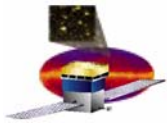


# GLAST Large Area Telescope: LAT System Engineering

Dick Horn  
SLAC  
System Engineering Manager

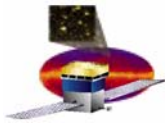
Dhorn@slac.stanford.edu  
408 771-3550



# Topics

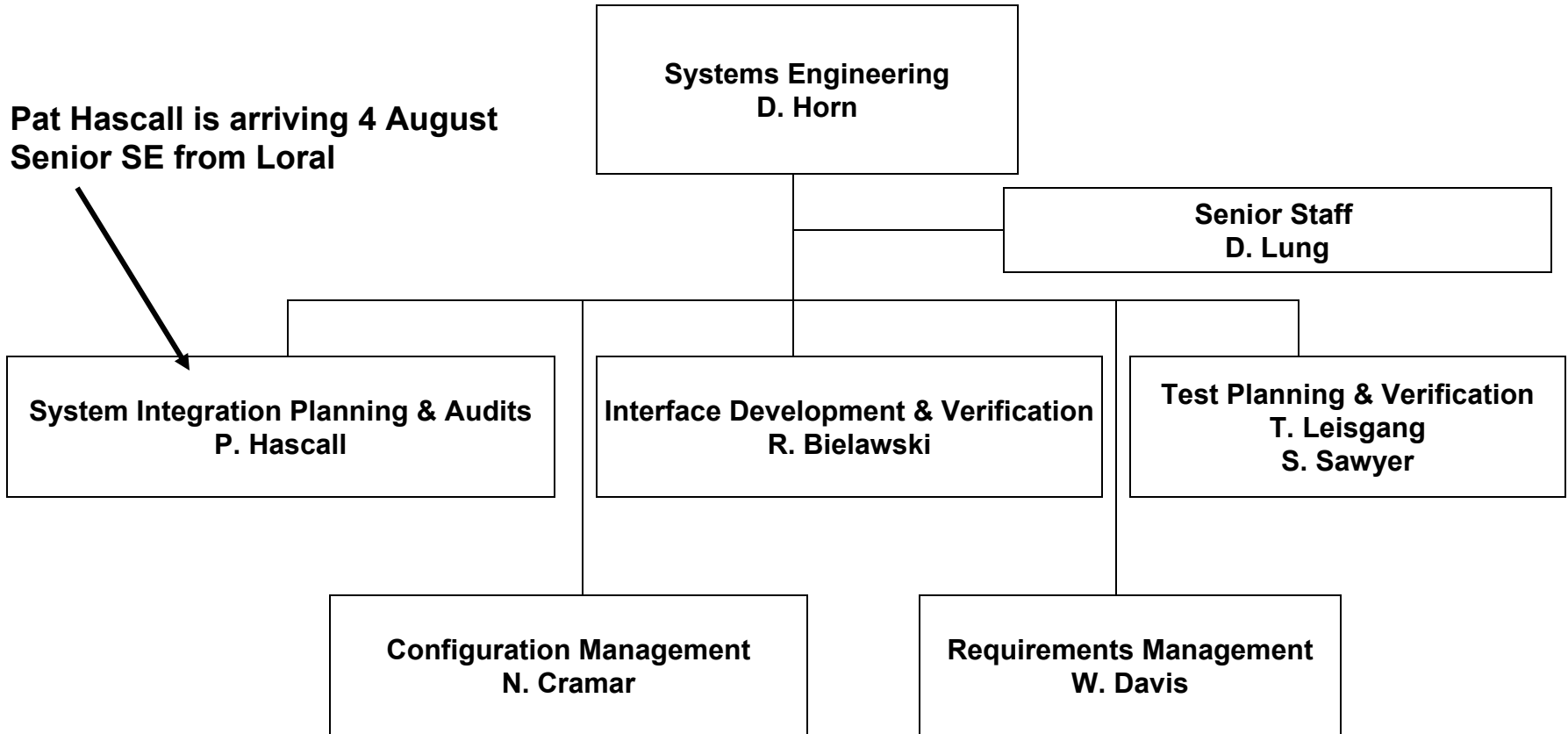
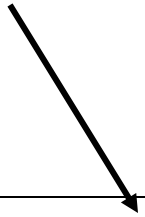
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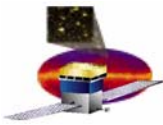
- **Organization Update**
- **RFA Closure**
- **Requirements Management**
- **Verification Planning**
- **Interface Control Documentation**
- **Key Metrics**
- **Risk Management**



# SE Organization Update

Pat Hascall is arriving 4 August  
Senior SE from Loral





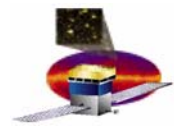
# CDR RFA Status

Subsystems	RFA		
	Assigned	Response	Submitted to GSFC for Closure
I&T	6	6	0
Electronics/DAQ/FSW	10	0	0
Systems	5	0	0
Design Integration	14	0	0
Science	2	0	0

		Recommendations		
Subsystem	WBS	Assigned	Response	Closed
TKR	4.1.4	3	3	0
CAL	4.1.5	5	0	0
ACD	4.1.6	2	2	0
Electronics/DAQ/FSW	4.1.7	6	0	0
Mech Sys	4.1.8	5	0	0
Systems Eng	4.1.2	9	0	0
I&T	4.1.9	6	6	0
PS&A	4.1.A	1	0	0
IOC/SAS	4.1.B/4.1.D	5	0	0
Cost/Schedule	4.1.1	3	0	0

**Need a new strategy to get old RFA's closed, remove duplication:**

**Suggest a joint LAT/Mission Office SE "Murder Board" to make program decisions on disposition and closing RFA's that are OBE'd**



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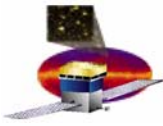
# Requirements Traceability & Verification Planning



# Requirements Traceability and Verification

---

- **Continuous tracking of requirements changes**
  - **CCB-approved changes to level 2 and 3 technical requirements have been incorporated into DOORS verification matrix**
- **Verification Working Group has been established which includes all mission elements**
  - **Develop overall GLAST verification plan**
  - **Coordinate verification activities that will occur after LAT delivery**
- **Expand current verification matrix to include interface requirements**
  - **Interface designs and resulting requirements have stabilized**
  - **Requirements from the ICDs will be added to the DOORS verification matrix (ECD 9/25/03)**
  - **Provide links to interface verification procedures and test/analysis reports (On-going as these activities are completed)**



# Requirements & Performance Verification Progress

---

- **EMI/EMC**
  - Addressed RFA and revised LAT-MD-00408 (LAT PVP) as required
  - Updated LAT Environmental Specification (Requirements document)
    - Reflects latest version of requirements document (433-SPEC-005)
  - EMI/EMC discipline review held with subsystems
- **Dynamics**
  - Revised test plan
  - discipline level reviews of proposed plan
- **Alignment**
  - Updated plan
  - discipline & performance level reviews of proposed plan
- **Test Data Requirements**
  - Refining subsystem test data requirements for delivery w/ flight hardware
- **Test Performance**
  - Coordinating planning & implementation of program EGSE
  - Developing comprehensive End to End test plan for instrument



# Acceptance Test Data Package Summary

---

*This information is deliverable with each unit*

**Described in LAT-MD-00408:**

- **ID Information (per LAT-MD-00466)**
- **Mechanical Summary Data**
  - **Show conformance to the subsystem component ICD**
- **Electrical Interface Data**
  - **Show conformance to the subsystem component ICD**
  - **Results of unit dependant Electrical Interface Tests**
    - **Isolation**
    - **Insulation resistance**
    - **Hi-Pot**
    - **CSCM/CECM Tests**
- **Unit Calibration Data**
  - **Data required to operate the unit properly**
- **Unit Performance Data**
  - **Data necessary to determine like or degrading performance**
  - **Functional Test Performance Summaries**

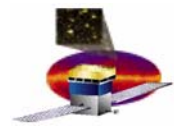




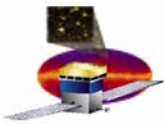
# Acceptance Test Data Package<sub>(continued)</sub>

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- **Unit Support Data is required**
  - to successfully operate the unit at the next level of assembly
  - to support spot verifications of unit acceptance test data
  - Supports unit Configuration
    - Internal component Cal Curves (like thermistors)
    - Dead Channel Lists
- **Operational Support Data**
  - Processes
  - Procedures
  - Test Scripts
- **Quality Data**
  - Certifications
  - NCR summary
  - Failure Free Power On Time
  - Installation, Mate/de-Mate Logs

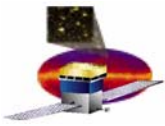


# Interface Management



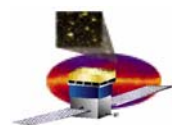
## Key Open Internal LAT Interface Issues

INTERFACE	KEY OPEN ISSUES	STATUS	RESOLUTION	ECD
<b>Tracker</b>	Validating TKR-Grid copper strap thermal design.	<ul style="list-style-type: none"> <li>Detailed design complete.</li> <li>Testing is underway.</li> </ul>	TKR to complete thermal testing as part of Engineering Model test plan closure.	9/30/03
<b>Calorimeter</b>	Validating CAL Base Plate to Grid structural design.	<ul style="list-style-type: none"> <li>Design trades complete.</li> <li>Menning Shear Plate design selected.</li> <li>Preliminary analysis and tests indicate design has positive margins.</li> </ul>	<ul style="list-style-type: none"> <li>Finalize detailed interface design.</li> <li>Conduct formal review with GSFC.</li> </ul>	8/8/03 8/15/03
<b>ACD</b>	None			
<b>Electronics</b>	Validating X-LAT Plate to Electronics box thermal joint design.	<ul style="list-style-type: none"> <li>Most design options have been eliminated. The rigid joint and copper strap designs remain.</li> <li>Preliminary analysis confirms both designs meet requirements.</li> </ul>	<ul style="list-style-type: none"> <li>Selection of rigid joint design expected this week.</li> <li>Develop shim plan for electronic boxes.</li> <li>Develop engineering model thermal test of stacked electronic box configuration.</li> </ul>	7/31/03 8/8/03 8/15/03



## Key Open External LAT Interface Issues

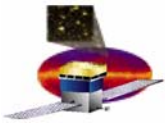
INTERFACE	KEY OPEN ISSUES	STATUS	RESOLUTION	ECD
Spacecraft	Radiator mechanical interface details need to be finalized.	<ul style="list-style-type: none"> <li>Face-to-Face meeting held on 7/16/03 and design details were agreed upon.</li> <li>Documentaion needs to be updated.</li> </ul>	<ul style="list-style-type: none"> <li>Update documentation.</li> </ul>	8/29/03
Spacecraft	Radiator static stay-clear envelope growth.	Submitted request to SAI for Radiator static stay-clear growth.	<ul style="list-style-type: none"> <li>SAI evaluated and accepted LAT request.</li> </ul>	CLOSED
Spacecraft	Finalize harness definition and routing.	<ul style="list-style-type: none"> <li>Interface connector procurement finalized.</li> <li>Interface connector pin-outs sent to SAI.</li> <li>Harness routing and strain relief concepts complete.</li> </ul>	<ul style="list-style-type: none"> <li>Finalize details of harness routing and strain relief.</li> </ul>	9/30/03



# Interface Documentation Status

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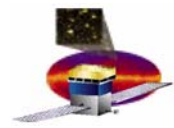
Document	Status
<b>LAT-SC Interface Control Document (Spectrum Astro Managed Document)</b>	
1196 EI-Y46311-000	Released 25 Apr 03
<b>1553 Bus Potocol Document</b>	
1196 EI-S46310-000	Released 25 Apr 03
<b>GBM-LAT Interface Control Document</b>	
433-ICD-0001	Second draft in-progress
<b>Calorimeter</b>	
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
<b>ACD</b>	
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
<b>Tracker</b>	
LAT-DS-00851-1: TKR-LAT Interface Definition Drawing	Second draft in-progress
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
<b>Electronics</b>	
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-progress



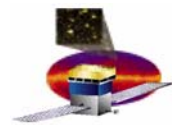
# Summary

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- **Since LAT CDR:**
  - **Shear Plate Design has been selected for the CAL Base Plate-Grid Interface**
  - **X-LAT Plate-Electronic Box interface design trades complete**
    - **Selection of rigid joint design anticipated this next week**
  - **Radiator-SC Interface design complete**
  - **Interface documents and drawings are being updated**



# **Key Design Metrics (No updates Since CDR)**



# LAT Mass Status

LAT Mass Status Report		LAT-TD-00564-06
<b>LAT Mass Status</b>		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
<b>LAT Total</b>	<b>2679.4</b>	<b>2795.0</b>
Rsrv/Margin	320.6	
Rsrv/Margin*	12.0%	
<b>Allocation</b>		<b>3000.0</b>

\* AIAA G-020 recommended min reserve = 7.2%

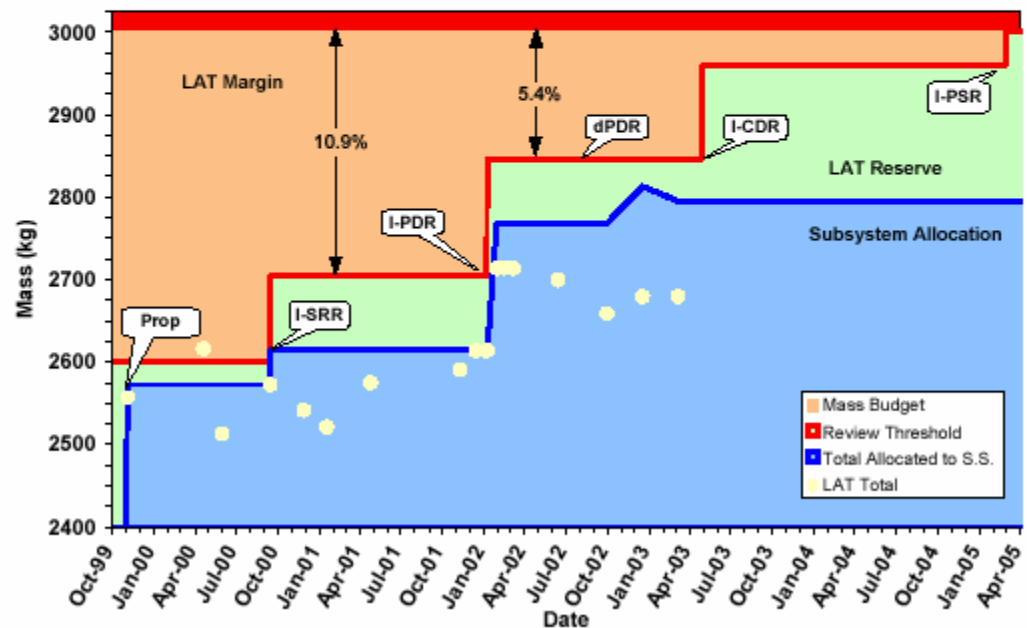
**Center of Mass (mm)**

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

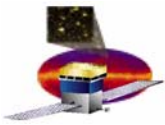
**Second Moment of Inertia (kg-m<sup>2</sup>)**

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%
<b>Total</b>	<b>2679.4</b>	<b>100%</b>







# LAT Power Status

Item	5-Apr-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	326.2	211.5	114.7	0.0	327.5
Grid/thermal	20.4	20.4	0.0	0.0	35.0
<b>Instrument Total</b>	<b>573.3</b>	<b>235.7</b>	<b>118.5</b>	<b>219.0</b>	<b>591.0</b>
Instrument Allocation	650.0				
% Reserve	13.4%				

LAT-TD-00125-04

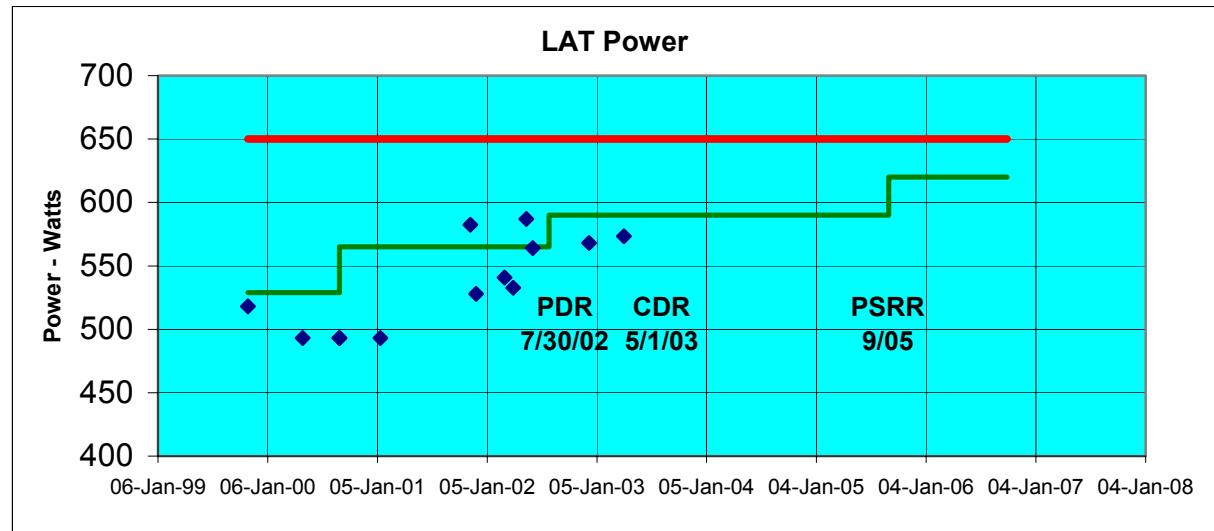
**PDR Reserve Was 15.2%**

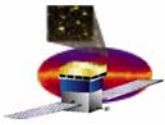
**Goal for CDR Reserve > 10%**

**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"

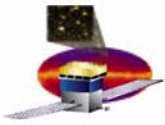




# FSW Resource Usage Current Estimates

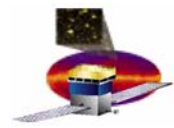
<b>Resource</b>	<b>Total Available</b>	<b>Anticipated Usage</b>	<b>Margin Factor</b>
<b>EPU Boot PROM</b>	<b>256 kB</b>	<b>128 kB</b>	<b>2</b>
<b>SIU Boot PROM</b>	<b>256 kB</b>	<b>128 kB</b>	<b>2</b>
<b>EPU EEPROM</b>	<b>4 MB</b>	<b>1.5 MB</b>	<b>2.7</b>
<b>SIU EEPROM</b>	<b>8 MB</b>	<b>1.5-2.5 MB</b>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

LAT-TD-1121-01

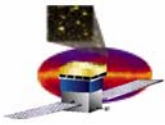


## Key Science Performance Metrics

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)



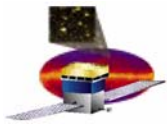
# Risk Management



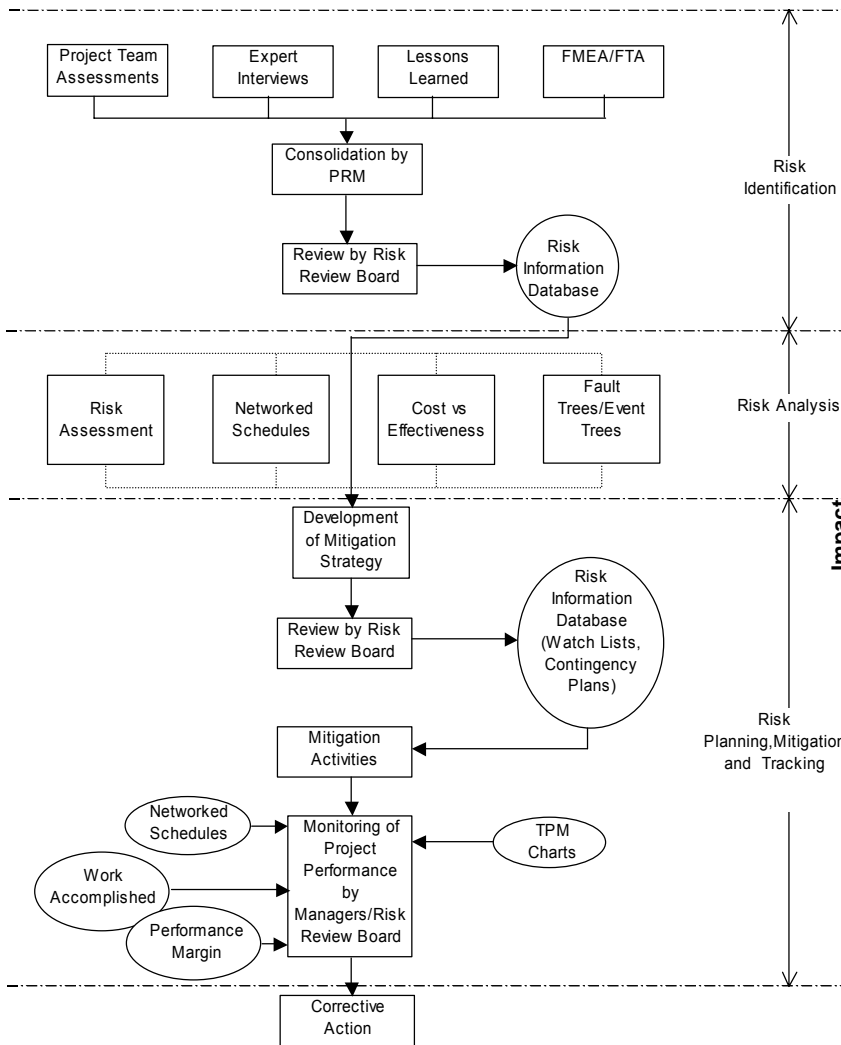
# Risk Management Activity

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- **Aligned ranking process to Mission Office scorecard**
- **Identified four new project risks as part of re-baseline activity**
  - **Completion of Tracker EM**
  - **TEM Power Supply**
  - **Closure of flight vendor selection and parts buy**
  - **Critical Skills**
- **Continuing to refine risk identification to ensure appropriate risks are identified and managed - ECD 9/30/03**
  - **Plan to audit database and focus risk assessments**
  - **Improve risk retirement planning**



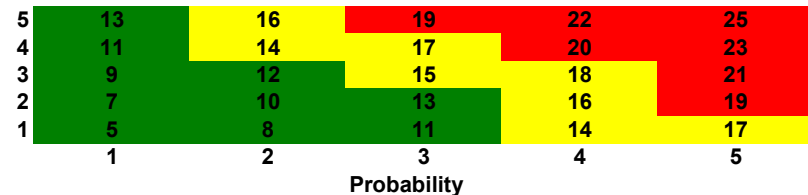
# Risk Management

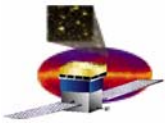


## LAT Risk Management Defined By LAT-MD-00067-03

- Parallel Process To GSFC ....
- Continuous Process Across LAT
- Risk Ranked By Probability and Impact to Technical, Cost & Schedule

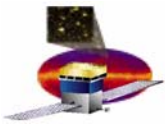
### Risk Ranking





# Top risks to cost

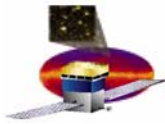
ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE--0007	Moderate	Critical component failure post LAT integration requiring de-integration impacting cost & schedule	<ul style="list-style-type: none"> <li>• Extensive use of EM test bed to support flight H/W &amp; S/W development</li> <li>• Thorough qualification and acceptance tests</li> <li>• Pre planned I&amp;T actions for de-integration</li> </ul>	<ul style="list-style-type: none"> <li>• Completed evaluation for improving access (9/02)</li> <li>• Qual &amp; acceptance planning in-place</li> <li>• I&amp;T developing contingency plans</li> </ul>
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 by 11/03</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</li> <li>• Software candidates interviews ongoing</li> <li>• Mechanical candidates interviews ongoing</li> <li>• ECD 10/03</li> </ul>



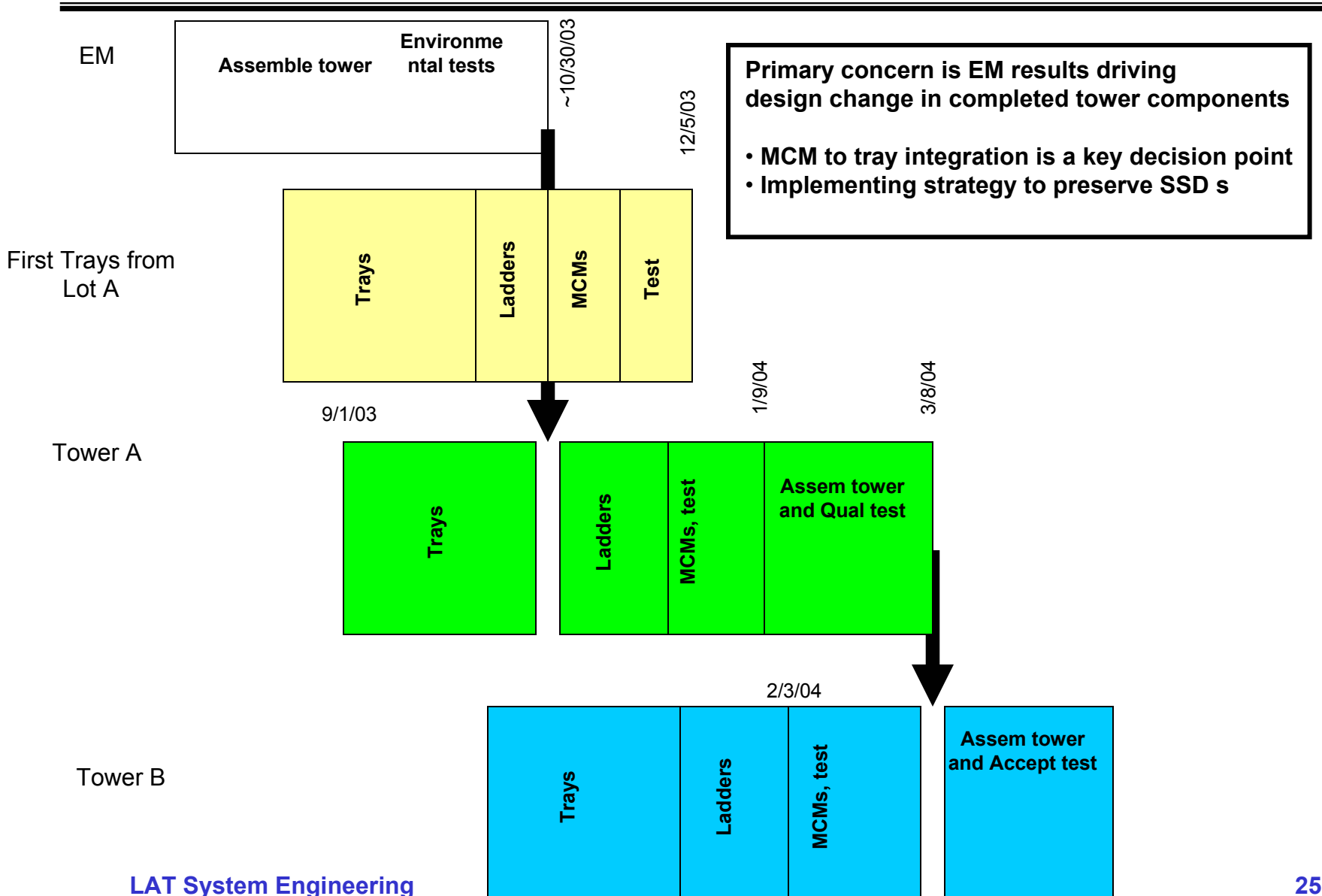
# Top risks to schedule

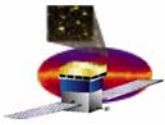
ID #	Risk Rank	Risk Description	Risk Mitigation	Status
Proj Mgt - 003	Moderate	Completion of Tracker subsystem qualification program delayed due to EM closure or MCM electronics	<ul style="list-style-type: none"> <li>• Manufacturing Eng assigned to close MCM issues</li> <li>• Increased team integration with Italian partners</li> <li>• GSFC audit/support to Tracker EM closure</li> </ul>	<ul style="list-style-type: none"> <li>• Teledyne contracted as MCM vendor</li> <li>• SLAC Site rep added to Italian team</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/DAQ ASIC's flight ready</li> <li>• Cal/ACD ASIC's expected 9/03</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 planned for 9/03</li> <li>• Basing approach on flight proven designs where possible</li> </ul>	<ul style="list-style-type: none"> <li>• Design closure 9/03</li> </ul>
SE-- 0007	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>• Completed evaluation for improving access (9/02)</li> <li>• Qual &amp; acceptance planning in-place</li> <li>• I&amp;T developing contingency plans</li> </ul>





# Tracker EM Closure Influence On Qual Program





## 3-Month Milestones

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- **Update the LAT-MD-00408 LATPVP – August**
- **Support Fault Management TIM - (TBD)**
- **Support STOP Analysis TIM's - (TBD)**
- **Complete FMEA – TBD (Pending Power Supply Design)**
- **Add ICD requirements to DOORS – September**
- **Complete Spacecraft ICD Review - September**
- **Refine risk program - September**
- **Close remaining Internal ICD TBX's - October**
- **Update System Metrics – October (Then Quarterly)**
- **Hold EM Test & Qualification Readiness Reviews – TBD (Re-plan)**
- **Close all open RFAs – October**