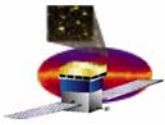


GLAST Large Area Telescope: LAT System Engineering

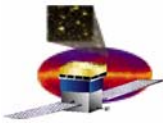
Dick Horn
SLAC
System Engineering Manager

Dhorn@slac.stanford.edu
408 771-3550



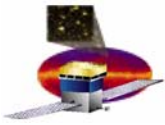
Topics

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



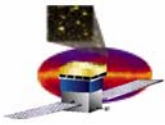
Monthly Action Item Status

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 (T/V, EMC.....)	OPEN: ECD 27 August; ECD 29 October Provided email to N. Thompson on 10/27
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)	Closed: 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 included in this package. Planning for NCR tracking in work ECD: 15 December.



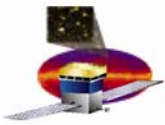
Technical Baseline

- **Progress**
 - **Transitioned to LATDocs**
 - **Still a few issues in the reports and document status**
 - **Broke semi-automated drawing status process**
 - **Briefed the team during the weekly Engineering Meeting on 9/30 and the Face-to-Face in October**
 - **Created Engineering Issues List, had first pass presentation at the weekly Engineering meeting on 10/21**
 - **Held working meeting on Solid Edge model management**
 - **Will result in additional intermediate placeholder drawings to connect subsystem models with Lat level models**
 - **DAQ created TEM drawing package as a pathfinder, feedback from this package should speed the review process on later packages**
- **Plans**
 - **Complete capture of technical baseline**
 - **Finalize drawing tree (including intermediate levels) by end of November (ensures all drawings are captured)**
 - **Review subsystem milestones for possible high level schedule of drawings vs time**



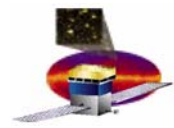
Drawing Metrics

Drawing Status				
Subsystem	Total	Planned	In Progress	Complete
Anticoincidence Detector	100	20	16	64
Tracker	92		37	55
Calorimeter	141	11	18	112
Mechanical	56	11	40	11
Data Acquisition	185	80	105	0
Integration	6	6		
Instrument Total	580	112	216	242
		21%	37%	42%



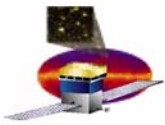
Issues

No.	Title/Description	Description/Status	Need Date	Actionee
1	Cal grid interface design not complete	Peer review held. Recommended mod to pad size approved through CRB. Bolt pattern change to be ICN to the Spectrum ICD.	Closed	M. Nordby
2	X-lat to electronics thermal interface not complete	Design nearly complete, still a few issues to work out. Peer review expected by end of October (Nov 5)		N. Nordby
3	Technical baseline	Drawing Tree completion by end of Oct. All drawings under CM prior to flight build. 1 Jan need date under review	1 Jan 04	P. Hascall
4	Tracker/tem/temps flex cable layouts	Conceptual redesign is complete, need to update drawings. Peer review 28 Oct	ASAP	M. Nordby
5	EMI/EMC design	Following items will be implemented to mitigate EMI/EMC issues: E Ni plating on metal to metal surfaces, Cal to implement presented design mods EMI gaskets per discussions with Fred, Venting unchanged	ASAP	F. Blanchette



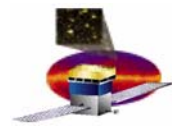
Issues (Continued)

No.	Title/Description	Description/Status	Need Date	Actionee
6	CAL dual PIN photodiode wire bonds suspect	Have remedial action for two suspected causes (tinning and thermal shock).	Closed	W. Johnson
7	Qualification of plastic encapsulated ASICs	Document to support qualification determined, DAQ has agreed to dates.	Closed	G. Haller
8	GTRC TOT timeouts	Cause understood. Fix would require GTRC redesign or correct in TEM.	ASAP	R. Johnson
9	GTRC extra clock delay	Fix to GTRC to correct understood. Fixing clock rise time is not enough.	ASAP	R. Johnson
10	Tracker EM program completion	Planned vib test in mid Nov and TV test starting early December using thermal model.	19 Dec 03	R. Johnson



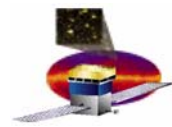
Issues (Continued)

No.	Title/Description	Description/Status	Need Date	Actionee
11	ACD TDA flexure / fiber interference	Rerouted fibers, tapered flexures and moved some flexures. Performing final analysis, drawings in review. –Present in Engineering review in November	Nov	D. Thompson
12	ACD – LAT interface definition not complete (blanket attachment, grounding, cable tie downs, optical survey mounts)	Cable tie downs to be addressed by the LAT. Remainder in work at low priority. (Will be broken into several issues as Martin plans effort)		M. Nordby
13	Tracker MCM attachment and wire bonding	Test boards from preproduction group to be sent to Italy for inspection to verify solution	1 Dec 03	R. Johnson
14	X-LAT heat pipe must be internally SPF tolerant	Decision made to add U shaped heat pipes. Peer per AI 2 on 5 Nov.	31 Oct 03 Closed	M. Nordby



Issues (Continued)

No.	Title/Description	Description/Status	Need Date	Actionee
15	Radiator integration clearances not sufficient	Resolution will impact either Grid wing cutouts or Radiator cut outs.	13 Nov	M. Nordby
16	Fly away instrumentation not finalized	Locations must be finalized to be able to assess impacts to Tracker Grid and DAQ. Radiator thermistors are the first priority due to DAQ schedule. Internal accels and strain gauge counts and locations to be updated by 31 October.	ASAP for thermistors	Hascall
17	New coupled loads results may create negative margins	Analysis nearly complete. Results positive – critical loads went down.	30 Oct	J. Ku
18	EMI/EMC requirements and test	System analysis tool under development, requires subsystems help. Will result in test requirements documented in the Performance Verification Plan		F. Blanchette

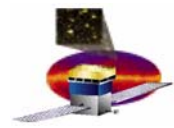


Materials and Processes

GLAST LAT Materials & Parts List

Total List

	Inorganic	Polymer & Composite	Lubricant	Process	Total
ACD	36	47	1	13	97
Calorimeter	21	32	2	7	62
Electronics	6	12	2	4	24
Mechanical	117	26	4	13	160
I&T	0	0	0	0	0
Tracker	24	37	2	3	66
Total	204	154	11	40	409
Accepted by LAT	202	150	11	39	402
Approved by GSFC	202	150	11	39	402



Requirements Traceability & Verification Planning



Requirements Traceability and Verification

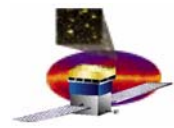
- **Continuous tracking of requirements changes (Monthly Status)**
 - **Level 2 and 3 documents undergoing revision**
 - **IOC Level 2 Specification, LAT-SS-00015**
 - **LOF Level 3 Specification, LAT-SS-00021**
 - **Changed Level 2 and 3 documents to be incorporated**
 - **ACD Level 3 Specification, LAT-SS-00016, released 9/30**
- **Continuous maintenance of verification matrix**



Requirements & Performance Verification Progress

Test Data Requirements

- Internal review of LAT Test plan and present mechanical test plan
- Test Planning
 - Continued revision of LAT Test Plan
 - Topic of 11/04 Eng Meeting
 - Reviewed Radiator flow to include Radiators installed for EMI testing
- Test Performance
 - Modified LAT Test plan to include Radiators in LAT EMI Tests
 - Updated LAT re-plan to I&T schedule and added required Test support activities
 - Meeting with I&T to resolve the work to be performed

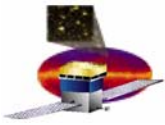


Interface Management



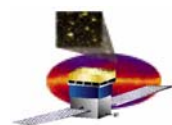
LAT-SC Interface – Open Issues

System	Subject	Closure Path	Need Date	Promise Date	Comments
Data	Digital signal grounding	Spectrum performing observatory grounding analysis.	6/1/2004	6/1/2004	Digital ground pins currently exist on LAT and Spectrum ebox connectors. Decision to add ground wires to flight harness needs to be made before harness build scheduled to begin in summer '04.
Mech	LAT Flexure Interface Details	Spectrum preparing ICN.	10/15/2003	Done	Reviewing preliminary I/F information now, formal review after CCR received. GSFC CCB 10/16. Spectrum is preparing ICD change.
Mech	LAT Radiator I/F pad size	GSFC preparing CCR.	10/15/2003	Done	Is in 00040 (LAT document). Need a CCR to put this into the IRD.
Mech	LAT Connector Locations	LAT Provide	10/15/2003	11/30/2003	Need X, Y and Z locations with connector orientations
Mech	Harness Routing on LAT	LAT Provide	10/15/2003	11/30/2003	Need pictures for ICD
Mech	Harness Support on LAT	LAT Provide	10/15/2003	11/30/2003	Need definition of support hardware
Therm	LAT Thermal Model Size	GPO Agree on Model, update IRD	10/15/2003	Done	Update IRD to clean up compliance. Delivery to GSFC finished. Still checking model at GSFC.
Therm	Heat transfer from SC to LAT Radiator Backsurface	LAT Provide	10/15/2003	Done	SC proposed <2W. LAT prepared ICN-34 and forwarded to Spectrum.
Elec	LAT current transients	Spectrum Provide	10/15/2003	Waiting	Waiting for measurements from Spectrum. Plan to sign up to measured values and close then.
Elec	LAT Impedence	Spectrum Provide	10/15/2003	Waiting	Waiting for measurements from Spectrum. Plan to sign up to measured values and close then.
Elec	42 V Input Voltage	GSFC to Respond	ASAP	Waiting	LAT submitted request to change IRD. Awaiting GSFC response.
Elec	LAT startup plan (??)	LAT Provide	10/15/2003	Waiting	Bernie has an action to define this. Was this in ICD lien list? Will provide a baseline for CDR.



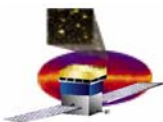
ICN's

- **LAT signed this month**
 - **ICN-8 Clarify <75W LAT Radiator IR Backloading Requirement (10-2-03)**
 - **ICN-23 LAT Interface Connector Pin-out Definitions (10-2-03)**
 - **ICN-24 LAT Survival Feed Connector Redefinition (10-10-03)**
 - **ICN-27 LAT Discrete Control Command Logic & Signal Names (10-10-03)**
 - **ICN-16R1 LAT-SC System Grounding (10-13-03)**
 - **ICN-31 Define Length of LAT Science Data Packet (10-13-03)**
 - **ICN-32 LAT Science Name Consistency (10-13-03)**
 - **ICN-34 Heat Transfer from SC Non-MLI Surfaces (10-13-03)**
- **Currently under signature review**
 - **None**
- **Currently in draft or revision**
 - **ICN-9 Reduce the High Speed Science Data Rate**
 - **ICN-17 LAT Alignment during Test**
 - **ICN-25 Add SC RT Address to 1553 Protocol Document**
 - **ICN-33 LAT Analog RTD Part Type**



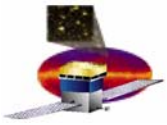
Interface Documentation Status

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



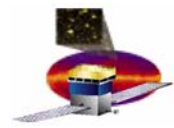
Working CDRL Delivery List

NO.	ITEM	PURPOSE	FROM	TO	MATURITY	Promise DATE	STATUS/NOTES
1.	LAT Safety Input to Launch Vehicle Documentation	Meet Range Safety Requirements	LAT	SAI	Preliminary FINAL	Feb. '04 Nov. '05	Prelim. MCDR- 2 months
2.	Spacecraft I & T Support	Obs. Development	LAT	SAI	N/A	Dec. '05	
3.	Launch Vehicle I & T Support		LAT	SAI/LV	N/A	Dec. '05	Items 2 & 3 previously combined
4.	Support Development of S/C I & T Procedures	Obs. Testing	LAT	SAI	N/A	Nov. '05	
5.	LAT Delivery	Obs. I & T	LAT	SAI	FM	Dec '05	
6.	LAT GSE (Mechanical and Electrical)	Obs. I & T	LAT	SAI	FM	Dec '05	
7.	Flight Connectors	Obs. I & T	SAI	LAT	Test FM	Oct '03	LAT Awaiting Delivery
8.	LAT Thermal Model		LAT	SAI			
	- Full TMM	STOP & Observatory TA	LAT	SAI	CDR	Oct '03	Delivered TMM
	- Launch Vehicle Model (200Nodes)	Obs. Case Studies & LV Delivery	LAT	SAI	CDR	Mar '06	
- TMM ↔ FEM Mapping	Support LAT T/M Distortion/STOP	LAT	GSFC	CDR	Dec '03		
9.	LAT FEM (Full)	Obs. Strength (10.03) CLA	LAT LAT	SAI SAI	CDR CDR+	Oct. 30 Dec '03	Delivered FEM
10.	LAT STEP	ICD Documentation (harness routing, connectors, etc)	LAT	SAI	CDR	Dec '03	Definition required w/SAI
11.	LAT Mass Properties Information	SAI to build mass simulators for S/C structural qualification	LAT	SAI	CDR	Dec '03	
12.	LAT Radiation Source Survey	Identify sources of radiation for range	LAT	SAI	CDR	Dec '05	
13.	LAT Instrument/Spacecraft Simulator	Obs. Development	LAT	SAI	FINAL	Apr '04	
14.	Spacecraft/LAT Instrument Simulator	LAT Development DIIS SIIS	SAI	LAT	Preliminary FINAL	Jul '03 Dec '03	
15.	LAT Input to ICD	ICD Development	LAT	SAI	Updates		See attached ICD closure list per priority
16.	S/C Flexures (Flight Like)	LAT Testing Model Hardware	SAI	LAT	Test	10/30/03 3/04	Flight Flexures remain at SAI
17.	Drill Template	LAT	SAI	LAT		1/04	
18.	S/C Acoustic Simulator	LAT Model (FEM) Hardware	SAI	LAT		12/04 4/05	
19.	Ground Ops Plan (Hazardous & Safety Critical Operations)	LAT Testing	LAT	SAI	Preliminary Final	7/03 2/04	

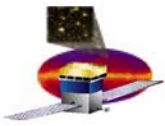


RFA Closure

- **Coordinated plan of attack in place –Horn/Graf/Hascall/Melton**
 - **37 RFAs total, submitted 17 answers, have 5 draft answers and 5 answers in final review**
 - **GSFC/LAT consolidation (murder board review) of CDR RFAs held in conjunction with the Face-to-Face meeting at Goddard**
 - **Plan is to complete 11 by end of October and the final 9 by the end of December**
- **Current status of all RFA's on SE website**



Key Design Metrics



LAT Mass Status

LAT Mass Status Report

LAT-TD-00564-07

LAT Mass Status

Martin Nordby

Effective Date: 29-Oct-03

Print Date: 28-Oct-03

October 2003

Mass (kg)	Estimate	Alloc.
TKR	504.9	510.0
CAL	1374.3	1440.0
ACD	278.8	280.0
Mech	358.6	345.0
Elec	226.2	220.0
I&T	7.0	0.0
LAT Total	2749.9	2795.0
Rsrv/Margin	250.1	
Rsrv/Margin*	9.1%	
Allocation		3000.0

* AIAA G-020 recommended min reserve = 6.2%

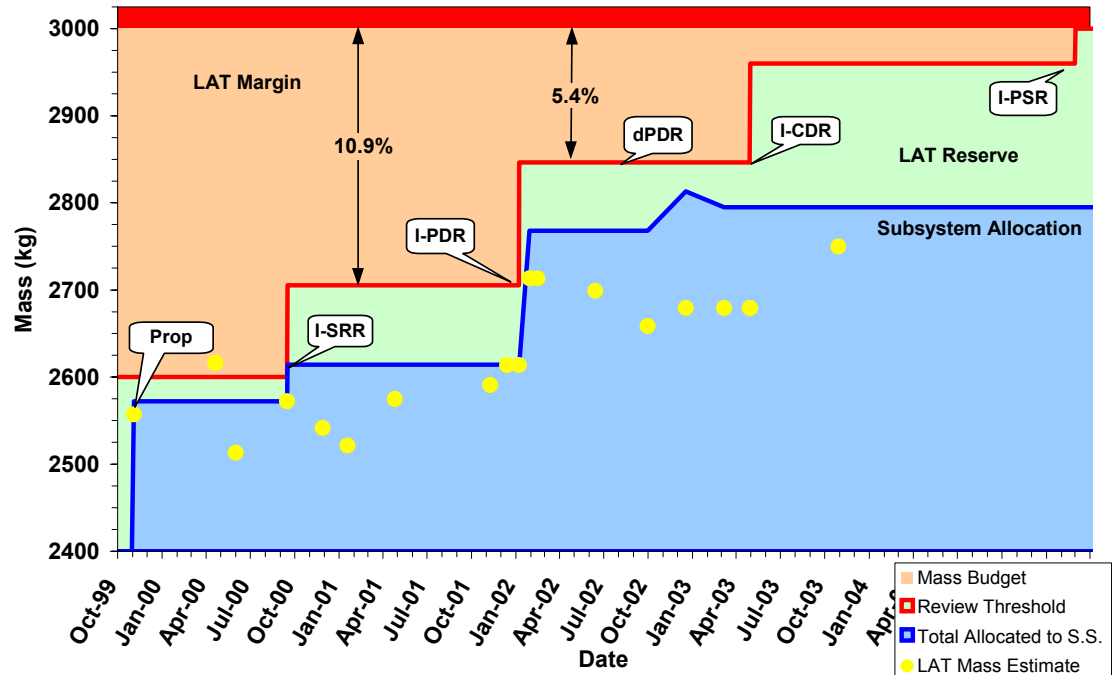
Center of Mass (mm)

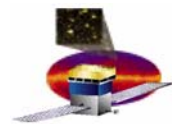
CMx	-0.67	-20 < CMx < 20
CMy	-0.94	-20 < CMy < 20
CMz	-71.69	CMz < -51.2
Ht off LIP	164.51	Ht < 185

Second Moment of Inertia (kg-m²)

Ixx	1047.8	1500.0
Iyy	1004.0	1500.0
Izz	1386.0	2000.0

Mass Estimate Breakdown		
	(kg)	%
Parametric	229.4	8.3%
Calculated	1050.5	38.2%
Measured	1470.0	53.5%
Total	2749.9	100%





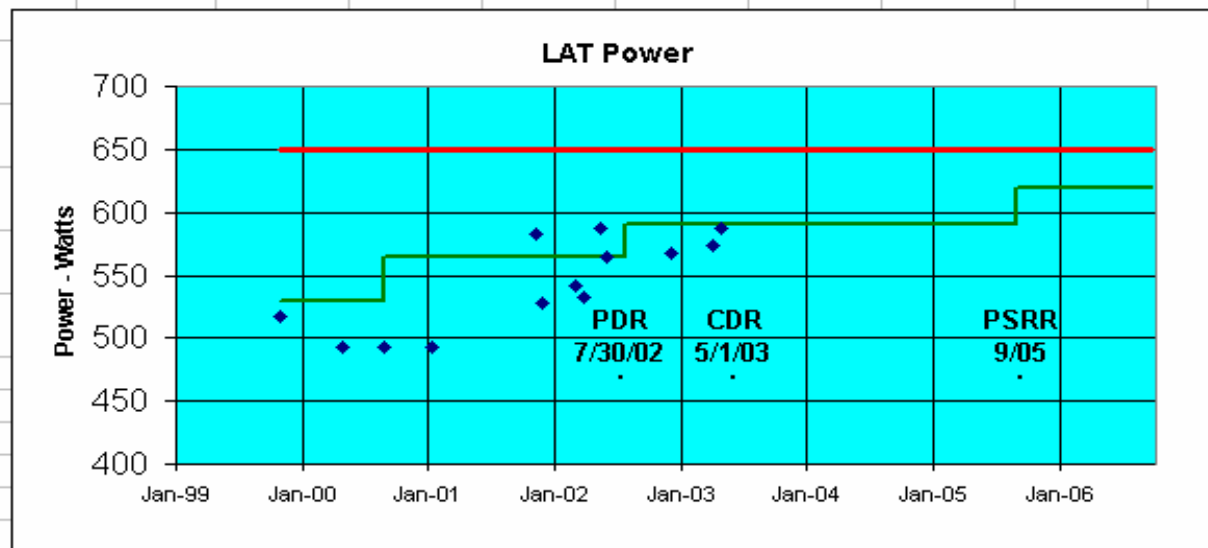
LAT Power Status

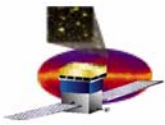
5-Sep-03	Estimate	PARA	CALC	MEAS	ALLOC.
Item	(Watts)	(Watts)	(Watts)	(Watts)	(Watts)
ACD	9.4	2.3	3.9	3.2	10.5
Tracker	152.4	1.5	0.0	150.9	153.0
Calorimeter	64.9	0.0	0.0	64.9	65.0
Trigger & Data Flow	340.9	227.6	86.8	26.6	327.5
Grid/thermal	20.4	20.4	0.0	0.0	35.0
Instrument Total	588.0	251.8	90.6	245.6	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"

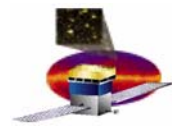




FSW Resource Usage Current Estimates

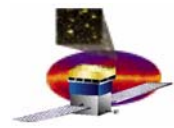
Resource	Total Available	Anticipated Usage	Margin Factor
EPU Boot PROM	256 kB	128 kB	2
SIU Boot PROM	256 kB	128 kB	2
EPU EEPROM	4 MB	1.5 MB	2.7
SIU EEPROM	8 MB	1.5-2.5 MB	3-5
EPU CPU cycles	200% in 2 EPUs	30%	> 6
SIU CPU cycles	100% in 1 SIU	25%	4
EPU memory	128 MB	16-32 MB	4-8
SIU memory	128 MB	< 16 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

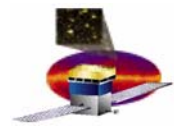


Key Science Performance Metrics

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)

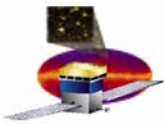


Risk Management



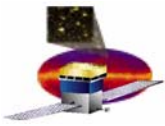
Risk Management Activity

- **No new issues**



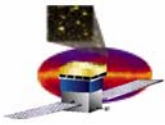
Top risks to cost

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
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 •2 New S/W Eng added 10/03, 3rd in work •Identified additional QA support requirements •Adding additional Structural analyst support



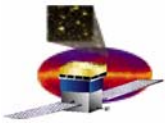
Top risks to schedule

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"> • 50 Unit Pre-production run established with Teledyne, ECD: 3 Nov start, Jan 04 Finish • Engineer (Dave Rich) added to drive closure
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"> • DAQ ASIC's flight ready, continued testing • Tracker GTRC error found, on issues list • Cal/ACD ASIC's continued testing
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 9/03 • Basing approach on flight proven designs where possible 	<ul style="list-style-type: none"> • Peer review completed 9/22/03 • Re-baselined, tight schedule for EGSE
SE-007	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"> • LAT Assembly plan under update to incorporate EM1 lessons learned, ECD: Jan 04



4.1.2 Cost & Schedule Status

- **Cost variance - \$373K**
 - \$150K delay in subcontract billing cycle through Stanford
 - \$95K expenditures transferred to IOC
 - \$108K underrun in ONE support cumulative, additional staff in-work
 - \$20K cumulative SLAC underrun
- **Schedule variance – On track/LOE**



3-Month Milestones

- Update the LAT-MD-00408 LATPVP – October - **December**
- 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 – Completed this month (Next update in January)
- **Complete X-LAT Review – 30 October (now 5 Nov)**
- **Complete CIDL update – 30 October (now 15 Nov)**
- Hold EM Test & Qualification Readiness Reviews – TBD (Re-plan)
- Close all open RFAs – October->**December**