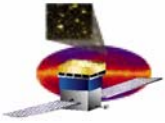


# GLAST Large Area Telescope: LAT System Engineering

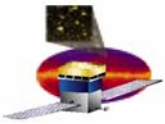
Pat Hascall  
SLAC  
System Engineering



# Topics

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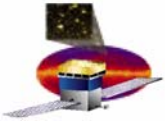
- **Action Item Status**
- **Technical Baseline Management**
- **Issues**
- **Interface Control Documentation**
- **RFA Closure**
- **Key Metrics**
- **Risk Management**



# Monthly Action Item Status

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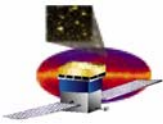
Action Item ID	Actionee	Description	Status



# Technical Baseline: Flight Drawing Release

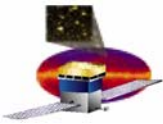
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- **Status details**
  - **Tracker**
    - **141 of 141 released**
  - **ACD**
    - **Completed**
  - **Calorimeter**
    - **Completed**
  - **Mech**
    - **Completed 66 of 73**
      - **3 MLI drawings in work**
      - **Remaining 4 drawings (shims and spacers) are needed in for radiator fit check (August earliest)**
  - **Design Integration**
    - **Major drawings: 4 of 6 signed off**
  - **DAQ**
    - **300 of 300 released**



# Issues

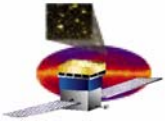
No.	Description	Status	Due Date	Actionee
3	Technical baseline: Flight Drawing release	-All drawings to be under CM prior to flight build -Flight drawing release plan generated and statused weekly	Weekly Review	P. Hascall
22	ASIC radiation testing status	Radiation testing scheduled for completion. <b>First round of tests complete, 2 documents in preparation. Request to eliminate TID for 3<sup>rd</sup> and 4<sup>th</sup> GTFE run</b>	30 April - >June->Jan 05 >March 05	Sadrozinski
31	Tracker flex cable coupon failures	Process change implemented. Coupons from flight panels failed. Steve Kahn assigned to work with Parlex on quality and schedule. <b>Pioneer having difficulty with anular ring specs.</b>	10/15/04- >11/5> 1/31	Rich
35	Reliability assessments not completed	FMEAs done, reviews with Subsystems started. Held TKR and Mech reviews with SLAC, TPS, GASU and PDU held on 5/13. Updates to FMEA provided on 5/21. <b>In review at ELX</b>	12/31/04	DiVenti
37	SIB EEPROM DPA Failure	PCB approved enough parts for flight build, still working parts for spares and qual		Haller



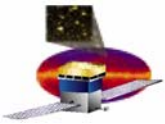
# Issues (continued)

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No.	Description	Status	Due Date	Actionee
38	RAD750 heat sink and Omnirel alert	Heat sinks reworked and Omnirel regulators to be replaced.		Haller
40	LAT-DAQ FPGA development and qualification	SLAC to respond to AIs' from FPGA reviews – AI's in review		Haller
41	Qualification of ERNI connectors	<b>Results still in test</b>		Haller
43	TEM/TPS voltage ripple	Combination of hardware test and modeling in process to determine cause and potential fixes. Cause and corrective action determined, retrofit in process. <b>Replacement of 2 installed TPS to be determined</b>		Haller



# Interface Management

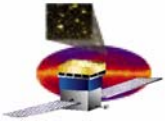


## Interface Document Status

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- **SC-LAT ICD ICN Status**
  - **LAT signed this month**
    - ICN-090 LAT Current Transients
  - **Currently under signature review**
    - None
  - **Currently in draft or revision**
    - ICN-087 LAT Deliveries Table
    - ICN-0XX LAT Survey Feature Locations and Access Requirements
    - ICN-0XX Location and Access Requirements for LAT test connectors, auxiliary cooling inlet/outlet and purge ports.
    - ICN-0XX MLI Interface
  
- **Internal LAT ICD's**
  - **Signed off this month**
    - ACD-LAT ICD
  - **Currently in signature review**
    - None
  - **Currently in update**
    - Electronics-LAT ICD (Comments being incorporated as they are received)

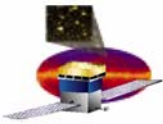




# Deliverables/Receivables

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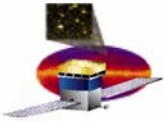
- **LAT Deliverables**
  - **June: None Scheduled**
  - **July: None Scheduled**
  - **Aug: None Scheduled**
  - **Sept: None Scheduled**
  
- **LAT Receivables**
  - **June: None Scheduled**
  - **July: SC Interface Tool, SC-LAT Flexure Pins**
  - **Aug: None Scheduled**
  - **Sept: None Scheduled**



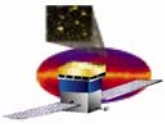
# LAT Level Verification Status

Category	Verification Method					Requirements		
	Test	Demonstration	Analysis	Inspection	Children	# Comp	Total	% Comp
	# Complete	# Complete	# Complete	# Complete	# Complete			
Requirement Identified	-	-	-	-	-	430	430	100.0%
Flow Down Complete	-	-	-	-	-	354	430	82.3%
Draft Verification Plan	169	46	85	23	4	327	430	76.0%
Final Verification Plan	0	0	20	0	4	24	430	5.6%
Verification Plan Executed	0	0	0	0	4	4	430	0.9%
Requirement Sold	0	0	0	0	4	4	430	0.9%

- Metrics above have been generated to track LAT requirements flow-down, verification, and sell-off.
- Requirements from NASA's Level 2a documents 433-SRD-0001, 433-MSS-0001, and 433-IRD-0001 and Spectrum Astro's 1196 EI-Y46311-000C LAT-SC ICD have been incorporated into LAT's version of DOORS.
- This has resulted in additional Level 2b requirements.
- Flow down of the Level 2b requirements is nearing completion, with only the LAT-SC ICD requirements remaining to be flowed.
- A Verification Compliance Requirements Matrix (VCRM) has been generated and is in the process of being updated with verification methods.



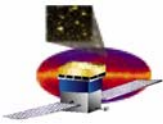
# Key Design Metrics



# Mass and Power Status Summary

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- **Mass**
  - Formal update complete
  - Mass estimate increased by 0.2kg
  - Z Center of mass increased by around 3mm, with remaining margin of around 18mm
- **Power**
  - No change to budget
  - LAT Power Consumption Estimate has increased by 21.7 W
    - Contributors are Tracker, TPS, PDU, and Calorimeter
- **FSW estimates updated**
  - Boot PROM replaced by EEPROM, single copy is less than 25% of capacity with multiple copies to fill memory used as risk mitigation
  - EPU CPU cycle loading estimates went from 30% to 40%



# LAT Mass Status

LAT Mass Status Report		LAT-TD-00564-11
<b>LAT Mass Status</b>		Effective Date: 2-Jun-05
Martin Nordby		Print Date: 29-Jun-05

Jun-05

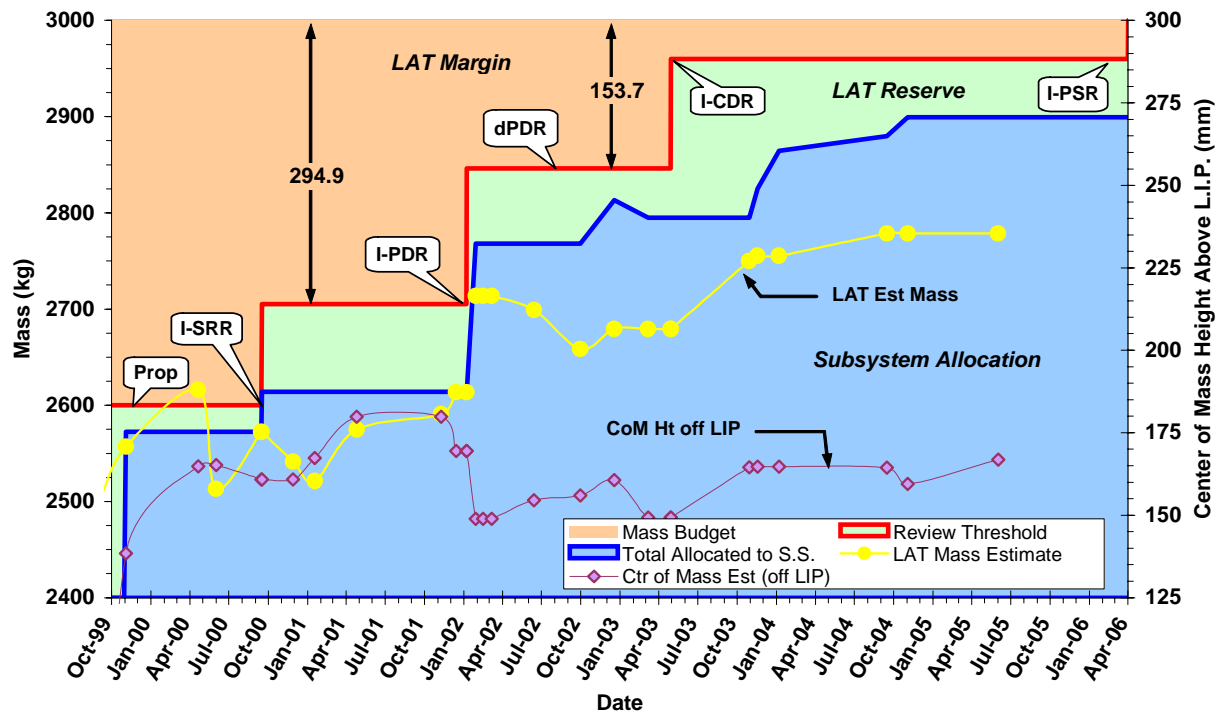
Mass (kg)	Estimate	Alloc.
TKR	523.6	530.0
CAL	1382.3	1440.0
ACD	277.6	295.0
Mech	355.7	386.6
Elec	232.0	240.0
Systems	7.5	8.0
<b>LAT Total</b>	<b>2778.7</b>	<b>2899.6</b>
Rsrv/Margin	221.3	
Rsrv/Margin*	8.0%	
Allocation		3000.0

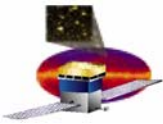
\* AIAA G-020 recommended min reserve = 4.7%  
 Allocations per latest mass CCB on 3 Nov 2004

Mass Estimate Breakdown		
	(kg)	%
Parametric	56.3	2.0%
Calculated	121.8	4.4%
Measured	2600.5	93.6%
<b>Total</b>	<b>2778.7</b>	<b>100%</b>

Center of Mass (mm)		
CMx	-1.06	-20 < CMx < 20
CMy	-0.87	-20 < CMx < 20
CMz	-69.32	CMz < -51.2
Ht off LIP	166.88	Ht < 185

Second Moment of Inertia (kg-m <sup>2</sup> )		
Ixx	1061.3	1400.0
Iyy	1013.6	1350.0
Izz	1398.4	1580.0





# LAT Power Status

LAT Power Consumption Estimate has increased by 21.7 W.

Item	8-Jun-05 Estimate (Watts)	PARA (Watts)	CALC (Watts)	MEAS (Watts)	SPEC (Watts)
ACD	11.5	2.4	3.9	5.2	11.5
Tracker	157.9	0.0	0.0	157.9	160.0
Calorimeter	67.7	0.0	0.0	67.7	71.0
Trigger & Data Flow	331.6	43.2	72.3	216.1	327.5
Grid/thermal	20.4	20.4	0.0	0.0	35.0
Instrument Total	589.1	66.0	76.2	446.9	605.0
Instrument Allocation	650.0				
% Reserve	10.3%				

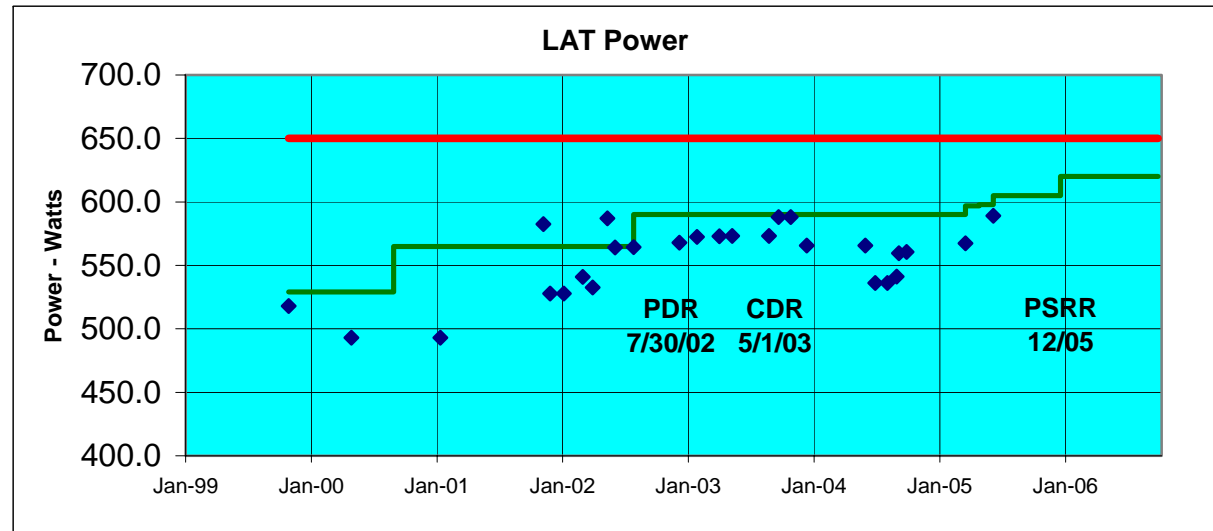
- TKR Estimate increase by 11.0 W based on average of measured modules. TKR Spec increased by 7 W.
- CAL Estimate increase by 0.3 W based on average of measured modules.
- T&DF Estimate increase by 10.4 W; 6.9 W due to TPS inefficiencies, 3.5 W due to flight PDU measurement.

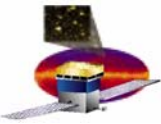
**PDR Reserve Was 15.2%**  
**CDR Reserve Was 13.4%**

**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"





# Measured LAT Power

LAT Tower Power	Unit Current (A)	Unit Power (W)
TWR 0	0.954	26.72
TWR 1	0.954	26.72
TWR 4	0.967	27.08
TWR 5	0.966	27.05
TWR 8	0.967	27.08
TWR 9	0.966	27.05
TWR Total	5.775	161.70
TWR Avg	0.963	26.95
Tower Variance	0.013	0.36

- 1. Tower measurements for bays 0,1,4,5,8,9 are consistent and above predicts
- 2. Measured Tower data indicates a 16.3 W increase in LAT power consumption which is supported by TKR, CAL, TPS unit level data (10.1W + 0.3W + 6.4W = 16.8W).

16 Tower Estimate	431.20
Orig 16 Tower Estimate	414.88
Estimated 16 Tower Increase	16.32

TEM/TPS Assembly Power Consumption			
Estimate	12.94 Watts		
Serial #	Cold	Ambient	Hot
GLAT1754[1]			
GLAT1752	8.97	10.73	10.36
GLAT1753	11.25	11.16	13.35
GLAT1832			
GLAT1833			
GLAT1834			
GLAT1835		9.98	
?			
?			
?			
?			
?			
?			
?			
?			
?			
Average	10.11	10.63	11.86
LAT Estimate	161.69	170.00	189.71

[1] Qualification Unit

Calorimeter Power Consumption			
Estimate	4.21 Watts		
Serial #	-30	25	50
FM101 [1]	4.48	4.12	3.96
FM102	4.59	4.22	4.06
FM103	4.60	4.24	4.07
FM104	4.59	4.25	4.07
FM105	4.55	4.22	4.02
FM106	4.61	4.21	4.05
FM107	4.53	4.25	3.99
FM108	4.56	4.23	4.05
FM109	4.58	4.23	4.05
FM110	4.61	4.26	4.08
FM111	4.61	4.26	4.08
FM112	4.60	4.25	4.07
FM113	4.62	4.25	4.10
FM114	4.59	4.22	4.06
FM115			
FM116			
FM117			
FM118			
Average	4.58	4.23	4.05
LAT Estimate	73.26	67.69	64.80

[1] Proto Flight Unit

Tracker Module Power Consumption	
Estimate	9.18
Serial #	Ambient
A [1]	9.70
B	9.80
1	9.87
2	9.80
3	9.90
4	9.86
5	10.15
6	
7	
8	
9	
10	
11	
12	
13	
14	
Average	9.87
LAT Estimate	157.90

[1] Proto Flight Unit



# LAT Power Status (Continued)

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- Survival Power

Component	Current Alloc.	Subsystem Power Estimates (W)				
		PARA	CALC	MEAS	Total	Margin
On-Orbit Average Power Total <sup>1</sup>	278.00	0.00	203.00	0.00	203.00	36.90%
Regulated VCHP Power Total	58.00	0.00	43.00	0.00	43.00	34.90%
Unregulated Passive Survival Power	220.00	0.00	160.00	0.00	160.00	37.50%

<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.

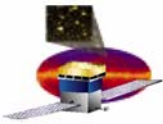




# FSW Resource Usage Current Estimates

Resource	Total Available	Current Usage	Margin Factor
EPU Boot EEPROM (SUROM)	256 kB	<64 kB*	4*
SIU Boot EEPROM (SUROM)	256 kB	<64 kB*	4*
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	40%	> 5
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

\* Storing multiple copies (4 currently to use available memory) for risk mitigation



# Instrument Bandwidth Resources

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

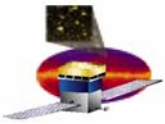
Resource	Max Total BW limited by Hardware	Max limited by SC-ground transmission	Ave current BW at 10 KHz max trigger rate*	Ave current BW at 2 KHz nominal trigger rate*	Margin Factor (for 10 KHz rate)
Detector to GASU-EBM	45	N/A	10	2	4.5
GASU-EBM to EPU-CPU	20	N/A	5	1	4
EPU-CPU to GASU-EBM	2.5	0.075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

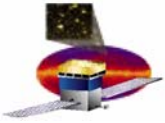
EPU: Event-Processing Unit

SIU: Spacecraft Interface Unit

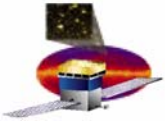


## Key Science Performance Metrics

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)



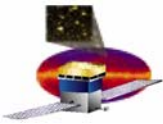
# Risk Management



# Risk Management Activity

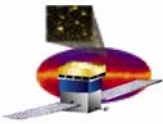
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- No changes



# Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
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>• Cal/ACD ASIC's continued testing</li><li>• Test Bed operating</li><li>• No new issues</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>• TEM/PS extensive EM use as EGSE</li></ul>	<ul style="list-style-type: none"><li>• Implementation plan in place and proceeding</li><li>• Fuse audit completed</li><li>• <b>Testing complete, data package in work</b></li></ul>



# Top risks

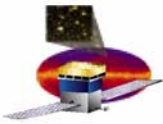
ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE-007	Moderate	If a critical component fails post LAT integration; then de-integration will result in cost & schedule impact	<ul style="list-style-type: none"><li>•Extensive use of EM test bed to support flight H/W &amp; S/W development</li><li>•Thorough 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>•Tracking EGSE resource utilization</li><li>•Updated detailed test plan released</li><li>•Demo frequency increased from monthly to approximately weekly</li></ul>



# Top risks

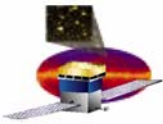
ID #	Risk Rank	Risk Description	Risk Mitigation	Status
Proj Mgt - 005	Moderate	If parts and vendor orders are delayed or bids exceed expectations; then flight production costs & delivery schedule will be impacted	<ul style="list-style-type: none"><li>•Manufacturing engineer added to expedite minimum cost closure</li><li>•Clarification and purchase package review to ensure accurate bids</li><li>•Increase production management staff</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><li>•Workarounds implemented for late parts</li><li>•Hired additional head to manage production</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>•Follow up Environmental Planning TIM held on 1 October at SLAC, I&amp;T driving AIs to conclusion</li><li>•Continuing periodic TIMS,</li></ul>





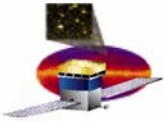
# Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE - 011	Low	If individual tracker towers do not meet performance requirements due to manufacturing issues (e.g. wire bond breaks) then the LAT may not meet science requirements	<p>Understand stability of performance to determine mitigation strategies</p> <p>Limit LAT temperature excursions to minimize possible propagation of some types of tracker issues</p> <p>Optimize placement of towers based on individual tower performance to minimize science effects and to minimize removal and replacement efforts should they become necessary</p>	<p>Temperature range reduced at the LAT level to allow a narrower range during Tracker and LAT tests</p> <p>Alternate plan for placement of Tracker A and B being implemented</p>



# Cost Report

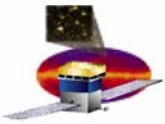
Reporting Category	Cost Incurred				Estimated Cost			Estimated Final Cost		Unfilled Orders Outstanding
	During Month		Cum. to Date		Detail		Balance of Contract	Contractor Estimate	Contract Value	
	Actual	Planned	Actual	Planned	JUN05	JUL05				
<b>4.1.2 SYSTEM ENGINEERING</b>										
4.1.2.1 REQ'TS MGMT, DESIGN INTEGRATION & TEST	29	140	3,107	3,253	0	0	146	3,253	3,253	0
4.1.2.3 SYSTEM ANALYSIS	24	10	1,040	991	11	10	-26	1,034	1,034	0
4.1.2.4 QUALIFICATION & TRACKING	104	59	537	448	62	56	34	689	689	10
4.1.2.5 RISK & RELIABILITY ANALYSIS	0	0	99	98	0	0	-1	98	98	0
4.1.2.6 CONFIGURATION MGMT & DOCUMENT / DATA LIB	11	9	291	285	10	9	12	321	321	0
4.1.2.7 MANAGEMENT & PLANNING	100	60	2,004	2,088	52	49	147	2,252	2,252	0
<b>CAPW[3]Totals:</b>	<b>269</b>	<b>278</b>	<b>7,078</b>	<b>7,163</b>	<b>134</b>	<b>124</b>	<b>311</b>	<b>7,647</b>	<b>7,647</b>	<b>10</b>



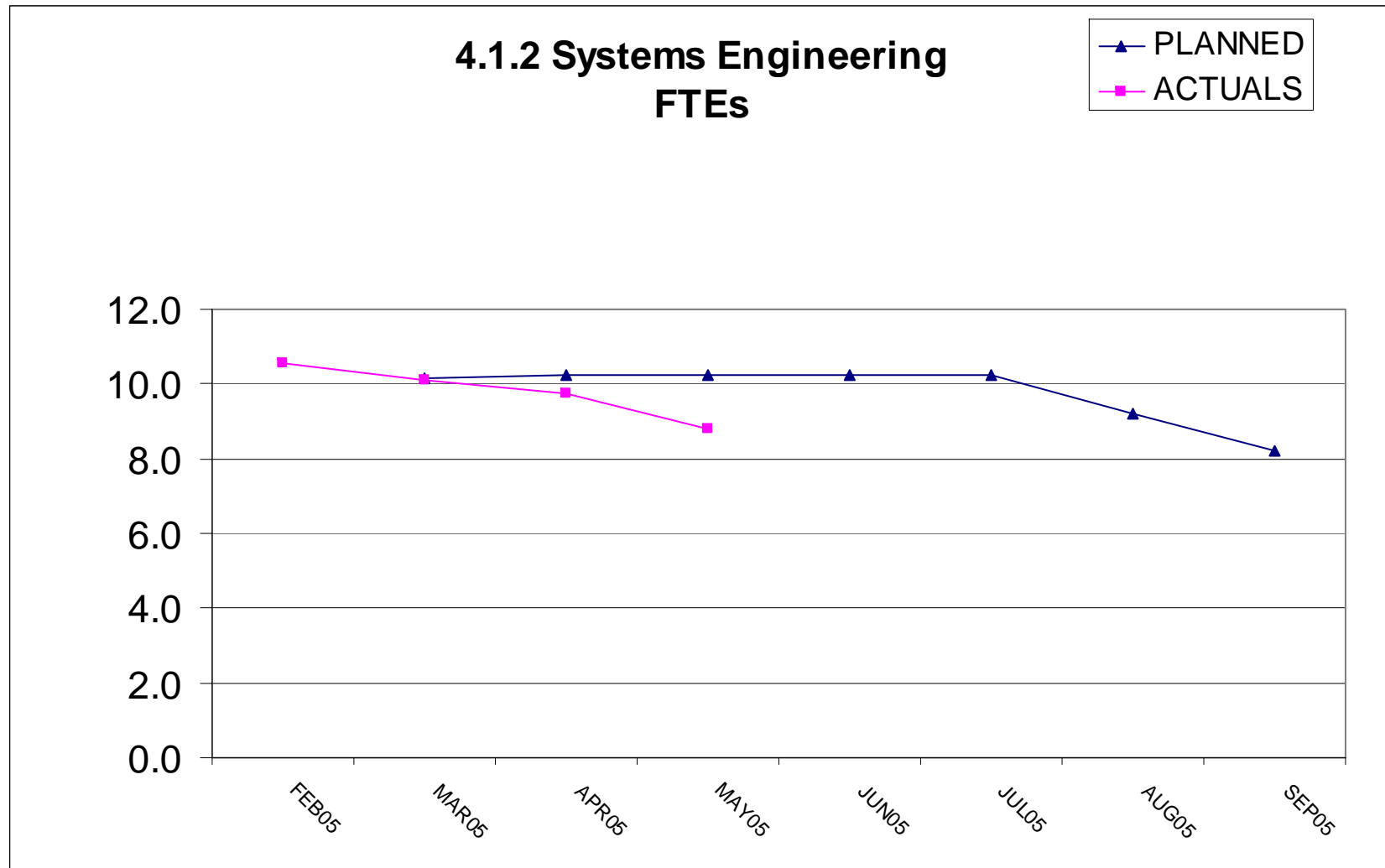
# Cost Variance Explanation

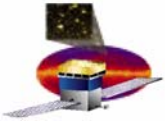
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- **Why overrun/underrun?**
  - **Cumulative underrun due to invoicing delays**
- **What will be done to correct?**
  - **No correction necessary**



# FTE Report





# FTE Variance Explanation

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- **Why overrun/underrun?**
  - **Production manager left, some vacations**
- **What is the impact?**
  - **Need to maintain production oversight**
- **What will be done to correct?**
  - **Keeping Russell Patterson on longer than originally intended**