.
  - The Tracker solid models were also found to be lacking in rigor, raising questions about many other aspects of the mechanical design, and many of the fabrication drawings were also found to have errors or missing information.
  - Manpower has been and still is being added at SLAC to bring this situation under control and to complete the design and qualification of the interface and bottom tray.
  - This process quickly resulted in the bottom tray becoming the critical path to getting Tower A built.

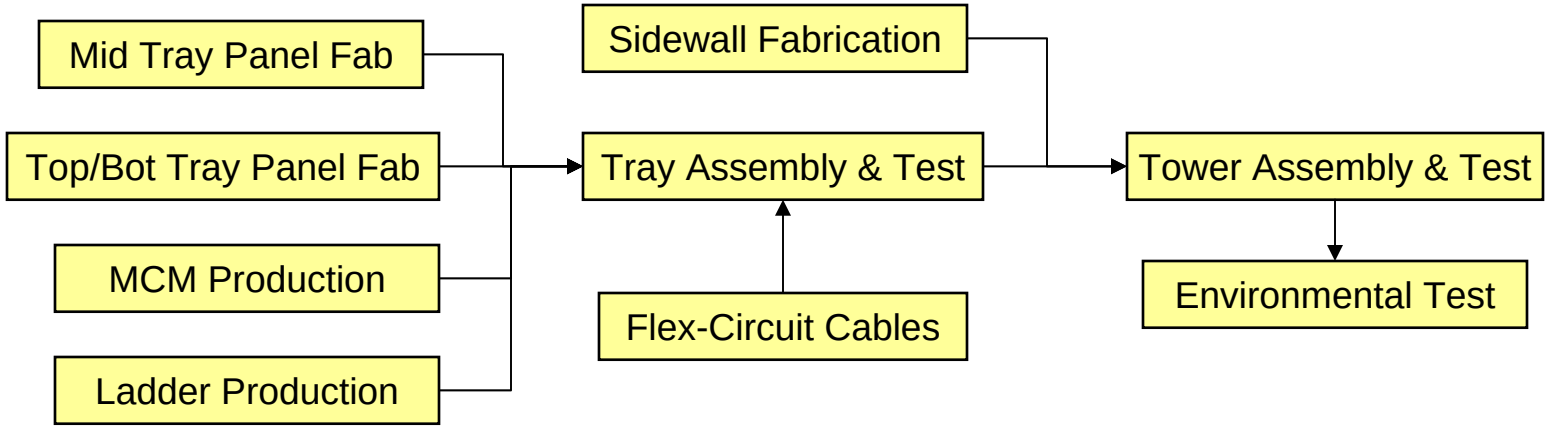
Schedule Slips Since Rebaseline

- **Mid-Tray Fabrication**
  - Start-up delays were encountered because of defects or damage found in the aluminum cores, requiring refabrication and manual rework.
  - Start-up delays were also encountered in getting all documentation in place to the satisfaction of LAT QA. This highlighted difficulties in communication between SLAC and INFN and the need for a QE in Italy. The problems are being addressed.
  - Start-up delays were also encountered in the bias circuit fabrication, due to errors that required starting over.
  - Finally, since tray fabrication began in February initial progress has been slow. INFN says that ramp-up to full production rates will occur after the first tray lot is complete.
  - This is so far not on the critical path, due to delays in the MCMs and bottom-tray parts.

Schedule Slips Since Rebaseline

- **Flex-Circuit Cable Design and Fabrication**
  - The tower solid modeling problems found by the new design team impacted the flex-circuit cable design.
  - A lot of mechanical design time has gone into the cables in the past 2 months. The passage through the Grid flange and the area at the top of the tower have been the most difficult. An addition strain-relief bend was added between the Tracker and Grid.
  - We also discovered a need to add some protection resistors on the address lines to be sure that the polyswitches can protect the system in the event of a short circuit on an MCM.
  - Every time the mechanical layouts are changed we have to redo the electrical layout. A new designer was hired to spend full time completing the electrical layouts.
  - In principle these are not on the critical path, but would be if other areas had not slipped.
  - I still have concern about the vendor Parlex meeting our schedule once production starts.

Roadmap to Flight Hardware



EGSE:

- MCM test and burn-in systems
- Stacked-tray and tower test systems

MGSE:

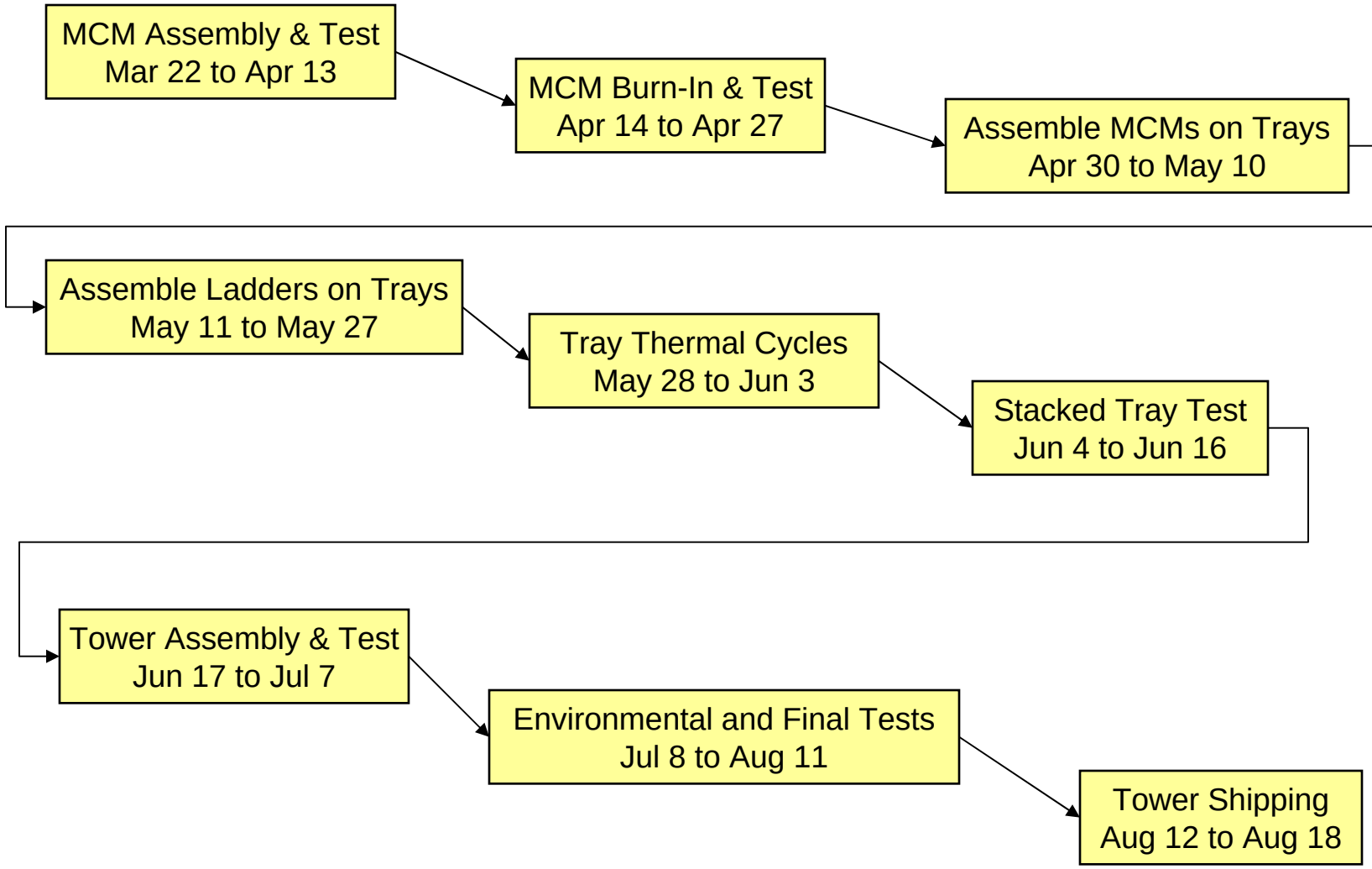
- Static test fixture
- Vibration fixtures
- Shipping containers
- Lifting fixture
- Tray storage boxes

Fixtures:

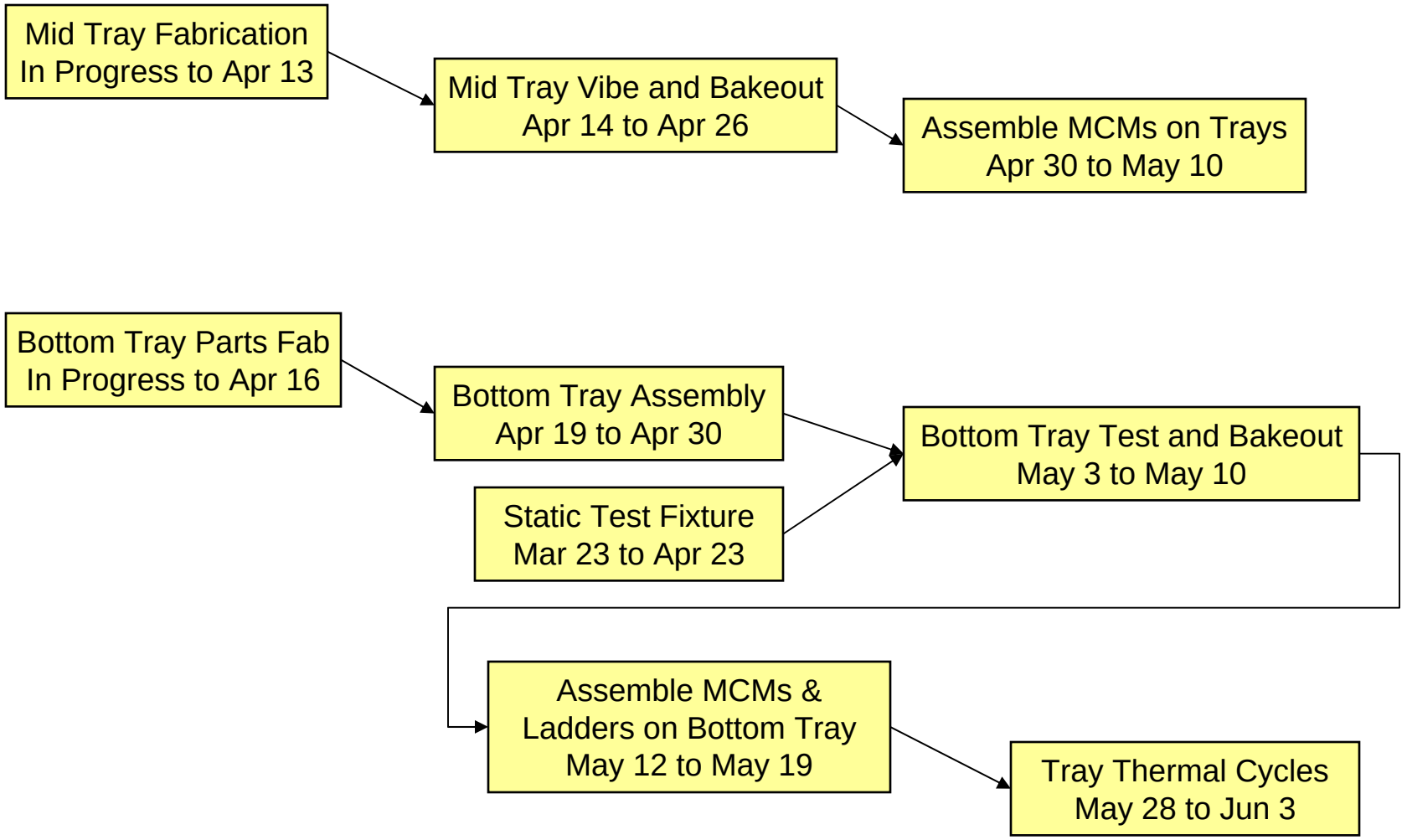
- Mid panel assembly
- Bottom/Top panel assembly
- Ladder assembly onto trays
- MCM assembly onto trays
- Stacked tray test
- Tower Assembly

This slide is still in progress to organize more information into the flow.

Critical Path for Tower A

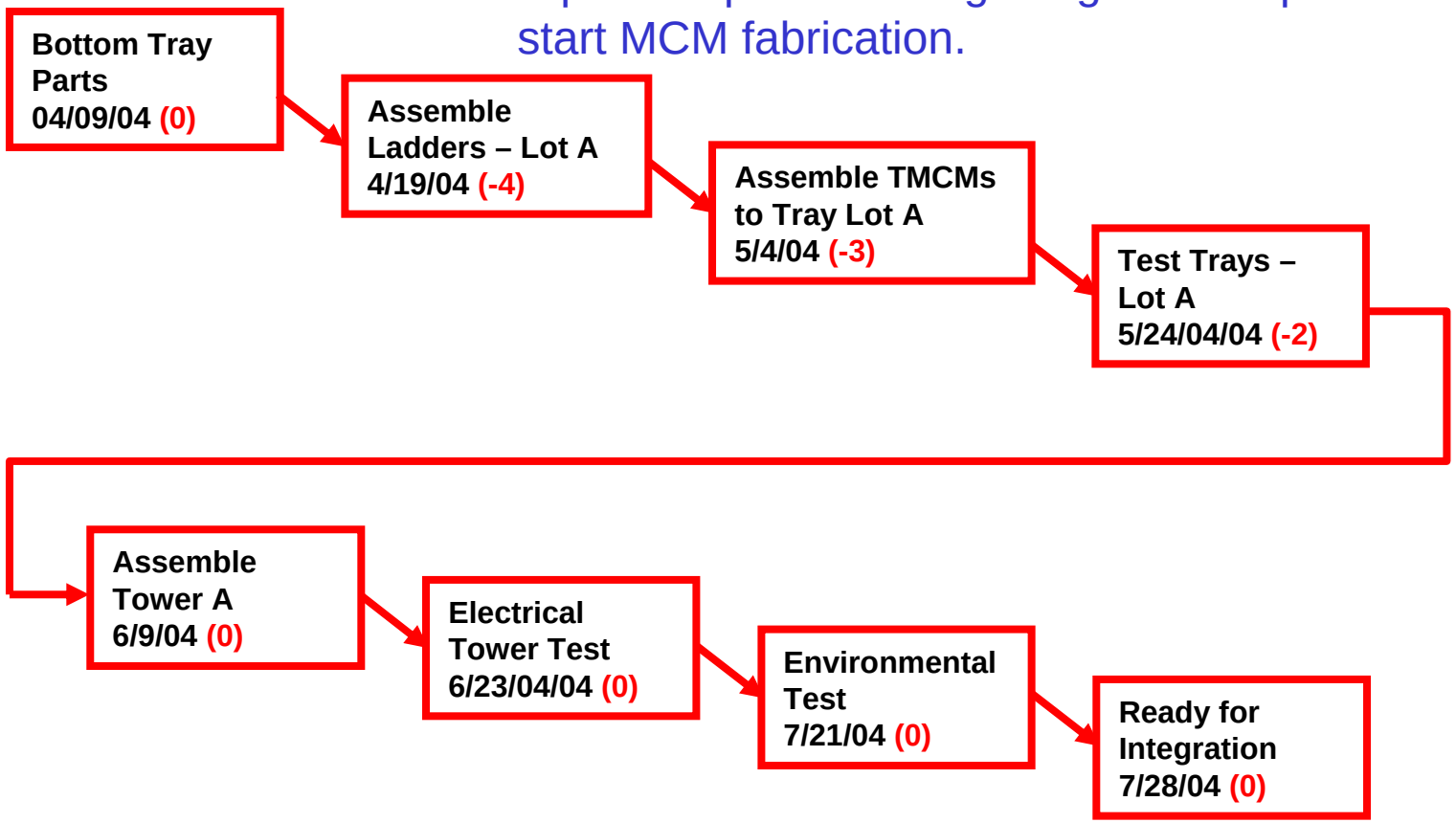


Other Nearly Critical Paths



PMCS Critical Path

This chart does not take into account the 4-week slip in the past month getting a PO in place to start MCM fabrication.



Completion Dates (baseline variance)

Schedule Risks

- **Tracker-Grid Interface Recovery**
  - The radical redesign, while necessary, impacts
    - Many aspects of the bottom tray design and fabrication
    - The static test fixture
    - The vibration fixtures
    - All tooling associated with bottom-tray fabrication and integration with detectors and electronics
  - Also, a lot of new custom interface hardware (cones, studs, washers, inserts, etc.) needs to be designed and fabricated before testing of the bottom tray can be carried out prior to integration with detectors and electronics.

Schedule Risks

- **MCM Production Rate: can Teledyne achieve 25/week?**
  - Rework can slow the production line appreciably, and we don't yet know how much rework will be needed during full production.
  - The proposed rate is slightly faster than the tower build rate (~18 MCMs/week), so there is some margin.
  - Teledyne does have extra resources in reserve (e.g. 2nd shift) that could be applied if needed to reach the agreed upon rate.
- **Tray Panel Production Rate**
  - The full production rate has never yet been attempted and proven at Plyform.
  - The number of assembly fixtures already available *does* support the needed rate.
  - Some streamlining of the process could be possible if needed:
    - Move ESPI and Static test equipment from Pisa to Plyform.
    - Is a vibration test on all panels needed?
    - Is the vacuum bakeout needed?

Schedule Risks

- **Tray Assembly Rate (integration of ladders & MCMs)**
  - Again, the full production rate has never yet been attempted or proven.
  - Only 1 vendor is qualified to do this work (G&A Engineering).
  - This is a small company without a lot of labor and equipment depth, in case a task becomes more labor intensive than foreseen.
  - There still is concern that the wire bonding from MCM to SSDs could be more difficult and time consuming than foreseen.
    - Tests with preproduction MCMs are in progress at G&A to evaluate this.
    - Work is in progress to complete the G&A fixture concept to get a more precise surface on the MCM pitch adapter for wire bonding. This cannot be accomplished in time for the first few towers, however.

Schedule Variance

- **February: –$112k**
- **Cumulative: –$434k**

Need to work with Shannon to add the explanations.

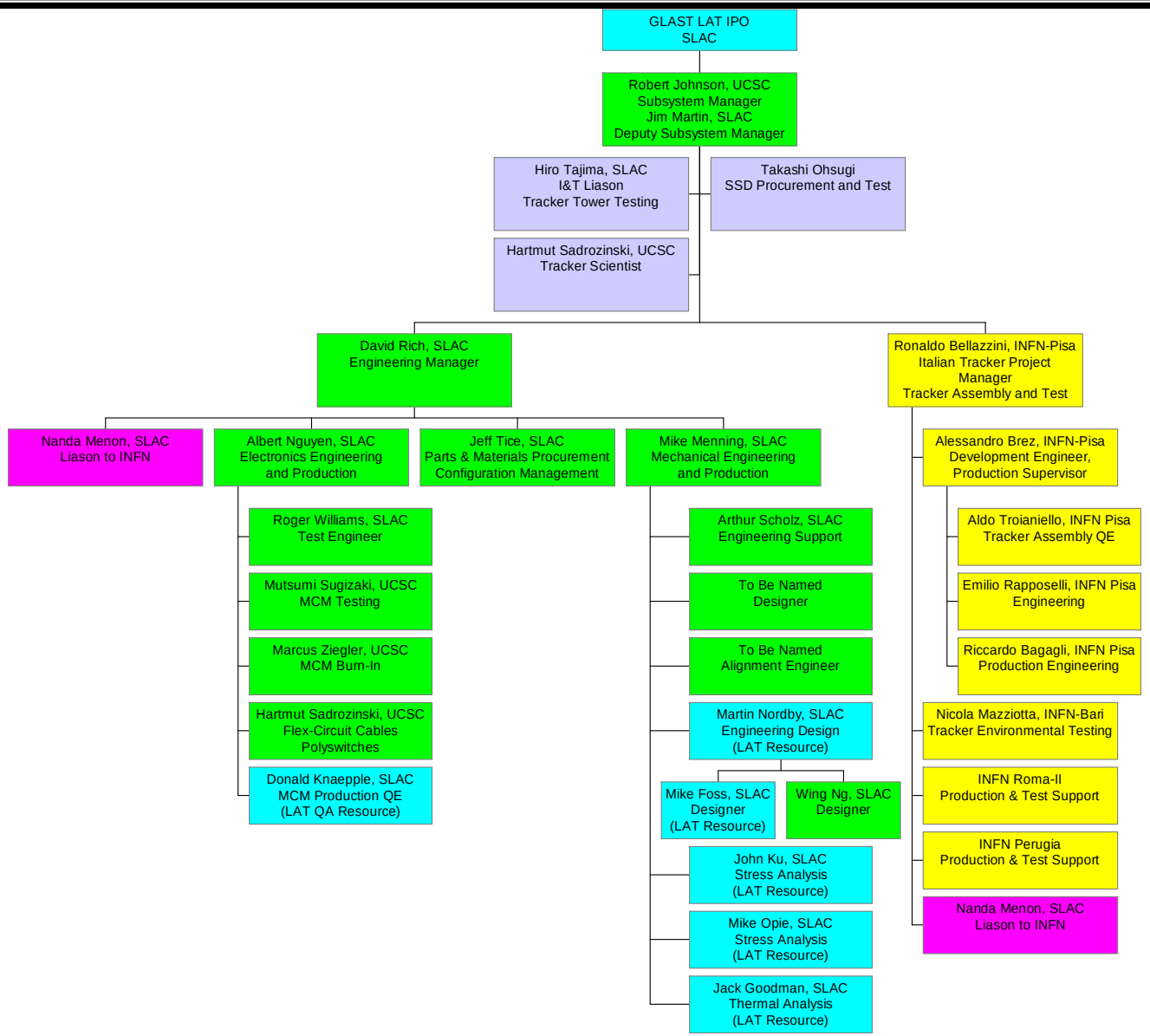
Staffing Plan

- **Tracker staffing changes at SLAC since rebaseline:**
  - M. Menning: lead ME, replaces T. Borden
  - A. Scholz: ME support
  - W. Ng: mechanical designer, replaces BJ Bhatnagar
  - A. Nguyen: lead EE
  - M. Hulligan: electrical designer
  - Increased Jeff Tice to 100% to support Tracker parts, materials, shipping, and configuration management.
  - Searching for
    - ME design supervisor
    - Alignment engineer
    - Mechanical designer
- **Engineering help borrowed from the LAT:**
  - M. Nordby: completion of mechanical engineering design
  - J. Ku and M. Opie: analysis
  - M. Foss: mechanical designer
  - J. Goodman: thermal engineering
- *Note: Hytec mechanical engineering support is being phased out, with only finalization of reports and some consulting help still in progress. Hytec is supplying the tower FEM to SLAC.*

Staffing Plan

- **Tracker Engineering Team at SLAC:**
  - Dave Rich, ME: Eng. Manager
  - Albert Nguyen, EE: Teledyne MCMs and other electronics
  - Alignment Engineer, ME: work with INFN, Design Integration, and I&T
  - Mike Menning: Chief ME
  - A Scholz, ME: TKR-Grid Interface (cones, studs, etc.)
  - New Hire, ME design supervisor, tower solid model
  - Wing Ng, designer: top tray, mid-trays, thermal straps
  - New Hire, designer: test fixtures, MGSE, shipping containers
- **Engineering support recently added in Italy:**
  - Aldo Troianiello, senior quality engineer
  - Emilio Rapposelli, senior mechanical engineer
  - Nicola Saggini, junior ME: Tower Assembly
  - Giovanni Foglia and Mirco Bagni, junior ME's: Production and QA

Staffing


GLAST LAT IPO
SLAC
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Subsystem Manager
Jim Martin, SLAC
Deputy Subsystem Manager
Hiro Tajima, SLAC
I&T Liason
Tracker Tower Testing
Takashi Ohsugi
SSD Procurement and Test
Hartmut Sadrozinski, UCSC
Tracker Scientist
David Rich, SLAC
Engineering Manager
Ronaldo Bellazzini, INFN-Pisa
Italian Tracker Project
Manager
Tracker Assembly and Test
Nanda Menon, SLAC
Liason to INFN
Albert Nguyen, SLAC
Electronics Engineering
and Production
Jeff Tice, SLAC
Parts & Materials Procurement
Configuration Management
Mike Menning, SLAC
Mechanical Engineering
and Production
Alessandro Brez, INFN-Pisa
Development Engineer,
Production Supervisor
Roger Williams, SLAC
Test Engineer
Mutsumi Sugizaki, UCSC
MCM Testing
Marcus Ziegler, UCSC
MCM Burn-In
Hartmut Sadrozinski, UCSC
Flex-Circuit Cables
Polyswitches
Donald Knaepple, SLAC
MCM Production QE
(LAT QA Resource)
Arthur Scholz, SLAC
Engineering Support
To Be Named
Designer
To Be Named
Alignment Engineer
Martin Nordby, SLAC
Engineering Design
(LAT Resource)
Mike Foss, SLAC
Designer
(LAT Resource)
Wing Ng, SLAC
Designer
John Ku, SLAC
Stress Analysis
(LAT Resource)
Mike Opie, SLAC
Stress Analysis
(LAT Resource)
Jack Goodman, SLAC
Thermal Analysis
(LAT Resource)
Aldo Troianiello, INFN Pisa
Tracker Assembly QE
Emilio Rapposelli, INFN Pisa
Engineering
Riccardo Bagagli, INFN Pisa
Production Engineering
Nicola Mazziotta, INFN-Bari
Tracker Environmental Testing
INFN Roma-II
Production & Test Support
INFN Perugia
Production & Test Support
Nanda Menon, SLAC
Liason to INFN

Approved Cost Changes Since Rebaseline

(k$)	
4.1.4 Baseline, November 03	**$13,595**
Changes:	
• QA Manpower at INFN	$ 738*
• Tracker/Grid Interface Redesign	$ 316
• Stanford Benefits Rate Increase	$ 49
Total Change	**$ 1,103**
4.1.4 Baseline, February 04	**$14,698**

**Corresponding NASA funding increase*

Budget Liens

- **MCM Production**
  - GTRC Redesign and Fabrication: $160,000 (~95% already paid)
  - Preproduction Overrun (development costs): $57,380
  - Parts and Materials
    - Omnetics connectors overruns, from costs needed to overcome performance and quality problems: $94,850
    - PWB machining overrun: $14,430
  - Teledyne Flight-Production Contract
    - Charges to support full-time source inspector: $84,248
    - Production cost overrun w.r.t. previous estimates: $191,766
- **Bias Circuits**
  - Addition budget needed to cover costs associated with refabricating the flight lot of circuits to correct design errors: $65,937
- **Flex-Circuit Cables**
  - Additional budget needed to cover the extended design effort and increased estimate of fabrication costs: $169,970
- **Tracker-Grid Interface Hardware**
  - Cones, studs, nuts, washers, inserts, etc. Cost unknown at present.

Budget Liens

- **Additional Staffing at SLAC: ~$230k estimated to cover the remaining 6 months of FY04.**

Cost Variance

- **February: –$127k**
- **Cumulative: –$190k**

Need to work with Shannon to add the explanations.

Budget Risks

Next 6 months

Summary