

# GLAST Large Area Telescope: LAT System Engineering

Pat Hascall  
SLAC  
System Engineering



# Topics

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



# Monthly Action Item Status

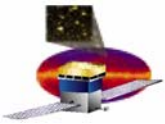
Action Item ID	Actionee	Description	Status
7-30-03-006	Haller	For TEM/TEM PS to be provided to CAL Qual/Accept program; provides a specific list of differences from flight (hardware/software/performance), include any constraints for use (T/V, EMC.....)	OPEN: ECD 27 August; ECD 29 October - Further definition required, plan in work.
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. Update provided early December, 2003. Next update and process for updateD: TBD.
1-28-04-013	Dick Horn	Provide risk assessment of LAT power requirements to support GSFC decision with respect to S/C power capability	Closed: Risk is low



# Monthly Action Item Status (Cont.)

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Action Item ID	Actionee	Description	Status
1-28-04-014	Johnson/ Thompson	CAL & ACD to include a summary of internal subsystem NCR's for info only and maintain a monthly summary.	<b>OPEN</b>
1-28-04-015	Andrews	Finalize and document ISIS detailed requirements.	<b>OPEN - Draft Complete, ECD:?</b>
1-28-04-017	B. Graf	Drive parts radiation issues to closure.	<b>OPEN</b>



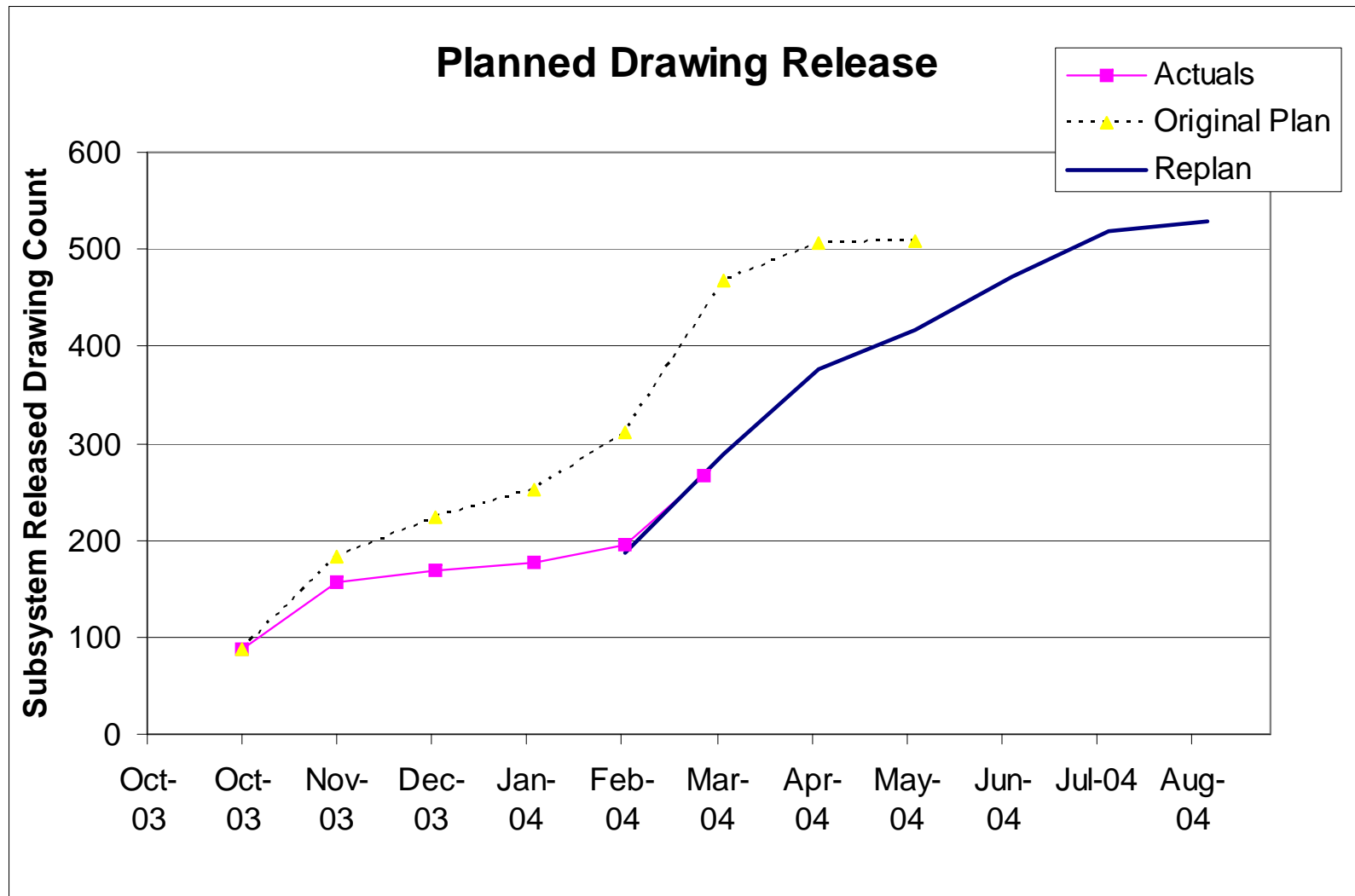
# Technical Baseline: Flight Drawing Release

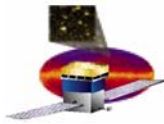
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- **Drawing release still slow, but shows promise**
  - **Planned release of 88 by end of April**
    - **Actual release to date - 11**
    - **Drawings in signoff - 63**
    - **Drawings deferred – 29**
    - **Not statused yet - 8**
  - **Tracker has 16 in signature cycle and has delayed 24 drawings from April to May**
  - **DAQ has 47 in signature cycle which would put them over plan if we get them out**
  - **ACD and Cal had a combined total of 8, status TBD**



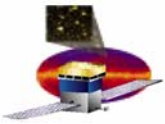
# Flight Drawing Release (As of 25 March)





# Cumulative Released Drawing Metrics as of 25 March

Subsystem	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04
Tracker Plan	28	49	61	62	64	81	127	129	130	130	130
Actuals	28	49	61	62	64	81					
ACD Plan	28	41	41	47	57	99	105	105	105	105	105
Actuals	28	41	41	47	57	99					
Cal Plan	28	28	28	28	28	36	38	38	38	38	38
Actuals	28	28	28	28	28	36					
DAQ Plan	0	0	0	0	0	30	50	78	125	172	181
Actuals	0	0	0	0	8	8					
Mechanical Plan	4	39	39	39	39	43	52	54	59	59	59
Actuals	4	39	39	39	39	43					
Integration Plan	0	0	0	0	0	0	5	13	15	15	15
Actuals	0	0	0	0	0	0					
Total Plan	88	157	169	176	188	289	377	417	472	519	528
Actuals	88	157	169	176	196	267					



# 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 30 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 signoff	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 <b>-Analysis indicated that there was no significant issue</b>	6 April <b>Closed</b>	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

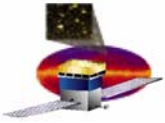


# Requirements & Performance Verification Progress

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## Test Planning

- **Post CDR LAT-MD-00408 update**
  - **Incorporated comments from a LAT walkthrough in February**
  - **Received comments from NASA**
    - **Over 100 comments**
    - **About half are incorporated**
- **Weekly test planning meetings**
  - **Have first cut at CPT that incorporates End-to-End committee recommendations**
  - **Have reviewed Cal and Tracker test list and verification matrix and started work on defining the Limited Performance Tests (LPT)**



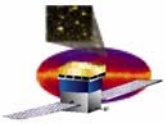
# Interface Management



# Interface Document Status

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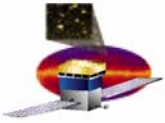
- **SC-LAT ICD ICN Status**
  - **LAT signed this month**
    - ICN-050 PRU SIU and VCHP Voltage Analog Range
    - ICN-051 LAT Connector Locations and Orientations
  - **Currently under signature review**
    - ICN-33 LAT Analog RTD Part Number
    - ICN-53 LAT Simulator Analog and Voltage Signals
    - ICN-54 Limit Checking of LAT Analogs
    - ICN-55 LAT Science Data Rate Reduction
  - **Currently in draft or revision**
    - ICN-38 LAT Limit Checking Clarification
    - ICN-57 1553 Connector Part Number
- **Internal LAT ICD's and IDD's (Pending Release or Change in Status Only)**
  - **Released this month**
    - ACD-LAT ICD Rev 6 released 4-6-04
    - X-LAT SCD Rev 2 released 4-21-04
  - **Currently in signature review**
    - TRK-LAT Electrical ICD
  - **Currently in draft or revision**
    - Electronics-LAT ICD.
      - Final updates being incorporated.
      - Should be in signature review by the end of the week.
    - TKR IDD
    - Radiator IDD
    - SAS-LAT ICD



# GFE Deliverables

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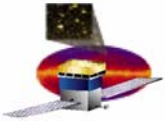
- **LAT GFE Deliverables**
  - **April: None. No deliverables were due.**
  - **May: No deliverables due.**
- **LAT GFE Receivables**
  - **April: Drill Template**
    - **Expected Drill Template 4-23-04.**
    - **Has not shipped as of 4-26-04.**
    - **Issues being worked by NASA Quality and Spectrum Astro.**
  - **May: None expected (SIIS would be a nice surprise though)**



# RFA Closure

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- **37 CDR RFAs total, submitted 33 answers**
- **Working questions on 7 PDR and CDR RFAs**



# 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

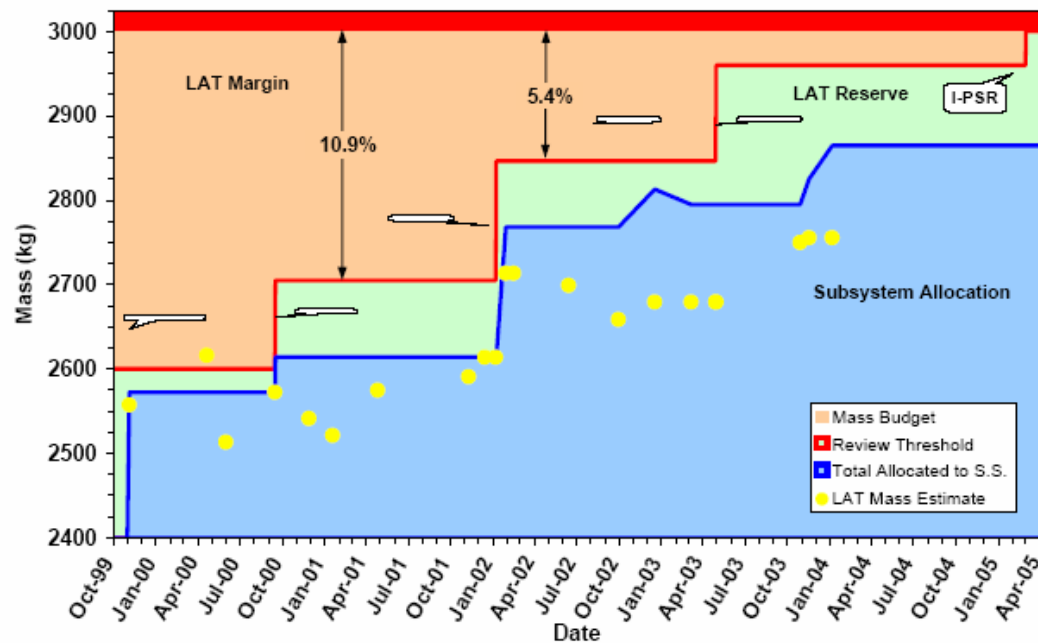
**Center of Mass (mm)**

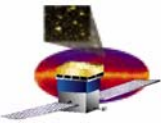
CMx	-0.67	-20 < CMx < 20
CMy	-0.94	-20 < CMy < 20
CMz	-71.45	CMz < -51.2
Ht off LIP	164.75	Ht < 185

**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 review, potential reduction of 20-30w)

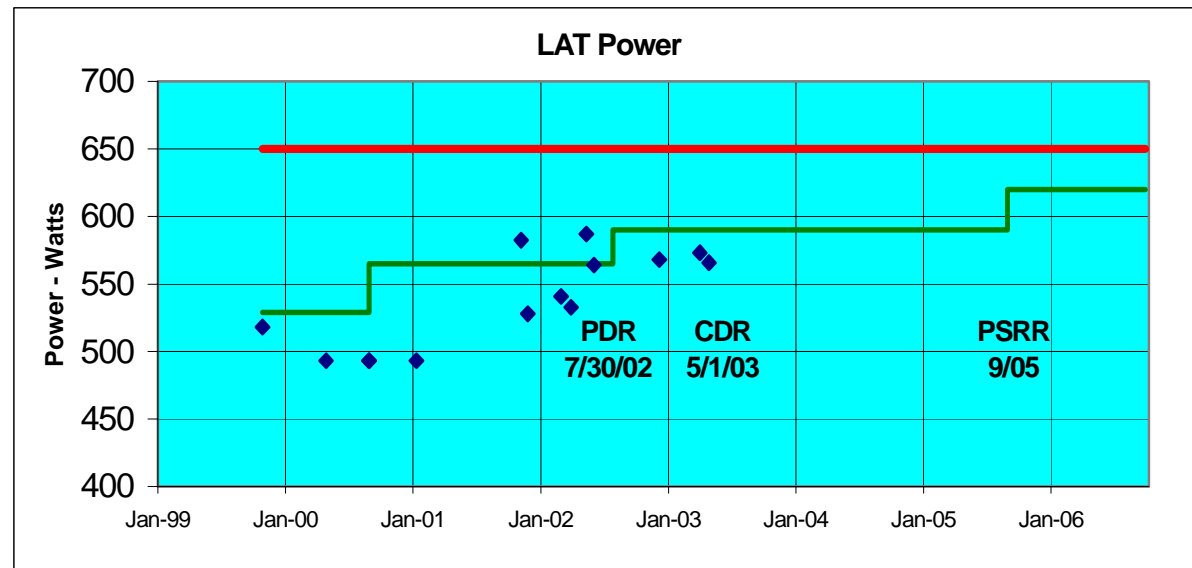
Item	10-Nov-03 Estimate (Watts)	PARA (Watts)	CALC (Watts)	MEAS (Watts)	ALLOC. (Watts)
ACD	9.4	2.3	3.9	3.2	10.5
Tracker	152.4	1.5	0.0	150.9	153.0
Calorimeter	64.9	0.0	0.0	64.9	65.0
Trigger & Data Flow	318.6	44.5	87.3	186.8	327.5
Grid/thermal	20.4	20.4	0.0	0.0	35.0
Instrument Total	565.7	68.7	91.1	405.8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

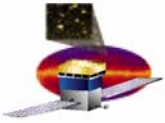
EPU: Event-Processing Unit

SIU: Spacecraft Interface Unit

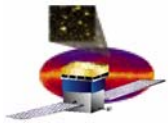


## Key Science Performance Metrics

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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- No new risks identified this month





# 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>• EM2 Review 26 Feb</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>



# 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"><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>• Processes in place</li><li>•Remaining vendor selections per production plan</li></ul>
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"><li>•Management team has identified critical skill needs</li><li>• Identify skilled personnel within Collaboration environment</li></ul>	<ul style="list-style-type: none"><li>• Added SLAC Site Rep in Italy</li><li>• Added Scientist to Tracker Team &amp; Proj Eng</li><li>•Continuing to expand FSW support</li><li>•Identified additional QA support requirements</li><li>•Added additional Structural analyst support</li><li>•Added Design Eng Support</li></ul>



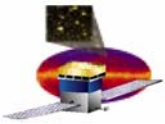
# Top risks to schedule

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"> <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 established with Teledyne, ECD: 9 Feb 04</li> <li>• Restructured SLAC engineering support</li> <li>• Additional INFN support in place</li> </ul>
Proj Mgt - 002	Moderate	ASIC's fail to meet requirements; results in schedule impact	<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> </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	TEM Power supply final design is delayed, final implementation may exceed current schedule	<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> </ul>	<ul style="list-style-type: none"> <li>• Implementation plan in place and proceeding</li> <li>• Reduce to Low risk after successful Qual program</li> </ul>



## Top risks to schedule

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE-007	Moderate	Critical component failure post LAT integration requiring de-integration impacting cost & schedule	<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>•LAT Assembly plan under update to incorporate EM1 lessons learned, update complete, in review ,ECD: Mar 04</li></ul>
Elec-004	Moderate	Flight-Software development schedule is tight and depends on execution of LAT software development approach. Delays in incremental review process may impact cost & schedule	Detail and implement incremental development program, ensure sufficient software test on target hardware during development to drive out any requirement disconnects. Include adequate peer reviews before each spiral cycle prior to release	<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>•Quick Look Review closure in work</li><li>• EM2 Review 26 Feb</li></ul>



## 3-Month Milestones

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- Update the LAT-MD-00408 LATPVP – Incorporated comments from walkthrough, resolving questions from NASA
- Update System Metrics – Electrical update presented, mass update in progress
- Close all open RFAs – October-> 15 May
- Draft Dynamics Plan – 1 June
- LAT Survey Plan –Draft on April 8, Final by May 31
- LAT Instrumentation Plan – 16 Jan 04 –> CR ECD 30 April
- LAT EMI/EMC Test Plan - First Release 3/04->TBD
- LAT Comprehensive Performance Plan, Limited Operational Performance Plan combined into one document, initial release - 3/04->15 May
- LAT Thermal Test Plan First release 1/16/04, final 6/04
  - Preliminary reassessment indicates no major changes, update to restart mid March