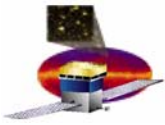


GLAST Large Area Telescope: LAT System Engineering

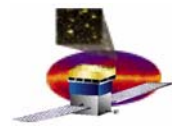
Dick Horn
SLAC
System Engineering Manager

Dhorn@slac.stanford.edu
408 771-3550



Topics

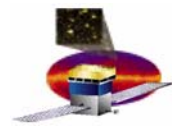
- **Action Item Status**
- **Technical Baseline Management**
- **Requirements Management**
- **Verification Planning**
- **Interface Control Documentation**
- **RFA Closure**
- **Key Metrics**
- **Risk Management**



Monthly Action Item Status

Open GSFC Monthly Review Notes/Actions

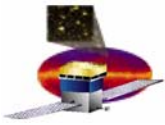
Action Item ID	Actionee	Description	Status
7-30-03-006	Haller	For TEM/TEM PS to be provided to CAL Qual/Accept program; provides a specific list of differences from flight (hardware/software/performance), include any constraints for use (TV, EMC.....)	OPEN: ECD 27 August; ECD 29 October
7-30-03-007	Haller	Provide current software schedule to Project Office, include specific time frame where integrated EM1 S/W in integrated configuration (all modules w/ planned capability)	OPEN: Updated schedule provided 11 September. Further development required for rebaseline. ECD 29 October
7-30-03-008	Jerry Clinton	Define and maintain the production readiness/execution plan to include vendor selection and associated schedule to ensure unit availability dates are met	OPEN: Draft production plan completed & provided to GSFC. Refinement required as vendors are selected. ECD:17 December.
7-30-03-009	Dick Horn	Establish subsystem metrics to ensure critical design elements are closing (e.g. drawings) and fabrication issues are monitored for closure and adverse trends (e.g. NCRs), phase in as possible	OPEN: Initial drawings and process status in place. Power & mass updates in work, ECD: 24 September. Planning for NCR tracking in work ECD: 15 December.



Monthly Action Item Status (Continued)

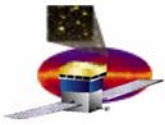
CLOSED GSFC Monthly Review Notes/Actions

Action Item ID	Actionee	Description	Status
7-30-03-001	Jim Martin/R.Johnson	GSFC is moving toward de-orbit decision – Assumes split tungsten foils: Need LAT impact assessment if implemented	CLOSED: Assessment Completed. Minimum impact expected, coupon test evaluation and analysis identified. GSFC reviewing Tabbed foil approach. Implementation change in process.
7-30-03-002	Dick Horn/Whipple	GSFC is moving toward ROM from SAI to conduct LAT environmental test. Ensure GSFC has sufficient data for quote.	CLOSED: Horn/Whipple coordinated on requirements.
7-30-03-003	Graf/Virmanti/Haller	Schedule a review of ACD parts plan. Resolve residual GSFC management concern.	CLOSED: Parts process review with GSFC. GSFC confirmed approach.
7-30-03-004	Campell/Bielawski	Mechanical Subsystem to determine if we can complete harness tie down details with ACD prior to 29 August.	CLOSED: Insufficient ACD/LAT Mockup to complete by 29 August, ECD:15 September.
7-30-03-005	Haller	Produce a specific list of ESSE versions & capabilities planned for each identified need & timeframe.	CLOSED: ESSE list completed; Rebaseline will incorporate coordinated need dates
8-27-03-10	Haller	Schedule EM2 S/W Peer Review	CLOSED: Proposed date 11 December 2003
8-27-03-11	N. Johnson	Provide SM1 strenght test procedure to LAT/GSFC Project Offices prior to September test	CLOSED: 4 Sept 03
8-27-03-012	J. Lebee	Implement requirements change process for design for demise	CLOSED: Mission System Specification in work.



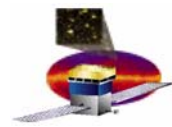
Technical Baseline

- **Progress**
 - **Finalized contents of the Configuration Item Data List (CIDL)**
 - **Configuration Items (CI) will be those items delivered to I&T**
 - **CIDL will also contain a full flight drawing list to support change tracking**
 - **Adding fields to track subsystem, status (not started, draft, released), and type (flight, MGSE, EGSE ...)**
 - **Extra fields will be folded into LATDocs when finalized.**
 - **Drafted high level drawing tree (At the CI level)**
 - **Reviewed by I&T and Design Integration**
 - **Consistent with integration plans but does not constrain the sequence**
 - **Created Engineering Issues List**
 - **Continued preparations for transition to LATDocs**
 - **Created users guide**
 - **Added placeholder documents**
 - **Created checklist for drawings and have started to review existing drawings against the drawing tree**



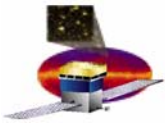
Technical Baseline (Continued)

- **Plans**
 - **Brief the team during the weekly Engineering Meeting on 9/30**
 - **Transition to LATDocs**
 - **Notification to go out Sept 24**
 - **Switch to LATDocs one week later**
 - **Complete capture of technical baseline**
 - **Near Term**
 - **Engineering Issues List used near term to ensure that design issues are captured and have adequate reviews (initial list on next slide)**
 - **All drawings used for flight builds are reviewed by J. Clinton and require release through LATDocs prior to flight build**
 - **Finalize drawing tree (including intermediate levels) by end of October (ensures all drawings are captured)**
 - **Drawings will be placed under CM as they are released for flight build**



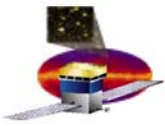
Engineering Change List

No	Topic	Discussion	Potential areas impacted	Actionee
1	EMI/EMC	Potential change, still under discussion. Changes include tongue and groove at several interfaces, surface finish of several items and others	Cal-Mech I/F – e Ni plating Mech – EMI shield butt joint Mech – Cross LAT butt joint Mech – Radiators installed for EMI test	Blanchette
2	Tracker/TEM/TEMPS cable layouts	Cables as designed had undesirable bend and potential interference issues.	Tracker Tracker I/F Cal I/F	Nordby
3	Cross LAT plate			



Drawing Metrics

Drawing Status				
Subsystem	Total	Planned	In Progress	Complete
Anticoincidence Detector	100	22	14	64
Tracker	93		62	31
Calorimeter	131	11	18	112
Mechanical	51	11	29	11
Data Acquisition	145	52	93	0
Integration	5	5		
Instrument Total	538	103	217	218
		19%	40%	43%

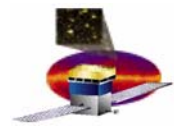


Materials and Processes

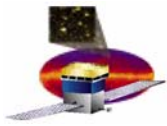
GLAST LAT Materials & Parts List

Total List

	Inorganic	Polymer & Composite	Lubricant	Process	Total
ACD	36	47	1	13	97
Calorimeter	21	32	0	6	59
Electronics	6	12	2	4	24
Mechanical	78	26	4	11	119
I&T	0	0	0	0	0
Tracker	24	35	2	3	64
Total	165	152	9	37	363
Accepted by LAT	163	138	9	37	347
Approved by GSFC	163	138	9	37	347



Requirements Traceability & Verification Planning



Requirements Traceability and Verification

- **Continuous tracking of requirements changes (Monthly Status)**
 - **Level 2 and 3 documents undergoing revision**
 - **ACD Level 3 Specification, LAT-SS-00016**
 - **IOC Level 2 Specification, LAT-SS-00015**
 - **LOF Level 3 Specification, LAT-SS-00021**
- **Continuous maintenance of verification matrix**
 - **Requirements from the ICDs are being added to the DOORS verification matrix (ECD 10/9/03)**



Requirements & Performance Verification Progress

Test Data Requirements

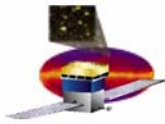
- Revised LAT Test plan to change TKR from Qual program to Proto-flight program. Submitted as RFA closure.
- Internal review of LAT Test plan and present mechanical test plan

• Test Performance

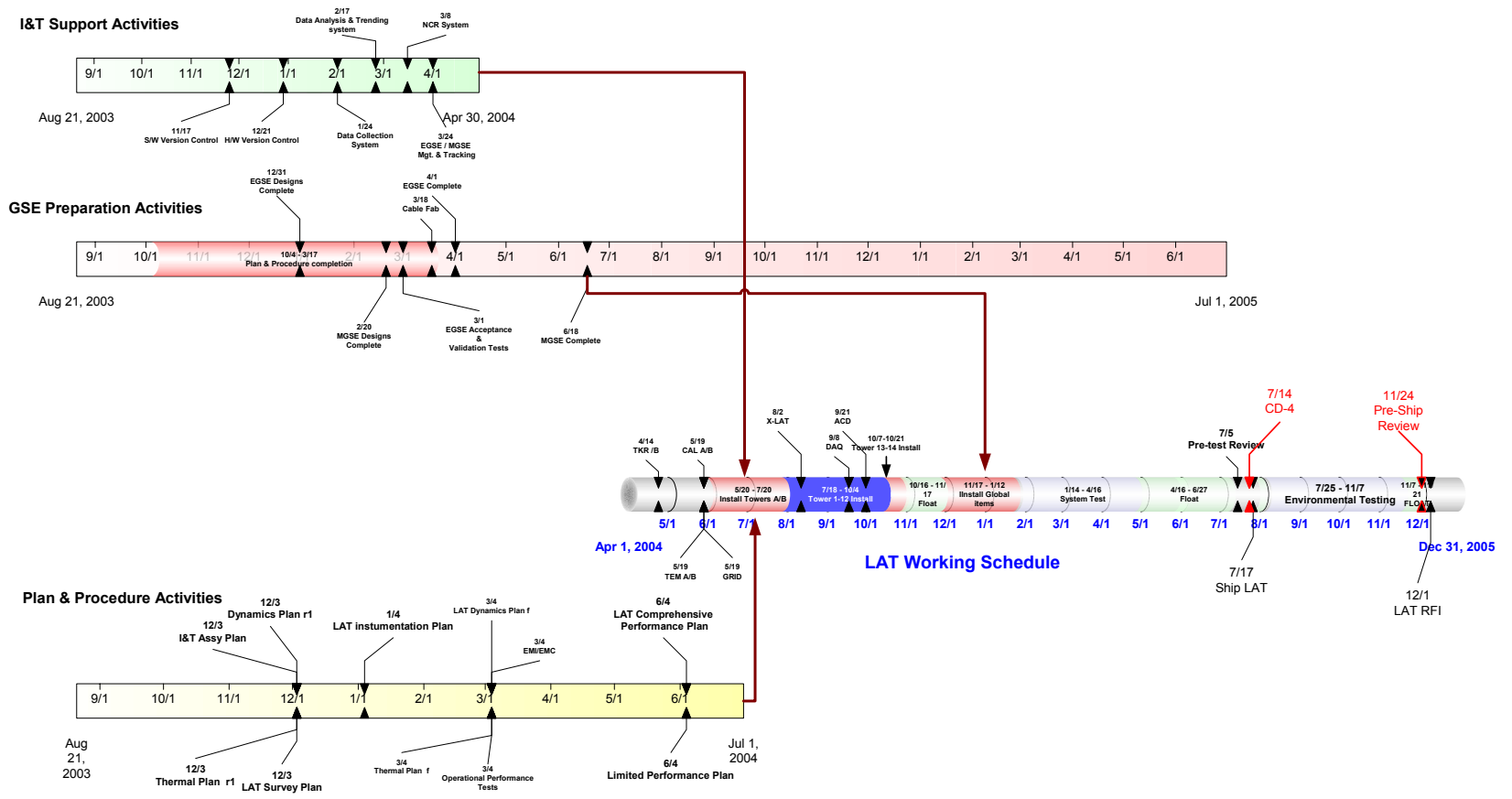
- Still Coordinating planning & implementation of program EGSE
 - Plan 75% complete (sample available)
- Supported Data Handling Working Group
 - Provided report on End to End test prepared to support System level testing

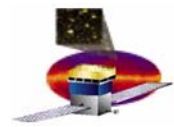
• Test Planning

- Prepared straw-man activities / work guide
- Prepared descriptions of Activities to go
- Developing process plan for Data packages
 - where the data goes when something is delivered

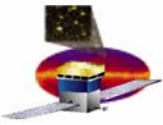


LAT GSE & Test Performance Plan



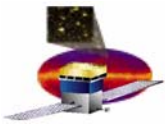


Interface Management



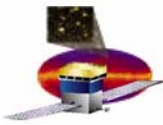
Key Open Internal LAT Interface Issues

INTERFACE	KEY OPEN ISSUES	STATUS	RESOLUTION	ECD
Tracker	Validating TKR-Grid copper strap thermal design.	<ul style="list-style-type: none"> • Detailed design complete. • Testing is underway. 	TKR to complete thermal testing as part of Engineering Model test plan closure.	11/30/03
Calorimeter	Validating CAL Base Plate to Grid structural design.	<ul style="list-style-type: none"> • Basic design and analysis complete. • Peer Review was held on 9/23/03 	<ul style="list-style-type: none"> • Update documents and drawings 	10/31/03
ACD	None			
Electronics	Validating X-LAT Plate to Electronics box thermal joint design.	<ul style="list-style-type: none"> • Continuing thermal analysis of stacked electronics and X-LAT Plate. • Thermal test plan is out for review • Complete interface thermal test. 	<ul style="list-style-type: none"> • Complete thermal analysis. ECD is moving to the right. Evaluating schedule mitigation plans • Formal design review scheduled for 9/25/03 • Complete interface thermal test. 	9/25/03 9/25/03 11/18/03



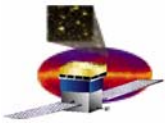
Key Open External LAT Interface Issues

INTERFACE	KEY OPEN ISSUES	STATUS	RESOLUTION	ECD
Spacecraft	ICD drawing details need to be finalized.	<ul style="list-style-type: none"> Face-to-Face Mechanical TIM held on 9/9/03. ICD drawing was iterated and Spectrum will incorporate redlines for the next ICD revision. 	<ul style="list-style-type: none"> Update ICD drawing. Possibly one more iteration. Release new revision of the ICD. 	10/3/03 10/10/03
Spacecraft	Finalize connector/harness definition and routing.	<ul style="list-style-type: none"> Finalized interface connector pin-outs. See ICN-23 for details. As part of the Mechanical TIM, toured LAT mock-up to review harness routing and strain relief. No new issues identified. 	<ul style="list-style-type: none"> Incorporate pin-outs in the ICD. 	10/3/03
Spacecraft	Four-point mount	<ul style="list-style-type: none"> LAT analysis shows that current design with the addition of bushings meets requirements. With bushings, bolt/pin spacing does not coincide with common design practices. LAT proposes to increase the bolt/pin spacing. See CAL-Grid Peer Review charts (9-23-03) for details. GSFC reviewing LAT proposal. 	<ul style="list-style-type: none"> GSFC and Spectrum to review LAT proposal and evaluate impacts. 	Early October



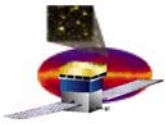
Interface Documentation Status

Document	Status
LAT-SC Interface Control Document (Spectrum Astro Managed Document)	
1196 EI-Y46311-000	Released 25 Apr 03
1553 Bus Potocol Document	
1196 EI-S46310-000	Released 25 Apr 03
GBM-LAT Interface Control Document	
433-ICD-0001	Second draft in-process
Calorimeter	
LAT-DS-00233-6: CAL-LAT Interface Definition Drawing	Released 6 May 03
LAT-SS-00238-4: CAL-LAT Mech, Therm, Elec Interface Control Document	Released 13 Mar 03
ACD	
LAT-DS-00309-3: ACD-LAT Interface Definition Drawing	Released 22 Apr 03
LAT-SS-00363-5: ACD-LAT Mech, Therm, Elec Interface Control Document	Released 28 Apr 03
Tracker	
LAT-DS-00851-1: TKR-LAT Interface Definition Drawing	Second draft in-process
LAT-SS-00138-5: TKR-LAT Mech, Therm Interface Control Document	Released 14 Apr 03
LAT-SS-00176-2: TKR-LAT Elec Interface Control Document	Released 27 Jan 03
Electronics	
LAT-DS-01630-1: Electronics-LAT Interface Definition Drawing	First draft review complete
LAT-SS-01794-1: Elec-LAT Mech, Therm, Elec Interface Control Document	Second draft in-process
SAS	
LAT-SS-02365-1: SAS-LAT Interface Control Document	First draft in-process



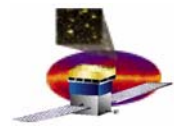
Summary

- **Accomplishments**
 - **LAT-SC ICD Data Review was conducted on 9/4/03**
 - Review was successful in that discrepancies were identified and action items were assigned
 - **LAT-SC Interface Mechanical TIM was conducted on 9/9/03**
 - Interface Drawing was thoroughly reviewed
 - **LAT-SC ICD Mechanical Review**
 - Review was successful in that discrepancies were identified and action items were assigned
 - Reviewed cable routing and strain relief (No surprises)
 - **Completed Interface Connector Pin-outs**
 - See ICN-23 for details
 - **CAL Baseplate-Grid Interface**
 - Basic design and analysis complete
 - Design review held on 9-23-03
- **X-LAT Plate-Electronic Box Interface**
 - Peer review scheduled for 10/30/03 (TBR)



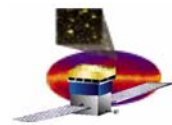
RFA Closure

- **Coordinated plan of attack in place –Horn/Graf/Hascall/Melton**
 - 37 RFAs total, submitted 4 answers, have 10 draft answers
 - GSFC/LAT consolidation (murder board review) of peer review RFA's – 22 September (proposed)
 - GSFC PDR/dPDR RFA closure follow-up – Mid October
- **Significant progress on key RFA's**
 - Electronics manufacturing plan – draft available
 - Cal/Grid closure – closure plan in on track
 - X-LAT Closure – closure plan on track
 - Tracker thermal margins – Design temperature relaxed
 - Mechanical analysis – closure plan on track
- **Current status of all RFA's on SE website**



Key Design Metrics

Update In Progress



LAT Mass Status

LAT Mass Status Report		LAT-TD-00564-06
LAT Mass Status		Effective Date: 7-Mar-03
Martin Nordby		Print Date: 7-Mar-03

March 2003

Mass (kg)	Estimate	Alloc.
TKR	504.9	510.0
CAL	1375.8	1440.0
ACD	270.1	280.0
Mech	329.3	345.0
Elec	199.3	220.0
LAT Total	2679.4	2795.0
Rsrv/Margin	320.6	
Rsrv/Margin*	12.0%	
Allocation		3000.0

* AIAA G-020 recommended min reserve = 7.2%

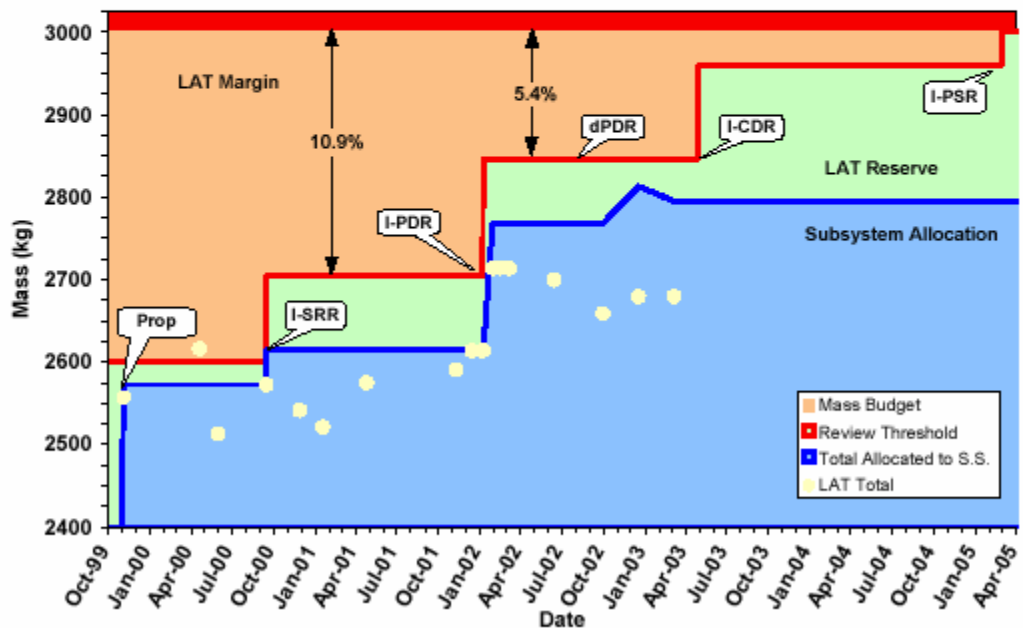
Center of Mass (mm)

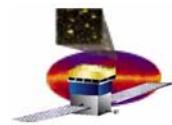
CMx	1.26	-20 < CMx < 20
CMy	-0.54	-20 < CMy < 20
CMz	-86.89	CMz < -51.2
Ht off LIP	149.31	Ht < 185

Second Moment of Inertia (kg-m²)

lxx	1057.7	1500.0
lyy	1014.9	1500.0
lzz	1339.5	2000.0

Mass Estimate Breakdown		
	(kg)	%
Parametric	382.3	14.3%
Calculated	975.8	36.4%
Measured	1321.3	49.3%
Total	2679.4	100%





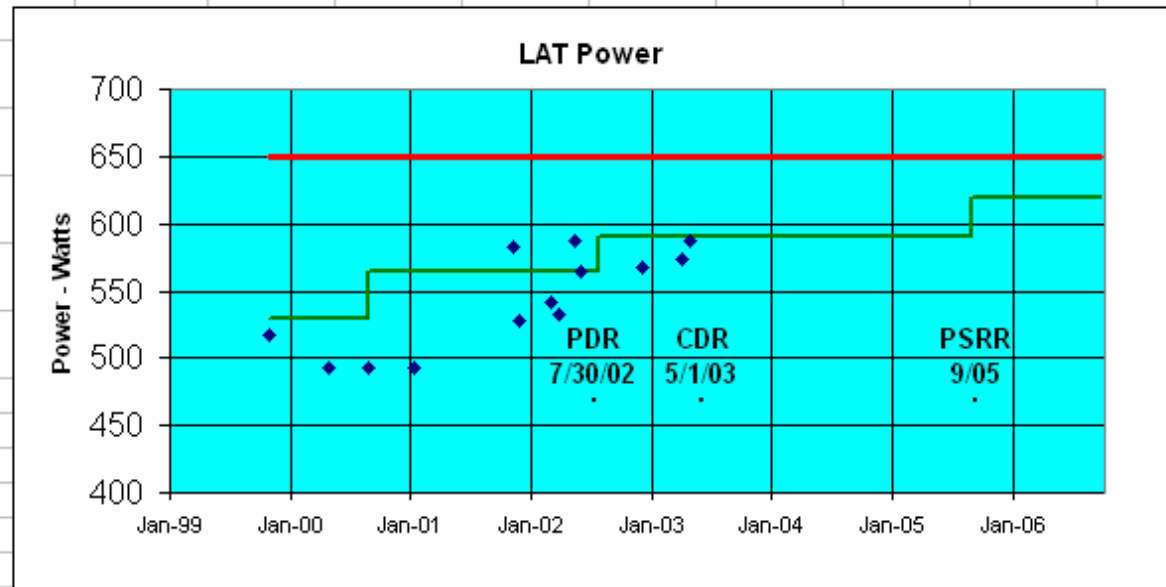
September 03 LAT Power Status (Proposed)

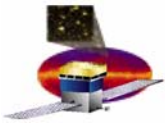
5-Sep-03	Estimate	PARA	CALC	MEAS	ALLOC.
Item	(Watts)	(Watts)	(Watts)	(Watts)	(Watts)
ACD	9.4	2.3	3.9	3.2	10.5
Tracker	152.4	1.5	0.0	150.9	153.0
Calorimeter	64.9	0.0	0.0	64.9	65.0
Trigger & Data Flow	340.9	223.3	99.8	0.0	327.5
Grid/thermal	20.4	20.4	0.0	0.0	35.0
Instrument Total	588.0	247.6	103.6	219.0	591.0
Instrument Allocation	650.0				
% Reserve	10.5%				

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"

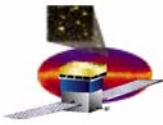




FSW Resource Usage Current Estimates

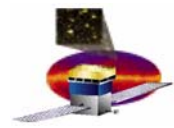
Resource	Total Available	Anticipated Usage	Margin Factor
EPU Boot PROM	256 kB	128 kB	2
SIU Boot PROM	256 kB	128 kB	2
EPU EEPROM	4 MB	1.5 MB	2.7
SIU EEPROM	8 MB	1.5-2.5 MB	3-5
EPU CPU cycles	200% in 2 EPUs	30%	> 6
SIU CPU cycles	100% in 1 SIU	25%	4
EPU memory	128 MB	16-32 MB	4-8
SIU memory	128 MB	< 16 MB	8
Bandwidth – instrument to EPU	20 MB/sec	5 MB/sec	4
Bandwidth – EPU or SIU to SSR	5 MB/sec	40 kB/sec	112
Bandwidth – CPU to CPU	2.5 MB/sec	20 kB/sec	125

LAT-TD-1121-01

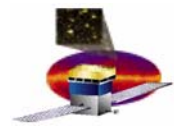


Key Science Performance Metrics

Parameter	SRD Value	Present Design Value
Peak Effective Area (in range 1-10 GeV)	>8000 cm ²	10,000 cm ² 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 ⁻⁹ cm ⁻² s ⁻¹	3x10 ⁻⁹ cm ⁻² s ⁻¹
Source Location Determination	<0.5 arcmin	<0.4 arcmin (ignoring BACK info)
GRB localization	<10 arcmin	5 arcmin (ignoring BACK info)

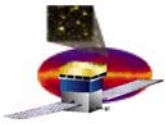


Risk Management



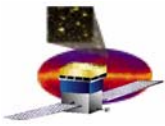
Risk Management Activity

- **No new risks added**
- **Progress on risk mitigation noted**



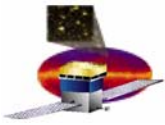
Top risks to cost

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE--0007	Moderate	Critical component failure post LAT integration requiring de-integration impacting cost & schedule	<ul style="list-style-type: none"> • Extensive use of EM test bed to support flight H/W & S/W development • Thorough qualification and acceptance tests • Pre planned I&T actions for de-integration 	<ul style="list-style-type: none"> • Completed evaluation for improving access (9/02) • Qual & acceptance planning in-place • I&T developing contingency plans
Proj Mgt - 005	Moderate	Parts and vendor orders have not been completed therefore flight production cost may exceed projection	<ul style="list-style-type: none"> • Manufacturing engineer added to expedite minimum cost closure • Clarification and purchase package review to ensure accurate bids 	<ul style="list-style-type: none"> • Processes in place • Remaining vendor selections by 11/03
Proj Mgt - 006	Moderate	Critical skilled positions (senior personnel) required to execute project remain open, potential impact to cost and schedule if not closed in short term	<ul style="list-style-type: none"> • Management team has identified critical skill needs • Identify skilled personnel within Collaboration environment 	<ul style="list-style-type: none"> • Added SLAC Site Rep in Italy • Added Scientist to Tracker Team & Proj Eng • 3 New Software Eng added 9/03 • Mechanical candidates interviews ongoing • ECD 10/03



Top risks to schedule

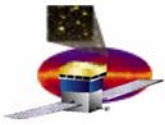
ID #	Risk Rank	Risk Description	Risk Mitigation	Status
Proj Mgt - 003	Moderate	Completion of Tracker subsystem qualification program delayed due to EM closure or MCM electronics	<ul style="list-style-type: none"> • Manufacturing Eng assigned to close MCM issues • Increased team integration with Italian partners • GSFC audit/support to Tracker EM closure 	<ul style="list-style-type: none"> • Teledyne contracted as MCM vendor • SLAC Site rep added to Italian team
Proj Mgt - 002	Moderate	ASIC's fail to meet requirements; results in schedule impact	<ul style="list-style-type: none"> • Focused review & test. Margin for re-runs protected where possible • Individual risks Identified by subsystem 	<ul style="list-style-type: none"> • Tracker/DAQ ASIC's flight ready • Cal/ACD ASIC's expected 9/03
Proj Mgt - 004	Moderate	TEM Power supply final design is delayed, final implementation may exceed current schedule	<ul style="list-style-type: none"> • Key focus item identified for DAQ • Design peer review planned for 9/03 • Basing approach on flight proven designs where possible 	<ul style="list-style-type: none"> • Design closure 9/03 • Successful peer review 9/22/03
SE-- 0007	Moderate	Critical component failure post LAT integration requiring de-integration impacting cost & schedule	<ul style="list-style-type: none"> • Extensive use of EM test bed to support flight H/W & S/W development • Thorough qualification and acceptance tests • Pre planned I&T actions for de-integration 	<ul style="list-style-type: none"> • Completed evaluation for improving access (9/02) • Qual & acceptance planning in-place • I&T developing contingency plans



4.1.2 Cost & Schedule Status

- **Cost variance - \$293K**
 - \$65K delay in subcontract billing cycle
 - \$92K expenditures transferred to IOC
 - \$100K underrun in ONE support cumulative, added engineer now in place
 - System Engineering expenditures are on plan

- **Schedule variance – On track/LOE**



3-Month Milestones

- Update the LAT-MD-00408 LATPVP – **October**
- Support Fault Management TIM - 26 August Kick-off, **on-going**
- Support STOP Analysis TIM's - On going
- Complete FMEA – **November** (Pending Power Supply Design)
- **Complete Power Supply Review – Completed 22 Sept**
- **Complete Cal Grid Review – Completed 23 Sept**
- Add ICD requirements to DOORS – **Complete, maintenance ongoing**
- Complete Spacecraft ICD Review – **Completed, TBX closure in work**
- Refine risk program - **October**
- Close remaining Internal ICD TBX's - October
- Update System Metrics – October (Then Quarterly)
- **Complete X-LAT Review – 30 October**
- **Complete CIDL update – 30 October**
- Hold EM Test & Qualification Readiness Reviews – TBD (Re-plan)
- Close all open RFAs – October->**December**