LAT Project Office – SLAC

DCN No. LAT-XR-441-01

DOCUMENT CHANGE NOTICE (DCN)

SHEET 1 **OF** 1

ORIGINATOR:	T. Boysen	**PHONE:**	(650) 926-5461	**DATE:**	11/26/01
CHANGE TITLE:	Initial WBS Release			**ORG.:**	4.1.1 Instr. Mgmt.

DOCUMENT NUMBER	TITLE	NEW REV.
LAT-MD-00033	LAT Work Breakdown Structure	05

CHANGE DESCRIPTION (FROM/TO):
New document.

REASON FOR CHANGE:
Initial document release.

ACTION TAKEN: ☐ **Change(s) included in new release** ☐ **DCN attached to document(s), changes to be included in next revision**
☐ **Other (specify):**

DISPOSITION OF HARDWARE (IDENTIFY SERIAL NUMBERS):	DCN DISTRIBUTION:
☒ **No hardware affected (record change only)**	
☐ **List S/Ns which comply already:**	
☐ **List S/Ns to be reworked or scrapped:**	
☐ **List S/Ns to be built with this change:**	
☐ **List S/Ns to be retested per this change:**	
☐	

SAFETY, COST, SCHEDULE, REQUIREMENTS IMPACT? ☐ **YES** ☐ **NO**
If yes, CCB approval is required. Enter change request number:

APPROVALS	DATE	OTHER APPROVALS (specify):	DATE
ORIGINATOR: T. Boysen (signature on file)	11/27/01		
ORG. MANAGER: W. Althouse (signature on file)	11/27/01		

DCC RELEASE:		Doc. Control Level: ☐ Subsystem ☒ LAT IPO ☐ GLAST Project

LAT MANAGEMENT DOCUMENT	Document # **LAT-MD-00033-05**	Date Effective 11/26/01
	Author(s) Tanya Boysen	Supersedes LAT-MD-00033-04
	System or Management Office Management	
Document Title **LAT Work Breakdown Structure**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Work Breakdown Structure

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
1	12/4/00	Ref. LAT-LR-00024-2; also reflects preliminary internal replanning in 4.1.1, 4.1.5, 4.1.7, 4.1.8, 4.1.C, 4.1.E.
2	12/22/00	Internal replanning in 4.1.1, 4.1.3, 4.1.4, 4.1.5, 4.1.6, 4.1.7, 4.1.8, 4.1.9, 4.1.A, 4.1.D, 4.1.E. Cost information has been suppressed in this version.
3	02/05/01	Internal replanning in 4.1.2, 4.1.4, 4.1.5, 4.1.7, 4.1.8, 4.1.9, 4.1.A,4.1.B, 4.1.D, 4.1.E. Preliminary WBS Dictionary entries have been included.
4	05/09/01	Internal replanning in all subsystems. WBS Dictionary, Responsible Institution, and Responsible Manager information included.
5	11/26/01	Internal replanning in all subsystems.

WBS	Task	Description	Responsibility	Manager
4.1	**GLAST LAT**	**All effort, materials and services required by the LAT team during formulation and hardware phases, from selection announcement (February, 2000) through launch. Includes: LAT instrument hardware and software development, fabrication, integration, test, calibration, and delivery; ground systems and software development (including equipment & software for post-launch data handling and analysis); supporting management and administration, systems engineering, performance and safety assurance, education & public outreach; support after delivery of the LAT instrument to the observatory contractor; and a balloon flight prototype test and other prototyping activities.**	**Stanford**	**Michelson**
4.1.1	**Instrument Management**	**All effort by the Instrument Principal Investigator, Instrument Project Manager, Instrument Technical Manager, and Instrument Scientist, including cost and schedule control (PMCS) management & staff, administrative support for the Instrument Project Office at SLAC and on the Stanford campus, and associated supplies, equipment, consultants and travel.**	**Stanford**	**Althouse**
4.1.1.1	Project Management	Provide the direction to complete the GLAST scientific investigation, and development of the LAT flight instrument and supporting elements. Includes the LAT Instrument Principal Investigator and administrative support at the Stanford campus, as well as the Instrument Project Manager, Instrument Technical Manager, and administrative support at SLAC, and associated supplies, equipment, consultants, and travel.	Stanford	Althouse
4.1.1.2	Cost & Schedule Control	Provide project control to develop and maintain instrument project master schedule and budget. Track actual costs (for DOE and NASA-funded activities) and schedule performance of all subsystems and institutions, and analyze performance compared to budget via the Project Management Control System (PMCS).	SLAC	Boysen
4.1.1.3	Instrument Scientist	In consultation with, and at the direction of, the LAT PI and LAT project office, the Instrument Scientist sets policy and plans: observation methodology, background rejection, onboard science, requirements and interface analysis, science operations planning and review, instrument calibration, instrument integration and test planning and review, observatory integration and test planning and review.	GSFC	Ritz
4.1.1.4	Science Preparation	Perform studies of observation and analysis methods, background, source characteristics (both point and diffuse emissions), AGN and GRB transient detection and analysis, and other generally related science issues as directed by the PI.	SLAC	Althouse
4.1.1.5	(Reserved)			
4.1.1.6	(Reserved)			

WBS	Task	Description	Responsibility	Manager
4.1.2	**System Engineering**	**The system engineering tasks of design integration, analysis, validation, and verification are contained in this work element. This element also contains system management, planning, tracking and documentation of the requirements, design, testing and data activities of the project.**	**SLAC**	**Thurston**
4.1.2.1	Requirements Management and Design Integration	This work element captures the requirements development and design integration of the LAT instrument.	SLAC	Thurston
4.1.2.1.1	Requirements Development, Validation & Verification	The systematic flow-down and capture of requirement activities are contained in this work element. It consists of documenting, reviewing, obtaining concurrence, tracking, and analyzing requirements for the Lat instrument. Effort is primarily labor related but does include M&S for engineering tools, and publications. Travel is not included.		
4.1.2.1.2	Design Integration	The integration activities related to the coordination of LAT subsystem design and interfaces. It consists of documenting, reviewing and tracking system and subsystem designs, and related interfaces. Effort is primarily labor and labor related M&S but does include engineering tools. Travel is not included.		
4.1.2.2	(Reserved)			
4.1.2.3	System Analysis	This element captures the system related analysis of LAT. This primarily consists of all functional and performance testing of LAT not covered in the subsystems and hardware I&T. Travel is not included.	SLAC	Thurston
4.1.2.4	Qualification and Tracking	This element captures the efforts related to maintaining, certifying, tracking and reporting on parts. Qualification lists are maintained, parts are qualified, and the use of all parts are tracked and reported.	SLAC	Thurston
4.1.2.4.1	Parts Qualification	This element captures parts qualification activities and hardware related to these activities. The effort covers labor and labor related M&S, testing equipment, laboratory usage, and test articles. Travel is not included.		
4.1.2.4.2	Parts Tracking/Reporting	This element captures the efforts necessary to maintain, update and report on the use of flight hardware. It documents part usage, heritage, certifications, and reliability. This effort is primarily labor and labor related M&S. Travel is not included.		
4.1.2.5	Risk and Reliability Analysis	This element covers the LAT reliability engineering activities. It addresses the required analyses and assurance activities for the LAT flight instrument and ground systems.	SLAC	Thurston
4.1.2.5.1	Risk Analysis	This element captures the risk analysis of the LAT instrument and ground systems. It also includes support of a Probabilistic Risk analysis to be performed by the GLAST project. This effort is primarily labor and labor related M&S, engineering tools, and periodic update of analyses. Travel is not included.		

WBS	Task	Description	Responsibility	Manager
4.1.2.5.2	Failure Analysis	This element captures the Failure Modes and Effects Analysis (FMEA) of the LAT instrument and ground systems. Periodic update of the analysis is also included. This effort is primarily labor and labor related M&S, and engineering tools. Travel is not included.		
4.1.2.6	Configuration Management and Document/Data Library	This element captures the efforts for maintaining documentation and data libraries for the project as well as managing the configuration of the instrument and ground systems throughout the development, implementation, and early operation of the LAT instrument.	SLAC	Thurston
4.1.2.6.1	Configuration Management	This element captures the operation of the configuration management system. It includes tracking changes, conducting changed boards reviews, and maintaining configuration documentation for the LAT instrument and LAT Ground Systems. This effort is primarily labor and labor related M&S, and engineering. Travel is not included.		
4.1.2.6.2	Document Library	This element captures the development, operation, and maintenance of a documentation library to warehouse, and distribute LAT documents. This effort is primarily labor and labor related M&S, but also includes library tools, and related software development. Travel is not included.		
4.1.2.6.3	Data Library	This element captures the development, operation, and maintenance of a data library to capture instrument performance data generated throughout the manufacturing, assembly, and performance testing processes. The library makes available data through out the LAT team. This effort is primarily labor and labor related M&S, but also includes engineering tools, and related software development. Travel is not included.		
4.1.2.7	Management and Planning	This element captures the efforts for managing and planning the system engineering activities of the LAT instrument and LAT ground systems. This effort is primarily labor and labor related M&S, but also includes engineering tools, and related software development. Travel is not included.	SLAC	Thurston

WBS	Task	Description	Responsibility	Manager
4.1.3	**(Reserved)**			

WBS	Task	Description	Responsibility	Manager
4.1.4	**Tracker**	**The Tracker consists of 16 towers mounted to the main instrument support structure, the grid. Each tower has 19 trays, 12 trays with thin converters (5% radiation length), 4 trays with thick converters (18% radiation length) and 3 trays with no converters. The tray structure is made of carbon fiber because it has a very low Z. The trays are stacked up and supported by four sidewalls that act as the thermal conductor for heat transfer to the grid. The towers are mounted to the grid with flexure attachments.**	**UCSC**	**R. Johnson**
4.1.4.1	Tracker Management	UCSC: Provide for analysis of scientific requirements relative to the design of the Tracker. Support the development of requirements for test and analysis, scientific analysis of calibration and performance test data. Support quarterly team meetings and travel thereto. SU-SLAC: Provide program scheduling, cost accounting, and performance tracking and reporting for entire subsystem, including managing performance of all activities related to the subsystem at UCSC, SU-SLAC, Hiroshima University, and INFN. Support development of subsystem specifications, verification plans, and interfaces between Tracker and neighboring subsystems, and control subsystems electrical, power, and environmental requirements and performance metrics. Support quarterly team meetings and travel thereto. Plan for, develop presentation data, and participate in the following reviews: DOE/NASA Reviews, I-SRR, Baseline Review, I-PDR, NAR, I-CDR, and suborbital test report. Support the closure of action items.	UCSC	R. Johnson
4.1.4.1.1	Management	Personnel and management of Tracker tasks.	UCSC/SLAC	R. Johnson/T. Borden
4.1.4.1.2	Tracker Support Personnel	Support science personnel for the Tracker.	UCSC/SLAC	R. Johnson/T. Borden
4.1.4.1.3	Travel (SLAC/UCSC)	Travel effort for UCSC and SLAC	SLAC/UCSC	R. Johnson/T. Borden
4.1.4.1.4	Project Support	Project support for office supplies, computers and related hardware/software as well as office support contracts.	SLAC/UCSC	R. Johnson/T. Borden
4.1.4.1.4.1	Project Support at SLAC	Project support for office supplies, computers and related hardware/software as well as office support contracts at SLAC	SLAC	T. Borden
4.1.4.1.4.2	Project Support at UCSC	Project support for office supplies, computers and related hardware/software as well as office support contracts at UCSC	UCSC	R. Johnson
4.1.4.2	Reliability & Quality Assurance	Tracker reliability and quality assurance effort	SLAC	T. Borden
4.1.4.2.1	Reliability Analysis	Develop written procedures and specifications for the procurement, fabrication, assembly, and testing of components, subassemblies, and complete Tracker modules in conjunction with UCSC, INFN, or any sub-suppliers.	SLAC	T. Borden
4.1.4.2.2	Quality Assurance Planning	Work with all organizations performing work for the subsystem, to ensure uniform compliance to standards and procedures, and to verify performance. Collect records and test data for the subsystem.	SLAC	T. Borden

WBS	Task	Description	Responsibility	Manager
4.1.4.3	Tray Sub-Assembly	Tracker tray design, analysis, fabrication and test activities.	SLAC-UCSC-INFN-Hiroshima	R. Johnson
4.1.4.3.1	Silicon Strip Detectors (SSD)	Design and prototype SSD's for the Tracker. Develop flight design, and testing procedures for detectors. Procure flight detectors, perform verification testing, and store detectors.	Hiroshima-INFN-SLAC	T. Ohsugi
4.1.4.3.1.1	SSD Production	Production and test of the SSDs at the commercial vendor.	Hiroshima-INFN-SLAC	T. Ohsugi
4.1.4.3.1.2	SSD Test and Storage	Test of cutouts at Hiroshima and storage of SSDs in Italy.	Hiroshima-INFN	T. Ohsugi/A. Brez
4.1.4.3.2	Tray Mechanical	Design, prototype, and test of the tracker trays including the development of the tray payload, including converters, bias circuit, and attachment methods including the SSD's, all fixtures required for the tray structure fabrication, and fabrication of all of the required tray structures.	SLAC/INFN	T. Borden
4.1.4.3.2.1	Design Prototype And Test Tray Structure (Hytec)	Detailed design, prototype and test of the tray panel structure (including tests with the payload attached).	SLAC	T. Borden
4.1.4.3.2.2	Thick-Converter Tray Development (INFN)	Detailed analysis and testing of the thick-converter tray assembly, based on the thin-converter tray-panel design, but with heavier face sheets and/or core.	INFN	A. Brez
4.1.4.3.2.3	Thin-Converter Payload Development	Development of the thin converter, bias circuit, and the SSD attachment method.	INFN	A. Brez
4.1.4.3.2.4	Thick-Converter Payload Development	Development of the thick converter, bias circuit, and the SSD attachment method based on the thin converter design.	INFN	A. Brez
4.1.4.3.2.5	Mechanical EM Tray Panel Fab (INFN)	Fabrication of the EM trays in Italy.	INFN	A. Brez
4.1.4.3.2.6	Tray Panel Fabrication Fixtures (INFN)	Fixtures required for the tray panel fabrication in Italy.	INFN	A. Brez
4.1.4.3.2.7	Fab Flight Instrument Tray Panel Structures (INFN)	Fabrication of the flight trays in Italy.	INFN	A. Brez
4.1.4.3.3	Tray Electronics	Design, prototype, fabricate, and test ASIC's and printed wiring boards for the Tracker subsystem front end electronics.	SLAC/UCSC	D. Nelson
4.1.4.3.3.1	Testing Of Prototype Electronics	All testing of the prototype electronics.	UCSC	R. Johnson
4.1.4.3.3.2	Electronics design reviews (SLAC/UCSC)	All of the design reviews associated with the electronics.	SLAC/UCSC	D. Nelson
4.1.4.3.3.3	Detector Bias Circuit/Converters (SLAC/UCSC)	Design of the Bias circuit.	SLAC/UCSC	R. Johnson
4.1.4.3.3.4	MCM board design (SLAC/UCSC)	Design and layout of the MCM electronics board including routing.	SLAC/UCSC	R. Johnson
4.1.4.3.3.5	Final Design Readout Chip (SLAC/UCSC)	Final iteration of the design of the front-end readout chip.	SLAC/UCSC	R. Johnson
4.1.4.3.3.6	Final Design Readout Controller Chip (SLAC/UCSC)	Final iteration of the design of the readout controller chip.	SLAC/UCSC	D. Nelson
4.1.4.3.3.7	Electronics test, QC, burn-in stations (UCSC)	Design, fabrication, and verification of the electronics test, QC, and burn in stations for the electronics.	UCSC	R. Johnson
4.1.4.3.3.8	Electronics Modules for Engineering Model (UCSC)	Production of dummy and live MCM readout modules for the Tracker engineering model.	UCSC	R. Johnson

WBS	Task	Description	Responsibility	Manager
4.1.4.3.3.9	Fabricate and test ASICs (UCSC)	Fabricate the ASICs and test them with wafer probing	UCSC	R. Johnson
4.1.4.3.3.A	Fabricate Flight Electronics Modules (SLAC/UCSC)	Fabricate, Test and ship to Italy the flight MCM's	SLAC/UCSC	R. Johnson
4.1.4.3.4	Tray Assembly	Prepare plans to assemble SSD ladders, tray structures, assemble trays (using bias/converter and MCM electronics assemblies supplied by UCSC/SLAC), and perform verification tests on assembled trays, in compliance with SLAC requirements.	INFN	A. Brez
4.1.4.3.4.1	Ladder Assembly Development (INFN)	Development of the tooling and processes for the SSD ladders.	INFN	A. Brez
4.1.4.3.4.2	Ladder Placement Development (INFN)	Development of the tooling and processes required for ladder placement on the tray panels.	INFN	A. Brez
4.1.4.3.4.3	Electronics Integration Development (INFN)	development of the tooling and processes required for MCM placement on the tray panels.	INFN	A. Brez
4.1.4.3.4.4	EM Ladder Assembly (INFN)	Assembly of the EM SSD ladders.	INFN	A. Brez
4.1.4.3.4.5	EM Tray Assembly (INFN)	Assembly of the EM trays.	INFN	A. Brez
4.1.4.3.4.6	Establish Flight-Tray Assembly Line (INFN)	Establish the tray assembly line, or lines, required for the flight tray assembly.	INFN	A. Brez
4.1.4.3.4.7	Assemble Flight Ladders (INFN)	Assembly of the flight SSD ladders.	INFN	A. Brez
4.1.4.3.4.8	Assemble Flight Trays (INFN)	Assembly of the flight trays.	INFN	A. Brez
4.1.4.3.5	SLAC Assembly Facilities	Design, establish, outfit and support clean room facilities at SLAC required for the assembly of the Tracker Towers.	SLAC	O. Millican
4.1.4.3.5.1	Establish Clean-Room at SLAC	Design and manage construction of the clean room at SLAC	SLAC	O. Millican
4.1.4.3.5.2	Procure Tracker Assembly Equipment	Define, purchase and commission the required tracker assembly equipment.	SLAC	O. Millican
4.1.4.4	Tower Structure & Assembly	Design the Tracker Tower structure, including attachement to the grid, procure required hardware and assemble the engineering model, qualification and flight towers.	SLAC-INFN-UCSC	T. Borden
4.1.4.4.1	Tower Structure (SLAC)	Perform structural and thermal design and analysis of the Tracker tower and trays in support of, and in conjunction with, the instrument design. Design and support the testing of the Tracker tower attachment and handling equipment.	SLAC	T. Borden
4.1.4.4.1.1	Tower Design, Analysis, Detailing (SLAC/Hytec)	Engineering design, analysis and detailing of the flight Tracker tower design.	SLAC	T. Borden
4.1.4.4.1.2	EM Engineering Support (Hytec)	Support of the EM Tracker tower design during the EM test phase.	SLAC	T. Borden
4.1.4.4.2	Tower Cable Plant (SLAC/UCSC)	Design, prototype, and test Kapton flex cables that connect tray front-end electronics to data acquisition system. Supply flight cables.	SLAC/UCSC	R. Johnson
4.1.4.4.2.1	Layout, Detail Flex Circuit Cables (UCSC)	Detailed design and layout of the Tower flex cables.	UCSC	R. Johnson
4.1.4.4.2.2	Fabricate Flex Circuit Cables (UCSC)	Fabrication of the Tower flex cables.	UCSC	R. Johnson
4.1.4.4.3	Tower Assembly	Develop tower assembly fixtures and procedures. Procure tower components. Assemble EM, Qualification, and Flight units.	SLAC/INFN	T. Borden

WBS	Task	Description	Responsibility	Manager
4.1.4.4.3.1	Tower Assembly Line (SLAC)	Procure and set up the equipment for tower assembly at SLAC.	SLAC	T. Borden
4.1.4.4.3.2	Procure EM Tower Components (SLAC)	Procurement of all components and materials needed for EM towers.	SLAC	T. Borden
4.1.4.4.3.3	Engineering Model Assembly (SLAC)	Stack the engineering model trays, attach readout cables and walls, and test.	SLAC	T. Borden
4.1.4.4.3.4	Procure Flight Tower Components (SLAC)	Procurement of all components and materials needed for flight towers.	SLAC	T. Borden
4.1.4.4.3.5	Qual Tower Assembly (SLAC)	Assembly of the first two Tracker towers to be used as the qualification units.	SLAC	T. Borden
4.1.4.4.3.6	Flight Tower Assembly (INFN)	Assembly of the 16 flight Tracker towers in Italy.	INFN	A. Brez
4.1.4.5	Tracker Test & Calibration	All activities associated with the test and calibration of the Tracker towers.	SLAC/INFN	T. Borden
4.1.4.5.1	EM Tower Testing (SLAC)	Prepare mechanical and electrical test plans for EM tower. Support integration and test of EM tower.	SLAC	T. Borden
4.1.4.5.2	Qualification Tower Testing (SLAC)	Prepare mechanical and electrical test plans for qualification towers. Support integration and test of qualification towers.	SLAC	T. Borden
4.1.4.5.3	Flight Tower Testing (INFN)	Perform mechanical and electrical tests on flight towers in Italy.	INFN	A. Brez
4.1.4.5.4	Tracker Test Facilities (SLAC)	Design, procure and fabricate mechanical and electrical test equipment and fixtures for Tracker towers at SLAC.	SLAC	T. Borden
4.1.4.6	(Reserved)			
4.1.4.7	Instrument Integration & Test (SLAC)	Support the integration and test of the Tracker towers to the instrument at SLAC.	SLAC	T. Borden
4.1.4.7.1	Qual-Tower GLAST I&T Support	Support GLAST integration and test effort of Tracker qualification towers. Support beam testing as required.	SLAC	T. Borden
4.1.4.7.2	Instrument I&T Support	Support GLAST integration and test effort of Tracker flight towers into instrument as required.	SLAC	T. Borden
4.1.4.7.3	Tracker I&T Equipment	Design, procure and fabricate integration and test equipment.	SLAC	T. Borden
4.1.4.7.4	Tracker Operations Support	Support Tracker operations during launch phase.	SLAC	T. Borden
4.1.4.8	Mission Integration & Test Support	Support to the mission integration and test process.	SLAC	T. Borden
4.1.4.8.1	Tracker Mission I&T Support	Support mission integration and test as required.	SLAC	T. Borden
4.1.4.8.2	Tracker Pre-Ops Support	Support to the mission integration and test pre operations as required.	SLAC	T. Borden

WBS	Task	Description	Responsibility	Manager
4.1.5	**Calorimeter**	The CAL provides the energy measurement of incident photons and background particles. These measurements, along with the information in the TKR, are used to reconstruct the energy of the incident photons. These CAL measurements are also critical to the background particle identification and rejection. The CAL responds to TDF requests by digitizing the energy loss in the CAL and outputs the data to the dataflow system. The CAL also provides fast signals to the T&DF system that report significant energy depositions in CAL. The T&DF system analyzes these fast signals to form requests for data readout of GLAST. The CAL subsystem consists of a 4x4 array of identical modules. Each module is a hodoscopic array of CsI scintillation crystals and associated readout electronics.	**NRL**	**N. Johnson**
4.1.5.1	Calorimeter Program Management and Administration	This WBS element provides for the planning, organizing, and controlling of the technical, administrative, and financial requirements of the program. It provides for program scheduling, performance tracking and reporting, contract administration. Supports preparation for and participation in scheduled program reviews. Cost & Schedule Control This element also provides support in the area of cost and cost control. Also includes the effort to develop and maintain program schedules. Subcontracting & Procurement	NRL	P. Carosso
4.1.5.1.1	Configuration & Document Management	This element includes the establishment and implementation of a formal configuration management system. It also includes the compilation, review, reproduction, and distribution of all needed project documentation.	NRL	P. Carosso
4.1.5.1.2	Program & Design Reviews	Participate in Program Reviews, design presentations, project technical interchange meetings.	NRL	P. Carosso
4.1.5.1.3	Travel	Travel to team meetings, coordination meetings, and reviews.	NRL	P. Carosso
4.1.5.1.4	Science	Provides for analysis of scientific requirements relative to design of calorimeter. Supports the development of requirements for the test and analysis systems and scientific analysis of calibration and performance test data. Supports quarterly team meetings and travel thereto.	NRL	P. Carosso
4.1.5.1.5	French Management	This WBS element provides for the planning, organizing, and controlling of the technical, administrative, and financial requirements of the french part of the program.		

WBS	Task	Description	Responsibility	Manager
4.1.5.2	Systems Engineering	This WBS element provides for the Calorimeter Systems analysis and for coordination of Systems Engineering activity across CAL sub-systems and across LAT elements This element does not include system specific systems engineering that do not cross system boundaries. Includes definition of all relevant technical interfaces. This element includes the effort to define the overall instrument design as well as the definition of the performance verification requirements and methods. The evaluation of instrument test data is also included. Life testing of critical elements is included in this task. Additional responsibilities include: .1 Calorimeter System Requirements and Specs .2 Allocation and Margin Mgmt. .3 System Verification	NRL	P. Carosso
4.1.5.3	Reliability and Quality Assurance	This element provides for the planning and implementation of all Mission Assurance related activities for the LAT Calorimeter. Mission assurance also provides input into the requirements of make-buy decision, build plan, configuration control, fabrication/assembly/test and software documentation, project management reports and reviews, inherited hardware, mission assurance program elements, performance verification, system safety, parts control, material and process control, design assurance and reliability, quality assurance, contamination control, and software assurance.	NRL	N. Virmani
4.1.5.3.1	Reliability	The reliability element refers to the performance of those tasks necessary to ensure the overall reliability of the Calorimeter subsystem.		
4.1.5.3.2	Safety	The Safety element refers to the performance of those tasks necessary to ensure the overall safety of the Calorimeter subsystem. Thi sincludes preparing inputs for Hazards Analysis Reports, development of safety non-compliance reports, performance of operating and support hazards analyses, preparing safety assessment reports and developing/reviewing ground operations plans.		
4.1.5.3.3	Flight Assurance	The Flight Assurance element refers to the effort required to establish requirements for and maintain the overall Quality of the Calorimeter subsystem. This effort includes the effort required to develop a Quality Plan and develop work order database system, as well as inspect, audit, and monitor Quality and maintain a non-conformance reporting system as required for the duration of the Calorimeter subsystem development effort.		
4.1.5.3.4	Flight Model Proc/Fab/Assy/Test	The Flight Model Proc/Fab/Assy/Test element refers to the effort required to fabricate and test for integration with the Flight LAT.		

WBS	Task	Description	Responsibility	Manager
4.1.5.4	Calorimeter Design	This element includes the analyses, technical trades to go from the initial concept to a mature design, generating manufacturing drawings, manufacturing, assembly, and verification. . Performance requirements for each assembly are to be allocated (TBR).	NRL	B. Phlips
4.1.5.4.1	Calorimeter Instrument Design	This element includes the Calorimeter design work performed at NRL, including technical oversight and engineering management.	NRL	
4.1.5.4.2	Structure	This element includes the Calorimeter Structural design work performed at NRL, including technical oversight and engineering management.	NRL	
4.1.5.4.2.1	PEM Structure Design	Design of the PEM mechanical structure, from concept definition through detailed fabrication design. Includes analytical and design work for all program phases and support of all program reviews. Design work is performed in close coordination with the NRL Program Office and the IPO.	IN2P3	Bederede
4.1.5.4.2.2	PEM Structure Verification	Development of comprehensive Verification Plan for the PEM at all development phases, from Verification Modules, through flight model. Addresses all requirements definition for test of the PEM, development of the Verification Matrix, development of test plans and procedures. Includes test implementation, staffing, and data analysis.	IN2P3	Ferreira
4.1.5.4.3	Thermal Design	Thermal design of CAL modules and CAL/LAT interface. Provides for the development of thermal models of the calorimeter to verify the integrity and performance expected at launch and in orbit. These models shall be integrated into the overall GLAST/LAT models. LPNHE to provide thermal model of PEM/Electronics to NRL for inclusion into the SLAC LAT model.	NRL	
4.1.5.4.4	Power	IPO to lead CAL power system design – integrated with tracker. This element coordinates design and requirements with IPO at SLAC. Power system elements (TBD) are developed by Saclay in coordination with IPO.	NRL	
4.1.5.4.5	Simulations	Provides for Monte Carlo simulations of calorimeter configurations to optimize calorimeter segmentation, calorimeter triggers, investigate scientific performance degradation caused by gaps and passive material inserted due to the calorimeter mechanical structure, investigates cosmic ray rejection algorithms which influence requirements on the calorimeter electronics as well as data acquisition processing requirements. Simulations of configurations used in beamtests will be used in comparison with beam test data for validation of the models and performance issues.	NRL	Grove

WBS	Task	Description	Responsibility	Manager
4.1.5.5	Csl Detector Elements (CDE)	The CsI detector module shall be designed in France to be compatible with the mechanical structure also designed there. Sweden will procure and acceptance test the CsI crystals. France will procure and acceptance test the PIN photodiodes and their connection (TBR). (An initial set of PIN photodiodes will also be procured by NRL and CEA in support of EM (VM2) development). Pin Diodes have to be optically coupled at both ends of the cristal. These assembled pieces are inserted into the module structure, tested, and finally shipped to NRL where the Calorimeter module integration and test is completed. Provides for the design, procurement, assembly and test of the CsI/PIN detector modules. Design is 12 crystals per layer and 8 layers in the calorimeter. Crystal dimensions are in LAT-DS-00095, Calorimeter CsI Crystal Specification. Custom dual PIN photodiode are procured from Hamamatsu.	NRL	P. Carosso
4.1.5.5.1	CDE design	Coordination of the overall Crystal Detector Elements, including PIN photodiodes and CsI crystal components. Performance of configuration trade studies. Development and approval of requirements and specifications.	NRL	P. Carosso
4.1.5.5.1.1	PIN optical coupling	R&T development of the optical coupling of the Dual PIN Photodiodes on the cristal, performances of the Dual Pin Photodiodes and wrapping of the cristal. Two options for the optical coupling: the base line is epoxy glue and the second option is silicone elastomer compressed on the cristal. Bonding material selection. Develop requirements and procedures to perform bonding on test samples, addressing various materials, bond thickness and bonding procedures. Evaluate mechanical and optical performance after implementation of radiation aging and thermal cycling.	IN2P3	Bogaert, Chaperon
4.1.5.5.1.1.1	Bonding process development	Development and choice of the PIN diode bonding process.	IN2P3	Bogaert, Chaperon
4.1.5.5.1.1.1.1	Bonding process choice	Study various bonding options, performing tests of bond strength and thermal cycling. Use glass and CsI samples.	IN2P3	Bogaert, Chaperon
4.1.5.5.1.1.1.2	EM Model CDE Bonding	Select bond material for EM crystal detector elements. Test performance.	IN2P3	Bogaert, Chaperon
4.1.5.5.1.1.1.3	PIN Bonding Test	Complete qualification testing of EM bond material	IN2P3	Bogaert, Chaperon
4.1.5.5.1.1.2	Bonding GSE	Realization of all the bonding tools for the test and the final indutrial assembly	IN2P3/CEA-Saclay	Bogaert, Chaperon
4.1.5.5.1.1.3	Silicone compression study	Determination of the compression to be appied on the PIN to have a good and reliableoptical coupling.	IN2P3/CEA-Saclay	Chapron , Bourgeois
4.1.5.5.1.1.4	Compression test GSE	Realization of the tools for the optical coupling for the tests and measurement of the Icosmic test bench (saclay)	IN2P3/CEA-Saclay	Chapron , Bourgeois
4.1.5.5.1.2	Dual PIN Photodiodes performance tests	Performances tests on the Dual Pin Photodiode have to be check as thermal and radioactive hardnesses, cross talk between the small and large Pin Photodiodes, sensibility at the CsI(Tl) scintillation wavelengthes.	CEA-Saclay	Bourgeois

WBS	Task	Description	Responsibility	Manager
4.1.5.5.1.3	Crystal performance & wrapping study	Studies on the cristal performances (tappering) and its wrapping will be perform on a cosmic test bench. This test bench will be used also for different performance tests on the cristals of VM2.	IN2P3/CEA-Saclay	Bogaert, Bourgeois
4.1.5.5.1.3.1	Improvement of Cosmic Bench	Provide materials and electronics to improve performance of cosmic bench hodoscope.	CEA-Saclay	Bourgeois
4.1.5.5.1.3.2	Wrapping	Order and test various wrapping materials from 3M to determine performance characteristics	IN2P3	Bogaert
4.1.5.5.2	Csi(TI) Scintillation Crystals	Procure 2240 CsI(Tl) crystals per LAT-DS-00095-02 LAT Calorimeter CsI Crystal Specification. Initial delivery of 24 crystals due May 1st, 2001, to support EM development. Partial deliveries (106 and 110 crystals respectively) are due in July 2001 and April 2002. Final delivery of 1800 crystals will occur on July 2002- April 2003. Perform acceptance testing – metrology and performance (light yield). Use temporary wrapping and PMT readout during testing.	KTH Sweden	Carlsson
4.1.5.5.2.1	CsI Procurement	Support development of the CsI crystals procurement specifications. Procurement of crystals according to agreeded upon phasing in support of EM development and flight units production. (Controlling documents: LAT/CAL-Sweden MoA, LAT-DS-00095-02 LAT Calorimeter CsI Crystal Specification.	KTH Sweden	
4.1.5.5.2.2	CsI Acceptance Testing/Verification	Upon arrival of crystals, photograph crystals for the record (recommended by NRL but not in Swedish plan), and measure physical dimensions, as well as surface finish on six surfaces. Enter data in database. Perform acceptance testing for absolute light yield and light asymmetry amplitude and uniformity. Compare acceptance measurements with those of the supplier. Note discrepancies and reject out-of-spec material. Acceptance test utilizes mechanical test bench described in GLAST XXX-YYY (TBD xxx copies located at: S, vendor, yyy, zzz) Acceptance test requirements and procedures defined in LAT-DS-00095-02 LAT Calorimeter CsI Crystal Specification.	KTH Sweden	
4.1.5.5.2.2.1	CsI Test GSE	Development of the test benches to perform acceptance testing defined in above para, including requirements definition, design, test specifications and procedures development. Mechanical test bench: 3 copies, located at TBD (1 in the Ukraine, 1 in Sweden, and 1 in France) - Optical test bench: 4 copies located at TBD(replace with 6 benches, 2 in Ukraine, 2 in Sweden, 1 in France, 1 in US)	NRL KTH Sweden	
4.1.5.5.2.2.2	CsI acceptance test in France	Test at french delivery	IN2P3/CEA	Bogaert

WBS	Task	Description	Responsibility	Manager
4.1.5.5.3	Dual PIN photoDiode (DPD)	Support development of the PIN photodiodes design and procurement specifications. Procurement of photodiodes according to agreed upon phasing in support of EM development and flight units production. (Controlling documents: LAT-MD-00044, Memorandum of Agreement – French Participation in GLAST , LAT-DS-00072, Specification for the Calorimeter PIN Photodiode Assembly, LAT-DS-00209, Specification for the Calorimeter PIN Photodiode Assembly (Flight Units). Purchase 4400 custom dual PIN photodiodes. Ceramic package and pin design will need modification from prototype design. Incoming inspection: Visual inspection of factory epoxy coating on surface for bubbles or inclusions (expect ~ 1% rejection rate). Inspect electrical contact. Measure capacitance and leakage current (at room temp) for each diode pair. Log serial number and batch number and diode test result.	CEA-Saclay	Bederede
4.1.5.5.3.1	DPD Procurement	Support development of the Dual PIN photodiodes procurement specifications. Procurement of photodiodes according to agreed upon phasing in support of EM development and Flight moduls production. (Controlling documents: LAT-MD-00044, Memorandum of Agreement – French Participation in GLAST , LAT-DS-00072, Specification for the Calorimeter PIN Photodiode Assembly, LAT-DS-00209, Specification for the Calorimeter PIN Photodiode Assembly (Flight Units).	CEA-Saclay	Bederede
4.1.5.5.3.1.1	VM2 EM Procurement	Procure photodiodes for VM2 and EM testing	CEA-Saclay	Bederede
4.1.5.5.3.1.2	DPD Flight Model Procurement	Develop specification and select vendor for flight diodes	CEA-Saclay	Bederede
4.1.5.5.3.1.3	PIN Manufacturing	Fabricate and deliver flight photodiodes by selected vendor.	CEA-Saclay	Bederede
4.1.5.5.3.2	DPD Acceptance & Test	Development of requirements, plans and execution of the photodiodes acceptance test according to the specification defined in 4.1.5.5.3.1.	CEA-Saclay	Bourgeois
4.1.5.5.3.2.1	DPD VM2 EM Tests	Perform testing on VM2 and EM PIN photodiodes	CEA-Saclay	Bourgeois
4.1.5.5.3.2.1.1	VM2 Electrical Tests	Measure leakage current and capacitance	CEA-Saclay	Bourgeois
4.1.5.5.3.2.1.2	EM DPD Acceptance Tests	Measure electrical and mechanical characteristics of EM diodes	CEA-Saclay	Bourgeois
4.1.5.5.3.2.2	Double PIN Main Procurement	Reception and acceptance of flight PIN photodiodes	CEA-Saclay	Bourgeois
4.1.5.5.3.3	DPD Test GSE	For VM2&EM DPD tests will use “lab bench”. For QM and FM DPD tests will be performed with “industrial bench”.	CEA-Saclay	Bourgeois
4.1.5.5.3.3.1	PIN Test for VM2 Bench	Create spec for PIN test bench	CEA-Saclay	Bourgeois
4.1.5.5.3.3.2	PIN Industrial Test Bench	Create spec for PIN test bench to be developed in industry for flight PIN processing. Develop procedures and train operators.	CEA-Saclay	Bourgeois

WBS	Task	Description	Responsibility	Manager
4.1.5.5.4	Dual PIN Photodiode Interconnect	Kapton cable is the base line for the connection of the Dual PIN photodiodes to the electronic board. Design and test kapton cable. Solder kapton connector on PIN diodes	NRL	Ampe
4.1.5.5.4.1	DPD connection procurement	Support development of the Dual PIN photodiode connection procurement specifications. Procurement of Kapton cables according to agreed upon phasing in support of EM development and Flight moduls production.	CEA-Saclay	Prat
4.1.5.5.4.2	Soldering on DPD	Subcontracting the soldering of the Kapton cable on the Dual PIN Photodiodes with respect to the Spatial norms.	CEA-Saclay	Prat
4.1.5.5.4.3	Connection Acceptance	Development of requirements, plans and execution of the Kapton cables acceptance test before and after soldering according to the specification defined in 4.1.5.5.4.1. and4.1.5.5.4.2.	CEA-Saclay	
4.1.5.5.4.4	Interconnect Qualification	Qualification of the connection part	CEA-Saclay	Prat
4.1.5.5.5	CDE I&T	France shall fixe Dual PIN Photodiodes at both ends of the Csi(Tl) cristal with a good optical coupling (assume the 5000e/MeV for the bigger Pin Photodiode). This assembly will be done in Lab for VM2 (12 CDE) and EM (96 CDE). This allow to define then valide the assembly procedure. The assembly and test of 2 QM and 16 FM will be subcontract to industry.	IN2P3/CEA-Saclay	Bederede
4.1.5.5.5.1	VM2 CDE I&T	College de France will assembly 12 CDE necessary to equip a layer of the Verification Module #2. They will check the good optical coupling (no bubbles in particular). Saclay will check the performance of the CDE after having check the performance of the cristal deliveryed from Sueden.	IN2P3	Chaperon
4.1.5.5.5.1.1	Crystal Test	Perform acceptance testing on crystals received from Sweden	IN2P3	Chaperon
4.1.5.5.5.1.2	CDE Manufacturing for VM2	Assemble VM2 CDE - bonding PINs to crystals, wrapping and testing on cosmic bench.	IN2P3	Chaperon
4.1.5.5.5.2	EM CDE A&T	College de France will assembly and test the 96 CDE of the Engineering Module. This will valide the CDE A&T procedure which will be used by industry for the next modules.	IN2P3	Chaperon
4.1.5.5.5.2.1	Swedish Crystals Receipt	Acceptance testing on EM crystals	IN2P3	Chaperon
4.1.5.5.5.2.2	EM's CDE Assembling	Bond PINs to crystals, wrap and test on cosmic bench	IN2P3	Chaperon
4.1.5.5.5.3	QM-FM CDE A&T	CDE Assembly and test for QM and FM will be subcontracting to industry.	IN2P3	Chaperon
4.1.5.5.5.4	CDE Performance Testing			
4.1.5.5.5.5	CDE test GSE	France shall supply any required test benches necessary for testing individual logs before placement in flight module (QM and FM). Develop GSE to perform the PIN photodiode bonding, and implement qualification and acceptance testing. This includes: mechanical strength, transparency, and light yield.	IN2P3	A. Djannati
4.1.5.5.5.5.1	Gluing Tools for Double PINS	Design and fab fixtures needed for bonding PIN diodes to the crystals	IN2P3	J.C. Vanel

WBS	Task	Description	Responsibility	Manager
4.1.5.5.5.2	Gluing Test Bench	Develop spec, procure, and assemble test bench to measure the light yield of PIN bonds to crystals.	IN2P3	J.C. Vanel
4.1.5.6	Pre-Electronics Module (PEM)	The Pre electronic module is made up of the CDE and the structure with all its elements . This chapter includ the Integration of the P and its test for all the models from VM2 , EM, tand F1 to F18	NRL	Carosso
4.1.5.6.1	PEM Structure Fabrication & Test	Provide the base structure onto which the CDE are assembled. These support the loads along the launch vector. Provides for the design and fabrication of the elastomeric pads separating the CsI blocks from the mechanical structure. The characteristics of the pads are tailored to provide the required loading while absorbing the thermal expansion of CsI over the expected temperature range. Need E/M version ~ 6/01(supressed) Need 1st Calib version ~ 12/01 (supressed)	IN2P3	Bogaert
4.1.5.6.1.1	VM2 Structure	Fabrication and test of the structure of VM2 to test the concept of PEM structure	IN2P3	Ferreira
4.1.5.6.1.1.1	Structure Mat'l Supply and Test	Evaluate materials for manufacturing of PEM structure and the holding of CsI crystals within the cells	IN2P3	Ferreira
4.1.5.6.1.1.2	Structure Hardware and Tests	Study hardware concepts - insert strength, CsI crystal bumpers, composite structure manufacturing	IN2P3	Ferreira
4.1.5.6.1.1.3	Structure Fabrication	Fab VM2 structure	IN2P3	Ferreira
4.1.5.6.1.2	EM Structure	Fabrication and test of the structure of EM to valide the concept of PEM structure	IN2P3	Ferreira
4.1.5.6.1.2.1	Structures Material Supply and Test	Evaluate materials for manufacturing of PEM structure and the holding of CsI crystals within the cells	IN2P3	Ferreira
4.1.5.6.1.2.2	EM Structure MFG	Study hardware concepts - insert strength, CsI crystal bumpers, composite structure manufacturing	IN2P3	Ferreira
4.1.5.6.1.2.3	EM Structure Qualification	Fab EM structure	IN2P3	Ferreira
4.1.5.6.1.3	QM-FM Structure	Fabrication and test of the structure of Flight Module following the procedure valided with EM (including the Qualification Module).	IN2P3	Ferreira
4.1.5.6.1.3.1	QMA Structure	Build and qualify the Qual Model structure	IN2P3	Ferreira
4.1.5.6.1.3.1.1	Structure FAB	Procure materials and manufacture the QM structure	IN2P3	Ferreira
4.1.5.6.1.3.1.2	QMA Structure Qualification	Qualify the QM structure	IN2P3	Ferreira
4.1.5.6.1.3.2	FM B - 16 Structures	Build and qualify the FM B structure	IN2P3	Ferreira
4.1.5.6.1.3.2.1	Structures FAB	Procure materials and manufacture the FM b structure	IN2P3	Ferreira
4.1.5.6.1.3.2.2	FMB Structure Qualification	Qualify the FMB structure	IN2P3	Ferreira
4.1.5.6.1.3.2.3	FM 1 - 16 Structure FAB	Procure materials and manufacture the FM 1 - 16 structure	IN2P3	Ferreira
4.1.5.6.1.4	Structure GSE	Tools and matrix for the fabrication of the structure. Also all the tools for assemblind and for handling the PEM	IN2P3	Ferreira
4.1.5.6.1.4.1	VM2 & EM Tooling for Composite Structure	Design, procure and assemble tooling for fabrication of VM2 and EM structure	IN2P3	Ferreira
4.1.5.6.1.4.2	QM & FM Tools for Structure Realization	Design, procure and assemble tooling for fabrication of Flight structure	IN2P3	Ferreira

WBS	Task	Description	Responsibility	Manager
4.1.5.6.2	PEM Assembly & Test	Provides mechanical support for stacking and aligning the CsI detectors (CDE) in the structural module. Compression application and measurement tools are required. Includes insertion of CDEs in the PEM Structures Handling fixtures for moving and orienting the loaded modules shall be designed and fabricated.	IN2P3	Bogaert
4.1.5.6.2.1	VM2 Integration & Test	I&T of the VM2 model built with 12 crystals	IN2P3	
4.1.5.6.2.1.1	VM2 Integration	Assembly of the VM2 module		
4.1.5.6.2.1.2	VM2 Testing	Testing of the VM2 model		
4.1.5.6.2.2	EM Integration & Test	I&T of the EM model with 96 crystal . It is send to NRL for comprehensive mounting & test of the complete calorimeter module	IN2P3	
4.1.5.6.2.2.1	EM Integration	Integration of the fully populated EM module		
4.1.5.6.2.2.2	EM Testing & Calibration	Test and calibration of the EM module		
4.1.5.6.2.3	QM-FM I&T	I&T all FM model of the calorimeter . It is send to NRL for comprehensive mounting & test of each of the 18 complete calorimeter modules	IN2P3	
4.1.5.6.2.3.1	FM A (Qual) Integration & Test	Integration and Test of PEM module A		
4.1.5.6.2.3.1.1	FM A Integration	Integration of PEM module A		
4.1.5.6.2.3.1.2	FM A Testing & Calibration	Test and calibration of PEM Module A		
4.1.5.6.2.3.2	FM B Integration & Test	Integration and Test of PEM module B		
4.1.5.6.2.3.2.1	FM B Integration	Integration of PEM module B		
4.1.5.6.2.3.2.2	FM B Testing & Calibration	Test and calibration of PEM Module B		
4.1.5.6.2.3.3	FM 1 Integration & Test	Integration and Test of PEM module number 1		
4.1.5.6.2.3.3.1	FM 1 Integration	Integration of PEM module no. 1		
4.1.5.6.2.3.3.2	FM 1 Testing & Calibration	Test and calibration of PEM Module no. 1		
4.1.5.6.2.3.4	FM 2 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.4.1	FM 2 Integration	Integration of PEM module		
4.1.5.6.2.3.4.2	FM 2 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.5	FM 3 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.5.1	FM 3 Integration	Integration of PEM module		
4.1.5.6.2.3.5.2	FM 3 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.6	FM 4 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.6.1	FM 4 Integration	Integration of PEM module		
4.1.5.6.2.3.6.2	FM 4 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.7	FM 5 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.7.1	FM 5 Integration	Integration of PEM module		
4.1.5.6.2.3.7.2	FM 5 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.8	FM 6 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.8.1	FM 6 Integration	Integration of PEM module		
4.1.5.6.2.3.8.2	FM 6 Testing & Calibration	Test and calibration of PEM Module		

WBS	Task	Description	Responsibility	Manager
4.1.5.6.2.3.9	FM 7 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.9.1	FM 7 Integration	Integration of PEM module		
4.1.5.6.2.3.9.2	FM 7 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.A	FM 8 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.A.1	FM 8 Integration	Integration of PEM module		
4.1.5.6.2.3.A.2	FM 8 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.B	FM 9 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.B.1	FM 9 Integration	Integration of PEM module		
4.1.5.6.2.3.B.2	FM 9 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.C	FM 10 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.C.1	FM 10 Integration	Integration of PEM module		
4.1.5.6.2.3.C.2	FM 10 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.D	FM 11 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.D.1	FM 11 Integration	Integration of PEM module		
4.1.5.6.2.3.D.2	FM 11 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.E	FM 12 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.E.1	FM 12 Integration	Integration of PEM module		
4.1.5.6.2.3.E.2	FM 12 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.F	FM 13 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.F.1	FM 13 Integration	Integration of PEM module		
4.1.5.6.2.3.F.2	FM 13 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.G	FM 14 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.G.1	FM 14 Integration	Integration of PEM module		
4.1.5.6.2.3.G.2	FM 14 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.H	FM 15 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.H.1	FM 15 Integration	Integration of PEM module		
4.1.5.6.2.3.H.2	FM 15 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.3.I	FM 16 Integration & Test	Integration and Test of PEM module		
4.1.5.6.2.3.I.1	FM 16 Integration	Integration of PEM module		
4.1.5.6.2.3.I.2	FM 16 Testing & Calibration	Test and calibration of PEM Module		
4.1.5.6.2.4	PEM GSE	Provides for mechanical and test GSE	IN2P3	Bogaert
4.1.5.6.2.4.1	Mechanical GSE	Provides mechanical support for stacking and aligning the CsI detectors (CDE) in the structural module. Compression application and measurement tools are required. Handling fixtures for moving and orienting the loaded modules shall be designed and fabricated.	IN2P3	Ferreira
4.1.5.6.2.4.1.1	VM2 Assembly Tools for CDE	MGSE for VM2 integration		
4.1.5.6.2.4.1.2	EM Insertion Tool for CDE	MGSE for EM assembly		

WBS	Task	Description	Responsibility	Manager
4.1.5.6.2.4.2	Test GSE	Detailed performance measurements will use muon telescope GSE. Test position resolution and light asymmetry. This test will test the 8 layers of 12 detectors simultaneously. GSE consists of an hodoscope triggering and loclising cosmic Muons. The test bench will be based on Preamp for Pin photodiodes, NIM shaping amps, discriminators, fan outs, CAMAC ADCs, discriminators, controller and PC-based data acquisition system.	IN2P3	Bogaert
4.1.5.6.2.4.2.1	VM2 Test Tools	GSE for VM2 test		
4.1.5.6.2.4.2.2	PEM Bench Realization	Production of the PEM test GSE		
4.1.5.6.2.5	PEM Assembly Facilities	The CDE A&T and insertion need Clean room and humidity condition and/or control	IN2P3/CEA-Saclay	Bederede
4.1.5.6.2.5.1	Clean Room for PEM	Clean Room for PEM		
4.1.5.6.2.5.2	Clean Room for CDE	Clean Room for CDE		
4.1.5.6.3	PEM Delivery to NRL	Delivery of the EM, QM and FM modules to NRL to finalize their assembly and test.	CEA-Saclay	Bederede
4.1.5.7	Analog Front End Electronics	NRL shall be responsible for the Calorimeter electronics. This responsibility includes development of two custom ASICs, electronics component selection, circuit board design, fabrication, assembly, testing, documentation and supporting GSE. NRL shall be responsible for the analog front end ASIC (being designed at SLAC, and produced and tested TBD), the supporting electronics and printed circuit board, and the test equipment. Calorimeter Modules (PEM + AFEE) will be assembled and tested at NRL	NRL	J. Ampe
4.1.5.7.1	AFEE Design	Provides for the engineering activities for the development of the front end electronics	NRL	
4.1.5.7.2	ASIC Development	The GLAST Calorimeter shall require two different types of custom Application Specific Integrated Circuit (ASIC)s for the flight electronics. Provides for analog and digital ASIC designs and productions.		

WBS	Task	Description	Responsibility	Manager
4.1.5.7.2.1	GCFE ASIC Development	Provides for the design, qualification, manufacture and packaging of the Glast Calorimeter Front-End (GCFE) ASIC. The requirement is 96 GCFE ASICS per tower. Design will be performed at SLAC in consultation with NRL. During the design cycle functional and performance tests will be run on the ASICs. Design will require at least three prototype runs. The EM calorimeter will utilize 200 good ASICs, of the best design at the time needed (not including spares) Production run shall produce at least 4000 good ASICs (not including spares). Following flight production, the ASICs shall be qualified for flight use.	SLAC/NRL	G. Haller
4.1.5.7.2.1.1	GCFE Design	Provides for the design, simulation, and testing of the analog ASIC prior to commiting to ASIC fabrication. Design concepts will be simulated and tested on the GCFE circuit card using a FPGA representation of the GCRC functionality.		
4.1.5.7.2.1.2	GCFE Production	Provides for two test runs and the flight fabrication run of the digital ASIC. Parts from test run #1 will be used on the EM module. Flight qualification and testing of the ASIC and its packaging are included here.		
4.1.5.7.2.2	Digital ASIC Development	Provides for the design, qualification, manufacture and packaging of the Glast Calorimeter Readout Control (GCRC) ASIC. The requirement is 16 GCRC ASICs per tower. Design will be performed at NRL. During the design cycle functional and performance tests will be run on the ASICs. Design is expected to have three prototype runs. The EM calorimeter will utilize 16 good ASICs, of the first design. Production run shall produce at least 400 good ASICs (not including spares). Following flight production, the ASICs shall be qualified for flight use.	SLAC/NRL	J. Ampe
4.1.5.7.2.2.1	Digital ASIC Design	Provides for the design, simulation, and testing of the digital ASIC prior to commiting to ASIC fabrication. Design concepts will be simulated and tested on the VM circuit card using a FPGA representation of the GCRC functionality.		
4.1.5.7.2.2.2	Digital ASIC Production	Provides for two test runs and the flight fabrication run of the digital ASIC. Parts from test run #1 will be used on the EM module. Flight qualification and testing of the ASIC and its packaging are included here.		
4.1.5.7.3	GCFE Test Board	A test circuit system will be built that can fully test the functionality of the GCFE ASIC. The test system will operate the ASIC in a flight system configuration. The test system will connect to a PC computer for commanding and display of results.	NRL	J. Ampe

WBS	Task	Description	Responsibility	Manager
4.1.5.7.4	VM Front End Electronics	The first partial prototype of the calorimeter circuit boards will be built as a single row log-end readout. This will test the AFEE flight board component placement and routing constraints, communication concept between devices, and serve as a testbed for developing the GCRC ASIC.	NRL	J. Ampe
4.1.5.7.5	EM Front End Electronics	The Engineering model electronics will be as close to the flight electronics as possible. Two different calorimeter circuit boards, “X” and “Y” sideboards, will be fabricated for reading out the log-ends of the four sides. The Calorimeter design will be complete following testing of this construction.	NRL	J. Ampe
4.1.5.7.6	Flight Front End Electronics	The final flight electronics will require 40 “X” and 40 ”Y” (not including spares) calorimeter circuit boards, fabricated and assembled to NASA standards. Tested final ASICs versions will be used to populate the boards. Assembled boards will be tested prior to flight calorimeter mounting.	NRL	J. Ampe
4.1.5.7.6.1	Assemble/Solder Boards	Provides for the assembly and soldering of parts on the boards		
4.1.5.7.6.2	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.3	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.4	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.5	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.6	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.7	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		

WBS	Task	Description	Responsibility	Manager
4.1.5.7.6.8	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.9	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.A	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.B	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.C	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.D	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.E	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.F	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.G	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		

WBS	Task	Description	Responsibility	Manager
4.1.5.7.6.H	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.I	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.J	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.K	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.L	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.M	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.N	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.O	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.6.P	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		

WBS	Task	Description	Responsibility	Manager
4.1.5.7.6.Q	4 Board Production Run	A four board production run completes the AFEE cards for a single CAL module. This activity provides for the manual soldering of plastic parts on the AFEE PCB, functional testing, conformal coating and final testing of the board set. A burn-in will be performed on the qualification board set.		
4.1.5.7.7	GSE for AFEE Test	The development of the Calorimeter flight electronics will require various test boards and PC computer software which are not directly related to the front-end electronics. The test boards and software include the following: Cal sideboard LED testbox, GCRC simulator board, TEM simulator board, TEM simulator FPGA code, TEM simulator PC Labview software.	NRL	J. Ampe
4.1.5.7.7.1	VM GSE (Partial TEM Simulator)	Ground support Equipment for VM testing		
4.1.5.7.7.2	TEM Simulator GSE	TEM simulator board production		
4.1.5.8	Calorimeter Tower Controller	This activity designs the Tower Electronics Module (TEM) Cal Controller which interfaces between the TEM Common Controller and the calorimeter AFEE boards. The design will also encompass the power supply interface to the AFEE, which may pass through the TEM or be its own independent connection.	NRL	J. Ampe
4.1.5.8.1	Design	The TEM Cal Controller will be designed with a Hardware Description Language (HDL), to interface directly with the other sections of the TEM HDL design. The Cal Controller design will perform command routing, housekeeping data acquisition, data compression, timing and formatting of calorimeter data.		
4.1.5.8.2	Fabrication	The TEM controller design will be integrated and built by SLAC. The TEM Cal controller may be tested in FPGA hardware at NRL prior to design release.		
4.1.5.8.3	Test	The TEM Cal controller will be tested in an interface between the Calorimeter AFEE circuit and the TEM common controller. The completely integrated TEM will also be tested in integration tests with the AFEE electronics.		
4.1.5.9	Calorimeter Module Assembly, Test & Calibration	This element provides for the integration, test and verification, and for the calibration of the Calorimeter modules, as the various major components are assembled, tested and verified. This element also includes any needed Facility Planning and modifications (including cost estimates), and Environmental Test Planning and Execution.	NRL	J.E. Grove

WBS	Task	Description	Responsibility	Manager
4.1.5.9.1	Engineering Model	VM 1) Single layer AFEE (ASIC v2) [functionally equivalent, commercial parts] 2) PEM VM2 Structure (12 CDE's + mass models) Items 1 and 2 are tested independently, do not integrate EM Fully populated, flight quality parts Cal Scientific Calibration: muons, radioactive sources - Provides for scientific calibration of the calorimeter using natural radiations (muons) as well as radioactive sources. To the extent possible, energy resolution and position resolution will be calibrated and measured. Hadronic Beam Test - Provides for a beam test of the calorimeter alone in a hadron beams of p, He, C. Required to measure light yield in hadronic interactions relative to EM showers. More accurate measurements and calibrations of the positioning in the CsI blocks can be performed. Performed on E/M model and 1 or 2 of 1st calorimeters.		
4.1.5.9.2	Flight Modules	Provides for the assembly, test and calibration of the Calorimeter flight modules according to LAT-SS-00262, Calorimeter Module Assembly and Test Plan		
4.1.5.9.2.1	Module A&T - FM A	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC. FM A is a qualification module and will be tested to qualification levels.		
4.1.5.9.2.2	Module A&T - FM B	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.3	Module A&T - FM 1	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		

WBS	Task	Description	Responsibility	Manager
4.1.5.9.2.4	Module A&T - FM 2	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.5	Module A&T - FM 3	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.6	Module A&T - FM 4	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.7	Module A&T - FM 5	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.8	Module A&T - FM 6	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.9	Module A&T - FM 7	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.A	Module A&T - FM 8	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		

WBS	Task	Description	Responsibility	Manager
4.1.5.9.2.B	Module A&T - FM 9	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.C	Module A&T - FM 10	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.D	Module A&T - FM 11	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.E	Module A&T - FM 12	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.F	Module A&T - FM 13	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.G	Module A&T - FM 14	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.2.H	Module A&T - FM 15	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		

WBS	Task	Description	Responsibility	Manager
4.1.5.9.2.I	Module A&T - FM 16	Provides for the mechanical and electrical assembly of a calorimeter module. A PEM is received from France, acceptance tested, and integrated with AFEE electronics. EM2 TEM electronics are used as the T&DF interface with the module. Functional testing and evironmental testing are performed. Calibrations with cosmic muons are performed. Completed module is shipped to SLAC.		
4.1.5.9.3	Cal Module GSE	CVAL module mechanical and electrical GSE - Detailed performance measurements will use muon telescope GSE. Test position resolution and light asymmetry. This test will test 12 detectors (1 layer) simultaneously. Design, manufacture and delivery of all the test equipment necessary for testing and validation of the PEM and CAL modules.		
4.1.5.9.3.1	Cal Module Mechanical GSE	Mechanical GSE for module testing		
4.1.5.9.3.2	Cal Module Electrical GSE	Electrical GSE for module testing		
4.1.5.9.4	Cal GSE SW	Provides test environment for development of flight instrument. Includes simulators, command and control, data reduction and analysis.		
4.1.5.9.5	Calorimeter A&T Facilities Support	This element provides for the preparation and maintenance of the laboratory facilities to be used in assembly and test of the calorimeter modules at NRL.		
4.1.5.A	Instrument I&T Support	This element provides for support to the integration, test and verification of the entire LAT instrument as the various sub-systems are assembled, tested and verified as a whole. Primary responsibility for Instrument I&T resides at SLAC.	NRL	B. Phlips
4.1.5.A.1	Instrument Integration Support	Provides for the packing and shipping of the completed calorimeter modules to the instrument integration site. Supports the post-ship functional test of the modules. Supports the mechanical and electrical integration of the calorimeter into the GLAST structure. Supports the post-integration functional test.	NRL	
4.1.5.A.2	Calibration Units	Provides for the assembly of the first two flight calorimeter modules. Also included are their test at SLAC and with hadronic beam.	NRL	
4.1.5.A.2.1	Reserved			
4.1.5.A.2.2	Assembly & Functional Test Support	Provides for the packing and shipping of the first 2 completed calorimeter modules to the instrument integration site. Supports the post-ship functional test of the modules. Supports the mechanical and electrical integration of the calorimeter into the GLAST calibration unit structure. Supports the post-integration functional test. Supports detailed system performance and EMI testing.		
4.1.5.A.2.3	SLAC Beam Test Support	Provides for the electromagnetic beam test of the Calibration Unit at SLAC. This beam test provides the performance demonstration of the tower as well as additional calibration data on calorimeter performance at higher energies than obtainable elsewhere. Assume 3 month beam tests.		

WBS	Task	Description	Responsibility	Manager
4.1.5.A.2.4	Hadron Beam Test Support	Provides for the hadronic beam test of the Calibration Unit with a proton beam. This beam test provides tests of hadronic shower pattern recognition for on-orbit background rejection. Assume TBD week test at site to be specified.		
4.1.5.A.3	Instrument Test Support	Provides for the functional and environmental testing of the completed instrument.	NRL	
4.1.5.B	S/C Integration Support	Provides support for the integration of the instrument to S/C. Personnel will be on site for instrument functional testing throughout the integration process.	NRL	B. Phlips
4.1.5.C	Mission Operations Support	Provides support for the activation of the instrument on orbit. Provides support for the performance assessment and calibration of the instrument during the first 30 days of the mission.	NRL	J.E. Grove
4.1.5.C.1	CAL State Tracking	Software to monitor the state of CAL commanding and the performance of the CAL detector elements under those commands, for input to event reconstruction and instrument response	NRL	

WBS	Task	Description	Responsibility	Manager
4.1.6	**Anticoincidence Detector (ACD)**	**The ACD Subsystem element refers to all effort required to be performed by GSFC to develop and deliver an Anti-Coincidence Detector (ACD) for the Gamma-ray Large Area Space Telescope (GLAST) Large Area Telescope (LAT).**	**GSFC**	**Thompson**
4.1.6.1	ACD Management	The ACD Project/Subsystem Engineering element refers to all effort required to be performed by GSFC to manage the ACD Subsystem's technical development and perform business management, systems & subsystems engineering and science support as necessary to develop a working ACD subsystem.	GSFC	Johnson
4.1.6.1.1	Project Management	The Project Management element refers to all effort required to be performed by GSFC to manage the business end of the development of the ACD subsystem. It includes all efforts associated with planning, organizing, directing, controlling, and approval actions necessary to accomplish overall program objectives.	GSFC	Johnson
4.1.6.1.1.1	Project Administration/Support	The Project Administration/ Support element refers to the effort required to be performed in the business administration of the ACD development contract. This includes the services of the project manager and his/her personal support staff.	GSFC	Johnson
4.1.6.1.1.2	Contracts/Procurement	The Contracts/Procurement element refers to the effort required to manage the ACD subsystem contract and develop subordinate subcontracts for the development of subsystem hardware, procurement of parts or services as needed.	GSFC	Johnson
4.1.6.1.1.3	Project Control	The Project Control element refers to the effort required to manage ACD subsystem costs and maintain financial control over ACD development efforts.	GSFC	Doria - Warner
4.1.6.1.1.4	Project Scheduling	The Project scheduling element refers to the effort required to develop and maintain schedules as may be needed for maintaining control of the time element.	GSFC	Wicks
4.1.6.1.1.5	Configuration & Data Management	The Configuration and Data Management element refers to the effort required to provide CDM and library services for all technical and business data developed to support the ACD subsystem.	GSFC	Anders
4.1.6.1.1.6	GSFC Code Taxes		GSFC	Johnson
4.1.6.1.1.7	(Reserved)			
4.1.6.1.1.8	ADP & Computer Support	The ADP and Computer Support element refers to all specialized automated data processing and/or computer equipment/ services to be acquired in support of the ACD subsystem development contract.	GSFC	Johnson

WBS	Task	Description	Responsibility	Manager
4.1.6.1.1.9	ACD Shipping	This element refers to the effort required to prepare, pack and ship all ACD and ACD support hardware/ software to development and integration facilities as needed to support program tests, demonstrations and events.	GSFC	Johnson
4.1.6.1.1.A	Program Review Support	This element refers to effort required to support project and ACD internal reviews as needed during the development of the ACD system. It also includes the services of inside/outside experts to analyze technical progress and/or performance.	GSFC	Johnson
4.1.6.1.2	System/Subsystems Engineering	The System / Subsystems Engineering element refers to the technical efforts needed to develop an integrated ACD subsystem. This element includes, but is not limited to the system engineering effort to transform an operational need or statement of deficiency into a description of system/subsystem requirements and a preferred system configuration/architecture. It excludes the actual design engineering directly related to the products or services of a deliverable end item.	GSFC	Shiblie
4.1.6.1.2.1	System/Subsystem Requirements/Specifications	The System/ Subsystem Requirements/ Specifications element refers to the effort required to develop and document ACD subsystem requirements and LAT system requirements as needed. This includes the development of ACD System requirements and ACD subsystem requirements throughout the ACD subsystem development effort.	GSFC	Shiblie
4.1.6.1.2.2	(Reserved)			
4.1.6.1.2.3	Subsystem Analysis and Trade Studies	The Subsystems Analysis and Trade Studies element refers to the subsystem definition and science trade studies necessary to define the necessary elements of the ACD subsystem. Examples of analyses/ trade studies to be performed under this element include the Scintillating Fiber Adhesive Trade, PMT Location Trade, and the PMT Power (Central HV Supplies vs. Distributed) Trade Study.	GSFC	Shiblie
4.1.6.1.2.4	System/Subsystem Engineering	This element refers to the efforts needed to be performed in support of systems engineering activities not included in the above systems engineering categories. It includes the effort required to track mass and power budgets, develop an overall systems architecture/design and perform any other efforts not specifically mentioned above.	GSFC	Shiblie
4.1.6.1.3	Science Support	The Science Support element refers to the effort to be performed in support of the ACD contribution to the science mission of the LAT instrument. It includes performance of science trade studies, support of science team meetings, and acting as liaison with the LAT instrument development team during documentation of science requirements in the Science Requirements Documents (SRDs).	GSFC	Moiseev

WBS	Task	Description	Responsibility	Manager
4.1.6.1.4	Simulations	The simulations element refers to the simulation effort to be performed in support of ACD subsystem development efforts and trade studies.	GSFC	Katani
4.1.6.2	Reliability & Quality Assurance	The Reliability and Quality Assurance element refers to those engineering specialty disciplines required to ensure the performance of the delivered ACD subsystem. This includes the performance of reliability and safety analyses, flight/Quality assurance, parts control, and material analyses and control.	GSFC	Huber
4.1.6.2.1	Reliability	The Reliability element refers to the performance of those tasks necessary to ensure the overall reliability of the ACD subsystem.	GSFC	DiVenti
4.1.6.2.2	Safety	The Safety element refers to the performance of those tasks necessary to ensure the overall safety of the ACD subsystem. This includes the performance of Failure Modes and Effects Analysis (FMEA), preparing inputs for Hazards Analysis Reports, development of safety non-compliance reports, performance of operating and support hazards analyses, preparing safety assessment reports and developing/reviewing ground operations plans.	GSFC	Anderson
4.1.6.2.3	Flight Assurance	The Flight Assurance element refers to the effort required to establish requirements for and maintain the overall Quality of the ACD subsystem. This effort includes the effort required to develop a Quality Plan and develop a Quality Manual, as well as inspect, audit, and monitor Quality and maintain a non-conformance reporting system as required for the duration of the ACD subsystem development effort.	GSFC	Huber
4.1.6.2.4	Parts Control	The Parts Control element refers to that effort required to control the parts that make up the ACD subsystem. This effort includes the effort required to establish and maintain a Parts Identification List, review selected parts against the Alert Advisory system and issue advisory alerts as needed. This element also includes the effort needed to test PWB coupons and provide test reports, as well as perform parts stress analyses.	GSFC	Perry/Vermani
4.1.6.2.5	Materials	The Materials element refers to the effort required to develop materials processes, develop materials processes lists and establish material usage agreements.	GSFC	Joy

WBS	Task	Description	Responsibility	Manager
4.1.6.3	Tile Shell Assembly (TSA)	The Tile Shell Assembly (TSA) element refers to the effort required to design, procure, fabricate, assemble and test the portions of the ACD subsystem that support the ACD detectors mechanically (Shell Subassembly), the ACD detectors (Tile Detectors Assemblies or TDAs), and the hardware required to mount the TDA's to the shell subassembly and interconnect the TSA. It also includes the effort required to fabricate the calibration components that will be used for Calibration Testing of the LAT and to fabricate the Flight Unit.	GSFC	T. Johnson/Moiseev
4.1.6.3.1	Tile Shell Assembly (TSA) Analysis/Design	The Tile Shell Assembly (TSA) Analysis/ Design element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test the Tile Shell Assembly. This includes the development of a TSA Integration Drawing, TSA Integration Procedure, and TSA Handling Procedure.	GSFC	T. Johnson
4.1.6.3.2	Tile Detector Assemblies (TDA's)	The Tile Detector Assembly (TDA) element refers to the effort required to design, procure, fabricate, assemble and test the various Tile Detector variants and mass-models used in the ACD subsystem. This includes the various rigid functional TDAs (TDA-F), various rigid non-functional TDA's (TDA-N) flexible functional TDAs that will provide edge coverage for the seams, flexible non-functional TDAs. The TDA will include that portion of the individual detectors up to the PMT & Divider Assembly.	GSFC	T. Johnson
4.1.6.3.2.1	Tile Detector Assembly (TDA) Analysis/Design and Fabrication	The Tile Detector Assembly (TDA) Analysis/Design and Fabrication element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test all the TDA variants required by the ACD Subsystem. This will include the development of Assembly Procedures, Assembly Drawings, and Handling Procedures. This element also refers to the effort required to fabricate and test new TDAs for integration with the Flight LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate new functional rigid and flexible TDAs in quantities required for integration with the LAT.	GSFC	Moiseev
4.1.6.3.2.2	TDA Components Procurements	The TDA Components Procurements element refers to the effort required to procure and deliver the raw wave shifting fibers components needed for integration into the Tile Detector Assemblies (TDAs).	GSFC	Moiseev
4.1.6.3.2.3	(Reserved)			
4.1.6.3.2.4	(Reserved)			
4.1.6.3.2.5	(Reserved)			

WBS	Task	Description	Responsibility	Manager
4.1.6.3.2.6	Cal Unit TDAs Proc/Fab Assy/Test	The Calibration Unit TDA Proc/Fab/Assy/Test element refers to the effort required to fabricate and test new TDAs for use during calibration testing of the LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate new functional and non-functional rigid and flexible TDAs in quantities required for calibration of the LAT and test spares.	GSFC	Johnson
4.1.6.3.2.7	Flight Model TDA Proc/Fab/Assy/Test	The Flight Model TDA Proc/Fab/Assy/Test element refers to the effort required to fabricate and test new TDAs for integration with the Flight LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate new functional rigid and flexible TDAs in quantities required for integration with the LAT and flight spares.	GSFC	Johnson
4.1.6.3.3	Shell Subassembly	The Shell Subassembly element refers to the effort required to design, procure, fabricate, assemble and test the Shell Subassembly used in development the ACD subsystem.	GSFC	Johnson
4.1.6.3.3.1	Shell Subassembly Analysis/Design and Fabrication	The Shell Subassembly Analysis / Design and Fabrication element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test the Shell Subassembly required by the ACD Subsystem. This will include all Shell Subassembly assembly drawings, assembly procedures, and shell handling procedures.This element refers to the effort required to fabricate and test the Shell Subassembly for integration with the Flight LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate Shell Subassembly required for integration with the LAT.	GSFC	Johnson
4.1.6.3.3.2	(Reserved)			
4.1.6.3.3.3	(Reserved)			
4.1.6.3.3.4	(Reserved)			
4.1.6.3.3.5	Flight Model Shell Subassembly Proc/Fab/Assy/Test	The Flight Model Shell Subassembly Proc/Fab/Assy/Test element refers to the effort required to fabricate and test new Shell Subassembly for integration with the Flight LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate Shell Subassembly in the quantities required for integration with the LAT and flight spares (if needed).	GSFC	Johnson

WBS	Task	Description	Responsibility	Manager
4.1.6.3.4	Tile Mounting Hardware & Assemblies	The Tile Mounting Hardware & Assemblies element refers to the effort required to design, procure, fabricate, assemble and test the various tile mounting & assembly hardware components required to attach the various Tile Detector variants and mass-models used in the ACD subsystem to the Shell Subassembly. This includes attaching various rigid functional TDAs (TDA-F), various rigid non-functional TDA's (TDA-N) , flexible functional TDAs that will provide edge coverage for the seams, and flexible non-functional TDAs. This hardware includes PMT Harness Tiedowns.	GSFC	Johnson
4.1.6.3.4.1	Tile Mounting Hardware Analysis/Design	The Tile Mounting Hardware Analysis/ Design element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test all the Tile Mounting Hardware & Assembly variants required by the ACD Subsystem. This will include all Tile Mounting Hardware & Assembly assembly drawings, assembly procedures, and shell handling procedures.	GSFC	Johnson
4.1.6.3.4.2	(Reserved)			
4.1.6.3.4.3	(Reserved)			
4.1.6.3.4.4	(Reserved)			
4.1.6.3.4.5	Flight Unit Tile Mounting Hardware & Assemblies Proc/Fab/Assy/Test	The Flight Unit Tile Mounting Hardware & Assemblies Proc/Fab/Assy/Test element refers to the effort required to fabricate and test new Tile Mounting Hardware & Assemblies for use with the Flight LAT instrument. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate new functional and non-functional rigid and flexible Tile Mounting Hardware & Assemblies in quantities required for integration and testing with the Flight LAT instrument and test spares.	GSFC	Johnson
4.1.6.3.5	(Reserved)			
4.1.6.3.6	(Reserved)			
4.1.6.3.7	Cal Unit components I&T	The Calibration Unit components integration and Test (I&T) element refers to the effort required to assemble, integrate and test the Cal Unit components at Goddard Space Flight Center (GSFC) prior to the calibration testing at SLAC. This includes Tile Detector Assemblies (TDAs) and testing these out to the extent possible before integration with Front End Electronics.	GSFC	Johnson

WBS	Task	Description	Responsibility	Manager
4.1.6.3.8	Flight Model TSA I&T	The Flight Unit Tile Shell Assembly (TSA) Integration and Test (I&T) element refers to the effort required to assemble, integrate and test the Flight Tile Shell Assembly components at Goddard Space Flight Center (GSFC) prior to the integration with the Flight Unit LAT at SLAC. This includes mounting Tile Detector Assemblies (TDAs) to the Shell Subassembly using Tile Mounting Hardware & Assemblies and testing these out to the extent possible before integration with Front End Electronics.	GSFC	Johnson
4.1.6.4	Base Electronics Assembly (BEA)	The Base Electronics Assembly (BEA)) element refers to the effort required to design, procure, fabricate, assemble and test the electronics portions of the ACD subsystem, the Base Frame Assembly which contains the electronics, and the hardware required to assemble and interconnect the Base Electronics Assembly. It also includes the effort required to fabricate the calibration components	GSFC	Unger
4.1.6.4.1	Base Electronics Assembly (BEA) Analysis/Design	The Base Electronics Assy (BEA) Analysis/Design element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test the Base Electronics Assembly. This includes the development of a BEA Integration Drawing, BEA Integration and Test Procedure, and BEA Handling Procedure as well as interface control documents for the various circuit card assemblies contained within.	GSFC	Unger
4.1.6.4.2	BEA Base Frame Electronics Assembly	The Base Frame Assembly element refers to the effort required to design, procure, fabricate, assemble and test the various circuit card assemblies and mass-models used in the BEA subsystem. This includes the various functional circuit card assemblies, and that portion of the front-end electronics which includes the PMT & Divider Assembly.	GSFC	Unger / Johnson
4.1.6.4.2.1	Base Frame Assembly Analysis/Design and Fabrication	The Base Frame Assy Analysis/Design and Fabrication element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test the Base Frame Subassembly required by the ACD Subsystem. This will include all Base Frame Subassembly assembly drawings, assembly procedures, and Base Frame Assembly handling procedures.This element refers to the effort required to fabricate and test the Base Frame Assembly for integration with the Flight LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate Base Frame Assembly required for integration with the LAT	GSFC	T. Johnson
4.1.6.4.2.2	(Reserved)			
4.1.6.4.2.3	(Reserved)			
4.1.6.4.2.4	(Reserved)			

WBS	Task	Description	Responsibility	Manager
4.1.6.4.2.5	Flight Frame Assy Proc/Fab/Assy/Test	The Flight Frame Assy Proc/Fab/Assy/Test element refers to the effort required to fabricate and test new Base Frame Assembly for integration with the Flight LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate Base Frame Assembly in the quantities required for integration with the LAT and flight spares (if needed).	GSFC	T. Johnson
4.1.6.4.3	High Voltage Power Supply Analysis/Procurement	The High Voltage Power Supply Analysis/Procurement element refers to the effort required to analyze requirements for and procure and deliver the High Voltage Power Supplies needed for integration with the Front-End Electronics.	GSFC	Thompson
4.1.6.4.4	Analog ASIC Design/Procurement	The Analog ASIC Design/Procurement element refers to the effort required to analyze requirements for, design, procure and test the Analog ASICs needed for integration with the Front-End Electronics.	GSFC	Singh
4.1.6.4.5	Digital ASIC Design/Procurement	The Digital ASIC Design/Procurement element refers to the effort required to analyze requirements for, design, procure and test the Digital ASICs needed for integration with the Front-End Electronics.	GSFC	Singh
4.1.6.4.6	Front-End Electronics and Event (FREE) Circuit Card Assembly (CCA)	The Front-End Electronics and Event (FREE) Circuit Card Assembly (CCA) element refers to the effort required to design, procure, fabricate, assemble and test the FREE CCAs variants used in the ACD subsystem. The FREE will include that portion of the front-end electronics beginning with the PMT & Divider Assembly.	GSFC	Unger
4.1.6.4.6.1	FREE CCA Analysis/Design	The FREE CCA Analysis/Design element refers to effort required to analyze requirements for, design, procure and test the Front-End Electronics and Event CCAs needed for supporting the analog and digital ASICs, the High Voltage Power Supplies and the PMT & Divider Assembly . This may include variants based upon maturity of designs used for the Balloon , Calibration and Flight.	GSFC	Unger
4.1.6.4.6.2	(Reserved)			
4.1.6.4.6.3	(Reserved)			
4.1.6.4.6.4	(Reserved)			

WBS	Task	Description	Responsibility	Manager
4.1.6.4.6.5	FREE CCA Flight Proc/Fab/Assy/Test	The FREE CCA Flight Proc/Fab/Assy/Test element refers to the effort required to fabricate and test new FREE CCAs for integration with the Flight LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate new FREE CCAs in quantities required for integration with the LAT and flight spares.	GSFC	Unger
4.1.6.4.7	(Reserved)			
4.1.6.4.8	(Reserved)			
4.1.6.4.9	BEA Electronics Mounting/Assembly Hardware	The BEA Electronics Mounting/Assembly Hardware element refers to the effort required to design, procure, fabricate, assemble and test the BEA electronics mounting & assembly hardware components required to attach the CCAs, harnesses and mass-models used in the BEA to the BEA Base Frame. This hardware includes BEA Harness Tiedowns.	GSFC	Murphy
4.1.6.4.A	(Reserved)			
4.1.6.4.B	(Reserved)			
4.1.6.4.C	Cal Unit BEA I&T	The Cal Unit BEA I&T element refers to the effort required to assemble, integrate and test the Calibration Engineering Model Base Electronics Assembly (BEA) components at Goddard Space Flight Center (GSFC) prior to calibration testing. This includes mounting CCAs to the Base Frame Assembly using BEA Electronics Mounting Hardware & Assemblies and testing these out to the extent possible before integration with Tile Shell Assembly (TSA) and Tile Detector Assemblies (TDAs).	GSFC	T. Johnson
4.1.6.4.D	Flight Model BEA I&T	The Flight Model BEA I&T element refers to the effort required to assemble, integrate and test the Flight Model Base Electronics Assembly (BEA) components at Goddard Space Flight Center (GSFC) prior to calibration testing. This includes mounting CCAs to the Base Frame Assembly using BEA Electronics Mounting Hardware & Assemblies and testing these out to the extent possible before integration with Tile Shell Assembly (TSA) and Tile Detector Assemblies (TDAs).	GSFC	T. Johnson
4.1.6.4.E	Photo-Multiplier Tubes (PMT) & Divider Assembly	The Photo-Multiplier Tube (PMT) & Divider Assembly Procurement element refers to the effort required to procure and deliver Photo-Multiplier Tubes (PMTs) and Divider Assemblies needed for integration into the FREE CCAs.	GSFC	Moiseev

WBS	Task	Description	Responsibility	Manager
4.1.6.5	Micrometeoroid Shield/Thermal Blanket Assembly	The Micrometeoroid Shield / Thermal Blanket Assembly element refers to the effort required to design, procure, fabricate, assemble and test the portions of the ACD subsystem that form the outer-layer of the LAT instrument and serve to form a light-tight cover, provide protection against micrometeoroid penetration, and serve as a thermal blanket for the LAT instrument. This includes those elements that support the assembly mechanically (Shield/Blanket Sections and Interconnecting Hardware) and the hardware required to mount the Blanket/Shield Assembly to the assembled ACD (excluding the LAT).	GSFC	T. Johnson/Fantano
4.1.6.5.1	Micrometeoroid Shield/Thermal Blanket Assembly	The Micrometeoroid Shield / Thermal Blanket Assembly element refers to the effort required to design, procure, fabricate, assemble and test the Micrometeoroid Shield / Thermal Blanket Assembly variants used in development the ACD subsystem.	GSFC	T. Johnson/Fantano
4.1.6.5.1.1	Micrometeoroid Shield/Thermal Blanket Assembly Analysis/Design and Fabrication	The Micrometeoroid Shield / Thermal Blanket Assembly Analysis/Design and Fabrication element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test all the Micrometeoroid Shield / Thermal Blanket Assembly variants required by the ACD Subsystem. This will include the performance of thermal analyses, penetration analyses and development of Assembly/ Integration Procedures, Assembly/ Integration Drawings, and Assembly Handling Procedures. This element also refers to the effort required to procure, fabricate and assemble the components needed and test a new Micrometeoroid Shield / Thermal Blanket Assembly for use on the Flight Model LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate a new Micrometeoroid Shield / Thermal Blanket Assembly required for Flight Unit	GSFC	T. Johnson/Fantano
4.1.6.5.1.2	(Reserved)			
4.1.6.5.1.3	(Reserved)			
4.1.6.5.1.4	Micrometeoroid Shield/Thermal Blanket Assembly Proc/Fab/Assy/Test for Cal Unit	The Micrometeoroid Shield / Thermal Blanket Assembly Proc/Fab/Assy/Test for Cal Unit element refers to the effort required to procure, fabricate and assemble the components needed and test a new Micrometeoroid facsimile Shield / Thermal Blanket for use during calibration of the LAT. This shield/blanket will be different in fit from the Flight unit, and will be tailored to facilitate calibration of the LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate a new Micrometeoroid Shield / Thermal Blanket Assembly required for calibration and test spares (if needed).	GSFC	T. Johnson/Fantano

WBS	Task	Description	Responsibility	Manager
4.1.6.5.1.5	Micrometeoroid Shield/Thermal Blanket Assembly Proc/Fab/Assy/Test for Flight Unit	The Micrometeoroid Shield / Thermal Blanket Assembly Proc/Fab/Assy/Test for Flight Unit element refers to the effort required to procure, fabricate and assemble the components needed and test a new Micrometeoroid Shield / Thermal Blanket Assembly for use on the Flight Model LAT. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate a new Micrometeoroid Shield / Thermal Blanket Assembly required for Flight Unit and test spares (if needed).	GSFC	T. Johnson/Fantano
4.1.6.6	(Reserved)			
4.1.6.7	Hardware/Software Integration & Test	The Hardware/Software Integration & Test element refers to that effort required to integrate and test the elements that make up the ACD subsystem at GSFC prior to delivery in support of demonstrations and tests off-site GSFC. The elements to be combined include the Tile Shell Assembly (TSA), Base Electronics Assembly (BEA), and Micrometeoroid Shield/ Thermal Blanket Assembly. Once combined, these elements create the Flight Model and components used for calibration	GSFC	T. Johnson
4.1.6.7.1	(Reserved)			
4.1.6.7.2	(Reserved)			
4.1.6.7.3	EM ACD I&T	The EM ACD Integration and Test (I&T) element refers to the effort required to assemble and test engineering unit and DAQ I/F Test Unit components to be used during the functional testing/qualification of the ACD design. This element includes all integration and test activities performed at GSFC prior to shipment.	GSFC	T. Johnson
4.1.6.7.4	Calibration Model Hardware/Software I&T	The Calibration Model Hardware/ Software Integration and Test (I&T) element refers to the effort required to assemble and test Calibration Model components to be used during the LAT Calibration testing. This element includes all integration and test activities performed at GSFC prior to shipment.	GSFC	La
4.1.6.7.5	Flight Model Hardware/Software I&T	The Flight Model Hardware/Software Integration and Test (I&T) element refers to the effort required to assemble and test Flight Model components. This element includes all integration and test activities performed at GSFC prior to shipment for integration with the Flight LAT instrument.	GSFC	La
4.1.6.8	LAT Instrument Integration & Test	The LAT Instrument Integration & Test element refers to the effort required to support ACD and Micrometeoroid Shield/ Thermal Blanket Assembly integration with the LAT instrument. This includes Calibration Model ACD/LAT integration for calibration testing, and Flight Model ACD/LAT integration.	GSFC	La
4.1.6.8.1	(Reserved)			

WBS	Task	Description	Responsibility	Manager
4.1.6.8.2	(Reserved)			
4.1.6.8.3	Cal Unit I&T w/LAT (Support)	The calibration Unit Integration and Test (I&T) element refers to the off-site effort required to support calibration testing of the LAT instrument.	GSFC	La
4.1.6.8.4	Flight Unit I&T w/LAT (Support)	The Flight Unit Integration and Test (I&T) element refers to the off-site effort required to support Flight Unit integration testing of the LAT instrument with the instrument integration team.	GSFC	La
4.1.6.9	Mission Integration & Test Support	The Mission Integration and Test Support element refers to that effort needed to support Flight ACD/LAT instrument integration with the spacecraft and associated launch support contractors.	GSFC	La
4.1.6.9.1	LAT Flight Unit I&T w/Spacecraft (Support)	The LAT Flight Unit Integration & Test w/Spacecraft element refers to that effort needed to support Flight ACD/LAT instrument integration with the spacecraft contractor.	GSFC	La
4.1.6.A	(Reserved)			
4.1.6.B	Ground Support Facilities & Equipment	The Ground Support Facilities and Equipment element refers to the design and development/ acquisition of any items needed by the ACD subsystem when it is not directly engaged in the performance of its mission.	GSFC	Johnson / Unger
4.1.6.B.1	(Reserved)			
4.1.6.B.2	Mechanical Ground Support Equipment	The Mechanical Ground Support Equipment element refers to development and acquisition of mechanical equipment developed specifically for and peculiar to the ACD subsystem.	GSFC	Johnson
4.1.6.B.2.1	ACD Turnover/Assembly Dolly Mechanical GSE Design & Fab	The ACD Turnover/ Assembly Dolly element refers to the effort needed to design, procure, fabricate, assemble and test a dolly for assembling and turning over the ACD during ACD assembly and test operations. The Mechanical GSE Design & Fab element refers to development and acquisition of mechanical equipment developed specifically for and peculiar to the ACD subsystem including the ACD Turnover/Assembly Dolly, Shell Handling Assembly, TDA Handling Cases, Base Frame Handling Assembly, Grid Interface Template, ACD Shipping Container, and ACD Lifting Slings.	GSFC	Johnson
4.1.6.B.2.2	Shell Handling Assembly	The Shell Handling Assembly element refers to the effort needed to design, procure, fabricate, assemble and test an assembly for handling the ACD shell during ACD shell assembly operations.	GSFC	Johnson
4.1.6.B.2.3	TDA Handling Cases	The Tile Detector Assembly (TDA) Handling Case element refers to the effort needed to design, procure, fabricate, assemble and test cases for handling and transporting Tile Detector Assemblies (TDAs) during the Functional Tile Detector assembly operations.	GSFC	Johnson

WBS	Task	Description	Responsibility	Manager
4.1.6.B.2.4	Base Frame Handling Assembly	The Base Frame Handling Assembly element refers to the effort needed to design, procure, fabricate, assemble and test an assembly for handling the Base Electronics Assembly (BEA) during BEA assembly and test operations.	GSFC	Johnson
4.1.6.B.2.5	Grid Interface Template	The Grid Interface Template element refers to the effort needed to receive, inspect, pack, ship and return a Grid Interface template from SLAC for fit-checking the ACD subsystem and developing design qualification test equipment.	GSFC	Johnson
4.1.6.B.2.6	ACD Shipping Container w/Nitrogen Purge	The ACD Shipping Container w/Nitrogen Purge element refers to the effort needed to design, procure, fabricate, assemble and test a container for shipping the ACD subsystem variants to test, demonstration, and integration facilities.	GSFC	Johnson
4.1.6.B.2.7	ACD Lifting Slings	The ACD Lifting Slings element refers to the effort required to design, procure, fabricate, assemble and test slings for moving ACD components during ACD assembly, test and shipping operations.	GSFC	Johnson
4.1.6.B.3	Electrical Ground Support Equipment	The Electrical Ground Support Equipment element refers to development and acquisition of electrical equipment developed specifically for and peculiar to the ACD subsystem.	GSFC	Unger
4.1.6.B.3.1	ACD Data Acquisition System/ Umbilical Cables	The ACD Data Acquisition System/ Umbilical Cables element refers to the effort needed to design, procure, fabricate, assemble and test an ACD Data Acquisition System and Cables needed to control, simulate, and/or stimulate ACD electrical interfaces.	GSFC	Unger
4.1.6.B.3.2	Analog ASIC Test Station	An Analog ASIC Test Station element refers to the effort needed to design, procure, fabricate, assemble, code and test a station for testing custom Analog ASICs used in the ACD subsystem.	GSFC	Unger
4.1.6.B.3.3	Digital ASIC Test Station	A Digital ASIC Test Station element refers to the effort needed to design, procure, fabricate, assemble, code and test a station for testing custom Digital ASICs used in the ACD subsystem.	GSFC	Unger
4.1.6.B.3.4	Front End Electronics and Event (FREE) Circuit Card Assembly (CCA) Test Set	A Front End Electronics and Event (FREE) Circuit Card Assembly (CCA) Test Set element refers to the effort needed to design, procure, fabricate, assemble, code and test a station for testing custom Front-End Electronics CCAs used in the ACD subsystem.	GSFC	Unger

WBS	Task	Description	Responsibility	Manager
4.1.7	**Electronics**	**Under 4.1.7 Electronics all the hardware and on-board software to operate the LAT is included with the exception of the front-end electronics of the CAL, TKR, and ACD system. Those are contained in the sub-system detector sections of the WBS. The front-end electronics have typically one analog and digital front-end ASIC which is placed on a board. That electronics interfaces for control, configuration, trigger, data readout, and environmental monitoring with components in this WBS. The main parts of the Electronics are tower-based electronics modules for each of the 16 TKR-CAL towers, plus an electronics module for the ACD, Global Trigger, plus processors to filter the event data. Interface electronics to the spacecraft as well as the entire LAT power system is included in this WBS.**	**SLAC**	**Haller**
4.1.7.1	Electronics Management	All manpower for management, simulation support, and meeting and reviews for the project, management team. Funds for travel for the management and support staff as well as funds needed to support the project administratively.	SLAC	Haller
4.1.7.2	Reliability & Quality Assurance	Reliability studies to decide on issues at architecture and component level. Identification of candidate materials and parts. Assurance of quality of fabrication and assembly. Assurance of the software performance.	SLAC	Nelson
4.1.7.3	Electronics System Design	Overall system architecture design and interfaces. Investigation of candidate integrated circuits technologies used in project. Candidates are Peregrine SOS, Agilent ad TSMC bulk CMOS processes.	SLAC	Haller
4.1.7.3.1	Overall System Design	Overall System Design includes requirements derivation and design of conceptual architecture of the complete electronics system.	SLAC	Haller
4.1.7.3.2	ASIC Evaluation	Evaluation of ASIC for use in flight electronics, evaluation includes single-event upset and latchup tests.	SLAC	Haller
4.1.7.3.2.1	Technology Evaluation	Test on 0.5 um Agilent technology, bulk CMOS with Epi layer	SLAC	Haller
4.1.7.4	DataFlow Electronics (TEMs + Processor Farm)	All Hardware related to L1/L2/L3 trigger and dataflow within LAT. Electronics to control and readout of all front-end electronics systems. Includes tower electronics modules, global L1 trigger, event-builder. Includes processors used for event-filtering and monitoring.	SLAC	Haller
4.1.7.4.1	Design Requisites	Includes engineering time to create dataflow requirement and conceptual design documents, including discussions to arrive at an appropriate design.	SLAC	Haller
4.1.7.4.2	Front End Simulator	VME module to simulate the behavior of CAL, ACD, TKR sub-system electronics. Used to validate dataflow electronics without having real sub-systems connected. Used in the testing of dataflow elecronics before sub-system tests commence.	HEPL	Wallace
4.1.7.4.2.1	Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	HEPL	Wallace

WBS	Task	Description	Responsibility	Manager
4.1.7.4.2.2	Fab, Assem & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	HEPL	Wallace
4.1.7.4.3	TKR/CAL TEM Electronics	Tower Electronics Module to control and readout one tower worth of TKR and CAL sub-system electronics. Interfaces to GLT-CPU Communicate Card, receives control commands and transfers event data. Contains event buffers for sub-system data, assembles TKR, CAL, and trigger event fragments to one tower event packet. Includes also electronics for environmental monitoring. There are a total of 16 flight-units plus 2 qual units.	SLAC	Saphoznikov
4.1.7.4.3.1	Pre Engineering Model	Prototype board to validate circuit function. Also used in prototype system tests. May control and readout subset of complete system. May only contain main function blocks and no auxiliary functions.	SLAC	Saphoznikov
4.1.7.4.3.1.1	Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.3.1.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.3.2	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Saphoznikov
4.1.7.4.3.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	SLAC	Saphoznikov
4.1.7.4.3.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.3.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.3.3	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Saphoznikov

WBS	Task	Description	Responsibility	Manager
4.1.7.4.3.3.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.3.3.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.3.4	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Saphoznikov
4.1.7.4.3.4.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.3.4.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.3.4.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.4	ACD TEM Electronics	Tower Electronics Module to control and readout the whole ACD sub system electronics. Interfaces to GLT-CPU Communicate Card, receives control commands and transfers event data. Contains event buffers for sub-system data, assembles ACD and trigger event fragments to event packet. There are a total of 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	SLAC	Saphoznikov
4.1.7.4.4.1	Pre Engineering Model	Prototype board to validate circuit function. Also used in prototype system tests. May control and readout subset of complete system. May only contain main function blocks and no auxiliary functions.	SLAC	Saphoznikov
4.1.7.4.4.1.1	Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.4.1.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.4.2	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Saphoznikov

WBS	Task	Description	Responsibility	Manager
4.1.7.4.4.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	SLAC	Saphoznikov
4.1.7.4.4.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.4.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.4.3	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Saphoznikov
4.1.7.4.4.3.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.4.3.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.4.4	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Saphoznikov
4.1.7.4.4.4.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.4.4.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.4.4.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.5	GLT-CPU Interface Card (LAT EP Com Card)	Receives event fragments from all towers and assembles them into complete events. Forwards them to processors. Can select to which processor a given event is to be forwarded. There may be a total of 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units. Or there may be up to eight, depending on the number of Data-CPU's (tbr).	SLAC	Nelson

WBS	Task	Description	Responsibility	Manager
4.1.7.4.5.1	Pre Engineering Model	Prototype board to validate circuit function. Also used in prototype system tests. May control and readout subset of complete system. May only contain main function blocks and no auxiliary functions.	SLAC	Nelson
4.1.7.4.5.1.1	Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.4.5.1.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.4.5.2	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.4.5.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	SLAC	Nelson
4.1.7.4.5.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.4.5.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.4.5.3	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.4.5.3.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.4.5.3.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.4.5.4	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components.Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Nelson

WBS	Task	Description	Responsibility	Manager
4.1.7.4.5.4.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.4.5.4.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.4.5.4.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.4.6	Data CPUs (and IO Card)	Data-CPU generates control commands to the towers (via the GLT-CPU Communicate card).It receives complete events from the GLT-CPU Communicate card and filters the events in a Level 2 and Level 3 software filter. Based either on a power-PC 603E or 750 processor, has memory, interface to other processors. There may be a total of up to 9 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	NRL	Lovellette
4.1.7.4.6.1	(Reserved)			
4.1.7.4.6.2	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.4.6.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	NRL	Lovellette
4.1.7.4.6.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.4.6.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.4.6.3	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.4.6.3.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette

WBS	Task	Description	Responsibility	Manager
4.1.7.4.6.3.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.4.6.4	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components.Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	NRL	Lovellette
4.1.7.4.6.4.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.4.6.4.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.4.6.4.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.4.7	Data CPU Backplane	The Data-CPU backplane provides the interconnection between data-cpu cards, GLT-CPU Communicate card, the power-supply card. May be of VME, PCI, or point-to-point serial connectivity. There are a total of up to 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	NRL	Lovellette
4.1.7.4.7.1	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.4.7.1.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	NRL	Lovellette
4.1.7.4.7.1.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.4.7.1.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette

WBS	Task	Description	Responsibility	Manager
4.1.7.4.7.2	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.4.7.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	NRL	Lovellette
4.1.7.4.7.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.4.7.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.4.7.3	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components.Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	NRL	Lovellette
4.1.7.4.7.3.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.4.7.3.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.4.7.3.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.4.8	Global Trigger (GLT) Electronics	Global Trigger Electronics Module. Interfaces to SIU Interface Card, receives control commands and transfers event data. Receives trigger inputs from TEM's and ACD EM and generates trigger acknoledge signal. Includes also electronics for environmental monitoring. There are a total of 2 flight-units plus 1 qual unit.	SLAC	Saphoznikov
4.1.7.4.8.1	Pre Engineering Model	Prototype board to validate circuit function. Also used in prototype system tests. May control and readout subset of complete system. May only contain main function blocks and no auxiliary functions.	SLAC	Saphoznikov
4.1.7.4.8.1.1	Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.8.1.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov

WBS	Task	Description	Responsibility	Manager
4.1.7.4.8.2	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Saphoznikov
4.1.7.4.8.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	SLAC	Saphoznikov
4.1.7.4.8.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.8.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.8.3	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Saphoznikov
4.1.7.4.8.3.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.8.3.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.8.4	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Saphoznikov
4.1.7.4.8.4.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Saphoznikov
4.1.7.4.8.4.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.8.4.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Saphoznikov
4.1.7.4.9	Test Bed Data Flow	Used for system test of data-acquisition system. Need several copies of TKR-TEM enineering models, ACD TEM, GLT-CPU Communicate cards. Also need CPU cards which maybe non-flight processor boards acquired from fliight model provider. Need several front-end simulator cards.	SLAC	Haller

WBS	Task	Description	Responsibility	Manager
4.1.7.5	Spacecraft Interface Unit	Spacecraft Interface Unit. Includes instrument-control processor with interface to spacecraft. Commanding via MIL1553, telemetry via lvds or RS422 bus at 32MB/s minimum. Control processor communicates with DATA-CPU cards. All interconnected via SIU backplane board. There are a total of up to 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	NRL	Lovellette
4.1.7.5.1	Design Requisites	Includes engineering time to create SIU requirement and conceptual design documents, including discussions to arrive at an appropriate design.	NRL	Lovellette
4.1.7.5.2	Spacecraft Communications Card	Distributes control commands to the Data-CPUs and TEMs from commands received from spacecraft. via MIL1553 interface. Command, configuration, and control function. Has high-speed telemetry data link to spacecraft.Based either on a power-PC 603E or 750 processor, has memory, interface to other processors. There are a total of up to 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	NRL	Lovellette
4.1.7.5.2.1	(Reserved)			
4.1.7.5.2.2	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.5.2.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	NRL	Lovellette
4.1.7.5.2.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.5.2.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.5.2.3	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.5.2.3.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette

WBS	Task	Description	Responsibility	Manager
4.1.7.5.2.3.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.5.2.4	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	NRL	Lovellette
4.1.7.5.2.4.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.5.2.4.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.5.2.4.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.5.3	Housekeeping Board	Housekeeping board receives sensor signals as temperatures, current, voltages, or status bits from LAT, processes the data, and communicates it to the instrument control CPU. May contain micro-controller or processor There are a total of up to 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	SLAC	Nelson
4.1.7.5.3.1	(Reserved)			
4.1.7.5.3.2	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.5.3.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	SLAC	Nelson
4.1.7.5.3.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.5.3.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson

WBS	Task	Description	Responsibility	Manager
4.1.7.5.3.3	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.5.3.3.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.5.3.3.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.5.3.4	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Nelson
4.1.7.5.3.4.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.5.3.4.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.5.3.4.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.5.4	SIU Backplane	The SIU backplane provides the interconnection between IC-CPU card, Housekeeping card, power-switching card, the power-conditioningcard. May be of VME, PCI, or point-to-point serial connectivity. There are a total of up to 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	NRL	Lovellette
4.1.7.5.4.1	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.5.4.1.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	NRL	Lovellette

WBS	Task	Description	Responsibility	Manager
4.1.7.5.4.1.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.5.4.1.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.5.4.2	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	NRL	Lovellette
4.1.7.5.4.2.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	NRL	Lovellette
4.1.7.5.4.2.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.5.4.2.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.5.4.3	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	NRL	Lovellette
4.1.7.5.4.3.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	NRL	Lovellette
4.1.7.5.4.3.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette
4.1.7.5.4.3.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	NRL	Lovellette

WBS	Task	Description	Responsibility	Manager
4.1.7.6	Power Conditioning	Power-supply system for the LAT includes switching and conditioning of power. Takes redundant 28-V input from spacecraft and switches power to the TEMs and other LAT electronics. Includes power-conditioning cards located in the SIU, 16-TKR-CAL TEM and ACD-TRG TEM boxes. There are 2 flight SIU power cards, 16 TKR-TEM power cards, 2 flight ACD-TRG TEM power cards (of of which is a non-powered-unless-needed redundant unit).	SLAC	Nelson
4.1.7.6.1	Design Requisites	Includes engineering time to create SIU requirement and conceptual design documents, including discussions to arrive at an appropriate design.	SLAC	Nelson
4.1.7.6.2	Power Switching Card (PSC)	The Power Switching Card takes the 28-V redundant supply from the spacecraft and directs them to the towers. the power-conditioningcard. May be of VME, PCI, or point-to-point serial connectivity. There are a total of up to 2 flight-units (one of it is a redundant, non-powered-unless-used unit.) Two Qual units.	SLAC	Nelson
4.1.7.6.2.1	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.6.2.1.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	SLAC	Nelson
4.1.7.6.2.1.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.2.1.3	Fab/Assembly/Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.2.2	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to control/readout to/from all interfaces. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.6.2.2.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.2.2.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson

WBS	Task	Description	Responsibility	Manager
4.1.7.6.2.3	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Nelson
4.1.7.6.2.3.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.2.3.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.2.3.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.3	Generic Power Conditioning Card (Generic-PCC)	Prototype to evaluate the selected principle of conversion and filtering of supply voltages.	SLAC	Nelson
4.1.7.6.3.1	Conceptual Design	Conceptual Design includes block diagram level design with description of operation and functions. Interface descriptions are included.	SLAC	Nelson
4.1.7.6.3.2	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.3.3	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.4	(Reserved)			
4.1.7.6.5	TKR/CAL-TEM Power Conditioning Card	The TKR-CAL Power Conditioning Card takes the 28-V from the power-switcing card and converts it down to the voltages used by the TEM and the CAL and TKR sub-system. It includes filtering. It provides monitoring interfaces. There are a total of up to 16 Flight-units plus two Qual units.	SLAC	Nelson
4.1.7.6.5.1	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to supply/monitor a tower. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.6.5.1.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.5.1.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson

WBS	Task	Description	Responsibility	Manager
4.1.7.6.5.2	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to supply/monitor a tower. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.6.5.2.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.5.2.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.5.3	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Nelson
4.1.7.6.5.3.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.5.3.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.5.3.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.6	ACD-TEM Power Conditioning Card (ACDTEM-PCC)	The ACD TEM Power Conditioning Card takes the 28-V from the power-switcing card and converts it down to the voltages used by the TEM and the ACD sub-system. It includes filtering. It provides monitoring interfaces. There are a total of up to 2 Flight-units plus two Qual units.	SLAC	Nelson
4.1.7.6.6.1	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to supply/monitor a tower. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.6.6.1.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson

WBS	Task	Description	Responsibility	Manager
4.1.7.6.6.1.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.6.2	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to supply/monitor a tower. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.6.6.2.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.6.2.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.6.3	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Nelson
4.1.7.6.6.3.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.6.3.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.6.3.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.7	Data CPU Power Conditioning Card (DCPU-PCC)	The Data-CPU Power Conditioning Card takes the 28-V from the power-switcing card and converts it down to the voltages used by the CPUs. It includes filtering. It provides monitoring interfaces. There are a total of up to 2 Flight-units plus two Qual units.	SLAC	Nelson
4.1.7.6.7.1	Engineering Model 1	Engineering 1 Model: First fully functional model used to validate circuit function and all interfaces. Contains all electronics to supply/monitor a tower. All functions are implemented. No-Flight qualified material or components are used. Components may not be pin-compatible with flight parts.	SLAC	Nelson

WBS	Task	Description	Responsibility	Manager
4.1.7.6.7.1.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.7.1.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.7.2	Engineering Model 2	Engineering 2 Model: Contains all modifications to be implemented as a result for the EM1 tests. Fully functional model used to validate circuit function and all interfaces. Contains all electronics to supply/monitor a tower. All functions are implemented. No-Flight qualified material or components are used. However components must be pin-compatible with flight parts.	SLAC	Nelson
4.1.7.6.7.2.1	Preliminary Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.7.2.2	Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.7.3	Flight Units	Qualification unit contains all required changes found in EM2 tests. Contains fully qualified flight material and components. Used for qualification of unit and system. May be used as flight spare. Subsequent fabrication and qualification of all flight-units. All functional, performance, environmental and EMI tests.	SLAC	Nelson
4.1.7.6.7.3.1	Qualification Unit Design	Preliminary Design includes creation of schematics, FPGA or ASIC codes and documentation. Design must be fully simulated. Interfaces are fully defined and simulated.	SLAC	Nelson
4.1.7.6.7.3.2	Qualification Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.6.7.3.3	Flight Unit Fab, Assembly & Test	Fab/Assembly/Test includes layout and fabrication of PC boards or ASICs, procurements of all components, loading of boards, and test for functionality and performance. If board is part of system test with interface boards are performed.	SLAC	Nelson
4.1.7.7	Enclosures	Includes the design and fabrication of the boxes holding the electronics boards.	SLAC	Freytag
4.1.7.7.1	TKR/CAL Enclosure	Includes the design and fabrication of the boxes holding the TKR-Cal TEM and the power conditioning electronics board.	SLAC	Freytag
4.1.7.7.1.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	SLAC	Freytag
4.1.7.7.1.1.1	Conceptual Design	Enclosure concept	SLAC	Freytag
4.1.7.7.1.1.2	Preliminary Design	Mechanical drawings of enclosure	SLAC	Freytag
4.1.7.7.1.1.3	Fab, Assembly & Test	Fabricate parts and assemble enclusure	SLAC	Freytag
4.1.7.7.1.2	Qualification Unit	Mechanical Encosure for qual model electronics	SLAC	Freytag
4.1.7.7.1.2.1	Design	Mechanical drawings of enclosure	SLAC	Freytag

WBS	Task	Description	Responsibility	Manager
4.1.7.7.1.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	SLAC	Freytag
4.1.7.7.1.3	Flight Unit	Mechanical Encosure for flight electronics	SLAC	Freytag
4.1.7.7.2	ACD-TRG Enclosure	Includes the design and fabrication of the boxes holding the ACD TEM and the power conditioning electronics board.	SLAC	Freytag
4.1.7.7.2.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	SLAC	Freytag
4.1.7.7.2.1.1	Conceptual Design	Enclosure concept	SLAC	Freytag
4.1.7.7.2.1.2	Preliminary Design	Mechanical drawings of enclosure	SLAC	Freytag
4.1.7.7.2.1.3	Fab, Assembly & Test	fabricate parts and assemble enclusure	SLAC	Freytag
4.1.7.7.2.2	Qualification Unit	Mechanical Encosure for qual model electronics	SLAC	Freytag
4.1.7.7.2.2.1	Design	Mechanical drawings of enclosure	SLAC	Freytag
4.1.7.7.2.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	SLAC	Freytag
4.1.7.7.2.3	Flight Unit	Mechanical Encosure for flight electronics	SLAC	Freytag
4.1.7.7.3	Data CPU Enclosure	Includes the design and fabrication of the boxes holding the Data-CPUs and the power conditioning electronics board.	NRL	Lovellette
4.1.7.7.3.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	NRL	Lovellette
4.1.7.7.3.1.1	Conceptual Design	Enclosure concept	NRL	Lovellette
4.1.7.7.3.1.2	Preliminary Design	Mechanical drawings of enclosure	NRL	Lovellette
4.1.7.7.3.1.3	Fab, Assembly & Test	Fabricate parts and assemble enclusure	NRL	Lovellette
4.1.7.7.3.2	Qualification Unit	Mechanical Encosure for qual model electronics	NRL	Lovellette
4.1.7.7.3.2.1	Design	Mechanical drawings of enclosure	NRL	Lovellette
4.1.7.7.3.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	NRL	Lovellette
4.1.7.7.3.3	Flight Unit	Mechanical Encosure for flight electronics	NRL	Lovellette
4.1.7.7.4	SIU Enclosure	Includes the design and fabrication of the boxes holding the spacecraft interface electronics boards.	NRL	Lovellette
4.1.7.7.4.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	NRL	Lovellette
4.1.7.7.4.1.1	Conceptual Design	Enclosure concept	NRL	Lovellette
4.1.7.7.4.1.2	Preliminary Design	Mechanical drawings of enclosure	NRL	Lovellette
4.1.7.7.4.1.3	Fab, Assembly & Test	Fabricate parts and assemble enclusure	NRL	Lovellette
4.1.7.7.4.2	Qualification Unit	Mechanical Encosure for qual model electronics	NRL	Lovellette
4.1.7.7.4.2.1	Design	Mechanical drawings of enclosure	NRL	Lovellette
4.1.7.7.4.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	NRL	Lovellette
4.1.7.7.4.3	Flight Unit	Mechanical Encosure for flight electronics	NRL	Lovellette
4.1.7.8	Cable Harness	Includes the design and fabrication of the cable harness in the LAT.	SLAC	Freytag
4.1.7.8.1	Engineering Model	Includes the design and fabrication of the cable harness for the engineering 2 model electronics.	SLAC	Freytag
4.1.7.8.2	Qualification Unit	Includes the design, fabrication, inspection of the cable harness for the Qual Unit electronics.	SLAC	Freytag
4.1.7.8.3	Flight Unit	Includes the design, fabrication, inspection of the cable harness for the Flight Unit electronics.	SLAC	Freytag
4.1.7.9	Flight Software	The flight software covers all software running on the LAT. It includes control, configuration, command, dataflow, event filtering, event classification, data monitoring, housekeeping, uplink of command script and new software, generate physics alerts.	SLAC	Russell

WBS	Task	Description	Responsibility	Manager
4.1.7.9.1	Infra-Structure Development/Test Bench Support	Engineering time to establish coding practices, code distribution procedures, lifecycle (test, development, production), code documentation and testing procedures.	SLAC	Russell
4.1.7.9.1.1	Infra-Structure Development	development of framework	SLAC	Russell
4.1.7.9.1.2	Test Bench Support	software support of hardware testbenches	SLAC	Russell
4.1.7.9.2	Determine CPU Resources	Characterize memory, IO, CPU cycle needs.	SLAC	Russell
4.1.7.9.3	Engineering Model 1	Software to support a system comprising electronics of a single tower plus one GLT-CPU Communicate-Card plus one CPU.	SLAC	Russell
4.1.7.9.3.1	Architecture	Design overall architecture of software	SLAC	Russell
4.1.7.9.3.2	Low Level Diagnostics	Write low level diagnostics code	SLAC	Russell
4.1.7.9.3.3	Tower Command & Configuration	Write code to configure and command a tower	SLAC	Russell
4.1.7.9.3.4	Dataflow	move the data from the tower	SLAC	Russell
4.1.7.9.3.5	Housekeeping	Readout housekeeping data	SLAC	Russell
4.1.7.9.3.6	EM1 Simulator	Write the driver for the Front-end simulator	SLAC	Russell
4.1.7.9.3.7	Low Rate Science	Readout the rate counters	SLAC	Russell
4.1.7.9.4	Engineering Model 2	Software to support a system comprising electronics of several towers plus several GLT-CPU Communicate-Card plus one or more CPU's.	SLAC	Russell
4.1.7.9.4.1	EM1/EM2 Transistion		SLAC	Russell
4.1.7.9.4.2	Low Level Diagnostics	Write low level diagnostics code	SLAC	Russell
4.1.7.9.4.3	Facilities	Facilities	SLAC	Russell
4.1.7.9.4.4	Fast Monitoring	Write code to fast monitor the data	SLAC	Russell
4.1.7.9.4.5	Space Craft Ops	Communication and I/O	SLAC	Russell
4.1.7.9.4.6	GSE	Ground Suypport Equipment exploitation	SLAC	Russell
4.1.7.9.4.7	Uplink/Downlink	SSR management, input and output data formatting	SLAC	Russell
4.1.7.9.4.8	Calibration	Code to calibrate systems	SLAC	Russell
4.1.7.9.4.9	EM2 Simulator	Write the driver for the Front-end simulator	SLAC	Russell
4.1.7.9.4.A	Science	Science software	SLAC	Russell
4.1.7.9.4.B	Mulit-CPU Toolbox Effort	All effort to talk between CPUs	SLAC	Russell
4.1.7.9.4.B.1	Multi-CPU Toolbox	Code to talk between CPUs	SLAC	Russell
4.1.7.9.4.B.2	Multi-CPU Low Level Diagnostics	Low-level diagnostics code	SLAC	Russell
4.1.7.9.4.B.3	Multi-CPU Calibration	Calibration Code	SLAC	Russell
4.1.7.9.5	Qualification Unit	Software to support a system comprising electronics of several towers plus several GLT-CPU Communicate-Card plus several CPU's.	SLAC	Russell
4.1.7.9.5.1	(reserved)	Facilities		
4.1.7.9.5.2	Multi-CPU Implementation	All effort to suppoort a system with multiple CPUs	SLAC	Russell
4.1.7.9.5.2.1	Facilities	Facilities	SLAC	Russell
4.1.7.9.5.2.2	(reserved)			
4.1.7.9.5.2.3	Fast Monitoring	Write code to fast monitor the data	SLAC	Russell
4.1.7.9.5.2.4	Space Craft Ops	Communication and I/O	SLAC	Russell
4.1.7.9.5.2.5	GSE	Ground Suypport Equipment exploitation	SLAC	Russell
4.1.7.9.5.2.6	(reserved)			
4.1.7.9.5.2.7	Science	Science software	SLAC	Russell
4.1.7.9.6	Flight Unit	Final software for the flight-unit electronics.	SLAC	Russell

WBS	Task	Description	Responsibility	Manager
4.1.7.9.6.1	Final Instrument Code Integration	Integrate all code	SLAC	Russell
4.1.7.9.6.2	SLAC Based Flight I&T	Support I&T at SLAC	SLAC	Russell
4.1.7.9.6.3	Non-SLAC Based I&T	Support I&T away from SLAC	SLAC	Russell
4.1.7.A	EGSE & Operations	All labor and material required for the ground support for the LAT electronics. Interfaces to the LAT via the spacecraft interface unit. Essentially simulates the spacecraft functions requried to control and readout the LAT.	HEPL	Williams
4.1.7.A.1	EGSE Requirements Definition	All labor required to define the requirements of the EGSE system.	HEPL	Williams
4.1.7.A.2	EGSE Development	All labor and material required to support the control and readout of the LAT electronics, hardware and software.	HEPL	Williams
4.1.7.A.2.1	EGSE S/W Development	Development of software	HEPL	Williams
4.1.7.A.2.2	EGSE H/W Development	Devlopment of hardware	HEPL	Williams
4.1.7.A.2.3	EM2 Support	GSE support for engineering 2 models	HEPL	Williams
4.1.7.A.2.4	Qual Unit Support	GSE support for qual models	HEPL	Williams
4.1.7.A.2.5	Flight Unit Support	GSE support for flight models	HEPL	Williams
4.1.7.A.3	S/C Interface Simulator	All labor and material required to build and operate a spacecraft simulator as seen from the LAT.	HEPL	Williams
4.1.7.A.3.1	SIS Development	design space craft interface simulator	HEPL	Williams
4.1.7.A.3.2	Qual Unit Support	support effort to interface to LAT via SIS	HEPL	Williams
4.1.7.A.3.3	Flight Unit Support	support effort to interface to LAT via SIS	HEPL	Williams
4.1.7.A.4	Instrument Power System	All labor and material required to build the power supply system supplying power to the LAT.	HEPL	Williams
4.1.7.A.4.1	IPS Development	Power systme development for LAT	HEPL	Williams
4.1.7.A.4.2	Qual Unit Support	Power supplies for qual units	HEPL	Williams
4.1.7.A.4.3	Flight Unit Support	Power supplies for LAT	HEPL	Williams
4.1.7.B	(Reserved)			
4.1.7.C	Instrument Integration & Test	All labor and material to integrate and test the LAT electronics.	SLAC	Haller
4.1.7.C.1	TKR/CAL-TEM Box I&T	All labor and material to integrate the TKR-CAL TEM electronics in the TKR-CAL TEM Box and test the assembly.	SLAC	Freytag
4.1.7.C.1.1	Engineering Model 2	Integrate engineering 2 model electronics in box	SLAC	Freytag
4.1.7.C.1.2	Qualification Unit	Integrate qualification model electronics in box	SLAC	Freytag
4.1.7.C.1.3	Flight Unit	Integrate flight model electronics in box	SLAC	Freytag
4.1.7.C.2	ACD TEM Box I&T	All labor and material to integrate the ACD TEM electronics in the ACD TEM Box and test the assembly.	SLAC	Freytag
4.1.7.C.2.1	Engineering Model 2	Integrate engineering 2 model electronics in box	SLAC	Freytag
4.1.7.C.2.2	Qualification Unit	Integrate qualification model electronics in box	SLAC	Freytag
4.1.7.C.2.3	Flight Unit	Integrate flight model electronics in box	SLAC	Freytag
4.1.7.C.3	Data CPU Box I&T	All labor and material to integrate the Data-CPU electronics in the Data-CPU Box and test the assembly.	NRL	Lovellette
4.1.7.C.3.1	Engineering Model 2	Integrate engineering 2 model electronics in box	NRL	Lovellette
4.1.7.C.3.2	Qualification Unit	Integrate qualification model electronics in box	NRL	Lovellette
4.1.7.C.3.3	Flight Unit	Integrate flight model electronics in box	NRL	Lovellette
4.1.7.C.4	SIU Box I&T	All labor and material to integrate the SIU electronics in the SIU Box and test the assembly.	NRL	Lovellette
4.1.7.C.4.1	Engineering Model 2	Integrate engineering 2 model electronics in box	NRL	Lovellette
4.1.7.C.4.2	Qualification Unit	Integrate qualification model electronics in box	NRL	Lovellette

WBS	Task	Description	Responsibility	Manager
4.1.7.C.4.3	Flight Unit	Integrate flight model electronics in box	NRL	Lovellette
4.1.7.C.5	Instrument I&T	All labor and material to integrate all the boxes with the cable-harness and test the assembly.	SLAC	Haller
4.1.7.C.5.1	Engineering Model 2	integration of engineering 2 models	SLAC	Haller
4.1.7.C.5.2	Qualification Unit	integration of qualification models	SLAC	Haller
4.1.7.C.5.3	Flight Unit	integration of flight models	SLAC	Haller
4.1.7.D	Mission Systems Integration & Test	All labor to test the Lat when integarated with the spacecraft. Prelauch and early post-launch support.	HEPL	Williams
4.1.7.D.1	Observatory Testing	Labor to test the LAT when integrated with the spacecraft	HEPL	Williams
4.1.7.D.2	Ground Systems Compatibility Tests	Labor to test the LAT in regards to its compatibility with the ground systems.	HEPL	Williams
4.1.7.D.3	Training Simulations	Simulations of the LAT.	HEPL	Williams
4.1.7.D.4	Launch & Early Operations Support	Support for testing pre-launch and post-launch operation of the LAT.	HEPL	Williams
4.1.7.D.5	MSI&T Travel	All travel for MSI&T phase	HEPL	Williams

WBS	Task	Description	Responsibility	Manager
4.1.8	**Mechanical Systems**	**Perform LAT system-level thermal and structural analysis, and manage system internal and external structural and thermal interfaces. Manage the LAT Mechanical Parts list, and mass and dimensional bookkeeping. Develop, fabricate, assemble, and test LAT Grid support structure, Radiators, and the LAT thermal control system. Support LAT integration and test by maintaining and updating system thermal and structural models through LAT, SC, and LV I&T, and on-orbit check-out.**	**SLAC**	**Nordby**
4.1.8.1	Management	Provide subsystem scheduling, cost-accounting, and performance tracking and reporting. Support development of subsystem specifications, plans, and interfaces. Control mass, power dissipation. Support team meetings and project reviews. Travel to team meetings, vendor visits, and integration facilities. This includes management of and by subcontractors. Also includes development of mechanical parts database, and tracking of all parts and materials for the LAT.	SLAC	Nordby
4.1.8.1.1	Management and Engineering	Provide program scheduling, cost-accounting, and performance tracking and reporting for entire subsystem. Support development of subsystem specifications, verification plans, and interfaces with neighboring subsystems. Control subsystem mass, electrical, power, and environmental requirements and performance metrics. Support quarterly team meetings and project reviews, and travel thereto.	SLAC	Nordby
4.1.8.1.2	Travel	Travel for subsystem support of team meetings, vendor visits, and technical meetings for all Mechanical Systems staff. This includes extended-stay travel required to support LAT, SC, and LV integration and test activities. Also includes travel for SRR, CDR, other reviews, and SC technical meetings.	SLAC	Nordby
4.1.8.1.3	Mech Parts and Material Engineering	Develop mechanical parts and materials plan for the LAT. Develop materials and parts database, for use by all LAT subsystems. Collect materials and parts information for all subsystems. Manage review and approval process and status of all candidate materials and parts. Update materials and parts list periodically. Ensure subsystem compliance with materials lists.	SLAC	Nordby

WBS	Task	Description	Responsibility	Manager
4.1.8.1.4	(LM) Sub-Contractor Management	Manage day-to-day activities of all personnel and activities at LM and any sub-contractor facilities. This includes technical management of efforts, as well as programmatic managing of cost accounts, charges, procurements, and all other expenditures for this contract. Communicate with the University Technical Representative (UTR) and LAT management regarding longer range planning and resource allocations for work under this contract, and as it pertains to the remainder of the LAT project. Write scheduling, cost-accounting, and performance tracking reports. Provide technical performance estimates monthly.	SLAC	Nordby
4.1.8.1.5	(LM) Sub-Contractor Travel	Travel for support of team meetings, subcontractor visits, technical meetings, and testing for all staff. This includes travel required to support any integration and test activities occurring at locales other than LM in Palo Alto or Sunnyvale, California, or at SLAC. Travel costs include transportation, lodging, and meal expenses, as well as any incidental expenses. All travel costs should concur with Federal Travel Regulations. Personnel time while on travel should be included in the appropriate WBS category for which the travel is performed. Specific events for which travel is required include: CDR at GSFC, 1 meeting with the spacecraft (SC) contractor on east coast. Specific events for which travel is required include: 1 LAT review at GSFC, 2 meetings with the spacecraft (SC) contractor on east coast, 3 meetings at HPPC in Mississippi, Observatory integration and test, PSR at GSFC.	SLAC	Nordby
4.1.8.2	Reliability & Quality Assurance	Provide input to LAT reliabilitiy and hazard analyses. Develop procedures for the fabrication of components and assemblies. Support PHA development. Collect quality records and report to LAT PSAM as needed. Includes subcontractor QA activities.	SLAC	TBD
4.1.8.2.1	Reliability	Covered by 4.1.A Performance and Safety Assurance	SLAC	Marsh
4.1.8.2.2	Quality Assurance	Covered by 4.1.A Performance and Safety Assurance	SLAC	Marsh
4.1.8.2.3	(LM) Sub-Contractor Quality Assurance	Develop Performance Assurance Implementation Plan (PAIP) to cover all activities under this contract, to ensure flow-down of requirements from the LAT project. Work with technical staff to identify or develop appropriate procedures to ensure that all activities relating to flight hardware and GSE are responsive to ISO 9001 quality provisions. Work with all organizations performing work for the subsystem, to ensure uniform compliance to standards and procedures, and to verify performance. Provide information about LM-supplied hardware for Preliminary Hazard Analysis (PHA) and support LAT safety officer in collecting hazard information on items under this contract. Collect fabrication and procurement records and test data for any work related to flight or qualification hardware or GSE.	SLAC	TBD

WBS	Task	Description	Responsibility	Manager
4.1.8.3	Mechanical Systems Development	Perform thermal and mechanical design integration and analysis for the instrument. Design and develop subsystem interfaces, and interfaces with spacecraft. Develop Grid structure, including prototyping and analysis of Grid.	SLAC	Nordby
4.1.8.3.1	LAT Mechanical Design Integration	Perform overall mechanical integration task for the instrument. Design and develop subsystem interfaces, and interfaces with spacecraft. Develop mechanical ICD's with other subsystems and with SC. Maintain design integration interfaces up to LAT integration. Then task is handed off to I&T group. Perform thermal-mechanical analysis and simulation for the instrument. Provide instrument structural and CAD models to the Project Office. Work with subsystem mechanical engineers in developing subsystem mechanical designs, and in providing FEA models of subsystem. Maintain LAT structural FEA model up to LAT integration. Develop instrument-level mechanical verification test specifications, and help write test procedures.	SLAC	Nordby
4.1.8.3.2	Grid Mech Development and Prototyping	Develop and update mechanical interface requirements document for, and within, subsystem. Perform mechanical and structural analysis of Grid, and complete trade studies on detailed designs of Grid. Perform any prototyping or development work of mechanical design, as needed. Perform prototype analysis, generate drawings, manage fabrication, and carry out testing. Prototypes include: bolt pull-out models; friction model of CAL joints; Grid heat pipe assembly process tests. Complete conceptual design of subsystem parts and assemblies.	SLAC	TBD
4.1.8.4	Thermal Systems Development	Perform overall orbital dynamic and radiation thermal analysis for the instrument, and interface with LAT thermal-mechanical analysis. Develop conceptual thermal and structural design of LAT Radiators and Grid heat pipes.	SLAC	Nordby
4.1.8.4.1	(LM) LAT Thermal Modeling	Perform overall radiation thermal analysis for the instrument, and provide appropriate details of the analysis to allow coordination of the LM radiation model with SLAC thermal-mechanical FEA model. This includes running orbital dynamic analysis of radiative heating of LAT to characterize overall LAT thermal performance over the full range of environmental and operational conditions. Develop specifications for thermal performance of Radiators and Thermal Shield, based on orbital thermal analyses. Specify heaters and controls needed for operations and survival mode. Work with project and SC thermal engineers in identifying and resolving thermal interface issues with the SC. Prepare radiation thermal analysis models and reports for review at Mech-PDR, I-PDR, Mech-CDR, and I-CDR. Update model every quarter, if needed, to include new developments in the LAT design. Prepare and deliver a reduced LAT Thermal Math Model, in the format specified, to GSFC at PDR and CDR. Maintain updated overall radiation thermal analysis for the instrument, and provide appropriate details of the analysis to allow	SLAC	Nordby

WBS	Task	Description	Responsibility	Manager
		coordination of the LM radiation model with SLAC thermal-mechanical FEA model by SLAC and with SC contractor's thermal models. This includes running orbital dynamic analysis of radiative heating of LAT with selected spacecraft, and with final operational configurations.		
4.1.8.4.2	(LM) Radiator Development	Perform thermal design and analysis of the radiators. This includes interfacing with LAT and SC thermal engineers in optimizing the Radiator design. Develop structural design and FEA analysis of radiators. This includes optimizing the radiator structural design with respect to the support method and locations. Generate Radiator detailed layout drawings, and rough fabrication and assembly plans for I-PDR. This is initial conceptual work up to I-PDR.	SLAC	Nordby
4.1.8.4.3	(LM) Grid Heat Pipe Development	Perform initial thermal design and analysis of the Grid heat pipes. Support mechanical design development of Grid work at SLAC with consulting on heat pipe fabrication and assembly issues. Specify heat pipe design and performance for I-PDR, based on SLAC requirements. This is conceptual work, through I-PDR.	SLAC	Nordby
4.1.8.5	Thermal Control System	Develop control system for thermal management of instrument, including heater and heater power design, feedback and control system for heaters, and monitoring systems. Procure, fab, assemble, and test on the LAT. Also includes thermal control GSE for bench-testing and during environmental testing (if separate from test GSE).	SLAC	Haller
4.1.8.5.1	Thermal Control System Development	Develop control system for thermal management of instrument, including heater and heater power design, feedback and control system for heaters, and monitoring systems. This includes controls during normal operation as well as when LAT is off. Also includes thermal control GSE for bench-testing and during environmental testing (if separate from test GSE). Interface with SC contractor and project office in establishing electronic interfaces for this system. Prototype control system.	SLAC	Haller
4.1.8.5.2	Control System Fabrication	Procure components for control system, and assemble and test. Support integration and test of controls on Qual and Flight Grids and Radiators.	SLAC	Haller
4.1.8.5.3	Controls Integration Support	Develop GSE for testing Mech Systems controls on the ground, and during verification testing. Design and fabricate dummy loads and controls for verification testing.	SLAC	Haller
4.1.8.6	(LM) Radiators	Fabricate Heat Pipe engineering model (EM). Finalize Radiator designs after I-PDR and fabricate, assemble, and test flight Radiators.	SLAC	Nordby

WBS	Task	Description	Responsibility	Manager
4.1.8.6.1	(LM) Heat Pipe EM Development	Size X-LAT HP EM based on heat loads from SLAC. Develop detailed design from SLAC Spec's. Engineering support of Heat Pipe fabrication, inspection, and testing, including developing shop drawings and processes, and supporting test planning and execution. Fabricate and verification test 1 X-LAT Heat Pipe EM, including any fixturing needed.	SLAC	Nordby
4.1.8.6.2	(LM) Radiator Development	Perform structural and thermal analyses of Radiators after I-PDR. Complete detailed design and manufacturing plans for Radiators and embedded VCHP's. Develop drawings and specifications for review at Mech-CDR, I-CDR, and for fabrication. Maintain CAD and FEA model of radiators. Update designs in preparation for CDR, and with input from SC contractor. Prepare info for Mech-CDR and I-CDR. Develop radiator environmental and performance test plans. Prepare info for Mech-CDR and I-CDR. Finalize radiator environmental and performance test plans. Design radiator test equipment. Tests include random vibe, sine sweep, model survey.	SLAC	Nordby
4.1.8.6.3	(LM) Radiator Fab and Test	Develop shop drawings and procedures for radiator and heat pipe fabrication. Oversee radiator fabrication and assembly. Finalize Radiator test procedures and oversee radiator testing. Maintain CAD and FEA model of radiators. Update as-built drawings after fabrication and testing. Fabricate radiators: procure materials, fabricate assembly fixtures, and assemble radiators. Fabricate transport and storage GSE for radiators. Fabricate radiator test fixtures. Procure test equipment. Test radiators. Includes cost of use of test facilities and support team. Testing includes vibration acceptance test and thermal functional testing of VCHP's, heaters, and thermistors.	SLAC	Nordby
4.1.8.6.4	(LM) Thermal Controls	Provide electrical engineering support for radiator heater and control system, in conjunction with subsystem-level electronics development. Specify radiator heaters and thermal monitors needed, with Electronics subsystem. Develop procedures for assembly and testing of heaters on radiators. Prepare procedures for assembly and testing of heaters on radiators. Procure radiator heaters and thermal monitors. Oversee integration of heaters and temperature monitors into radiator assemblies. Oversee heater testing during radiator testing.	SLAC	Nordby
4.1.8.7	Grid	Develop, fab, and test Grid engineering models and prototypes after I-PDR. Finalize flight Grid interface designs. Fabricate flight Grid. Complete detailed design and fabricate heat pipes for flight Grid and X-LAT Thermal Plate. Supervise fabrication.	SLAC	TBD

WBS	Task	Description	Responsibility	Manager
4.1.8.7.1	Grid EM Development and Testing	Perform mechanical design, analysis, and complete detailed drawings of engineering models, prototypes, and qual test units. This includes developing model requirements and fabrication and test procedures. Fabricate and assemble engineering models. This includes fabricating any fixturing and test equipment. Models include: Grid two-bay mechanical mock-up, and thermal contact resistance tests of key thermal joints, X-LAT HP EM and test, Grid HP struc and thermal qual test units, CAL-Grid joint structural qual test unit. Support EM, proto, and qual testing. All work at SLAC.	SLAC	TBD
4.1.8.7.2	Grid/X-LAT Plate Design Finalization	Update Grid, X-LAT Thermal Plate CAD models after I-PDR and EM testing. Prep for Mech- and I-CDR and detail fab drawings and procedures. Make detailed drawings and fabrication plans for Flight Grid and X-LAT Plates. Engineering support of Grid and X-LAT Plate component fabrication, inspection, and X-LAT Plate assembly.	SLAC	TBD
4.1.8.7.3	Flight Grid Fabrication	Fabricate and inspect Flight Grid unit and associated fixtures. This includes developing any shop or manufacturing drawings and any fabrication fixturing needed. Fabricate any manufacturing fixtures or jigs and transport containers. Develop manufacturing prototypes.	SLAC	TBD
4.1.8.7.4	Cross-LAT Thermal Plate Fab	Fabricate X-LAT Thermal Plate parts (excluding HP's, which are covered in 4.1.8.7.5). Inspect parts. Fab and assemble assembly and test tooling. Qual final assembly processes. Assemble and inspect X-LAT Thermal Plates.	SLAC	Nordby
4.1.8.7.5	(LM) Grid/X-LAT Heat Pipe Fabrication	Develop design and perform analyses of Grid Heat Pipes after PDR. Make detailed drawings and fabrication plans for Heat Pipes. Prep for Mech- and I-CDR. Support planning for assembling heat pipes in Grid and X-LAT Thermal Plates. Develop any shop or manufacturing drawings for heat pipes. Design and fabricate any bending/fabrication fixtures or jigs, transport containers, and test/inspection gauges or templates. Develop any manufacturing prototypes. Fabricate and inspect Heat Pipes. Quantity: 5 + 1 spare of full-length Grid CCHP's, 6 + 1 spare full length X-LAT CCHP's. Inspect and functional test heat pipes. Engineering support of Heat Pipe fabrication, inspection, and integration into next assembly. Write test report for heat pipes.	SLAC	Nordby
4.1.8.8	Subsystem Integration & Test	Develop assembly and inspection plans for Grid/Heat Pipe assembly and qualification testing. Carry out fabrication, assembly and test work for flight and spare Grids. This includes fabricating all assembly fixtures and procedures, and structural and thermal testing, including thermal-balance test with flight Radiators and spare Grid.	SLAC	Nordby

WBS	Task	Description	Responsibility	Manager
4.1.8.8.1	Grid/X-LAT Plate Assembly and Test	Develop assembly, inspection procedures and drawings for Grid/Heat Pipe assembly. Develop drawings for assembly fixtures. Fabricate and inspect fixtures. Procure test equipment. Assemble heat pipes into Flight Grid. Inspect and survey. Develop structural test plans, test procedures for Grid. Develop structural, thermal test plans, test procedures for X-LAT Thermal Plate. Design special test equipment. Fabricate test fixtures and procure equipment for Grid structural testing. Execute structural testing (proof, deflection tests) of Grid. Fabricate structural, thermal test fixtures and procure equipment for X-LAT Thermal Plate testing. Execute testing (vibe, T-Vac) of X-LAT Thermal Plate. Engineering support of testing.	SLAC	Nordby
4.1.8.8.2	(Reserved)			
4.1.8.8.3	(Reserved)			
4.1.8.8.4	(LM) TCS Protoflight Testing	Specify Radiator, X-LAT Thermal Plate, and TCS thermal-balance test plan for Mech-CDR and update for I-CDR. Develop conceptual plans for test GSE and dummy heat loads and masses. Perform thermal analyses of Radiators/X-LAT Plate with dummy heat loads while in the test configuration and environment. This includes running a full radiation model of the test configuration, to predict test responses. Develop designs and make detailed drawings and fabrication plans for thermal test hardware. This includes test fixtures, dummy heat loads representing LAT and electronics heat loads and capacitance, and test equipment. Develop thermal test plans and procedures. Fabricate thermal test supports and fixtures, including temporary supports, dummy heat loads. Procure equipment and instrumentation. Thisi ncludes power supplies and controls for test unit heaters. Ship sub-assemblies to test contractor. Integrate radiators and X-LAT Thermal Plate with test units. Execute thermal balance testing, balance as needed, and performance test TCS system. This includes contracting for testing time and contractor engineering support. Break down test and ship.	SLAC	Nordby
4.1.8.8.5	Thermal Engineering Support	Support thermal test effort on Radiators. This includes developing and maintaining FEA models of LAT during testing, and updating model to correlate with test results. Provide engineers to help monitor tests.	SLAC	Nordby
4.1.8.9	LAT Integration & Test Support	Support LAT instrument integration and structural and thermal testing. This includes engineering support to resolve interface issues, to update as-built drawings and to perform structural and thermal analysis and testing during LAT integration and test.	SLAC	Nordby

WBS	Task	Description	Responsibility	Manager
4.1.8.9.1	LAT Integration Support	Support LAT instrument integration. This includes engineering support to resolve mechanical interface or structural problems, and to perform modal and structural testing during integration. Provide mechanical technicians to integrate X-LAT Thermal Plate onto LAT. Finalize as-built drawings, ICD's, and structural model deliverables.	SLAC	Nordby
4.1.8.9.2	LAT Structural Test Support	Support instrument testing, including structural engineering support to monitor instrument environmental and structural testing, at testing contractor. Includes time to update/modify procedures, and complete test reports and documentation. Update LAT FEA models based on test results.	SLAC	Nordby
4.1.8.9.3	LAT Thermal-Vacuum Test Support	Support instrument thermal testing, including engineering support to monitor instrument environmental and structural testing, at testing contractor. Includes time to update/modify procedures, and complete test reports and documentation. Update LAT FEA models based on test results.	SLAC	Nordby
4.1.8.9.4	(Reserved)			
4.1.8.A	Mission Integration & Test Support	Support integration to SC and LV, and test activities after delivery of full instrument to SC vendor. This includes engineering and technician support of testing at SC test site. Includes engineering support at SLAC of post-launch check-out.	SLAC	Nordby
4.1.8.A.1	SC/LV I&T Support	Support integration to spacecraft and test activities after delivery of full instrument to SC vendor. This includes structural engineering support of testing at SC test site. Also includes technicians to integrate radiators and skirts on instrument, after integration with SC. Provide engineering support of SC integration on LV in Florida.	SLAC	Nordby
4.1.8.A.2	Post-Launch Engineering Support	Provide engineering support for launch and on-orbit check-out, including analysis of actual temperature data, and structural analysis of Grid behavior on-orbit.	SLAC	Nordby
4.1.8.A.3	(LM) Mission Thermal Test Support	Support SC thermal testing, including thermal engineering support to monitor SC environmental testing at testing contractor and during LV integration.	SLAC	Nordby
4.1.8.A.4	(LM) Post-Launch Thermal Engineering	Provide thermal engineering support for launch and on-orbit check-out, including thermal analysis of actual temperature data.	SLAC	Nordby

WBS	Task	Description	Responsibility	Manager
4.1.9	**Instrument Integration & Testing**	**Integrate and Test the LAT. This includes developing I&T plans and procedures, developing, prototyping, fabricating, assembling, and testing I&T mechanical GSE, and integrating the Calibration Unit and flight LAT. Also includes thermal and structural environmental test planning, execution, and GSE, and planning and running of Calibration Unit beam tests.**	**SLAC**	**Bloom**
4.1.9.1	I&T Management	Provide program scheduling, cost-accounting, and performance tracking and reporting for entire subsystem. Support development of subsystem specifications, verification plans, and interfaces with neighboring subsystems. Control subsystem electrical, power, and environmental requirements and performance metrics. Support quarterly team meetings and project reviews. Travel to meetings and site visit for test support.	SLAC	TBD
4.1.9.1.1	I&T Milestones	Key subsystem milestones and links to remainder of project.	SLAC	TBD
4.1.9.1.2	Management and Engineering	Provide program scheduling, cost-accounting, and performance tracking and reporting for entire subsystem. Support development of subsystem specifications, verification plans, and interfaces with neighboring subsystems. Control subsystem electrical, power, and environmental requirements and performance metrics. Support quarterly team meetings and project reviews, and travel thereto. Scheduling, cost-accounting, and performance tracking and reporting. Develop subsystem spec's, verification plans, and interfaces. Control subsystem req's metrics. Prep and attend review, IDT meetings, etc.	SLAC	TBD
4.1.9.1.3	Travel	Travel for subsystem support of team meetings, vendor visits, and technical meetings for engineering and professional staff. This includes travel required to support integration and test activities. Travel for subsystem attendance at reviews and other meetings. Travel for vendor visits. Travel for targeted meetings with other members of GLAST. Travel for instrument testing. Travel for SC integration. Travel for LV integration.	SLAC	TBD
4.1.9.1.4	I&T Support	Computers and software for supporting engineering effort for I&T.	SLAC	TBD
4.1.9.2	Reliability and Quality Assurance	Support reliability analysis and Quality Assurance activities for the subsystem. This includes participating in system-level reliability analysis. QA activities include helping develop procedures and collecting quality records. Also includes developing training programs for other LAT personnel involved in LAT I&T activities.	SLAC	TBD
4.1.9.2.1	Reliability	Perform reliability analysis of subsystem	SLAC	TBD

WBS	Task	Description	Responsibility	Manager
4.1.9.2.2	Quality Assurance	Develop written procedures and specifications for the procurement, fabrication, assembly, and testing of all subsystem components and assemblies. Work with sub-contractors to ensure uniform compliance to standards and procedures, and to verify performance. Collect records and test data, and verify performance for subsystem components, and for incoming flight hardware to be integrated. Develop and implement LAT training program for integration training of subsystem personnel.	SLAC	TBD
4.1.9.3	I&T Preparation	Develop I&T and verification plans for the LAT. Develop LAT calibration plans, procedures, and equipment. Prototype and fab flight LAT calibration equipment. Layout, spec, and procure equipment and facilities needed for LAT integration at SLAC. Provide on-going operational support of integration facilities.	SLAC	Bloom
4.1.9.3.1	I&T Development	Develop I&T and verification plans for the LAT. Work with susbsystem and system engineering in writing Verification Plans for PDR. Update Plans for CDR, based on final hardware configuration and production plans. Develop conceptual design of I&T hardware and GSE. Work with system engineering to set susbystem interfaces for I&T.	SLAC	Bloom
4.1.9.3.2	Calibration Test Development	Develop LAT calibration concepts. Simulate as needed. Prototype calibration equipment concepts as needed. Test, and update calibration plans.	SLAC	Bloom
4.1.9.3.3	Integration Facilities	Layout integration facilities to meet needs of integration plans. Procure equipment and hardware need to support integration of LAT in SLAC clean room high bay. This includes basic infrastructure equipment like computers, storage lockers, crane, tables, etc. Provide on-going support of integration facilities, including consummable supplies and services, and any monitoring and calibration services needed.	SLAC	Millican
4.1.9.4	Calibration Unit I&T	Develop procedures and plans for the LAT Calibration Unit. Design, fab, assemble, and install Cal. Unit beam test equipment and fixtures, and prep beam lines with equipment. Integrate flight hardware on Cal. Unit GSE and transport and install on beamline. Run beam test and disassemble Cal. Unit and beamlines.	SLAC	TBD
4.1.9.4.1	Engineering	Develop procedures and plans for the LAT Calibration Unit. Design and detail hardware and GSE for calibration unit support, integration, beam testing, and shipping. Support Calibration Unit integration and beam testing. This includes finalizing procedures, tracking fabrication of hardware, and managing integration and test activities.	SLAC	Bloom
4.1.9.4.2	Equipment and Preparation	Procure and fabricate equipment and GSE for the Calibration Unit support, integration, beam testing, and shipping. Assemble and test fixtures as needed.	SLAC	Bloom

WBS	Task	Description	Responsibility	Manager
4.1.9.4.3	Cal. Unit Integration and Test	Integrate Cal. Unit modules at SLAC. This includes integrating flight and flight spare modules of the TKR and CAL, plus engineering models of the ACD and electronics.	SLAC	TBD
4.1.9.4.4	Cal. Unit SLAC Beam Test	Fabricate and assemble special equipment needed for Cal. Unit beam testing at SLAC. Prepare beamline test area for Cal. Unit hardware. Install Cal. Unit on beamline at SLAC, run beam test, then remove Cal. Unit and break down test facilities.	SLAC	TBD
4.1.9.5	(Reserved)			
4.1.9.6	Flight LAT I&T	Develop LAT integration and test plans. Develop, fab, assemble, and test all integration and structural and thermal test mechanical GSE and fixturing. Integrate the flight LAT, and prepare for, set up, and execute structural and thermal testing of the flight LAT.	SLAC	TBD
4.1.9.6.1	LAT Integration	Develop LAT integration plans. Develop, fab, assemble, and test integration mechanical GSE and facilities. Prepare for LAT integration. Integrate flight LAT and support functional testing on the integration stand.	SLAC	Bloom
4.1.9.6.1.1	Engineering	Develop preliminary I&T plans for LAT and concepts for GSE (for PDR). Develop detailed integration procedures and drawings for GSE fixtures. Prep for CDR, and finalize drawings. This includes working with subsystem managers to coordinate integration plans for subystem flight hardware. Manage fabrication/procurement of integration GSE, and support integration activities for the LAT.	SLAC	Bloom
4.1.9.6.1.2	Integration Preparation	Fabricate/procure integration GSE fixturing and equipment. Assemble and test GSE in preparation for LAT integration. This includes the support stand and lifting rigging for the integrated LAT. It does NOT include electrical GSE for integration (covered in Electronics). Fabricate, assemble, and test equipment for calibrating LAT during integration. Fabricate, assemble transport and storage GSE for the integrated LAT. Prepare the integration clean room, including mounting and aligning all specialized integration fixturing.	SLAC	Bloom
4.1.9.6.1.3	LAT Integration	Receive and test subsystem flight hardware. Integrate flight subassemblies onto the LAT and test after integration. Align, test, and calibrate integrated LAT.	SLAC	Bloom
4.1.9.6.2	LAT Mechanical Testing	Detail LAT mechanical test plans and test fixturing. Procure, assemble, and test fixtures and equipment. Set up and execute mechanical test contract, and support testing at contractor. Help write report after testing. Note that detailed analysis of test and reduction of test data is covered by Mechanical Systems.	SLAC	TBD

WBS	Task	Description	Responsibility	Manager
4.1.9.6.2.1	Engineering	Detail LAT mechanical test plans and test fixturing. This includes supports for LAT vibration testing. Set up mechanical test contract, and support testing at contractor. Help write report after testing. Note that detailed analysis of test and reduction of test data is covered by Mechanical Systems.	SLAC	TBD
4.1.9.6.2.2	LAT Mech Test Preparation	Procure test fixtures and equipment. Assemble and test equipment.	SLAC	TBD
4.1.9.6.2.3	LAT Mech Testing	Set up and execute mechanical testing at contractor. This includes integrating fixturing with LAT, shipping to/form contractor, and technician support of testing at contractor.	SLAC	TBD
4.1.9.6.3	LAT Thermal Testing	Detail LAT thermal test plans and test fixturing. Procure, assemble, and test fixtures. Set up and execute tests and support testing at contractor. Help write report after testing.	SLAC	TBD
4.1.9.6.3.1	Engineering	Detail LAT thermal test plans and test fixturing. This includes supports and cold plates for LAT thermal testing. Set up mechanical test contract, and support testing at contractor. Help write report after testing. Note that detailed analysis of test and reduction of test data is covered by Mechanical Systems.	SLAC	TBD
4.1.9.6.3.2	LAT Thermal Test Preparation	Procure test fixtures and equipment. Assemble and test equipment.	SLAC	TBD
4.1.9.6.3.3	LAT Thermal Testing	Set up and execute thermal testing at contractor. This includes integrating fixturing with LAT, shipping to/form contractor, and technician support of testing at contractor.	SLAC	TBD
4.1.9.6.4	Special Testing and Calibration	Reserved for future use. No budgeted activities included in this element.	SLAC	TBD
4.1.9.6.5	LAT Delivery	Engineering preparation for I-PSR and shipping. Prepare LAT for transport to Spacecraft contractor. Ship to contractor. Unpack and test LAT at spacecraft contractor, prior to turn-over. De-commission integration facilities at SLAC. Store integration and test equipment.	SLAC	TBD
4.1.9.7	Mission I&T Support	Support planning and execution of Observatory and LV integration and test. Provide on-site and SLAC technician and engineering support of Observatory I&T through launch and on-orbit check out.	SLAC	TBD
4.1.9.7.1	S/C Integration Planning	Layout and detail plans for Observatory integration and test.	SLAC	Bloom
4.1.9.7.2	S/C Integration and Test Support	Engineering and technician support of LAT integration on Observatory. This includes nominal support to oversee work, plus time for test the LAT after integration.	SLAC	TBD
4.1.9.7.3	LV Integration Planning	Work with spacecraft and launch vehicle providers to plan integration and testing on the LV.	SLAC	Bloom
4.1.9.7.4	LV Integration Support	Engineering oversight of LV integration. LAT testing after integration on the LV.	SLAC	TBD
4.1.9.7.5	Launch Support	Oversee preparation for launch. Nominal support for post-launch analysis of initial on-orbit check-out. Does not include enough for detailed diagnosis of on-orbit anomalies.	SLAC	TBD

WBS	Task	Description	Responsibility	Manager
4.1.A	**Performance and Safety Assurance**	**The scope of the LAT Performance and Safety Assurance includes quality assurance, inspection, safety, and problem failure reporting. The predominant assurance objective is that the LAT will operate in a safe and environmentally sound manner, and will meet the science objectives and corresponding measurement requirements specified in the GLAST Science Requirements Document. To achieve these top-level objectives, the project will establish formal programs to address the process for achieving safety and mission success. These include Problem/Failure Resolution reporting, inspection protocols, parts selection and control plan, reliability analysis, software verification and validation, developing workmanship standards, and developing a safety hazard analysis.**	**SLAC**	**Marsh**
4.1.A.1	Performance Assurance Management	Manage the instrument performance assurance program. Work closely with all team organizations to ensure quality consistency for all activities. Provide practical guidance in implementing a variety of lower-level, detailed, technical mission assurance activities.	SLAC	Marsh
4.1.A.1.1	Management	Personnel to perform Performance & Safety Assurance Management function.		
4.1.A.1.2	Travel	Travel to support performance & safety assurance responsibilities at vendors, subcontractors and collaborating team members facilities.		
4.1.A.1.2.1	Domestic Travel	Travel to domestic vendors, subcontractors and collaborating team members facilities to support performance & safety assurance activities.		
4.1.A.1.2.2	Foreign Travel	Travel to foreign vendors, subcontractors and collaborating team members facilities to support performance & safety assurance activities.		
4.1.A.1.3	Project Support at SLAC	Incidental materials & supplies, computer hardware & software and telecommunication costs to support Performance & Safety Assurance activities.		
4.1.A.2	Quality Assurance	Assure compliance with requirements, process controls, and procedures, needed for the fabrication, assembly, integration, and testing of all components and assemblies for the instrument.	SLAC	Marsh
4.1.A.2.1	Quality Assurance Oversight & Inspection	Conduct higher-level oversight function to oversee project developmental and operational efforts. Perform hardware inspections to assure requirements are adhered to.		
4.1.A.2.2	ISO 9000 Program Implementation	Develop systems, procedures and plans at SLAC and provide guidance to other team organizations to assure that all elements of the project quality plan are implemented throughout the instrument project.		
4.1.A.2.3	Equipment and Services	Consulting services and materials & supplies to support project quality assurance activities.		
4.1.A.2.4	Contamination Control	Contamination control measuring equipment to assure project contamination requirements are met.		

WBS	Task	Description	Responsibility	Manager
4.1.A.3	Training	Implement training programs to qualify engineers, scientists, and technicians for work associated with the instrument integration and testing. Convene specific training courses, as needed, at team institutions.	SLAC	Marsh
4.1.A.3.1	Workmanship and QA Training	Train and certify project personnel to NASA workmanship standards. Attend specific training courses on NASA and commercial standards, specifications and programs related to performance assurance.		
4.1.A.4	Records Management	Assure compliance to records management requirements for all procedures, travelers, inspection reports, and other quality records used for the fabrication, assembly, integration and testing of the instrument. Assure revision-and configuration-control on these documents, working with subsystem quality assurance personnel. Develop and implement reporting and documentation procedures to track non-conformances, problems, and failures occurring during assembly, integration and testing, and their causes and corrective actions.	SLAC	Marsh
4.1.A.4.1	Documentation Administration	Personnel to perform records management function.		
4.1.A.5	System Safety	Implement a system safety program that identifies and controls hazards to personnel, facilities, support equipment, and the flight system, during all stages of the mission development. Perform a hazard analysis throughout all program phases. This is a subsystem and system-level qualitative analysis that identifies potential hazards and assures their resolution. Document the analysis of identified critical or catastrophic potential hazards in the Project System Safety Plan. Develop hazard control plans to mitigate the potential hazard, and verify that the plans are implemented in hardware design and applicable procedures.	SLAC	Marsh
4.1.A.5.1	Equipment, Services and Supplies	Materials, services and incidentals to support system safety function.		
4.1.A.6	EEE Parts Control Program	Review and provide inputs to program documents that speak to EEE parts, packaging, integration of hardware quality, and reliability requirements. Conduct radiation analysis and prepare radiation test plan. Work with design engineers and scientists regarding planned parts usage, identify parts list, and manufacturing processes. Attend subsystem and related meetings to provide input regarding design, schedule or cost impacts on the parts and packaging program. Provide parts list reviews. Conduct Parts Control Board activity. Provide technical services for procurement documentation for EEE, photonic parts, and electronic packaging. Maintain controlled parts list. Coordinate procurement, screening, qualification, or failure analysis activities in support of GLAST LAT hardware development. Coordinate flight assurance of electronic parts, packaging, and processes.	SLAC	Marsh

WBS	Task	Description	Responsibility	Manager
4.1.B	**Instrument Operations Center**	**Design, develop, and maintain a LAT Operations Facility (LOF) which will monitor LAT health and safety, perform LAT calibration, provide configuration control, validation and verification for LAT flight software updates, generate LAT command uploads, and support LAT operations planning and a rapid alert capability.**	**HEPL**	**Williams**
4.1.B.1	Project Management	Manage the instrument operations effort including personnel and facilities management, planning, budgeting, and reporting	HEPL	Williams
4.1.B.1.1	Project Administration	Develop plans and schedules for meeting the operational and scientific requirements of the instrument operations effort. Negotiate subcontracts as required with Co-Investigators and third parties for services and materials. Monitor task performance and review work breakdown structure and schedules. Develop personnel plans, job descriptions, and task assignments. Prepare and review budgets, and authorize expenditures. Prepare and submit regular status and progress reports to PI, PM, and laboratory management as required. Participate in internal reviews to assess Instrument Operations Center (IOC) development. Maintain cognizance of relevant rules and regulations of the University and the contracting agencies, and implement.		
4.1.B.1.2	Meetings & Reviews	Participate in a series of internal reviews to assess the status of each element of the IOC design. Support weekly videoconferences, quarterly progress reviews, external design and interface reviews, technical interchange meetings, mission design and readiness reviews, and Science Support Center (SSC) and Mission Operations Center (MOC) design reviews.		
4.1.B.1.3	Logistics Management	Establish special site requirements of major hardware components (computers and data storage systems) including floor space and access space, electrical and cabling requirements, operating environmental conditions, environmental conditions for media storage, security, storage space, and work space. Prepare appropriate site facilities for hardware and for off-line media storage. Arrange connectivity and sufficient bandwidth and reliability for data transfer to/from the IOC, Science Data Processing Facility (SDP), SSC, MOC, and other NASA centers and team members as required.		
4.1.B.1.4	Travel	Support travel to meetings, reviews, vendors, and development sites.		

WBS	Task	Description	Responsibility	Manager
4.1.B.1.5	Project Support	Maintain a library of non-configuration controlled paperwork and distribute information within GLAST program. Support electronic mail, teleconferencing and videoconferencing for operations planning and coordination. Provide materials and services that support the IOC development effort including computer systems and software. Provide IOC computer hardware maintenance and software licenses and make regular data backups.		
4.1.B.2	Performance Assurance	Develop ,implement and monitor the IOC quality assurance and verification plans.	HEPL	TBD1
4.1.B.2.1	IOC Performance Assurance	Develop the IOC Quality Assurance plan in compliance with overall LAT quality assurance plans. Monitor operation of quality assurance program and report on compliance. Identify critical elements of LOF software for which special quality assurance procedures are to be implemented and followed. Specify appropriate quality assurance procedures applicable to critical code elements, consistent with the system software quality assurance plan and ISO 9001. Include procedures for verification of compliance with coding and software standards, independent reviews, carrying out of tests under specified ranges of conditions, certification, revision procedures, and provisions for locking of code against unauthorized changes. Implement and monitor quality assurance procedures.		
4.1.B.2.2	IOC Verification	Validate and verify IOC procedures, drawings, inspections and tests. Assist in the development of the system verification program. Develop a verification plan for the IOC. Participate in the verification efforts and evaluate the results of various tests. Support configuration control and verification of the command and telemetry database.		
4.1.B.3	Mission & Operations Planning	Identify requirements and develop plans to support mission operations from integration and test through launch and early orbital operations.	HEPL	Williams
4.1.B.3.1	Operations Concept Development	Document the requirements on the various components of the LOF as derived from the science requirements, instrument functional requirements, mission requirements, science support center requirements, mission operations center requirements, and developments in theory and technique. Develop specifications for the LOF that includes support for both ground and space-based commanding and data acquisition. Support the development of ICDs with the SDP, SSC, MOC, ground stations, and the Flight Instrument.		

WBS	Task	Description	Responsibility	Manager
4.1.B.3.2	Integration & Test Planning	Develop plans to support instrument and mission systems integration and test. Include in the plans the evolutionary development and verification of the LOF and support for instrument commanding and verification of commands and procedures. Develop plans to acquire and archive engineering and calibration measurements taken with the prototype and flight instruments.		
4.1.B.3.3	Mission Operations Planning	Plan initial operations to provide instrument verification and calibration after launch. Develop procedures and contingency plans to identify and resolve in-flight anomalies. Support development of the on-orbit calibration plan and procedures. Develop plans to implement the observing programs, monitor instrument status and health, and generate instrument command loads to initiate specific functions and modify on-board programming. Develop early operations and calibration programs. Develop implementation of the observation plan for the basic program and plan observing sequences. Create contingency plans and emergency preparedness procedures in conjunction with experiment team. Create procedures for alerting instrument team members in the event of instrument or spacecraft anomalies or the existence of potential targets of opportunity.		
4.1.B.4	LAT Operations Facility	Design, develop, and maintain a LAT operations facility which acquires LAT telemetry, monitors LAT health, status, and resources, develops and transmits commands, and supports science planning and instrument scheduling.	HEPL	TBD2
4.1.B.4.1	System Conceptual Design	Develop IOC conceptual design. Perform trade studies to support detailed design. Specify combination of hardware, Commercial Off-The-Shelf (COTS) and Non-Developmental Item (NDI) software to meet system requirements. Establish requirements and develop data processing plan.		

WBS	Task	Description	Responsibility	Manager
4.1.B.4.2	Data Acquisition S/W Development	Prepare code for decompression of telemetry data, conversion of measurements to physical quantities, identification and separation of data streams, verification of real time network data with archived data, and sorting of data sets. Develop system to acquire data from all channels, perform data reduction procedures, catalog and distribute data. Implement programs for decommutation and decoding of network (real time) data and to process the data to provide instrument performance verification and quick look data products. Develop programs to monitor integrity and quality of decoded real time housekeeping data and to perform science data processing and analysis to support science data quality assessment including transient alert notification and verification. Develop the means to verify receipt of network data and to identify network problems resulting in interruptions or lost data. Implement programs to monitor integrity and quality of decoded real time science data and to perform Level 0 reductions as raw data is acquired. Develop Level 0 reductions from raw data and develop metrics to monitor pro(		
4.1.B.4.3	Operations Software Development	Provide software for real-time and playback acquisition and display of the instrument housekeeping and engineering telemetry to support monitoring the health of the instrument. Develop software to distribute data and display on LOF workstations to provide an instrument status monitor. Provide software to perform health & status monitoring and long term trend analysis. Develop database of red and yellow limits for instrument health and safety. Develop system to maintain documentation and operations logbooks. Develop planning tools to support early operations and calibration programs. Develop observation planning tools for the basic program. Develop software for building the observing sequences and command loads from the observing plan. Develop a variety of communications means to assemble and organize the investigations including videoconferences, electronic mail, and web based forms for observing requests. Develop software tools to build and submit the observing programs and instrument command sequences to the MOC.		
4.1.B.4.4	Command & Telemetry Development	Develop and maintain the command and telemetry database. Develop software tools to support command procedure development and validation. Develop software tools to build and submit the observing programs, software uploads, and command sequences from the LOF to the MOC.		

WBS	Task	Description	Responsibility	Manager
4.1.B.4.5	LOF System Development	Procure and integrate hardware and COTS/NDI software with locally developed software. Acquire, install, and maintain data processing hardware. Provide for system operation, management, and maintenance. Support appropriate display and peripheral systems including color graphics image capability, data storage, off-line data access and network access. Monitor hardware system performance, and identify sources of problems. Perform periodic preventive maintenance as required, and repair or replace malfunctioning equipment.		
4.1.B.4.5.1	Development Model	Hardware, software, system amnagement and operation to support development of the LOF system.		
4.1.B.4.5.2	Operational Model	Hardware, software, system amnagement and operation to support upgrade of the LOF system in preparation for flight operations.		
4.1.B.4.6	(Reserved)			
4.1.B.5	LOF Test	Perform LOF validation and verification testing.	HEPL	TBD1
4.1.B.5.1	Test Planning	Develop plans to support LOF integration and test.		
4.1.B.5.2	Test Development	Develop test procedures, software tools, and hardware to perform full-scale end-to-end tests of entire LAT operations activity including data acquisition, commanding, housekeeping monitoring and operations planning.		
4.1.B.5.3	Verification Testing	Validate and verify LOF software, command, command and telemetry databases, and command procedures. Support full-scale end-to-end tests of entire data processing procedure to verify hardware and software performance and operational organization. Test using simulated telemetry data generated at the LOF in both network and media form. Test telemetry decommutation and decoding, data reduction through Level 0 for each of the expected data streams, cataloging and archiving, and simulated data distribution to selected sites.		
4.1.B.5.4	LOF Interface Tests	Perform interface and verification tests with the Science Data Production facility, MOC, SSC, and the ground station network. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.		
4.1.B.5.4.1	IOC/SAS Interface Tests	Perform interface and verification tests with the Science Data Production facility. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.		
4.1.B.5.4.2	IOC/MOC Interface Tests	Perform interface and verification tests with the MOC. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.		
4.1.B.5.4.3	IOC/SSC Interface Tests	Perform interface and verification tests with the SSC. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.		
4.1.B.5.4.4	IOC/GN Interface Tests	Perform interface and verification tests with the ground station network. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.		
4.1.B.5.5	LOF I&T Travel	Provide travel to support LOF I&T activities.		

WBS	Task	Description	Responsibility	Manager
4.1.B.6	LAT Performance Verification	Perform planning and support implementation of LAT performance verification programs.	HEPL	Lauben
4.1.B.6.1	Performance Verification Test Planning	Support development of test plans for LAT performance verification. Develop test procedures and command procedures.		
4.1.B.6.2	Analysis Software	Develop analysis software to support performance verification and calibration programs.		
4.1.B.6.3	Display Software	Develop displays to support performance verification and calibration programs.		
4.1.B.6.4	LAT Calibration Support	Develop plan to deliver I&T data to science team and support development of a calibration parameter table for the LAT as a function of instrument settings, temperature, spacecraft parameters and other variables. Collect and organize the calibration data taken during instrument development, assembly, testing and integration. Prepare code for conversion of measurements to physical quantities, identification and separation of data streams, verification of real time network data with archived data, and sorting of data sets. Prepare code for calibration of data based on known instrument characteristics and monitored performance. Specify and prototype the algorithms using ground-based data and models. Evaluate the effectiveness of the calibration software and approach.		
4.1.B.6.5	LAT Simulator	Support LAT simulator development from the flight software testbed. Use the simulator to validate the observing programs, flight software updates, and instrument command sequences.		
4.1.B.7	LAT Integration & Test	Support LAT integration and test.	HEPL	TBD1
4.1.B.7.1	Qualification Unit Test Support	Support qualification unit integration and test, including beam tests and other calibrations and alignment activities. Develop and verify command loads and procedures. Verify instrument science data acquisition and housekeeping data processing. Support instrument commanding as required for system tests. Track and verify red and yellow telemetry limits to provide operator warnings for threat conditions.		
4.1.B.7.2	Flight Unit Test Support	Support flight unit instrument integration and test. Perform planning and analysis to support operations and calibration programs. Develop and verify command loads and procedures. Verify instrument science data acquisition and housekeeping data processing. Support instrument commanding as required for system tests. Track and verify red and yellow telemetry limits to provide operator warnings for threat conditions.		
4.1.B.7.3	LAT I&T Travel	Provide travel to support LAT I&T activities.		
4.1.B.8	Mission Systems Integration & Test	Support mission systems integration and test.	HEPL	TBD1

WBS	Task	Description	Responsibility	Manager
4.1.B.8.1	Observatory Testing	Support mission systems integration and test. Perform planning and analysis to support operations and calibration programs. Develop and verify command loads and procedures. Verify instrument science data acquisition and housekeeping data processing. Support instrument commanding as required for system tests. Track and verify red and yellow telemetry limits to provide operator warnings for threat conditions.		
4.1.B.8.2	Ground Systems Compatibility Testing	Support ground systems compatibility test definition and performance. Perform planning and analysis to support operations and calibration programs. Develop and verify command loads and procedures. Verify instrument science data acquisition and housekeeping data processing. Support instrument commanding as required for system tests. Track and verify red and yellow telemetry limits to provide operator warnings for threat conditions. Support		
4.1.B.8.3	Training Simulations	Support the integrated operations training and simulations as required. Develop and verify operations procedures.		
4.1.B.8.4	Launch & Early Operations Support	Provide launch and early orbital operations support. Perform verification of the entire telemetry acquisition, monitoring, command processing, and data processing system during the on-orbit checkout.		
4.1.B.8.5	MSI&T Travel	Provide travel to support MSI&T activities		
4.1.B.9	Mission Operations & Data Analysis	Perform LAT mission operations and data acquisition.	HEPL	Williams
4.1.B.9.1	Science Operations	Perform science planning and operations. Coordinate and implement observing programs. Develop observation plans and observing sequences in coordination with the SWG, the SSC, and other LAT investigators. Perform planning and analysis to support operations and calibration programs. Perform science data processing and analysis to support science data quality assessment including transient alert notification and verification. Build the observing sequences and command loads required for implementing the observing plan. Assemble and organize the operations planning using videoconferences, electronic mail, and web-based forms for observing requests.		

WBS	Task	Description	Responsibility	Manager
4.1.B.9.2	LAT Operations	Perform real-time acquisition and display of the instrument housekeeping and engineering telemetry to monitor the health of the instrument. Acquire telemetry at the LOF both as real-time and playback data. Distribute data to the LOF workstations and displays. Monitor the instrument status and health, and generate instrument command loads to initiate specific functions and modify on-board programming. Track and verify red and yellow telemetry limits to provide operator warnings for threat conditions. Implement early operations and calibration programs. Process data to provide instrument performance verification and quick look data products. Monitor the integrity and quality of decoded real time housekeeping data. Perform health & status monitoring and long term trend analysis. Maintain documentation and logbooks. Perform planning and analysis to support operations and calibration programs. Submit the command loads and configuration commands and procedures to the MOC. Monitor and validate the command histories generated by the MOC. Verify the instrument state changes in response to commanding. Implement and exercise procedures for alerting instrument team members in the event of instrument or spacecraft anomalies or the existence of potential targets of opportunity. Acquire data from all channels, perform data reduction procedures, catalog raw data and reduced data sets, distribute data, and archive. Perform Level 0 reductions as raw data is acquired and catalogued. Monitor program performance diagnostics and Level 0 data quality.		
4.1.B.9.3	LOF Systems Support	Perform incremental and permanent archival backups of software and selected on-line data on external media and systems on a regular schedule. Establish the appropriate backup schedule. Maintain LOF systems through combinations of warranty agreements, service contracts, and self-maintenance. Perform periodic preventive maintenance as required. Repair or replace malfunctioning equipment. Monitor hardware system performance, and identify sources of problems.		
4.1.B.9.4	LAT Simulator	Support and maintain the LAT simulator. Use the simulator to validate the observing programs, flight software updates, and instrument command sequences.		
4.1.B.9.5	LAT Engineering Support	Provide thermal, electronics, and flight software engineering support as required.		

WBS	Task	Description	Responsibility	Manager
4.1.C	**Education and Public Outreach**	**Education and Public Outreach Program for entire GLAST mission**	**SSU**	**Cominsky**
4.1.C.1	Management	Overall program management of all elements, including scientific content, educational standards alignment, EPO presentations, reporting and financial management	SSU	Cominsky
4.1.C.2	Reliability & Quality Assurance (Assessment)	Formal evaluation of all EPO activities and dissemination by WestEd	SSU	Cominsky
4.1.C.3	Web Materials	2 Space Mystery Modules developed with Videodiscovery; the GLAST EPO website, design, maintenance and upkeep.	SSU	Cominsky
4.1.C.4	Educator Training	Bi-yearly educator conferences hosted by GSFC, 2 workshops with AAVSO coordinated by MSFC, 1 workshop hosted by TAMUK,. Also the GLAST Ambassador Program: 10 educators who will be helping to develop and disseminate GLAST EPO materials	GSFC, MSFC, SSU and SLAC	Cominsky
4.1.C.5	Printed Materials and Curriculum Development	3 Modules of five lessons to be developed by TOPS, Annual poster and booklet sets	SSU	Cominsky
4.1.C.6	SLAC VVC Exhibit	Upgrade to SLAC VVC web site to include gamma-ray detector information	SLAC	Cominsky
4.1.C.7	PBS TV Special	1 or 2 hour television show on gamma-ray astronomy to be developed by TL Lucas Productions and co-funded by PBS	SSU	Cominsky
4.1.C.8	Telescope Network	Network of existing small and/or robotic telescopes: observations with these telescopes to be coordinated by GSFC personnel in order to track optical behavior of GRBs and AGN	GSFC	Cominsky

WBS	Task	Description	Responsibility	Manager
4.1.D	**Science Analysis Software**	**The Science Analysis Software comprises several components: (1) Prompt processing of instrument data through to Level 1 event quantitites; (2) Provide near real-time monitoring information to the IOC; (3) Monitor and update instrument calibrations; (4) Create high level science products from Level 1 for the PI team; (5) Reprocessing of instrument data; (6) Provide access to event and photon data for higher level data analysis; (7) Bulk production of Monte Carlo simulations; (8) Interface with mirror PI team site(s) - sharing data and algorithims; (9) Interface with the SSC - sharing data and algorithms.**	**SLAC**	**Dubois**
4.1.D.1	Sources, Simulation and Reconstruction	Particle flux generators provide input to GlastSim. These model the characteristics (origin, energy) of the signal photons as well as background cosmic rays, albedo and heavy nuclei used for calibrations. GlastSim takes input distributions of photons or background particles, follows their path through GLAST and simulates any interactions with the device. The simulation phase outputs "raw data" that is identical in form to real data, but adds Monte Carlo truth to the record. Reconstruction takes the raw data and attempts to recover the initial properties of the incident particle, and to tag it as signal or background.	UW	Burnett
4.1.D.1.1	Sources	Particle flux generators, which are the input to GlastSim.	HEPL/Hiroshima	Fukazawa
4.1.D.1.2	Intial Framework Prototyping	The initial prototype of the GLAST Gaudi code framework. Involves making code packages adhere to the framework and to communicate via data in a transient store, with the abillity to interact with a persistent store.	UW	Burnett
4.1.D.1.3	GISMO	simulation package developed and supported by GLAST to simulate the transport and interactions of particles traversing the instrument, and to record the intrinsic energy deposits in the detector elements.	UW	Burnett
4.1.D.1.3.1	Existing Simulation Upgrade	Modify AO-era code to new infrastructure plus small upgrades	UW	Burnett
4.1.D.1.3.2	New Geometry & Hits Scheme	Modify Gismo to make use of new geometry & "hits" schemes	UW	Burnett
4.1.D.1.3.3	Ongoing Support	Gismo Maintenance	UW	Burnett
4.1.D.1.4	GEANT 4	similar to Gismo, but a separate package supported by a CERN-led consorium.	Italy	Giannitrapani
4.1.D.1.4.1	External Package Requirements	Provide code build capabilities for CMT code management system	SLAC	Lindner
4.1.D.1.4.2	detModel Geometry converter	Use detModel interface to XML geometry description to derive GEANT4 geometry	Italy	Giannitrapani
4.1.D.1.4.3	GEANT4 Prototype	Create prototype simulation with GEANT4, using proper geometry and outputting standard GLAST data structures representing the energy deposit in the LAT.	Italy	Giannitrapani
4.1.D.1.4.4	GEANT4 Validation	Validate basic physics and compare to Gismo, TB99 and BFEM data.	Italy	deAngelis
4.1.D.1.4.5	Ongoing Support	Maintenance and consulting on the use of G4	Italy	deAngelis

WBS	Task	Description	Responsibility	Manager
4.1.D.1.5	ACD Simulation	The ACD-specific portions of the simulation and reconstruction in terms of response to traversing particles and corrrelation with found tracks.	GSFC	Kelly
4.1.D.1.5.1	Existing Digitization Upgrade	update digitization to use new structures	GSFC	Kelly
4.1.D.1.5.2	Upgrade for new hits scheme	Modify ACD digitization to accept new "hits" definition and structure	GSFC	Kelly
4.1.D.1.5.3	Ongoing Support	Maintenance and adiabatic upgrades	GSFC	Kelly
4.1.D.1.6	Calorimeter geometry, simulation & reconstruction	The CAL-specific portions of the simulation and reconstruction in terms of response to traversing particles, reconstruction of deposited energy, and corrrelation with found tracks and hit ACD tiles.	NRL/France	Grove/Djannatti-Atai
4.1.D.1.6.1	Geometry	Create and maintain geometry descriptions for engineering models and the flight instrument	NRL	Chekhtman
4.1.D.1.6.2	Simulation	Simulation of the Calorimeter		
4.1.D.1.6.2.1	Initial Version of Simulation	Import existing simulation into new framework + small upgrades	NRL	Chekhtman
4.1.D.1.6.2.2	Simulation Improvements	Programme to include new digitization effects, such as light taper, electronics non-linearities and optical gains.	NRL	Chekhtman
4.1.D.1.6.3	Reconstruction	Calorimeter reconstruction algorithms - determine the deposited energy, estimating leakage. Determine shower directions.	NRL/France	Grove/Djannatti-Atai
4.1.D.1.6.3.1	Initial Version of Reconstruction	Import existing reconstruction into new framework + small upgrades	NRL	Chekhtman
4.1.D.1.6.3.2	Reconstruction Improvements	Implement programme of improvements to algorithm	NRL/France	Grove/Djannatti-Atai
4.1.D.1.6.3.3	Iterative Reconstruction with TKR	Develop iterative recon with TKR, allowing each to use the other for positions and energy estimates.	NRL/France	Grove/Djannatti-Atai
4.1.D.1.6.3.4	Failure modes/perforamce state	Prepare strategies for handling expected failure modes	NRL/France	Grove/Djannatti-Atai
4.1.D.1.7	Tracker geometry, simulation & reconstruction	The TKR-specific portions of the simulation and reconstruction in terms of response to traversing particles, reconstruction of tracks and attempt to combine tracks into gamma candidates	SLAC	Usher
4.1.D.1.7.1	Simulation Improvements	Import existing simulation into new framework + small upgrades	SLAC	Usher
4.1.D.1.7.2	Digitization Improvements	Programme to improve charge sharing and TOT simulation	Italy	Giglietto
4.1.D.1.7.3	Initial Tracker Reconstruction	Import existing reconstruction into new framework + small upgrades	SLAC	Usher
4.1.D.1.7.4	Tracker Reconstruction Resdesign	Rework the pattern recognitiion and fitting	SLAC	Usher
4.1.D.1.8	Trigger Simulation	The flight trigger code, made to run in the offline environment and any analysis that goes with the understanding of the trigger code.	GSFC	Ritz
4.1.D.1.9	Background Rejection	Algorithms, tuned to different science goals, which identify incident particles as background, allowing the remaining interactions to be identified as signal photons.	GSFC	Ritz
4.1.D.1.A	Major Releases of Sim & Recon	Milestones for code releases	SLAC	Dubois
4.1.D.2	Analysis Tools	Tools and infrastructure to facilitate event analysis and give access to the data.	GSFC	Kelly
4.1.D.2.1	Coding conventions	Standard coding rules	SLAC	Bogart

WBS	Task	Description	Responsibility	Manager
4.1.D.2.2	Static Constants Handling	These are for non-time dependent constants.	SLAC	Bogart
4.1.D.2.3	Gaudi developments	Infrastructure developments supporting the Gaudi framework	UW	Burnett
4.1.D.2.4	Event Display	Interactive tool to view detector response correlated to the instrument geometry		
4.1.D.2.4.1	GlastSim GUI/graphics	event display contained in sim/recon packages	UW	Burnett
4.1.D.2.4.2	Event Display for All Clients	event display external to sim/recon package. Takes data input from server or sim/recon processes. Acts as client of data.	Italy	Giannitrapani
4.1.D.2.5	Root-to-IDL	Interface for IDL users to access Root output classes directly	GSFC	Kelly
4.1.D.2.6	Merit Improvements	Standard analysis package	UW	Burnett
4.1.D.2.7	New Geometry Mechanism	Ascii file description of the instrument and its required surroundings (eg spacecraft, gondola etc); utilities to extract the information from the input file; interfaces to the simulation packages (eg GEANT4 and Gismo) to create the geometric volumes; interface to the reconstruction to extract needed geometrical quantities.	SLAC	Bogart
4.1.D.2.8	PSF/Effective Area Monitoring and Optimization	An ongoing effort to optimize and track the performance of the instrument through the PSF and effectve area measures.	GSFC	Ritz
4.1.D.2.9	Code & Release Management	Utilities & procedures needed to reliably tag the versions of code that form releases and to validate the performance of those releases.	SLAC	Young
4.1.D.2.A	Continuing tools development	Incremental development and support of analysis tools	GSFC	Not assigned
4.1.D.2.B	Ongoing User Support	Ongoing support of users and code packages	GSFC	Not assigned
4.1.D.3	Engineering Models	These are the tasks that are specific to supporting Engineering Model tests. These are in addition to the GlastSim efforts that provide the base for doing simulations and reconstruction. Specifics include handling the raw data format; setting up the balllon instrument geometry and doing reconstruction in the balloon environment, particularly with the external targets.		
4.1.D.3.1	Test Beam 99 Support	These are the simulation and reconstruction tasks needed in support of the SLAC Test Beam run of 1999-2000.	SLAC	Dubois
4.1.D.3.2	Balloon Flight Support	These are the tasks that are specific to supporting the 2001 Balloon Flight.	SLAC	Dubois
4.1.D.3.3	4-Module Test Support	These are the tasks that are specific to supporting the 2003 module test	SLAC	Dubois
4.1.D.4	Science Software	The high level tasks required to extract science from the reconstructed data and MC. These include the various utilities to manipulate the Level 1 data and perform the required analyses, such as GRB detection, sky maps and so on.	GSFC	Digel
4.1.D.4.1	Utilities	Basic Utilities used by multiple analysis tools	GSFC	Digel
4.1.D.4.2	Analysis Software	Analysis tools	GSFC	Digel
4.1.D.4.3	Analysis Databases	Databases supporting utilities and analysis tools	GSFC	Digel

WBS	Task	Description	Responsibility	Manager
4.1.D.5	Data Processing Facility	Co-located with the IOC to perform near-real time data reconstruction from the instrument and provide feedback to Operations from high level subsystem-correlated instrument response, as well as input to the instrument calibration process. It will also perform bulk MC production. It will provide the Level 1 reconstructed photons that will be used for science and passed on to the Science Support Center.	SLAC	Young
4.1.D.5.1	Prototype Data Manager	First version of data server to handle performance studies and BFEM	SLAC	Young
4.1.D.5.2	Automated Server	Fully automated server to receive data from IOC and process it through to Level 1. Deliver rear real-time diagnostics to the IOC. Facilitate computation of calibration constants and apply to processed to data.	SLAC/HEPL	Young
4.1.D.5.3	Instrument Diagnostics	Near real time histograms, statistics, etc to feed back to IOC for high level assessment of instrument performance.	SLAC/HEPL	Not Assigned
4.1.D.6	Calibration	These include the subsystem instrumental calibrations and alignment as well as higher level calibrations of overall instrument response.	SLAC	do Couto e Silva
4.1.D.6.1	Tools for Accessing Constants	Tools for Accessing Constants	SLAC	Bogart
4.1.D.6.2	ACD Calibration	ACD Calibration: tile gains and pedestals	GSFC	Kelly
4.1.D.6.3	CAL Calibration	CAL Calibration: log gains and pedestals	NRL	Grove
4.1.D.6.4	TKR Calibration	TKR Calibration: hot, noisy strips; alignment	SLAC	Usher
4.1.D.6.5	High Level Calibrations	Determining Instrument Response Functions	SLAC	do Couto e Silva
4.1.D.7	Management		SLAC	Dubois
4.1.D.7.1	Science Analysis Software Management	Management oversight and code architect	SLAC, UW	Dubois/Burnett
4.1.D.7.2	Science Analysis Software Requirements	Level 3 & 4 requirements	SLAC	Dubois
4.1.D.7.2.1	Level 3 Requirements	Level 3 Requirements	SLAC	Dubois
4.1.D.7.2.2	Level 4 Requirements	Level 4 Requirements	SLAC	Dubois
4.1.D.7.3	PDR Support	PDR Support: prep for Instrument Performance studies	SLAC	Dubois
4.1.D.7.4	Mock Data Challenge I	Extensive simulation/reconstruction/analysis effort to exercise the entire data chain	SLAC	Dubois

WBS	Task	Description	Responsibility	Manager
4.1.E	**Suborbital Flight Test**	**Design, develop, and operate a Balloon Flight Engineering Model (BFEM) of the Large Area Telescope (LAT) instrument on a high altitude balloon flight at the NASA Scientific Balloon Facility (NSBF). Analyze acquired data and produce preliminary assessment of BFEM performance and implications for LAT flight design and operations.**	**GSFC**	**Thompson**
4.1.E.1	Science	Assure balloon flight effort provides data sufficient to meet established objectives. Analyze data and develop preliminary performance report.	GSFC	Thompson
4.1.E.1.1	Pre Balloon Flight Planning	Review and approve objectives and requirements for the balloon flight. Develop plans and schedules for meeting the operational and scientific requirements of the BFEM effort. Monitor task performance and review work breakdown structure, budgets, and schedules.		
4.1.E.1.2	Post Balloon Flight Data Analysis	Analyze the data acquired during the balloon flight and produce a preliminary report on BFEM performance.		
4.1.E.2	Tracker	Refurbish the Beam Test Engineering Model (BTEM) tracker for the balloon flight.	UCSC	H. Sadrozinski
4.1.E.2.1	Refurbish Tracker	Determine optimal configuration of BTEM tracker components to support balloon flight requirements. Refurbish, assemble, and test BFEM version of tracker and deliver to SLAC.		
4.1.E.3	Calorimeter	Refurbish the BTEM calorimeter for the balloon flight.	NRL	N. Johnson
4.1.E.3.1	Crystal-PIN Bond	Investigate the optical quality of PIN photodiode bonds and prepare for the balloon flight thermal environment. Thermal cycle crystals to investigate light yield changes. Replace or rebond PIN photodiodes as necessary.		
4.1.E.3.2	Mechanical	Refurbish or rework calorimeter mechanical structure and mounting to meet balloon flight environment requirements.		
4.1.E.3.3	Assembly & Test	Assemble and test the BFEM calorimeter and deliver to SLAC.		
4.1.E.4	Anticoincidence Detector	Refurbish the BTEM anticoincidence detector (ACD) for the balloon flight.	GSFC	J. Ormes
4.1.E.4.1	Refurbish BTEM ACD	Provide, test, and integrate new scintillators for the top of the ACD. Revise mechanical attachments to support balloon flight vibration and shock environment. Refurbish, assemble, and test ACD electronics. Assemble and test BFEM ACD and deliver to SLAC.		
4.1.E.5	External Gamma-Ray Target (XGT)	Design, develop and test External Gamma-ray Target (XGT) for the balloon flight.	JGC	T. Kamae
4.1.E.5.1	XGT Fabrication	Develop and fabricate XGT detectors and supporting HV power supplies and deliver to SLAC.		
4.1.E.5.2	XGT Integration	Support mechanical integration of the XGT detectors and electronics into the pressure vessel. Support electrical integration of the XGTs into the data acquisition system.		
4.1.E.6	Electronics Hardware	Refurbish and upgrade BTEM electronics to support the balloon flight.	SLAC	G. Haller

WBS	Task	Description	Responsibility	Manager
4.1.E.6.1	Tower Electronics Modules	Upgrade the Tower Electronics Modules (TEMs) to support the higher event rate anticipated for the balloon flight. Integrate the TEMs into a single backplane with a single CPU for data acquisition and control. Test and verify interfaces of refurbished TEMs with subsystems.		
4.1.E.6.2	Power System	Design, develop, assemble, and test a power system for the BFEM. Provide housekeeping readouts of voltage, current, and temperature as appropriate.		
4.1.E.6.3	Cable Harness	Design, fabricate, and test a cable harness for the BFEM.		
4.1.E.6.4	GPS	Procure and test a GPS receiver for the BFEM.		
4.1.E.6.5	Chassis	Procure, assemble and test electronics chassis for the BFEM. Provide support for network interfaces and housekeeping data acquisition. Procure and shock mount hard disk drives and other data recording devices as required.		
4.1.E.7	Balloon Interface Unit	Design, develop, and test electronics to provide an interface from the BFEM electronics to NSBF provided power and communications systems.	NRL	M. Lovellette
4.1.E.7.1	BIU Fabrication	Define interface requirements imposed by using existing NSBF and GSFC ground and flight resources. Develop interface ground and flight electronics to meet those requirements while supporting the BFEM data acquisition system (DAQ). Design and develop software as appropriate for flight and ground electronics. Procure, assemble and test flight Balloon Interface Unit (BIU) and Ground Support Equipment (GSE). Support interface testing and verification and deliver BIU and associated GSE to GSFC.		
4.1.E.8	Flight Software	Design, develop, and test flight software for the BFEM electronics to support data acquisition and instrument configuration of the BFEM.	SLAC	J. Russell
4.1.E.8.1	Flight Software Development	Develop VxWorks configuration and boot code. Develop flight application software to support data readout to memory, save to onboard disk, and transmission to the BIU. Develop instrument configuration command and control software.		
4.1.E.8.2	Flight Software Implementation	Implement data acquisition software, error detection and recovery, command interpreter, and configuration control. Support BFEM integration and test.		
4.1.E.8.3	Flight Software Integration	Update, debug, test, and verify flight software. Support balloon flight payload integration and test.		
4.1.E.8.4	Final Flight Software	Install, validate and verify final BFEM flight software.		
4.1.E.9	EGSE & Instrument Operations	Design, develop, and test electrical ground support equipment (EGSE) and operations software.	HEPL	S. Williams
4.1.E.9.1	EGSE Power System	Procure and test power supplies and control software.		
4.1.E.9.2	EGSE S/W Development	Define and develop command and telemetry format database. Define EGSE and operations display requirements. Design, develop, and test ground software for data acquisition, distribution, archive, and display. Provide and validate command interface to support ground testing.		

WBS	Task	Description	Responsibility	Manager
4.1.E.9.3	EGSE S/W Integration	Implement EGSE and support BFEM integration and test. Improve, update, debug, test, and verify EGSE software. Validate and verify final operations software for balloon flight.		
4.1.E.A	Gondola	Develop and assemble a gondola to support the pressure vessel, BFEM, NSBF electronics and batteries during the balloon flight. Support thermal analysis of pressure vessel/BFEM/BIU combination and provide thermal control as required.	GSFC	D. Thompson
4.1.E.B	Pressure Vessel	Refurbish and assemble a pressure vessel to house the BFEM, XGT, and BIU electronics during the balloon flight.	SLAC	G. Godfrey
4.1.E.C	Integration & Test	Integrate, test, and deliver the BFEM subsystems, BIU, XGT, and pressure vessel. Integrate the pressure vessel to the gondola and test against simulated NSBF interfaces. Deliver the integrated balloon flight payload to NSBF facilities, verify interfaces, and support the balloon flight and payload recovery.	SLAC	G. Godfrey
4.1.E.C.1	SLAC Integration & Test	Provide integration facility. Receive and test subsystems. Mechanically integrate subsystems into pressure vessel. Electrically integrate subsystems into pressure vessel, DAQ and power system. Verify and install cable harness. Support flight and ground software development and test. Verify performance via test prior to ship.		
4.1.E.C.2	GSFC Integration & Test	Provide integration facility. Receive and test pressure vessel, BFEM, and BIU. Mechanically integrate subsystems into gondola. Electrically integrate and test subsystems. Verify and install gondola cable harness. Support flight and ground software development and test. Verify performance via test prior to ship.		
4.1.E.C.3	NSBF Integration & Test	Perform receiving inspection and test. Integrate mechanically and electrically with NSBF provided electronics and batteries. Test and verify interfaces with flight instrument and ground support equipment. Verify readiness for flight.		
4.1.E.C.4	Balloon Flight	Support balloon flight, payload recovery, de-integration, and shipment.		
4.1.E.D	Science Analysis Software	Design, develop, test and operate data processing software for the balloon flight.	SLAC	R. Dubois
4.1.E.D.1	Define Requirements	Define analysis goals, data formats, simulation requirements, and data analysis products.		
4.1.E.D.2	Develop Software	Develop simulation of BFEM and balloon flight environment and produce simulation results. Develop background rejection and track reconstruction software and verify against simulation. Develop analysis software and test on ground data. Verify simulations against ground data.		
4.1.E.D.3	Data Analysis	Process BFEM flight data to identify background and reconstruct events. Support data analysis and development of preliminary performance report.		