Integration, Test, and Calibration

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Integration, Test, and Calibration

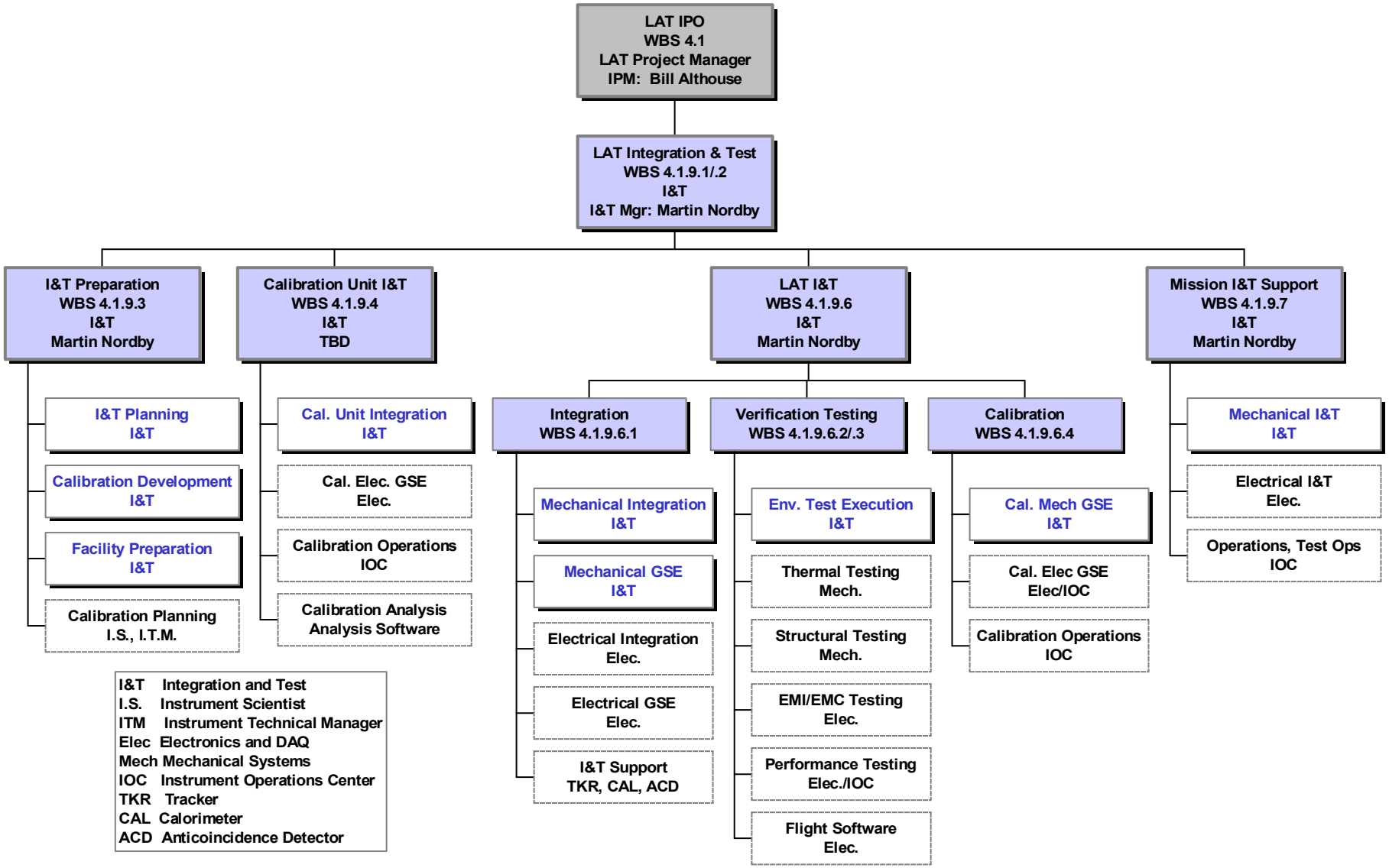
Outline

- I & T Work Breakdown and organization
- I & T activity flow
- Qualification & Verification testing
- Calibration planning
- Integration planning
- I & T scheduling and milestones
- I & T budget summary
- Issues

Integration and Test Subsystem Work Breakdown

- **4.1.9.1 I & T Management**
  - Coordinate I & T planning
  - Develop LAT I & T plan, to ensure flow of verification test activities
- **4.1.9.2 Reliability and Quality Assurance**
  - Collect subsystem verification test results
  - Manage LAT verification test assurance activities
- **4.1.9.3 I & T Preparation**
  - Prepare LAT I & T facilities
  - Develop calibration equipment
- **4.1.9.4 Calibration Unit I & T**
  - Prepare for and integrate Calibration flight modules
  - Prepare for and test Cal. Unit in electron, photon, and hadron beams
- **4.1.9.6 Flight LAT I&T**
  - Prepare for integration of flight LAT; fabricate and test all mechanical GSE
  - Mechanically integrate flight LAT
  - Plan for and execute environmental verification testing
- **4.1.9.7 Mission I&T Support**
  - Support planning and execution of Observatory I&T

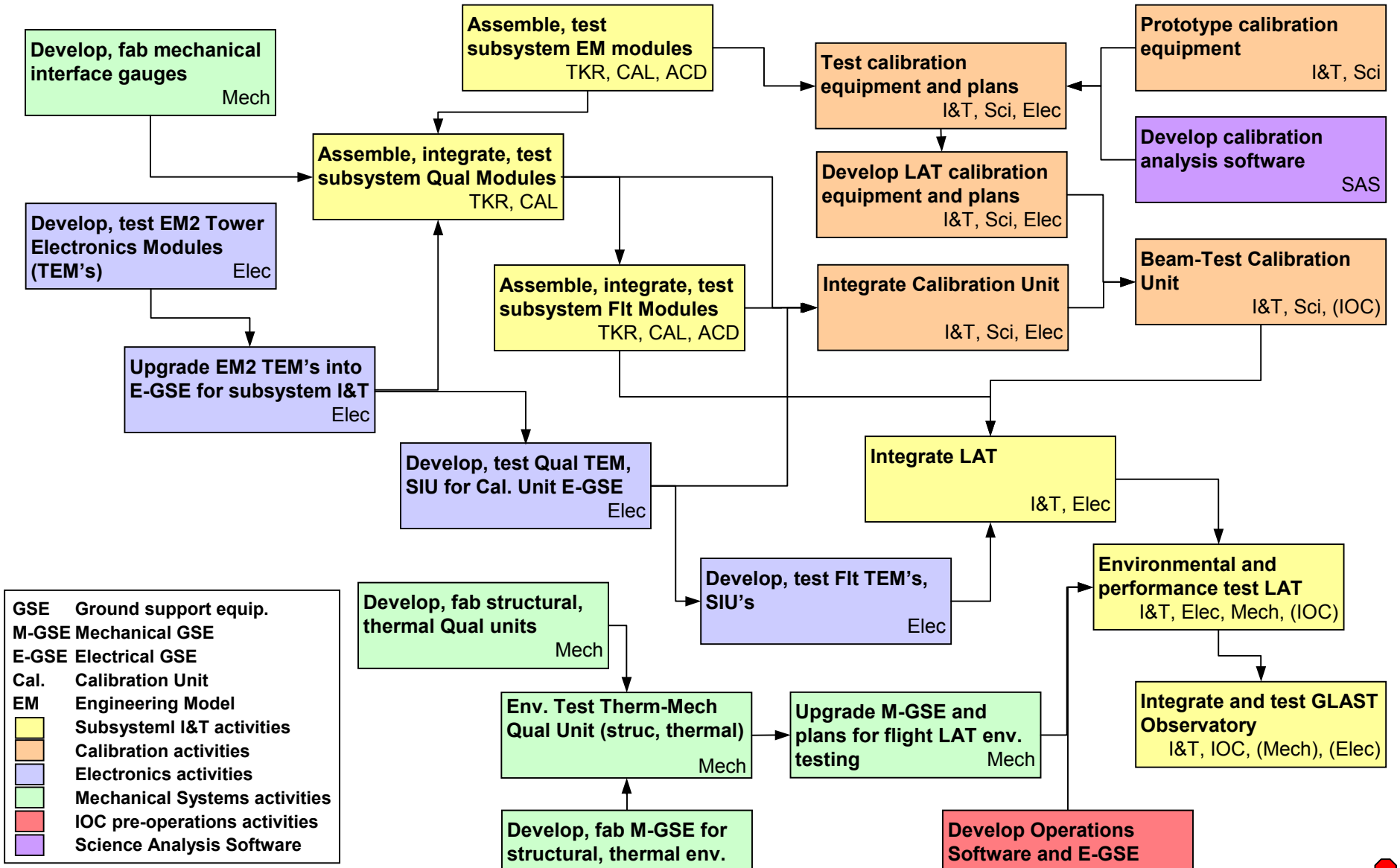
Integration, Test, and Calibration Organization



Integration, Test, and Calibration Activities

- I & T "subsystem" is focal point of LAT integration activities
  - I & T team plans and manages activities
  - TKR, CAL, and ACD subsystem teams provide support for integration
- Total effort involves:
  - I & T Subsystem
    - LAT integration planning and management
    - Mechanical integration and GSE development
    - Environmental test execution
    - Calibration test equipment development
  - Mechanical Systems
    - Environmental test planning
    - LAT qualification testing
  - Electronics and Data Acquisition
    - LAT electrical integration
    - Performance test planning and execution
    - Flight software verification testing
    - Electrical GSE development, including calibration DAQ system
  - IOC
    - LAT performance test planning
    - GSE operations and support during LAT I & T
  - Science Analysis Software
    - Calibration analysis software development

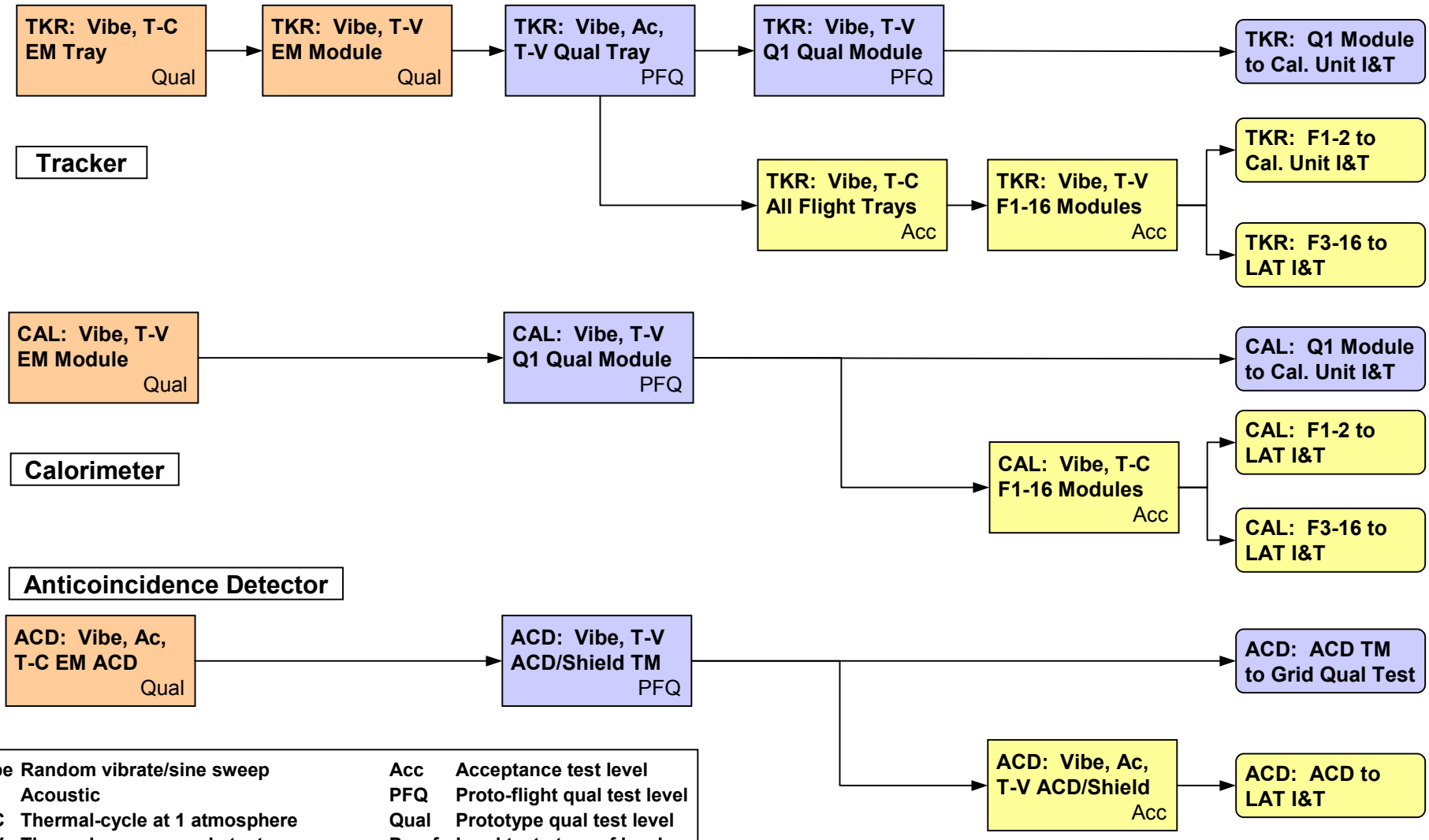
Integration, Test, and Calibration Activity Flow



Qualification and Verification Test Planning

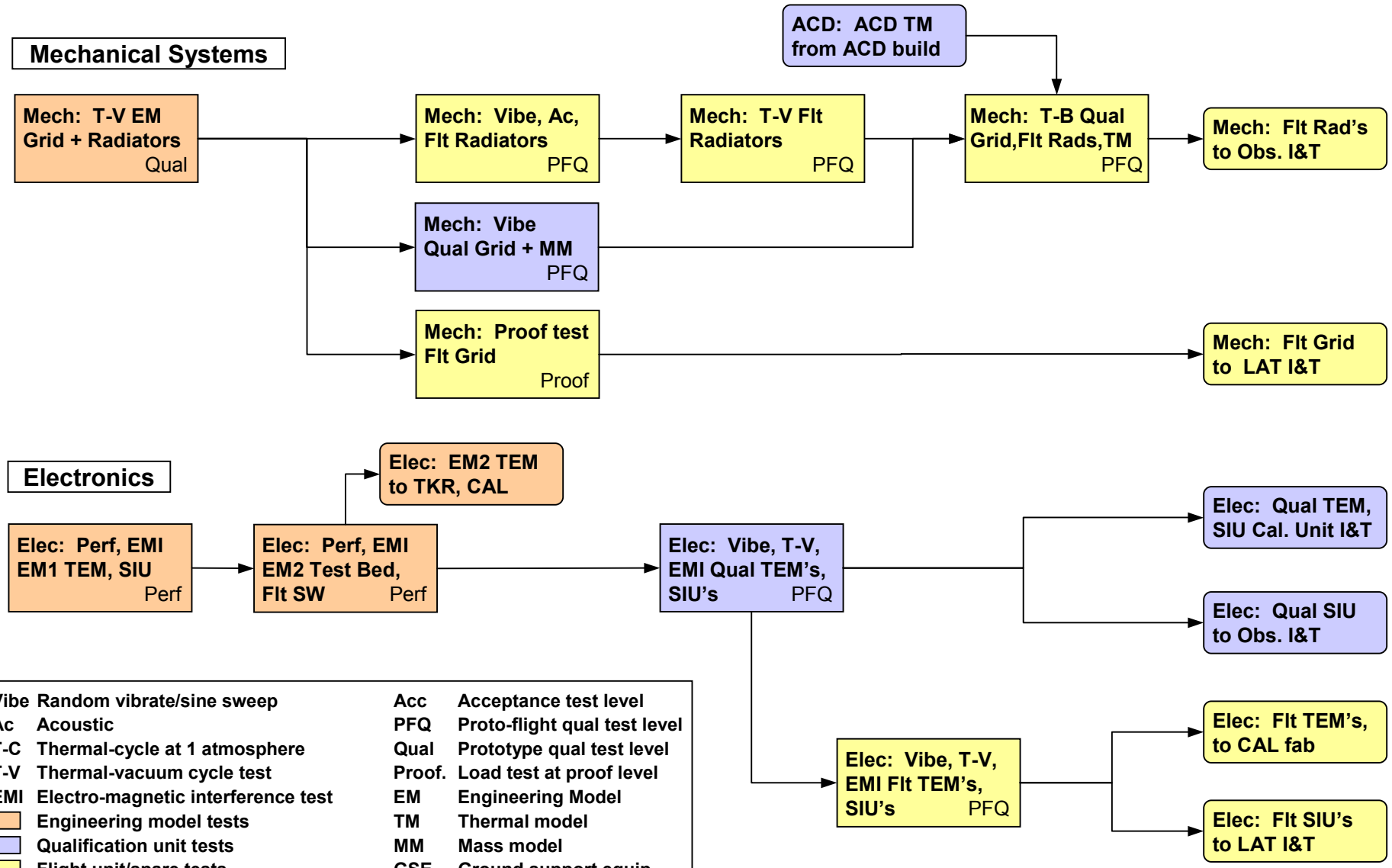
- **Validation and Qualification**
  - Incrementally validating models and qualifying processes
  - We are in-process on this plan
    - Prototypes: electrical/mechanical prototypes being built and tested now, to validate analysis and develop fab. processes
    - Engineering Models: CAL, TKR, ACD, Elec and Mech plan high-fidelity models which use processes planned for flight units
    - Qual Units: actual flight qualification will be done bottom-up
- **Verification and Acceptance Testing**
  - Subsystem performance verified as part of the assembly process
    - Provides immediate feedback for production line process control
    - With world-wide production effort, this clarifies responsibilities
    - Minimizes schedule and shipping risk if re-work is needed
  - Test as you build
    - Uses modularity to our advantage, reducing risk of high-level failure/non-compliance

Subsystem Test Flow



Vibe	Random vibrate/sine sweep	Acc	Acceptance test level
Ac	Acoustic	PFQ	Proto-flight qual test level
T-C	Thermal-cycle at 1 atmosphere	Qual	Prototype qual test level
T-V	Thermal-vacuum cycle test	Proof.	Load test at proof level
EMI	Electro-magnetic interference test	EM	Engineering Model
	Engineering model tests	TM	Thermal model
	Qualification unit tests	MM	Mass model
	Flight unit/spare tests	GSE	Ground support equip.

LAT System Test Flow



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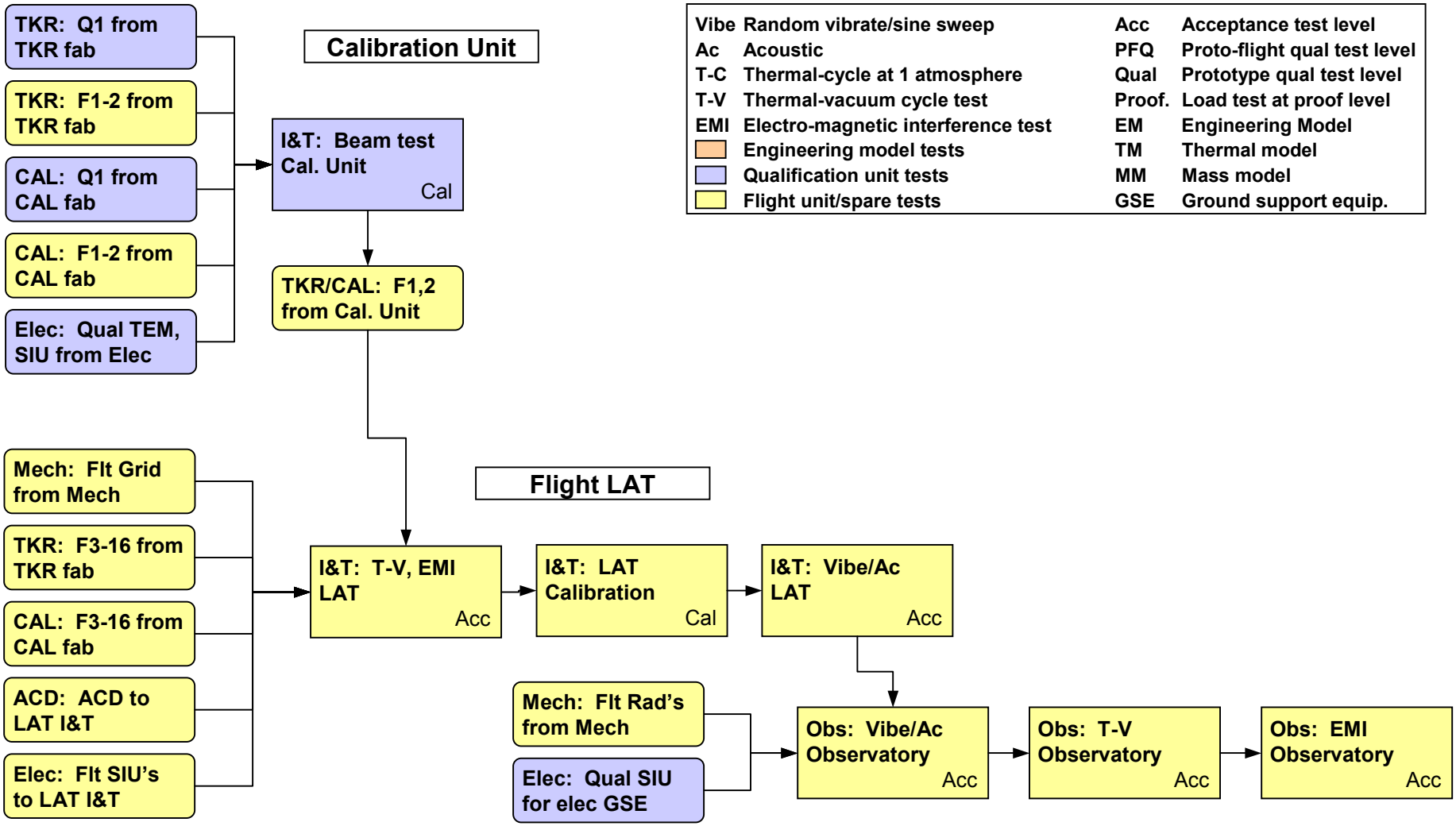
LAT I&T Verification Test Flow



Environmental Test Matrix

	Fit / Dim Check	Struc Strength	Mass, C.G.	Mass Properties	Sine sweep	Random Vibe	Acoustic	Mechanical shock	Thermal Balance	Thermal Cycling	Thermal-Vacuum	EMC	Alignment	Pressure	Flight Qt'y	Flight Spares
Tracker																
Qual Trays	M	Proof	M		PFQ	PFQ	PFQ			PFQ	PFQ		M			10
Qual Module (TKR #1)	M	Proof	M	M	PFQ	PFQ					PFQ	PFQ	M	Ana		1
Trays	M		M			Acc				Acc			M		304	28+20
Modules (TKR #2-18)	M		M		Acc	Acc					Acc	Acc	M		16	1
Calorimeter																
Qual Module (CAL #1)	M	Proof	M	M	PFQ	PFQ					PFQ	PFQ	M	Ana		1
Modules (CAL #2-18)	M		M		Acc	Acc					Acc	Acc			16	1
Anti-Coincidence Detector																
ACD Flight Unit	M	Proof	M	M	PFQ	PFQ	PFQ				PFQ	PFQ	M	Ana	1	
Mechanical Systems																
Grid Structure	M	Proof	M												1	1
Heat Pipes	M									PFQ				Proof	34	4
Radiators	M	Proof	M		PFQ	PFQ	PFQ			PFQ	PFQ				2	
Qual. Grid Assembly	M	Proof	M		PFQ, MM	PFQ, MM				PFQ, TM						1
Flight Grid Assembly	M	Proof	M												1	
Grid Ass'y w/ Radiators									PFQ, TM		PFQ, TM				1	
Electronic Systems																
TEM, SIU, ACD Units	M		M		PFQ	PFQ					PFQ	PFQ		Ana	20	3
Cable Harness	M		M													
LAT Flight Unit	M		M				Acc				Acc	Acc	M	Ana	1	
GLAST Observatory			M	M	Acc		Acc	Acc		Acc		Acc	M		1	

Ana:	Analysis	Acc:	Acceptance-level testing	M:	Measure or Inspect
MM:	Test, using Mass Models	PFQ:	Protoflight Qual-level testing	S:	Test sample of total
TM:	Test, using Thermal Models	Qual:	Prototype Qual-level testing	Y:	Yes, this is performed
		Proof:	Test to Proof levels		

Rev date: 26 Jan 01

Performance Test Matrix

	Parts Screening	Radiation/SEE	Visual, Dim.	Hi Temp Burn-In	Functional	Calibration	Special Testing	Flight Qt'y	Flight Spares
Tracker									
ASIC's	Y	Proof, S			Acc	Y		16128	2016+
EEE Parts	Y	Proof, S							
Front-End Boards				Proof	Acc			588	76+30
Silicon Detectors	Y		M, S				Leakage current, bad channels	9216	1152+518
Silicon Ladders			M, S				Leakage current, bad channels	2304	288+64
Qual Trays			M		Acc			10	
Qual Module (TKR #1)			M		Acc	Y		1	
Trays			M		Acc			294	38+10
Modules (TKR #2-18)			M		Acc	Y		15	2
Calorimeter									
ASIC's	Y	Proof, S			Acc	Y		3072	384+
EEE Parts	Y	Proof, S							
Front-End Boards				Proof	Acc			64	8
CsI Logs			M		Acc		Light output and uniformity	1536	192+24
Qual Module (CAL #1)			M		Acc	Y		1	
Modules (CAL #2-18)			M		Acc	Y		15	2
Anti-Coincidence Detector									
ASIC's	Y	Proof, S			Acc	Y		290	54
EEE Parts	Y	Proof, S							
Front-End Boards				Proof	Acc				
ACD Tiles, Fibers, PMT's			M		Acc		EMC testing on components	145	27
ACD Flight Unit					Acc	Y		1	
Mechanical Systems									
EEE Parts	Y	Proof, S							
Grid Assembly			M	Proof	Acc	Y	SC, GSE fit checks	1	
Electronic Systems									
ASIC's	Y	Proof, S			Acc	Y			
EEE Parts	Y	Proof, S							
TEM, SIU, ACD Boards				Proof	PFQ		Board-level EMC testing	62	10
TEM, SIU, ACD Units					Acc			20	3
LAT Calibration Unit					Acc	Y		1	
LAT Flight Unit					Acc	Y		1	

Ana:	Analysis
MM:	Test, using Mass Models
TM:	Test, using Thermal Models
Acc:	Acceptance-level testing
PFQ:	Protoflight Qual-level testing
Qual:	Prototype Qual-level testing
Proof:	Test to Proof levels
M:	Measure or Inspect
S:	Test on sample of total
Y:	Yes, this is performed

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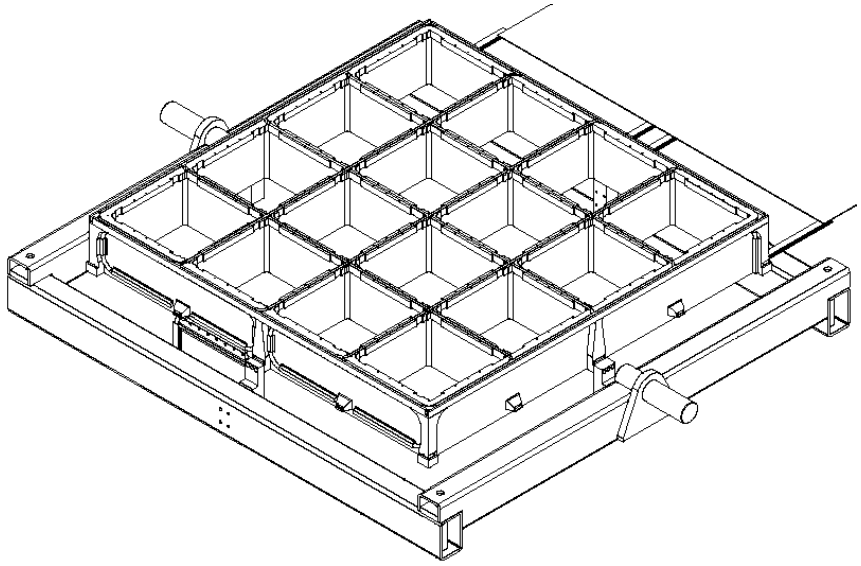
Calibration Planning

- "Calibration" means
  - Determining the fundamental response of detector elements
  - Determining the performance of the instrument
    - Characterizing variations over range of operations environments
    - Characterizing variations over time
- Calibration plan flows from the requirements: ground and on-orbit – integrated approach.
- Ground-based calibration effort is tightly coupled to the I&T plan:
  - sea-level muons and sources for detector elements
  - sea-level muons for LAT testing during environmental testing
  - beam tests in photon, electron, and hadron beams
- I&T and Calibration Planning Committee formed to:
  - develop systematic flow of requirements to detailed tests
  - develop Calibration Plan and I&T Plan
  - evaluate personnel needs, baseline schedule and budget
  - assess the facilities, equipment, and resources needed

Integration Planning Activities

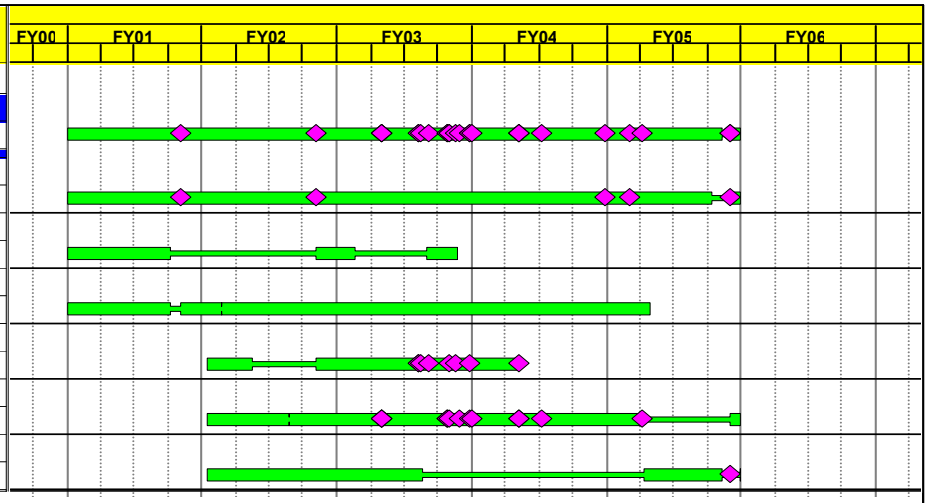
- LAT integration planning
  - Planning for subsystem integration has been included in development of interfaces and LAT design integration
  - Started developing concepts for integration GSE
- LAT integration facilities
  - New clean room facilities being built at SLAC for GLAST
  - Facilities include I&T infrastructure
    - Clean room with high bay
    - Storage for flight hardware
    - Environmental chambers for thermal-cycle testing
- Observatory integration support
  - LAT team has been involved in investigating options for Observatory integrating
  - LAT and Observatory require combined GSE and coordinated plans



Concept of LAT Integration Frame

4.1.9 I & T Schedule

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish
Gamma Ray Large Area Space Telescope				
4.1.9 INSTRUMENT INTEGRATION AND TESTING				
Subtota		1,241	10/02/00	09/30/05
+ 4.1.9.1 INTEGRATION & TEST MANAGEMENT				
		1,240	10/02/00	09/29/05
+ 4.1.9.2 RELIABILITY AND QUALITY ASSURANCE				
		717	10/02/00	08/22/03
+ 4.1.9.3 I & T PREPARATION				
		1,070	10/02/00	01/28/05
+ 4.1.9.4 CALIBRATION UNIT I & T				
		570	10/15/01	02/06/04
+ 4.1.9.6 FLIGHT LAT I & T				
		983	10/15/01	09/29/05
+ 4.1.9.7 MISSION INTEGRATION & TESTING				
		984	10/15/01	09/30/05



- **Currently developing I&T schedule**
  - ✓ **Scoping work**
  - ✓ **Identifying key I&T milestones**
  - o **Establishing linkages to other subsystems**
  - o **Identifying key hand-offs with other subsystems**

I&T Milestones

• Verification Test Plan Review	06/15/01
• TKR & CAL Modules A & B Ready for Integration into Calibration Unit	05/15/03
• TKR & CAL Modules 1 & 2 Ready for Integration into Calibration Unit	08/01/03
• Calibration Unit Beam Test Complete	01/17/04
• Flight Grid Ready for Integration	10/01/03
• Flight TKR & CAL Modules 3 & 4 Ready for Integration	10/01/03
⋮	
• Flight TKR & CAL Modules 15 & 16 Ready for Integration	12/24/03
• Flight TKR & CAL Modules 1 & 2 Ready for Integration	01/26/04
• Flight ACD Ready for Integration	01/26/04
• LAT Instrument Ready for Environmental Testing	04/09/04
• LAT Instrument Pre- ship Review	10/07/04
• LAT Instrument Ready for Integration with Observatory	12/22/04
• GLAST Launch	9/05

Interim Integration & Test Cost Estimate*

4.1.9 Integration & Test	FY00	FY01	FY02	FY03	FY04	FY05	Total
SLAC (DOE)	0	222.0	618.4	792.3	262.4	272.9	2168.0
HEPL (NASA)	0	0	0	802.1	1486.1	202.9	2491.2
Total	0	222.0	618.4	1594.4	1748.5	475.9	4659.2

Escalated k$
*DOE/NASA funding

- Interim estimate based on Proposal cost estimate
- Currently developing and checking I&T cost estimate

Issues

- **Integration schedule is tight**
  - Integration plans are for just-in-time delivery of subsystem modules
  - Early and incremental verification testing assures high probability of performance when integrating the LAT
  - Subsystem delivery milestones are visible at the project level to ensure close tracking of progress leading up to LAT integration
- **LAT and Observatory verification activities require close coordination**
  - We have been working on coordinated test plans with mission office
  - Expect to advance this work during the upcoming accommodation study