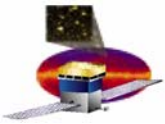


# GLAST Large Area Telescope: Systems Engineering

Pat Hascall  
SLAC  
System Engineering Manager

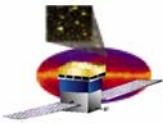
hascallp@slac.stanford.edu  
650-926-4266



# Contents

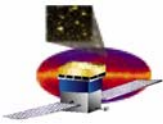
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- **Issues**
- **Drawing release metrics**
- **Documentation Status**
- **Verification and test planning**
- **Budgets (Mass, Power, Flight Software)**
- **Risk Management**
- **Summary**



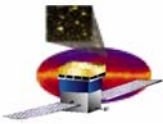
# Issues

No.	Description	Status	Due Date	Actionee
3	Technical baseline: Flight Drawing release	-All drawings to be under CM prior to flight build -Flight drawing release plan generated and stasured weekly	Weekly Review	P. Hascall
10	Tracker EM program completion	-TV test completed, good correlation with model -Vibration test with redesigned bottom tray scheduled to be completed by 15 June	15 June	R. Johnson
13	Tracker MCM attachment and wire bonding process	-Methodology for Tower A with potential improvements identified. -Tests in work to determine if manufacturing rates can be met given hardware tolerances	30 April	R. Johnson



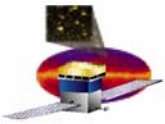
## Issues (Continued)

No.	Description	Status	Due Date	Actionee
16	Fly away instrumentation not finalized	-Thermistor locations defined, no impacts to current grid design or DAQ. -Accel counts reduced, locations defined.	CR for update by 10 April	Lee
17	New coupled loads results may create negative margins	-Analysis complete, no negative margins found (critical loads went down) -LAT Structural Analysis Report in signof ECD 15 April -Environmental Spec update Change Request in process	15 April	J. Ku/Lee
18	-EMI/EMC requirements and test need definition	-Radiated emissions and susceptibility defined and in Environmental Specification update -Conducted emissions and susceptibility update TBD	9 April	F. Blanchette



## Issues (Continued)

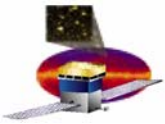
No.	Description	Status	Due Date	Actionee
20	PMT could be exposed to helium from the heat pipe pinch off tubes	-Have leak rates from vendor and new PMT susceptibility levels -Analysis in work	6 April	Fatin Bulos
21	Three PMT Tubes failed during TV testing	-Mounting redesigned -TV test on tubes successful -Mounting qualification complete by 2 April	2 April	T. Johnson/ D. Thompson
22	ASIC radiation sensitivity testing completion	Radiation testing scheduled for completion	30 April	Sadrozinski
23	ACD bit map parity bit not set correctly in limited situations	-Bit not used by DAQ, so flight operations are not affected -Will add to LAT characteristics document for inclusion in the Operations Handbook.	15 April	Ritz
25	High Voltage Cap failed life	-Replacement cap received on March 22 -Will complete testing by April 10	10 April	Thompson



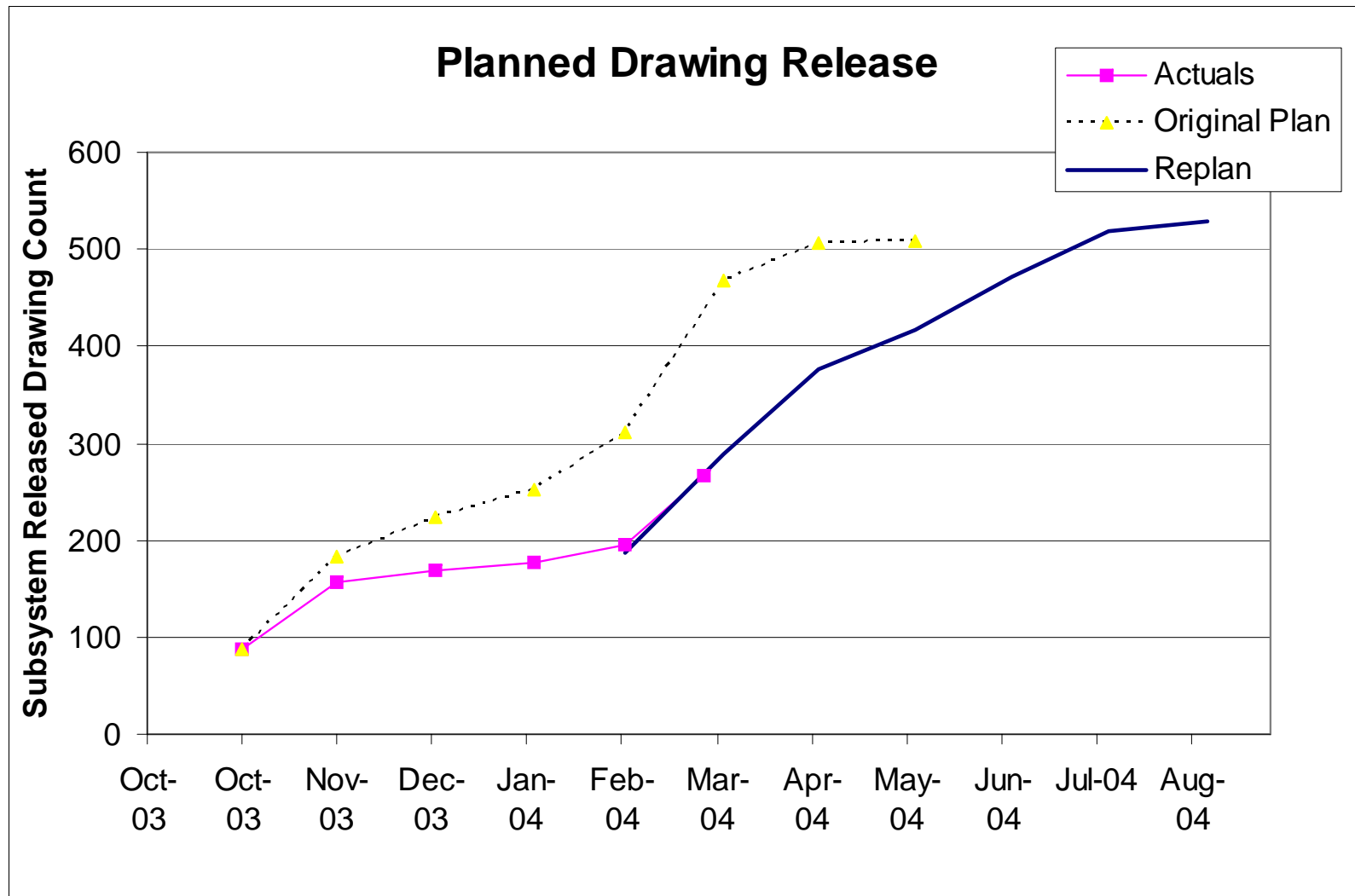
# Technical Baseline: Flight Drawing Release

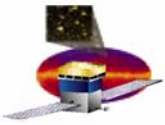
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- **Lack of timely drawing release beginning to delay hardware build**
- **Replan completed**
  - **Based on improved knowledge of hardware build and test planning and hardware need dates**
  - **Still aggressive with some margin, expect to continue to massage the plan**
- **Mitigation**
  - **Hiring four designers to speed drawing finalization**
  - **Management focused on closing remaining design details**
  - **DAQ has the majority of drawings left to complete**
    - **EM drawings to procure and build Ground Support Equipment, but still have to refine and formally release the drawings prior to flight build**
    - **Of the 181 drawings, 8 are released, 24 are in the release cycle and 94 mature drawings are in Configuration Management System (LATDocs) but not yet in the signature process**



# Flight Drawing Release

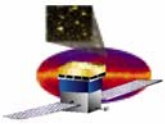




# Changes over the last month

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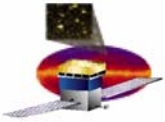
- **DAQ provided replan to match drawing needs to start of qual build and added 11 drawings**
  - **Connector to backplane wiring diagrams**
  - **Additional sizes of thermal shunt cable blocks**
- **Tracker provided replan and added 12 drawings**
  - **Flex cables bent configuration**
  - **Cable restraint**
  - **Flexure pin and retainer**
- **Mechanical provided replan and added 1 drawing**
  - **Wing closeout bar**
- **ACD provided replan for release**



## Systems Engineering Documentation Status

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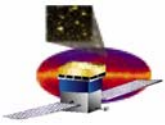
- **Total of 9 ICDs and 6 IDD's**
  - **7 ICD's and 4 IDD's Approved and Released**
    - Ongoing process to track minor issues in Lien list
  - **Two IDD's in work**
    - Cross LAT Plate is in signoff
    - Working aggressively to close Tracker interface issues
  - **2 ICD's Still Planned**
    - **Electronics-LAT ICD**
      - » Captures Small Number Of Interface Requirements Not Already Captured In Other ICD's
      - » These Requirements Are Captured In Level 4 Documents
      - » This ICD Will Elevate Those To Level 3 Requirements
      - » ECD April 15
    - **SAS-LAT ICD**
      - » Purpose Is To Document Monte Carlo Model
      - » Need Date Coincides With Data Challenge 2
      - » ECD Dec '04



# Systems Engineering Documentation Status (Continued)

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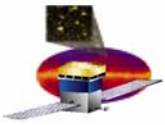
- **Design integration assembly drawings (15)**
  - **Deferred to support near term flight hardware design**
  - **Mitigation**
    - **LAT Assembly Sequence defines assembly in sufficient detail to begin integration planning**
    - **Combining efforts with Mechanical Subsystems on several of the drawings**
    - **Two of the four new designers will support this effort**
    - **Interviewing for an additional engineer**



# Verification and Test Planning

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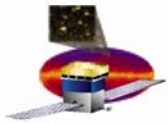
- **Documentation Status**
  - **LAT Program Instrument Performance Verification Plan and Science Verification Analysis and Calibration Plan well established**
  - **Detailed test planning approach focuses on planning for first 6 months of testing**
    - **Three driving requirements documents**
      - **LAT Assembly Sequence (in signoff)**
      - **Performance & Operations Test Plan (Test Requirements)**
        - » **Phased release of drafts will continue with initial release in early June to allow parallel effort by I&T**
        - » **Incremental releases planned to cover initial Comprehensive Test TRR and Environmental Test TRR**
      - **Survey Plan**
        - » **Draft by April 30, Final by May 31**
  - **Environmental Test Plans**
    - **Thermal, Mechanical and EMI/EMC test plans drafted, final details deferred until June, in time to support the later phases of detailed test implementation effort**



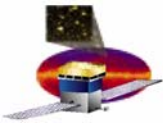
# Verification and Test Planning (continued)

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- **Test Planning Approach**
  - **Weekly meetings with a cross discipline team to**
    - **Finalize test requirements through multi-tower testing and ensure that they are understood by all**
    - **Support maximum use of subsystem test activities, scripts and procedures**
    - **Identify any additional information needed by I&T to complete test implementation for the initial phases of integration and test**
  - **Working closely with PI chartered End-to-end test committee**
    - **The committee is defining tests of the integrated LAT system**
    - **Some key members of that committee are also members of the cross discipline team, and are drafting the test requirements for the risk mitigation testing on towers in flight configuration in the grid during integration**



# Key Design Metrics



# LAT Mass Status

- Update in progress

LAT Mass Status Report	LAT-TD-00564-09
<b>LAT Mass Status</b>	Effective Date: 7-Jan-04
Martin Nordby	Print Date: 7-Jan-04

**Jan-04**

Mass (kg)	Estimate	Alloc.
TKR	508.7	510.0
CAL	1374.3	1440.0
ACD	278.8	280.0
Mech	360.4	386.6
Elec	226.2	240.0
Systems	7.0	8.0
<b>LAT Total</b>	<b>2755.5</b>	<b>2864.6</b>
Rsrv/Margin	244.5	
Rsrv/Margin*	8.9%	
Allocation		3000.0

\* AIAA G-020 recommended min reserve = 6.0%  
Current allocations per CCB action on 18 Nov 03

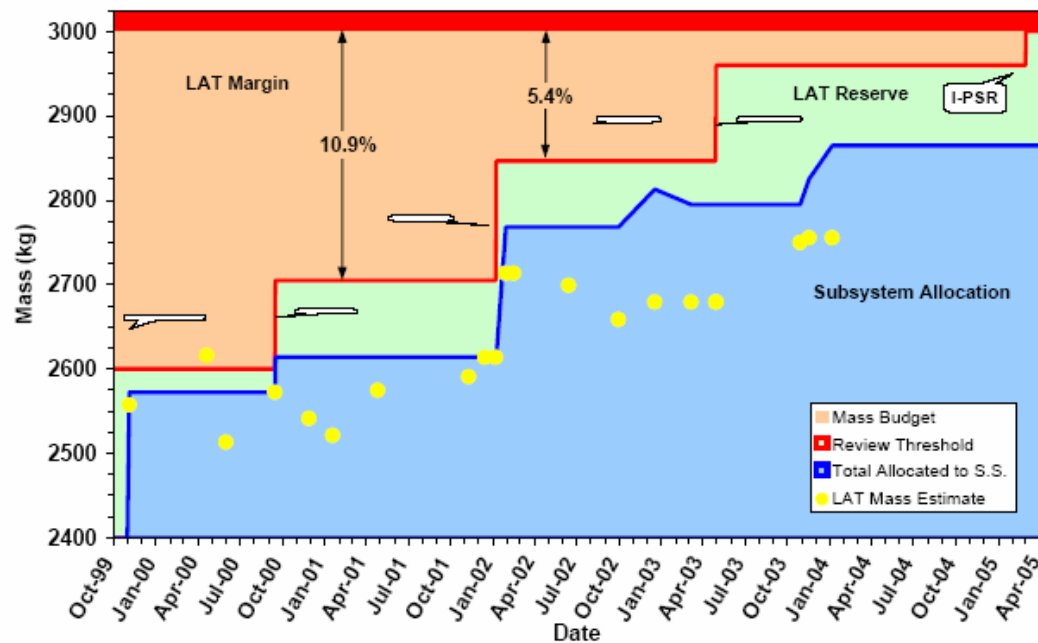
**Center of Mass (mm)**

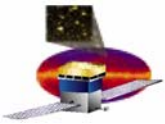
CMx	-0.67	-20 < CMx < 20
CMy	-0.94	-20 < CMy < 20
CMz	-71.45	CMz < -51.2
Ht off LIP	164.75	Ht < 185

**Second Moment of Inertia (kg-m<sup>2</sup>)**

Ixx	1050.0	1500.0
Iyy	1006.2	1500.0
Izz	1388.9	2000.0

Mass Estimate Breakdown		
	(kg)	%
Parametric	230.7	8.4%
Calculated	585.5	21.2%
Measured	1939.4	70.4%
<b>Total</b>	<b>2755.5</b>	<b>100%</b>





# LAT Power Status

- Operational Power (update in progress)

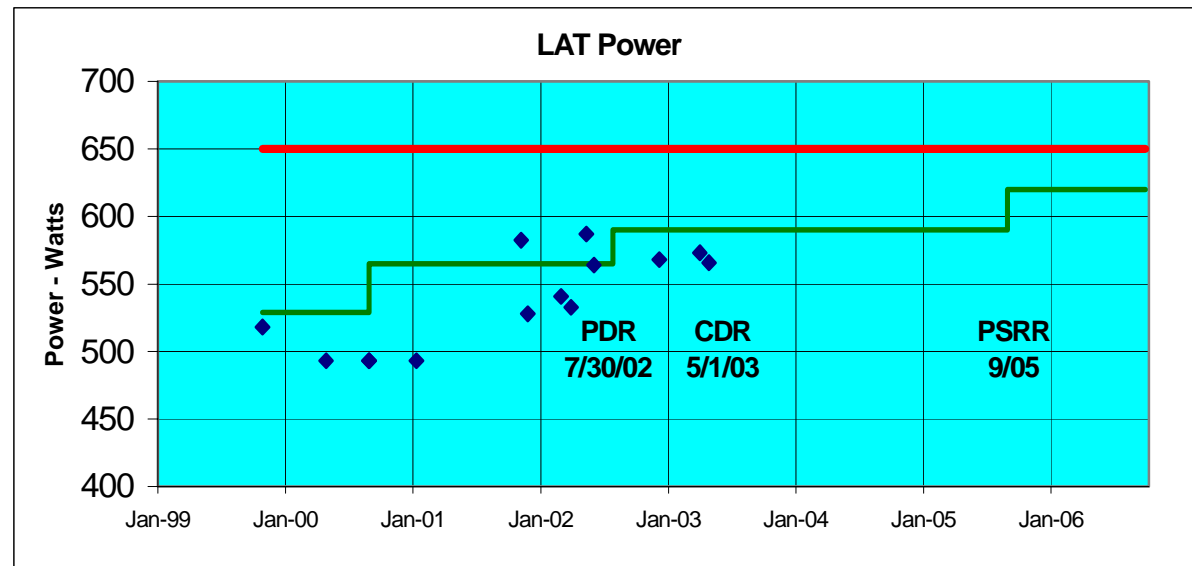
Item	10-Nov-03 Estimate (Watts)	PARA (Watts)	CALC (Watts)	MEAS (Watts)	ALLOC. (Watts)
ACD	9.4	2.3	3.9	3.2	10.5
Tracker	152.4	1.5	0.0	150.9	153.0
Calorimeter	64.9	0.0	0.0	64.9	65.0
Trigger & Data Flow	318.6	44.5	87.3	186.8	327.5
Grid/thermal	20.4	20.4	0.0	0.0	35.0
Instrument Total	565.7	68.7	91.1	405.8	591.0
Instrument Allocation	650.0				
% Reserve	14.9%				

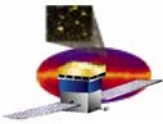
**PDR Reserve Was 15.2%**  
**CDR Reserve Was 13.4%**

**Goal for PSRR Reserve > 5%**

**PARA** - Best Estimate based on conceptual design parameters  
**CALC** - Estimate based on Calculated power from detailed design documentation  
**MEAS** - Actual power measurements of components

Goals estimated using guidelines given in ANSI/AIAA G-020-1992 "Estimating and Budgeting Weight and Power Contingencies for Space Craft Systems"



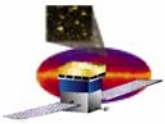


# LAT Power Status (Continued)

- Survival Power

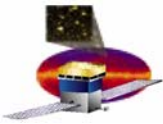
Component	Current Alloc.	Subsystem Power Estimates (W)				
		PARA	CALC	MEAS	Total	Margin
<b>On-Orbit Average Power Total<sup>1</sup></b>	<b>278.00</b>	<b>0.00</b>	<b>230.40</b>	<b>0.00</b>	<b>230.40</b>	<b>20.7%</b>
Regulated VCHP Power Total	58.00	0.00	48.40	0.00	48.40	19.8%
Unregulated Passive Survival Power	220.00	0.00	182.00	0.00	182.00	20.9%

<sup>1</sup>Power estimates reflect the LAT steady state orbit average. Numbers do not reflect transition into or out of survival mode, i.e. early orbit operations.



# FSW Resource Usage Current Estimates

Resource	Total Available	Current Usage	Margin Factor
EPU Boot PROM	256 kB	128 kB	2
SIU Boot PROM	256 kB	128 kB	2
EPU EEPROM	6 MB	1.5 MB	4
SIU EEPROM	6 MB	1.5-2.5 MB	3
EPU CPU cycles	200% in 2 EPUs	30%	> 6
SIU CPU cycles	100% in 1 SIU	25%	4
EPU memory	128 MB	16-32 MB	4-8
SIU memory	128 MB	< 16 MB	8



# Instrument Bandwidth Resources

- LAT communication, bandwidth (BW) in Mbyte/sec

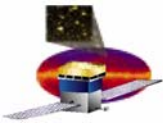
Resource	Max Total BW limited by Hardware	Max limited by SC-ground transmission	Ave current BW at 10 KHz max trigger rate*	Ave current BW at 2 KHz nominal trigger rate*	Margin Factor (for 10 KHz rate)
Detector to GASU-EBM	45	N/A	10	2	4.5
GASU-EBM to EPU-CPU	20	N/A	5	1	4
EPU-CPU to GASU-EBM	2.5	0.075	0.04*	0.02*	2
GASU-EBM to SIU-CPU	5	0.15	0.08*	0.015*	2
SIU-CPU to Spacecraft	5	0.15	0.08*	0.015*	2

\* Present performance of event filter for EPU-CPU, still being optimized. Eventually the physics filter will be adjusted/loosened to take advantage of the max average bandwidth

EBM: Event-Builder Module

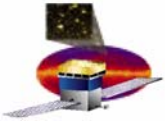
EPU: Event-Processing Unit

SIU: Spacecraft Interface Unit

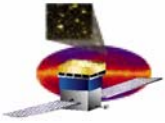


## Key Science Performance Metrics

Parameter	SRD Value	Present Design Value
Peak Effective Area (in range 1-10 GeV)	>8000 cm <sup>2</sup>	10,000 cm <sup>2</sup> at 10 GeV
Energy Resolution 100 MeV on-axis	<10%	9%
Energy Resolution 10 GeV on-axis	<10%	8%
Energy Resolution 10-300 GeV on-axis	<20%	<15%
Energy Resolution 10-300 GeV off-axis (>60°)	<6%	<4.5%
PSF 68% 100 MeV on-axis	<3.5°	3.37° (front), 4.64° (total)
PSF 68% 10 GeV on-axis	<0.15°	0.086° (front), 0.115° (total)
PSF 95/68 ratio	<3	2.1 front, 2.6 back (100 MeV)
PSF 55°/normal ratio	<1.7	1.6
Field of View	>2sr	2.4 sr
Background rejection (E>100 MeV)	<10% diffuse	6% diffuse (adjustable)
Point Source Sensitivity(>100MeV)	<6x10 <sup>-9</sup> cm <sup>-2</sup> s <sup>-1</sup>	3x10 <sup>-9</sup> cm <sup>-2</sup> s <sup>-1</sup>
Source Location Determination	<0.5 arcmin	<0.4 arcmin (ignoring BACK info)
GRB localization	<10 arcmin	5 arcmin (ignoring BACK info)



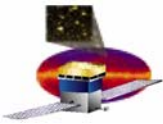
# Risk Management



# Risk Management Activity

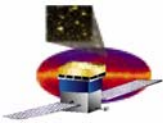
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- **Top Risks identified this month**
  - Added risk of logistic/planning error impacting LAT environmental tests at NRL (IT-006)
- **Changes in risk assessment**
  - Tracker development risk (Proj Mgt – 003) & impact continues to be a challenge
  - Risk now more appropriately identified as LAT schedule issue
- **Risks deleted from top list**
  - Removed cost of critical skills (Proj Mgt – 006)
    - Although maintaining critical skills continues to be project management focus, team is nearly fully staffed



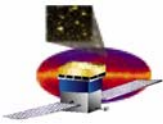
# Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
Proj Mgt - 003	Moderate	If completion of Tracker subsystem qualification is delayed due to EM or MCM electronics closure; then start of LAT I & T and schedule will be impacted	<ul style="list-style-type: none"> <li>• Manufacturing Eng assigned to close MCM issues</li> <li>• Increased team integration with Italian partners</li> <li>• GSFC audit/support to Tracker EM closure</li> </ul>	<ul style="list-style-type: none"> <li>• 50 Unit Pre-production run completed</li> <li>• Restructured SLAC engineering support</li> <li>• Additional INFN support in place</li> <li>• Key schedule issue</li> </ul>
Proj Mgt - 002	Moderate	If ASICs fail to meet qualification requirements; then schedule impact will occur	<ul style="list-style-type: none"> <li>• Focused review &amp; test. Margin for re-runs protected where possible</li> <li>• Individual risks Identified by subsystem</li> <li>• Extensive use of DAQ test bed to drive out system issues</li> </ul>	<ul style="list-style-type: none"> <li>• Tracker GTRC error found, plan in place</li> <li>• Cal/ACD ASIC's continued testing</li> <li>• ACD GARC Mitigation in progress</li> </ul>
Proj Mgt - 004	Moderate	If TEM Power supply fails qualification; then final implementation may exceed schedule impacting delivery to I&T	<ul style="list-style-type: none"> <li>• Key focus item identified for DAQ</li> <li>• Design peer review 9/03</li> <li>• Basing approach on flight proven designs where possible</li> <li>• TEM/PS extensive EM use as EGSE</li> </ul>	<ul style="list-style-type: none"> <li>• Implementation plan in place and proceeding</li> </ul>



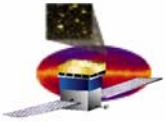
# Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE-007	Moderate	If a critical component fails post LAT integration; then de-integration will result in cost & schedule impact	<ul style="list-style-type: none"><li>•Extensive use of EM test bed to support flight H/W &amp; S/W development</li><li>•Thorough qualification and acceptance tests</li><li>•Pre planned I&amp;T actions for de-integration</li></ul>	<ul style="list-style-type: none"><li>•Qual &amp; acceptance planning in-place</li><li>•I&amp;T developing re-work contingency plans.</li><li>•Integration plan baselined</li></ul>
Elec-004	Moderate	If target hardware, requirement development or manpower is delayed; Then Flight-Software development schedule will be impacted	<ul style="list-style-type: none"><li>•Detailed incremental development program</li><li>•Ensure sufficient software test on target hardware during development to drive out any requirement disconnects.</li><li>• Include adequate peer reviews before each spiral cycle prior to release</li><li>•Include monthly Demos to verify functionality/measure progress</li></ul>	<ul style="list-style-type: none"><li>•Adapting monthly demos</li><li>•Enhanced software team and processes</li><li>•Added software management support</li><li>• <a href="#">EM2 Review 26 Feb</a></li></ul>



# Top risks

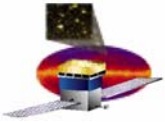
ID #	Risk Rank	Risk Description	Risk Mitigation	Status
Proj Mgt - 005	Moderate	If parts and vendor orders are delayed or bids exceed expectations; then flight production costs & delivery schedule will be impacted	<ul style="list-style-type: none"> <li>•Manufacturing engineer added to expedite minimum cost closure</li> <li>•Clarification and purchase package review to ensure accurate bids</li> </ul>	<ul style="list-style-type: none"> <li>•Purchase order tracking/monitoring system in place to highlight roadblocks</li> <li>•Design documentation release plan prioritized by vendor selection and component fabrication need dates</li> </ul>
IT - 006	Moderate	If logistic or facility integration issues are found during LAT environmental test program; then re-work will delay schedule	<ul style="list-style-type: none"> <li>•LAT I&amp;T to plan a roadmap of activities from LAT building 33 to completion of environmental testing</li> <li>•LAT I&amp;T to consider and develop opportunities to path find key activities required prior to LAT shipment to NRL</li> </ul>	<ul style="list-style-type: none"> <li>• New risk identified</li> <li>• I &amp; T will provide risk mitigation plan at Environmental kick-off , ECD Aug '04</li> </ul>



# Variances

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- **Total budget: \$6,601k**
- **Work Scheduled up to date: \$4,532k**
- **Work Performed: \$4,532k**
- **Actuals: \$4,426k**
- **Cost Variance: \$105k**
  - \$85K due to late subcontract invoicing
  - \$20K due to delayed hire



# Summary

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- **Systems Engineering is focused on the near term flight hardware build and test planning activities to support a tower in the grid by the end of the year**