LAT PROJECT DOCUMENT CHANGE NOTICE (DCN)

DCN No. LAT-XR-02718-01

SHEET 1 **OF** 1

ORIGINATOR: T. Boysen	**PHONE:** (650) 926-5461	**DATE:** 01/13/04
CHANGE TITLE: WBS Revision		**ORG.:** 4.1.1 Instr. Mgmt.

DOCUMENT NUMBER	TITLE	NEW REV.
LAT-MD-00033	**LAT Work Breakdown Structure**	**08**

CHANGE DESCRIPTION (FROM/TO):

This version reflects changes associated with the following approved change requests::

* LAT Work Breakdown Structure – Version 8 (LAT-XR-02713-01)
* Work Packages for Calorimeter CDEs. PIN Diodes & Mech Structure (LAT-XR-02254-01)

REASON FOR CHANGE:
Change request actions.

ACTION TAKEN: X **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:
X **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? X **YES** ☐ **NO**
If yes, CCB approval is required. Enter change request number: see above.

APPROVALS	DATE	OTHER APPROVALS (specify):	DATE
ORIGINATOR: T. Boysen (signature on file)	1/13/04		
ORG. MANAGER: L. Klaisner (signature on file)	1/13/04		
DCC RELEASE:		Doc. Control Level: ☐ Subsystem X LAT IPO ☐ GLAST Project	

DCN No: LAT-XR-02718-01

LAT MANAGEMENT DOCUMENT	Document # LAT-MD-00033-08	Date Effective 12/08/03
	Author(s) Tanya Boysen	Supersedes LAT-MD-00033-07
	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.
6	07/08/02	Internal replanning in 4.1.2, 4.1.5, 4.1.6, 4.1.7, 4.1.8, 4.1.9, 4.1.B, 4.1.D (Reference DCN LAT-XR-00823-01). Inclusion of "Phase" field on subsystem sections.
7	3/13/03	Internal replanning in 4.1.1, 4.1.2, 4.1.6, 4.1.8, 4.1.9, 4.1.B, 4.1.C (Reference DCN LAT-XR-01790-01).
8	12/8/03	Internal replanning in all subsystems (reference LAT-XR-02713-01, LAT-XR-02254-01).

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**

WBS	Task	Description	Responsibility	Manager	Phase
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**	**Klaisner**	Fabrication/ Commissioning
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	Klaisner	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Klaisner	Fabrication/ Commissioning
4.1.1.5	Instrument Design Engineering	Manage technical development, fabrication, integration, and test of LAT instrument. Develop and maintain system-level structural, thermal, and design models for use in systems analysis and interface management.	SLAC	Klaisner	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.1.5.1	Design Engineering Management	Manage technical development, fabrication, integration, and test of LAT instrument. Direct system and subsystem-level design activities. Manage technical and scientific trade studies. Manage production planning and fabrication efforts of subsystem. Provide primary technical interface with Mission and Spacecraft teams. Manage development and implementation of all interfaces with spacecraft and launch vehicle. Travel for Design Engineering support of LAT technical meetings and reviews, as well as interface meetings and technical reviews of the spacecraft and mission. This includes extended-stay travel required to support LAT, SC, and LV integration and test activities.	SLAC	Klaisner	Fabrication/ Commissioning
4.1.1.5.2	Mechanical Design Integration	Perform overall mechanical and thermal integration for the instrument. Develop and write mechanical and thermal verification test plans. Design subsystem interfaces, and interfaces with spacecraft. Develop and maintain LAT assembly drawings and subsystem outline drawings. Provide LAT CAD models as needed to GLAST and SC teams. Perform structural analysis of the LAT. Interpret results of mission-level requirements flow-down and results of Observatory coupled-loads analysis. Develop LAT mechanical verification test specifications. Support LAT structural testing. Correlate results with LAT structural model. Perform thermo-mechanical analysis of the LAT.	SLAC	Nordby	Fabrication/ Commissioning
4.1.1.5.3	Fabrication Engineering	Direct production and procurement efforts for instrument fabrication. Review production plans for subsystems and LAT integration efforts. Monitor fabrication, assembly, and test efforts of subsystems. Develop end-item delivery list with System Engineering. Review subysystem data packages and hardware deliverables for compliance. Develop mechanical parts and materials plan for the LAT. 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	Clinton	Fabrication/ Commissioning
4.1.1.5.4	Thermal Engineering (LM)	Review thermal issues in external ICDs and system-level requirements document and interfaces to the SC. Write LAT thermal test report. Review subsystem thermal qualification test plans and results.	SLAC	Nordby	Fabrication/ Commissioning
4.1.1.6	(Reserved)				

WBS	Task	Description	Responsibility	Manager	Phase
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**	**Horn**	Fabrication/ Commissioning
4.1.2.1	Requirements Management, Design Integration and Test Integration	This work element captures the requirements development and design integration of the LAT instrument.	SLAC	Horn	Fabrication/ Commissioning
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. Includes design compliance integration. Effort is primarily labor related but does include M&S for engineering tools, and publications. Travel is not included.	SLAC	Horn	Fabrication
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 included.	SLAC	Horn	Fabrication
4.1.2.1.3	Test Integration	The integration activities related to the coordination of LAT subsystem test plans and test interfaces. It consists of documenting, reviewing and tracking tests, and test interfaces. Effort is primarily labor and labor-related M&S, and includes travel.	SLAC	Horn	Fabrication
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. Includes system trades and audits, concept of operations, and development of system metrics. Travel is not included.	SLAC	Horn	Fabrication/ Commissioning
4.1.2.4	Qualification and Tracking	This element captures the audit 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. Data discrepancy analysis & resolution is included.	SLAC	Horn	Fabrication/ Commissioning
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.	SLAC	Horn	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.	SLAC	Horn	Fabrication/ Commissioning
4.1.2.4.3	Test Report Review & Audit	This effort includes review of test results to ensure verification requirements are achieved, discrepancies are adequately closed and documented in the final test report. Travel is not included.	SLAC	Horn	Fabrication/ Commissioning
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	Horn	Fabrication
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.	SLAC	Horn	Fabrication
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.	SLAC	Horn	Fabrication
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	Horn	Fabrication/ Commissioning
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.	SLAC	Horn	Fabrication/ Commissioning
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.	SLAC	Horn	Fabrication/ Commissioning
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.	SLAC	Horn	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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 included.	SLAC	Horn	Fabrication/ Commissioning

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

WBS	Task	Description	Responsibility	Manager	Phase
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**	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.4.1.1	Management	Personnel and management of Tracker tasks.	UCSC/SLAC	R. Johnson/T. Borden	Fabrication/ Commissioning
4.1.4.1.2	Tracker Support Personnel	Support science personnel for the Tracker.	UCSC/SLAC	R. Johnson/T. Borden	Fabrication/ Commissioning
4.1.4.1.3	Travel (SLAC/UCSC)	Travel effort for UCSC and SLAC	SLAC/UCSC	R. Johnson/T. Borden	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.4.2	Reliability & Quality Assurance	Tracker reliability and quality assurance effort	SLAC	T. Borden	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
4.1.4.3	Tray Sub-Assembly	Tracker tray design, analysis, fabrication and test activities.	SLAC-UCSC-INFN-Hiroshima	R. Johnson	Fabrication/ Commissioning
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	Fabrication
4.1.4.3.1.1	SSD Production	Production and test of the SSDs at the commercial vendor.	Hiroshima-INFN-SLAC	T. Ohsugi	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.4.3.2.5	Mechanical EM Tray Panel Fab (INFN)	Fabrication of the EM trays in Italy.	INFN	A. Brez	Fabrication
4.1.4.3.2.6	Tray Panel Fabrication Fixtures (INFN)	Fixtures required for the tray panel fabrication in Italy.	INFN	A. Brez	Fabrication
4.1.4.3.2.7	Fab Flight Instrument Tray Panel Structures (INFN)	Fabrication of the flight trays in Italy.	INFN	A. Brez	Fabrication
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	Fabrication
4.1.4.3.3.1	Testing Of Prototype Electronics	All testing of the prototype electronics.	UCSC	R. Johnson	Fabrication
4.1.4.3.3.2	Electronics design reviews (SLAC/UCSC)	All of the design reviews associated with the electronics.	SLAC/UCSC	D. Nelson	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.4.3.3.3	Detector Bias Circuit/Converters (SLAC/UCSC)	Design of the Bias circuit.	SLAC/UCSC	R. Johnson	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.4.3.3.9	Fabricate and test ASICs (UCSC)	Fabricate the ASICs and test them with wafer probing	UCSC	R. Johnson	Fabrication
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	Fabrication
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	Fabrication
4.1.4.3.4.1	Ladder Assembly Development (INFN)	Development of the tooling and processes for the SSD ladders.	INFN	A. Brez	Fabrication
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	Fabrication
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	Fabrication
4.1.4.3.4.4	EM Ladder Assembly (INFN)	Assembly of the EM SSD ladders.	INFN	A. Brez	Fabrication
4.1.4.3.4.5	EM Tray Assembly (INFN)	Assembly of the EM trays.	INFN	A. Brez	Fabrication
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	Fabrication
4.1.4.3.4.7	Assemble Flight Ladders (INFN)	Assembly of the flight SSD ladders.	INFN	A. Brez	Fabrication
4.1.4.3.4.8	Assemble Flight Trays (INFN)	Assembly of the flight trays.	INFN	A. Brez	Fabrication
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	Fabrication
4.1.4.3.5.1	Establish Clean-Room at SLAC	Design and manage construction of the clean room at SLAC	SLAC	O. Millican	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.4.3.5.2	Procure Tracker Assembly Equipment	Define, purchase and commission the required tracker assembly equipment.	SLAC	O. Millican	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.4.4.2.1	Layout, Detail Flex Circuit Cables (UCSC)	Detailed design and layout of the Tower flex cables.	UCSC	R. Johnson	Fabrication
4.1.4.4.2.2	Fabricate Flex Circuit Cables (UCSC)	Fabrication of the Tower flex cables.	UCSC	R. Johnson	Fabrication
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	Fabrication
4.1.4.4.3.1	Tower Assembly Line (SLAC)	Procure and set up the equipment for tower assembly at SLAC.	SLAC	T. Borden	Fabrication
4.1.4.4.3.2	Procure EM Tower Components (SLAC)	Procurement of all components and materials needed for EM towers.	SLAC	T. Borden	Fabrication
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	Fabrication
4.1.4.4.3.4	Procure Flight Tower Components (SLAC)	Procurement of all components and materials needed for flight towers.	SLAC	T. Borden	Fabrication
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	Fabrication
4.1.4.4.3.6	Flight Tower Assembly (INFN)	Assembly of the 16 flight Tracker towers in Italy.	INFN	A. Brez	Fabrication
4.1.4.5	Tracker Test & Calibration	All activities associated with the test and calibration of the Tracker towers.	SLAC/INFN	T. Borden	Fabrication
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	Fabrication
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	Fabrication
4.1.4.5.3	Flight Tower Testing (INFN)	Perform mechanical and electrical tests on flight towers in Italy.	INFN	A. Brez	Fabrication
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	Fabrication
4.1.4.6	(Reserved)				

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication/ Commissioning
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	Fabrication
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	Fabrication
4.1.4.7.3	Tracker I&T Equipment	Design, procure and fabricate integration and test equipment.	SLAC	T. Borden	Fabrication
4.1.4.7.4	Tracker Operations Support	Support Tracker operations during launch phase.	SLAC	T. Borden	Commissioning
4.1.4.8	Mission Integration & Test Support	Support to the mission integration and test process.	SLAC	T. Borden	Commissioning
4.1.4.8.1	Tracker Mission I&T Support	Support mission integration and test as required.	SLAC	T. Borden	Commissioning
4.1.4.8.2	Tracker Pre-Ops Support	Support to the mission integration and test pre operations as required.	SLAC	T. Borden	Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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**	Fabrication/ Commissioning
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	Raynor	Fabrication/ Commissioning
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	Raynor	
4.1.5.1.2	Program & Design Reviews	Participate in Program Reviews, design presentations, project technical interchange meetings.	NRL	Raynor	Fabrication/ Commissioning
4.1.5.1.3	Travel	Travel to team meetings, coordination meetings, and reviews.	NRL	Raynor	Fabrication/ Commissioning
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	Raynor	Fabrication/ Commissioning
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	Phase
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	Raynor	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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.			Fabrication/ Commissioning
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.			Fabrication/ Commissioning
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.			Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.5.3.4	Flight Model Proc/Fab/Assy/Tes	The Flight Model Proc/Fab/Assy/Test element refers to the effort required to fabricate and test for integration with the Flight LAT.			Fabrication/ Commissioning
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	Fabrication
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		Fabrication
4.1.5.4.2	Structure	This element includes the Calorimeter Structural design work performed at NRL, including technical oversight and engineering management.	NRL		Fabrication
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	Fabrication
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	Fabrication
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		Fabrication
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		Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
4.1.5.5	CsI Crystal Detector Elements (CDE)	The CsI detector module shall be designed to be compatible with the mechanical structure. 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	Raynor	Fabrication/ Commissioning
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	Raynor	Fabrication
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, CEA	Bederede	Fabrication
4.1.5.5.1.1.1	Bonding process development	Development and choice of the PIN diode bonding process.			Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
4.1.5.5.1.1.1.3	PIN Bonding Test	Thermal cycling of proposed bonding material.	IN2P3	Bogaert, Chaperon	Fabrication
4.1.5.5.1.1.2	Bonding GSE	Realization of all the bonding tools for the test and the final indutrial assembly			Fabrication
4.1.5.5.1.1.3	Silicone Compression Study				Fabrication
4.1.5.5.1.1.4	Compression Test GSE				Fabrication
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(TI) scintillation wavelengthes.	CEA-Saclay	Bourgeois	Fabrication
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	Fabrication
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	Fabrication
4.1.5.5.1.3.2	Wrapping	Order and test various wrapping materials from 3M to determine performance characteristics	IN2P3	Bogaert	Fabrication
4.1.5.5.2	Csi(TI) Scintillation Crystals	Procure 2240 CsI(TI) 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	Fabrication/ Commissioning
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		Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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		Fabrication
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		Fabrication
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	Fabrication
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	Fabrication
4.1.5.5.3.1.1	VM2 EM Procurement	Procure photodiodes for VM2 and EM testing	CEA-Saclay	Bederede	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.5.5.3.1.2	DPD Flight Model Procurement	Develop specification and select vendor for flight diodes. Two procurements to a common spec share the cost of the DPD between NRL and CEA.	NRL	Raynor	Fabrication
4.1.5.5.3.1.3	PIN Manufacturing	Fabricate and deliver flight photodiodes by selected vendor.	CEA-Saclay	Bederede	Fabrication
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	Fabrication
4.1.5.5.3.2.1	DPD VM2 EM Tests	Perform testing on VM2 and EM PIN photodiodes	CEA-Saclay	Bourgeois	Fabrication
4.1.5.5.3.2.1.1	VM2 Electrical Tests	Measure leakage current and capacitance	CEA-Saclay	Bourgeois	Fabrication
4.1.5.5.3.2.1.2	EM DPD Acceptance Tests	Measure electrical and mechanical characteristics of EM diodes	CEA-Saclay	Bourgeois	Fabrication
4.1.5.5.3.2.1.3	EM DPD Evaluation	Prepare for DPD qualification by performing mechanical, electrical, and environmental tests on EM diodes	CEA-Saclay	Bourgeois	Fabrication
4.1.5.5.3.2.2	Double PIN Main Procurement	Reception and acceptance of flight PIN photodiodes	CEA-Saclay	Bourgeois	Fabrication
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	Fabrication
4.1.5.5.3.3.1	PIN Test for VM2 Bench	Create spec for PIN test bench	CEA-Saclay	Bourgeois	Fabrication
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	Fabrication
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	Fabrication
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. Development of requirements, plans and execution of the Kapton cables acceptance test.	CEA-Saclay	Acker	Fabrication
4.1.5.5.4.1.1	VM2 Flex connection procurement	Support procurement of prototype flexible interconnect cables in support of LM and VM2 testing.	CEA-Saclay	Acker	Fabrication
4.1.5.5.4.1.2	EM Flex connection procurement	Support procurement of prototype flexible interconnect cables in support of EM testing.	CEA-Saclay	Acker	Fabrication
4.1.5.5.4.1.3	Flight Flex connection procurement	Support procurement of flex interconnect cables for flight models.	CEA-Saclay	Acker	Fabrication
4.1.5.5.4.2	VM & EM PIN - Flex Soldering & Test	Soldering of the Kapton cable on the Dual PIN Photodiodes for prototypes - LM/VM2 and EM. Post soldering performance tests are included.	CEA-Saclay	Acker	Fabrication
4.1.5.5.4.3	Flight PIN - Flex Soldering & Testing	Soldering of the flight flex interconnect cables to the PIN diodes and acceptance testing of the finished assemblies.	CEA-Saclay	Acker	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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 delivered from Sweden.	IN2P3	Chaperon	Fabrication
4.1.5.5.5.1.1	Crystal Test	Perform acceptance testing on crystals received from Sweden	IN2P3	Chaperon	Fabrication
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	Fabrication
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.	CEA	Bederede	Fabrication
4.1.5.5.5.2.1	Swedish Crystals Receipt	Acceptance testing on EM crystals	CEA	Bederede	Fabrication
4.1.5.5.5.2.2	EM's CDE Assembling	Bond PINs to crystals, wrap and test on cosmic bench	CEA	Bederede	Fabrication
4.1.5.5.5.3	Flight Model CDE Assembly & Test	CDE Assembly and test for QM and FM will be subcontracting to industry.	CEA	Bederede	Fabrication
4.1.5.5.5.3.1	FMA CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.2	FMB CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.3	FM1 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.4	FM2 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.5	FM3 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.6	FM4 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.7	FM5 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.8	FM6 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.9	FM7 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.A	FM8 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.B	FM9 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.C	FM10 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.D	FM11 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.E	FM12 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.F	FM13 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.G	FM14 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.H	FM15 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.3.I	FM16 CDE Assy & Test	Bond, wrap, test and ship CDE for flight model			
4.1.5.5.5.4	CDE Performance Testing				

WBS	Task	Description	Responsibility	Manager	Phase
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.	CEA	Bederede	Fabrication
4.1.5.5.5.5.1	Gluing Tools for Double PINS	Design and fab fixtures needed for bonding PIN diodes to the crystals	CEA	Bederede	Fabrication
4.1.5.5.5.5.2	Gluing Test Bench	Develop spec, procure, and assemble test bench to measure the light yield of PIN bonds to crystals.	CEA	Bederede	Fabrication
4.1.5.5.6	CDE Bonding Study	Develop alternate PIN - CsI bonding techniques and materials. Document processes and performances	NRL	Raynor	Fabrication
4.1.5.5.6.1	Process Development	Develop and prototype bonding, wrapping processes and materials			
4.1.5.5.6.2	Materials	Procure study materials			
4.1.5.5.6.3	Fabrication	Manufacture prototype CDEs			
4.1.5.5.7	Flight PIN Diode Assembly Manufacture	Manufacture and test the flight PIN Diode Assemblies	NRL	Raynor	Fabrication
4.1.5.5.8	Flight CDE Manufacture (USA)	Manufacture all flight CDEs in the USA.	NRL	Raynor	Fabrication
4.1.5.5.8.1	Flight CDE Manufacture - Design and Qualification	Develop process and tooling for CDE manufacture. Fab and qualify process.	NRL	Raynor	Fabrication
4.1.5.5.8.2	Flight CDE Manufacture - Production	Production runs for the manufacture of flight CDEs and acceptance testing.	NRL	Raynor	Fabrication
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	Raynor	Fabrication
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)	NRL	Raynor	Fabrication
4.1.5.6.1.1	VM2 Structure	Fabrication and test of the structure of VM2 to test the concept of PEM structure	IN2P3		
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		
4.1.5.6.1.1.2	Structure Hardware and Tests	Study hardware concepts - insert strength, CsI crystal bumpers, composite structure manufacturing	IN2P3		
4.1.5.6.1.1.3	Structure Fabrication	Fab VM2 structure	IN2P3		
4.1.5.6.1.2	EM Structure	Fabrication and test of the structure of EM to valide the concept of PEM structure	IN2P3		

WBS	Task	Description	Responsibility	Manager	Phase
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		
4.1.5.6.1.2.2	EM Structure MFG	Study hardware concepts - insert strength, CsI crystal bumpers, composite structure manufacturing	IN2P3		
4.1.5.6.1.2.3	EM Structure Qualification	Fab EM structure	IN2P3		
4.1.5.6.1.3	FM Structures	Fabrication and test of the structure of Flight Module following the procedure valided with EM (including the Qualification Module).	IN2P3		
4.1.5.6.1.3.1	FM Structure Manufacture	Procure materials and manufacture non-composite components of the FM structures.	IN2P3		
4.1.5.6.1.3.2	FMA Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.3	FMB Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.4	FM1 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.5	FM2 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.6	FM3 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.7	FM4 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.8	FM5 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.9	FM6 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.A	FM7 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.B	FM8 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.C	FM9 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.D	FM10 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.E	FM11 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.F	FM12 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.G	FM13 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.H	FM14 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.I	FM15 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
4.1.5.6.1.3.J	FM16 Structure	Manufacture FMA composite and assemble structure.	IN2P3		
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		
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		
4.1.5.6.1.4.2	QM & FM Tools for Structure Realization	Design, procure and assemble tooling for fabrication of Flight structure	IN2P3		
4.1.5.6.1.5	FM Structure Metallic Parts	Machine and surface treat aluminum nad titanium parts for the flight mechanical structures.	NRL	Raynor	
4.1.5.6.2	PEM Assembly & Test	Provides installation of the CsI detectors (CDE) in the mechanical structure. Cell closeouts and associated compression of the CDE are preformed. Functional performance of the CDEs in the structure is measured with muons. Assembled PEMs are delivered to Module Integration and Test.	NRL	Raynor	Fabrication
4.1.5.6.2.1	VM2 PEM Assembly & Test	A&T of the VM2 model built with 12 crystals	IN2P3	Ferreira	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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 Assembly & Test	A&T of the EM model with 96 crystals	NRL	Raynor	Fabrication
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 PEM Assembly and Test	A&T all flight models of the calorimeter at NRLmodules	NRL	Raynor	Fabrication
4.1.5.6.2.3.1	FM A (Qual) Assembly & Test	Assembly and Test of PEM module A			
4.1.5.6.2.3.2	FM B Assembly & Test	Assembly and Test of PEM module B			
4.1.5.6.2.3.3	FM 1 Assembly & Test	Assembly and Test of PEM module number 1			
4.1.5.6.2.3.4	FM 2 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.5	FM 3 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.6	FM 4 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.7	FM 5 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.8	FM 6 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.9	FM 7 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.A	FM 8 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.B	FM 9 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.C	FM 10 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.D	FM 11 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.E	FM 12 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.F	FM 13 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.G	FM 14 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.H	FM 15 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.3.I	FM 16 Assembly & Test	Assembly and Test of PEM module			
4.1.5.6.2.4	PEM GSE	Provides for mechanical and test GSE	NRL	Raynor	Fabrication
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	Fabrication
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			
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.	NRL	Raynor	Fabrication
4.1.5.6.2.4.2.1	VM2 Test Tools	GSE for VM2 test	IN2P3	Ferreira	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.5.6.2.4.2.2	PEM Bench Realization	Production of the PEM test GSE	IN2P3	Ferreira	Fabrication
4.1.5.6.2.5	PEM Assembly Facilities & Support	The CDE A&T and insertion need Clean room and humidity condition and/or control	NRL	Raynor	Fabrication
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	Fabrication
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.			
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	Fabrication
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.			

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.5.7.6.1	Flight Parts and Qualification	Provides for the procurement and qualification of all flight parts. GSE for qualification program is included.			
4.1.5.7.6.2	Flight AFEE Board Manufacture	Provides for the procurement and fabrication of the flight AFEE printed circuit boards.			

WBS	Task	Description	Responsibility	Manager	Phase
4.1.5.7.6.3	Flight AFEE Board Assembly	Provides for the assembly and soldering of parts on the boards. Functional test and unpowered thermal cycling is included.			
4.1.5.7.6.4	AFEE A, B, 1 - 4 Test	24 AFEE boards (enough for 6 CAL modules) are subjected to thermal burn in testing while powered and functionally tested. After burn in test they are conformal coated and functionally tested. At this point they are ready for installation on the PEM.			
4.1.5.7.6.5	AFEE 5 - 10 Test	24 AFEE boards (enough for 6 CAL modules) are subjected to thermal burn in testing while powered and functionally tested. After burn in test they are conformal coated and functionally tested. At this point they are ready for installation on the PEM.			
4.1.5.7.6.6	AFEE 11 - 16 Test	24 AFEE boards (enough for 6 CAL modules) are subjected to thermal burn in testing while powered and functionally tested. After burn in test they are conformal coated and functionally tested. At this point they are ready for installation on the PEM.			
4.1.5.7.6.7	AFEE Spare 1 - 6 Test	24 AFEE boards (enough for 6 CAL modules) are subjected to thermal burn in testing while powered and functionally tested. After burn in test they are conformal coated and functionally tested. At this point they are ready for installation on the PEM.			
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	Fabrication
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			
4.1.5.7.7.3	Flight Fab GSE & Facilities	Support equipment and facilities used in fabrication of the flight AFEE boards			
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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			

WBS	Task	Description	Responsibility	Manager	Phase
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.			
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.			

WBS	Task	Description	Responsibility	Manager	Phase
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.			
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.			

WBS	Task	Description	Responsibility	Manager	Phase
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.			
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.			

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication/ Commissioning
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		Fabrication
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		Fabrication/ Commissioning
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.			Fabrication
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.			Commissioning
4.1.5.A.3	Instrument Test Support	Provides for the functional and environmental testing of the completed instrument.	NRL		Fabrication/ Commissioning
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	Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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	Phase
4.1.6	**Anticoincidence Detector (ACD)**	**The ACD Subsystem element refers to all effort required to design, develop, integrate, test and deliver an Anti-Coincidence Detector (ACD) for the Gamma-ray Large Area Space Telescope (GLAST) Large Area Telescope (LAT).**	**GSFC**	**Thompson**	Fabrication/ Commissioning
4.1.6.1	ACD Project Management/Systems Engineering/Science Support	The ACD Management/Systems Engineering/Science Support element refers to all effort required to manage the ACD Subsystem's technical development and perform business management, systems engineering and science support as required to develop an ACD subsystem that meets its specified requirements.	GSFC	Johnson	Fabrication/ Commissioning
4.1.6.1.1	Project Management	The Project Management element refers to all effort required 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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Fabrication
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	Johnson	Fabrication/ Commissioning
4.1.6.1.1.4	Project Scheduling	The Project scheduling element refers to the effort required to develop and maintain schedules as needed for maintaining control of the time element.	GSFC	Johnson	Fabrication/ Commissioning
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	Johnson	Fabrication
4.1.6.1.1.6	GSFC Taxes	This WBS Element refers to the overhead charge assessed to the ACD by the GSFC. It is based upon the number of on-site Civil Servant and Contractor FTE's working on the ACD. Included within this element are the lab taxes assessed to the ACD by the lab in which the ACD is developed.	GSFC	Johnson	Fabrication/ Commissioning
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.	GSFC	Johnson	Fabrication
4.1.6.1.1.9	ACD Shipping	This element refers to the effort required to pack and ship the ACD and all ACD support hardware as required to support LAT activities.	GSFC	Johnson	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication/ Commissioning
4.1.6.1.2	System Engineering	The System 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 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	Amato	Fabrication/ Commissioning
4.1.6.1.2.1	General Systems Engineering	The General Systems Engineering element refers to the effort required to develop and document ACD subsystem requirements, specifications, Interface Control Documents (ICD's), Verification Planning, and perform technical trades studies.	GSFC	Amato	Fabrication
4.1.6.1.2.2	(Reserved)				
4.1.6.1.2.3	System Analysis and Trade Studies	The Systems 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	Amato	Fabrication
4.1.6.1.2.4	Systems Engineering Support	The Systems Engineering Support element refers to the contractor System Engineering support received by the ACD.	GSFC	Amato	Fabrication/ Commissioning
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	Thompson	Fabrication/ Commissioning
4.1.6.1.4	Science Simulations/Test	The science simulations/test element refers to the simulations and testing effort to be performed in support of ACD subsystem development efforts and trade studies.	GSFC	Thompson	Fabrication
4.1.6.2	Safety and Mission Assurance	The Safety and Mission Assurance element refers to those engineering specialty disciplines required to ensure the performance of the ACD subsystem. This includes the performance of reliability and safety analyses, quality assurance, parts analyses control, and material analyses and control.	GSFC	Huber	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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. This includes the performance of Failure Modes and Effects Analysis (FMEA), the Fault Tree Analysis (FTA), and reliability/risk assessments/tradeoffs.	GSFC	DiVenti	Fabrication
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	Fabrication
4.1.6.2.3	Quality Assurance	The Quality Assurance element refers to the effort required to establish requirements for, and maintaining 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	Fabrication
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 parts and provide test reports, as well as perform parts stress analyses.	GSFC	Perry/Vermani	Fabrication
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. This element includes the effort needed to evaluate materials, including PWB coupons, and provide test reports.	GSFC	Joy	Fabrication
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 connect the TSA to the BEA.	GSFC	Segal	Fabrication
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 and analyze the Tile Shell Assembly. This includes the development of a TSA Integration Drawing, TSA Integration Procedure, and TSA Handling Procedure.	GSFC	Segal	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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 Assemblies used in the ACD subsystem. This includes the TDA's, fiber ribbons, clear fiber cables, and fiber connectors.	GSFC	Moiseev	Fabrication
4.1.6.3.2.1	Tile Detector Assembly (TDA) Analysis/Design	The Tile Detector Assembly (TDA) Analysis/Design element refers to the non-recurring engineering effort required to design and analyze all the TDA variants required by the ACD Subsystem. This will include the development of Assembly Procedures, Assembly Drawings, and Handling Procedures.	GSFC	Moiseev	Fabrication
4.1.6.3.2.2	TDA Components Procurements	The TDA Components Procurements element refers to the effort required to procure and deliver the components needed for the fabrication and assembly of the Tile Detector Assemblies (TDAs).	GSFC	Moiseev	Fabrication
4.1.6.3.2.3	Fiber Ribbon Test Unit	The Fiber Ribbon Test Unit element refers to the design, analysis, fabrication and testing required to develop the ACD Fiber Ribbons	GSFC	Moiseev	Fabrication
4.1.6.3.2.4	Fiber Ribbon Flight Unit	The Fiber Ribbon Flight Unit element refers to the design, analysis, fabrication and testing required to develop the Flight ACD Fiber Ribbons	GSFC	Moiseev	Fabrication
4.1.6.3.2.5	Development Model TDA's Proc/Fab Assy/Test	The Development Model TDA Proc/Fab/Assy/Test element refers to the effort required to fabricate and test Development Model TDA's. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate TDA's in quantities required to prove the design of the TDA's.	GSFC	Moiseev	Fabrication
4.1.6.3.2.6	Test Unit TDAs Proc/Fab Assy/Test	The Test Unit TDA Proc/Fab/Assy/Test element refers to the effort required to fabricate and test Test Unit TDA's. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate twenty TDA's. The Test Unit TDA's will be used for the LAT calibration unit.	GSFC	Moiseev	Fabrication
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 89 Flight TDA's and 28 flight spare TDA's.	GSFC	Moiseev	Fabrication
4.1.6.3.2.8	Clear Fiber Cables	The Clear Fiber Cable element refers to effort required to design, fabricate, assemble and test the clear fiber cables. This includes the wave shifting fiber to clear fiber connectors and PMT connectors.	GSFC	Moiseev	Fabrication
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	Segal	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.3.3.1	Shell Subassembly Analysis/Design	The Shell Subassembly Analysis / Design element refers to the non-recurring engineering effort required to design and analyze the Shell Subassembly required by the ACD Subsystem. This will include all Shell Subassembly assembly drawings, assembly procedures, and shell handling procedures	GSFC	Segal	Fabrication
4.1.6.3.3.2	(Reserved)				
4.1.6.3.3.3	(Reserved)				
4.1.6.3.3.4	Test Unit Shell Proc/Fab/Assy/Test	The Test Unit Shell Subassembly Proc/Fab/Assy/Test element refers to the effort required to fabricate and test a Test Unit Shell Subassembly. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate the Test Unit Shell Subassembly.	GSFC	Segal	Fabrication
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 a flight Shell Subassembly for integration with the Flight ACD. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate the Flight Shell Subassembly.	GSFC	Segal	Fabrication
4.1.6.3.4	TDA Tiedown	The TDA Tiedown element refers to the effort required to design, procure, fabricate, assemble and test the various TDA Tiedown components required to attach the various Tile Detector Assemblies and mass-models used in the TSA.	GSFC	Segal	Fabrication
4.1.6.3.4.1	TDA Tiedown Analysis/Design	The TDA Tiedown Analysis/ Design element refers to the non-recurring engineering effort required to design and analyze all the TDA Tiedown variants required by the ACD Subsystem. This will include all TDA Tiedown assembly drawings and procedures.	GSFC	Segal	Fabrication
4.1.6.3.4.2	TDA Tiedown Development Unit	The TDA Tiedown Development Unit element refers to the effort required to fabricate and test TDA Tiedowns for use with development testing. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate TDA Tiedowns in quantities required for development testing.	GSFC	Segal	Fabrication
4.1.6.3.4.3	TDA Tiedown Engineering Test Unit	The TDA Tiedown Engineering Test Unit element refers to the effort required to fabricate and test TDA Tiedowns for use with ETU testing. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate TDA Tiedowns in quantities required for ETU testing.	GSFC	Segal	Fabrication
4.1.6.3.4.4	(Reserved)				

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.3.4.5	TDA Tiedown Flight Unit	The TDA Tiedown Flight Unit element refers to the effort required to fabricate and test TDA Tiedown for use with the Flight ACD instrument. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate TDA Tiedowns in quantities required for integration and testing with the Flight ACD instrument and flight spares.	GSFC	Segal	Fabrication
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 and the Base Frame Assembly which houses the electronics.	GSFC	Unger	Fabrication
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 and analyze the Base Electronics Assembly. This includes the development of a BEA Integration Drawing, BEA Integration and Test Procedure, BEA Handling Procedure, interface control documents for both the mechanical and electrical subsystems, and electrical specifications documents.	GSFC	Unger	Fabrication
4.1.6.4.2	Base Frame Assembly	The Base Frame Assembly element refers to the effort required to design, fabricate, and assemble the mechanical structure that houses the ACD electronics and provides the mechanical interface between the ACD and the LAT Grid.	GSFC	Segal	Fabrication
4.1.6.4.2.1	Base Frame Assembly Analysis/Design	The Base Frame Assy Analysis/Design element refers to the non-recurring engineering effort required to design and analyze the Base Frame Assembly. This will include all Base Frame Assembly drawings and procedures	GSFC	Segal	Fabrication
4.1.6.4.2.2	(Reserved)				
4.1.6.4.2.3	(Reserved)				
4.1.6.4.2.4	(Reserved)				
4.1.6.4.2.5	Base Frame Fab & Assembly	The Base Frame Assy Fab and Assy element refers to the effort required to fabricate and assemble test unit and flight unit Base Frame Assemblies. This effort includes non-recurring manufacturing costs for tooling and fixturing, as well as recurring procurement, manufacturing and testing effort required to fabricate the Base Frame Assembly.	GSFC	Segal	Fabrication
4.1.6.4.3	High Voltage Bias Supply Analysis/Procurement	The High Voltage Bias Supply Analysis/Procurement element refers to the effort required to analyze requirements for and procure and deliver the High Voltage Bias Supplies needed for integration with the ACD Electronics.	GSFC	Unger	Fabrication
4.1.6.4.3.1	HVBS, Test Board Development	This is a test board that needs to be built to test the HVBS. It also includes the procedures required to perform the testing.	GSFC	Unger	Fabrication
4.1.6.4.3.2	HVBS, DU Develop 1	This element refers to the design, analysis, fabrication and test of the development unit HVBS.	GSFC	Unger	Fabrication
4.1.6.4.3.3	HVBS, EU Develop 7	This element refers to the fabrication and testing of seven engineering unit HVBS's.	GSFC	Unger	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.4.3.4	HVBS, FU Develop 14	This element refers to the fabrication and testing of fourteen flight unit HVBS's.	GSFC	Unger	Fabrication
4.1.6.4.3.5	Resistor Network	The Resistor Network element refers to the effort required to design, analyze, fabricate and test the resistor networks that are required for the PMT's. They are printed circuit boards that are populated with resistors. This includes both engineering and flight unit Resistor Networks.	GSFC	Unger	Fabrication
4.1.6.4.4	Analog ASIC Development	The Analog ASIC Development element refers to the effort required to analyze requirements, design, procure and test the Analog ASICs needed for integration with the Front-End Electronics.	GSFC	Unger	Fabrication
4.1.6.4.4.1	Analog Test ASIC	The analog test ASIC element refers to the effort required to design and fabricate a test analog ASIC prior to the 1st generation ASIC.	GSFC	Unger	Fabrication
4.1.6.4.4.2	1ST GEN Analog ASIC Development	This element refers to the design, layout, and test of the 1st analog ASIC design.	GSFC	Unger	Fabrication
4.1.6.4.4.3	2ND GEN Analog ASIC Development	This element refers the design, layout, and test of the 2nd analog ASIC design.	GSFC	Unger	Fabrication
4.1.6.4.4.4	Flight Analog ASIC Development	This element the design, layout, and test of the Flight analog ASIC design.	GSFC	Unger	Fabrication
4.1.6.4.5	Digital ASIC Development	The Digital ASIC Development element refers to the effort required to analyze requirements, design, procure and test the Digital ASICs needed for integration with the Front-End Electronics.	GSFC	Unger	Fabrication
4.1.6.4.5.1	Tanner 1 year Maintenance (Digital ASIC)	This element refers to the action taken to complete a purchase request for Tanner Maintenance so that the ASIC design could continue.	GSFC	Unger	Fabrication
4.1.6.4.5.2	Digital Test ASIC	The digital test ASIC element refers to the effort required to design and fabricate a test digital ASIC prior to the !ST generation ASIC.	GSFC	Unger	Fabrication
4.1.6.4.5.3	1ST GEN Digital ASIC Development	This is the design, layout, and test of the 1ST generation digital ASIC design.	GSFC	Unger	Fabrication
4.1.6.4.5.4	2ND GEN Digital ASIC Development	This is the design, layout, and test of the 2ND generation digital ASIC design.	GSFC	Unger	Fabrication
4.1.6.4.5.5	Flight Unit Digital ASIC Development	This is the design, layout, and test of the Flight digital ASIC design.	GSFC	Unger	Fabrication
4.1.6.4.6	Front-End Electronics (FREE) Card	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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.4.6.1	FREE DU Development	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	Fabrication
4.1.6.4.6.2	FREE EU Development	FREE circuit card engineering unit development	GSFC	Unger	Fabrication
4.1.6.4.6.3	FREE FU Development	FREE circuit card flight unit development	GSFC	Unger	Fabrication
4.1.6.4.6.4	(Reserved)				
4.1.6.4.6.5	(Reserved)				
4.1.6.4.7	(Reserved)				
4.1.6.4.8	(Reserved)				
4.1.6.4.9	(Reserved)				
4.1.6.4.A	(Reserved)				
4.1.6.4.B	(Reserved)				
4.1.6.4.C	(Reserved)				
4.1.6.4.D	(Reserved)				
4.1.6.4.E	Photo-Multiplier Tubes (PMT's)	The Photo-Multiplier Tube (PMT) element refers to the effort required to procure and deliver Photo-Multiplier Tubes (PMTs). The PMTs shall be procured all at once but fabricated in groups of 30 and shall be delivered each month. It also includes the integration and test with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.1	PMT Flight Unit Development (1-30)	This element refers to the 1st group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.2	PMT Flight Unit Development (31-60)	This element refers to the 2nd group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.3	PMT Flight Unit Development (61-90)	This element refers to the 3rd group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.4	PMT Flight Unit Development (91-120)	This element refers to the 4th group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.5	PMT Flight Unit Development (121-150)	This element refers to the 5th group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.6	PMT Flight Unit Development (151-180)	This element refers to the 6th group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.7	PMT Flight Unit Development (181-210)	This element refers to the 7th group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
4.1.6.4.E.8	PMT Flight Unit Development (211-240)	This element refers to the 8th group of PMTs to be delivered; and integrated and tested with the resistor networks.	GSFC	Unger	Fabrication
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 Micrometeoroid Shield / Thermal Blanket Assembly. The Micrometeoroid Shield / Thermal Blanket Assembly provides protection against micrometeoroid penetration and serves as a thermal blanket for the ACD.	GSFC	T. Johnson	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.5.1	Micrometeoroid Shield/Thermal Blanket Design	The Micrometeoroid Shield / Thermal Blanket Design element refers to the effort required to design the Micrometeoroid Shield / Thermal Blanket Assembly.	GSFC	T. Johnson	Fabrication
4.1.6.5.2	Micrometeoroid Shield	The Micrometeoroid Shield element refers to the non-recurring engineering effort required to design, procure, fabricate, assemble and test the Micrometeoroid Shield. This will include orbit modeling and simulation, penetration analyses and high velocity ballistic testing.	GSFC	T. Johnson	Fabrication
4.1.6.5.3	Thermal Blanket	The Thermal Blanket element refers to the design and analysis of the thermal blanket. This includes performing the thermal analysis required to incorporate the thermal blanket with the micrometeoroid shield and selecting and procuring the thermal blanket materials.	GSFC	C. Peters	Fabrication
4.1.6.5.4	Micrometeoroid Shield/Thermal Blanket Test Unit	The Micrometeoroid Shield / Thermal Blanket Test Unit element refers to the effort required to fabricate and test a Micrometeoroid Shield / Thermal Blanket test unit. This shield/blanket will be used to qualify the design of the flight Micrometeoroid Shield / Thermal Blanket.	GSFC	T. Johnson	Fabrication
4.1.6.5.5	Micrometeoroid Shield/Thermal Blanket Cal Unit	The Micrometeoroid Shield / Thermal Blanket Cal Unit element refers to the effort required to procure, fabricate and assemble a Micrometeoroid facsimile Shield / Thermal Blanket for use on the LAT calibration unit. This shield/blanket will be different in fit from the Flight unit, and will be tailored to fit the LAT calibration unit.	GSFC	T. Johnson	Fabrication
4.1.6.5.6	Micrometeoroid Shield/Thermal Blanket Flight Unit	The Micrometeoroid Shield / Thermal Blanket Flight Unit element refers to the effort required to procure, fabricate and assemble a Micrometeoroid Shield / Thermal Blanket Assembly for use on the Flight ACD.	GSFC	T. Johnson	Fabrication
4.1.6.6	ACD Mechanical Qualification & Calibration Unit	The ACD Mechanical Qualification and Calibration Unit element refers to the effort required to perform mechanical qualification testing on the ACD Mechanical Subsystem as well as providing the ACD specific hardware required to build up the LAT Calibration Unit.	GSFC	Johnson/Segal	Fabrication
4.1.6.6.1	ACD Mechanical Subsystem Qualification	This element refers to the effort required to perform all of the activities required to qualify the ACD Mechanical Subsystem prior to the start of ACD I&T. It includes the cost of all procedures and tests required to qualify the ACD Mechanical Subsystem.	GSFC	Segal	Fabrication
4.1.6.6.1.1	TSA Mechanical Subsystem I&T	This element refers to the effort required to perform all of the activities required to qualify the TSA Mechanical Subsystem. It includes the cost of all procedures and tests required to qualify the TSA Mechanical Subsystem.	GSFC	Segal	Fabrication
4.1.6.6.1.2	BEA Mechanical Subsystem I&T	This element refers to the effort required to perform all of the activities required to qualify the BEA Mechanical Subsystem. It includes the cost of all procedures and tests required to qualify the BEA Mechanical Subsystem.	GSFC	Segal	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.6.1.3	ACD Mechanical Subsystem I&T	This element refers to the effort required to perform all of the activities required to qualify the ACD Mechanical Subsystem prior to the start of ACD I&T. It includes the cost of all procedures and tests required to qualify the ACD Mechanical Subsystem.	GSFC	Segal	Fabrication
4.1.6.6.2	Calibration Unit	This element refers to providing all of the ACD specific hardware required to build up the LAT Calibration Unit	GSFC	T. Johnson	Fabrication
4.1.6.7	ACD Integration & Test	The ACD 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. 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 ACD Flight Model.	GSFC	La	Fabrication
4.1.6.7.1	ACD Subsystem Integration	The ACD Subsystem Integration element refers to the effort required to integrate the TSA and BEA Subsystems.	GSFC	La	Fabrication
4.1.6.7.1.1	Tile Shell Assembly (TSA) Integration	The Tile Shell Assembly Integration element refers to the integration of all of the fiber ribbons, clear fiber cables and 85 TDA's to the TSA.	GSFC	La	Fabrication
4.1.6.7.1.2	Base Electronics Assembly (BEA) Integration	The BEA integration element refers to the integration of the electronics to the base frame assembly.	GSFC	La	Fabrication
4.1.6.7.2	ACD Integration	The ACD Subsystem Integration element refers to the effort required to integrate the TSA and BEA together to form the complete ACD Instrument. This includes the mating of 194 fiber cables to PMT's, bolting the TSA to the BEA, and installing the lowest row of TDA's.	GSFC	La	Fabrication
4.1.6.7.3	ACD Environmental Testing	The ACD Environmental Testing element refers to the effort required to perform all of the environmental testing on the ACD Instrument. This element includes EMI/EMC testing, Vibration Testing, Acoustic Testing, Thermal Vacuum Testing, Mass properties testing and preparing the ACD for shipment to the LAT Instrument.	GSFC	La	Fabrication
4.1.6.7.3.1	ACD EMI/EMC Testing	The ACD EMI/EMC Testing element refers to performing EMI/EMC testing on the ACD. It includes test planning, procedures, set up, operation, tear down, and test reports.	GSFC	La	Fabrication
4.1.6.7.3.2	ACD Vibration Testing	The Vibration Testing element refers to performing Vibration testing on the ACD. It includes test planning, procedures, set up, operation, tear down, and test reports.	GSFC	La	Fabrication
4.1.6.7.3.3	ACD Acoustic Testing	The ACD Acoustic Testing element refers to performing Acoustic testing on the ACD. It includes test planning, procedures, set up, operation, tear down, and test reports.	GSFC	La	Fabrication
4.1.6.7.3.4	ACD Thermal Vacuum/Thermal Balance Testing	The ACD Thermal Vacuum/Thermal Balance (TV/TB) Testing element refers to performing TV/TB testing on the ACD. It includes test planning, procedures, set up, operation, tear down, and test reports.	GSFC	La	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.7.3.5	ACD Mass Properties	The ACD Mass Properties Testing element refers to performing Mass Properties testing on the ACD. It includes test planning, procedures, set up, operation, tear down, and test reports.	GSFC	La	Fabrication
4.1.6.7.4	(Reserved)				
4.1.6.7.5	(Reserved)				
4.1.6.7.6	ACD Shipping Preparations	The ACD Shipping Element refers to the effort required to prepare the ACD and all support hardware for shipment to SLAC. This does not include the actual shipping costs.	GSFC	La	Fabrication
4.1.6.7.7	ACD Post Ship Activities	This WBS Element refers to the unpacking and setting up the ACD for post shipment functional testing and checkouts prior to integration to the LAT.	GSFC	La	Fabrication
4.1.6.8	LAT Integration & Test Support	The LAT Integration & Test element refers to the effort required to support ACD integration to the LAT instrument. This includes Calibration Model ACD/LAT integration and Flight Model ACD/LAT integration.	GSFC	La	Fabrication
4.1.6.8.1	(Reserved)				
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	Fabrication
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	Fabrication
4.1.6.9	Mission Integration & Test Support	The Mission Integration and Test Support element refers to that effort needed to support LAT instrument integration with the spacecraft and associated launch support contractors.	GSFC	La	Commissioning
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 LAT instrument integration with the spacecraft contractor.	GSFC	La	Commissioning
4.1.6.A	(Reserved)				
4.1.6.B	Ground Support Equipment (GSE) & Facilities	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	Segal / Unger	Fabrication
4.1.6.B.1	(Reserved)				
4.1.6.B.2	Mechanical Ground Support Equipment	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, TSA Handling Dolly, TDA Handling Cases, Mass Simulators, Base Electronics Assembly (BEA) Handling Assembly, Grid Interface Template, ACD Shipping Container, and ACD Lifting Slings.	GSFC	Segal	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.6.B.2.1	ACD Turnover/Assembly Dolly	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.	GSFC	Segal	Fabrication
4.1.6.B.2.2	TSA Handling Dolly	The TSA Handling Dolly element refers to the effort needed to design, procure, fabricate, assemble and test a dolly for handling the ACD TSA during ACD TSA I&T operations.	GSFC	Segal	Fabrication
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).	GSFC	Segal	Fabrication
4.1.6.B.2.4	ACD/Base Frame Handling Dolly	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. This dolly will also be used for the ACD Instrument.	GSFC	Segal	Fabrication
4.1.6.B.2.5	Grid Interface Template	The Grid Interface Template element refers to the effort needed to design and fabricate a Grid Interface Template. This template will be used to install the Base Frame Assembly to LAT Grid interface holes as well as be used to install inserts into the composite shell.	GSFC	Segal	Fabrication
4.1.6.B.2.6	ACD Shipping Container	The ACD Shipping Container 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	Segal	Fabrication
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	Segal	Fabrication
4.1.6.B.2.8	Mass Simulators	The Mass Simulator element refers to all of the mass simulators required to fully test all ACD flight and GSE hardware.	GSFC	Segal	Fabrication
4.1.6.B.2.9	Multi-Purpose Test Fixture	This element refers to the test fixture that will be used for vibration and thermal vacuum testing of the ACD.			Fabrication
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	Fabrication
4.1.6.B.3.1	ACD Electrical Test Cables	The ACD Electrical Test Cables element refers to the effort required to design, test, and fabricate the electrical test cables required for testing the ACD. This element includes the thermal vacuum test cables as well as the thermal vacuum feedthroughs.	GSFC	Unger	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
4.1.6.B.3.4	Event Simulator	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	Fabrication
4.1.6.B.3.5	EGSE Software Development	The EGSE Software Development element refers to the programming of ACD-specific commands, displays, test scripts, and analytical tools on the Electrical Ground Support Equipment workstation supplied to the ACD by the I&T group.	GSFC	La	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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**	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.3.2.1	Technology Evaluation	Test on 0.5 um Agilent technology, bulk CMOS with Epi layer	SLAC	Haller	Fabrication
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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.	SLAC	Haller	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.4.4	GASU ACD EM Electronics	GASU DAQ 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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
4.1.7.4.5	LAT Communication Board	Interface between GASU and cPCI processor. One LCB per processor crate. Two SIU, 3 EPU crates. Contains 2 ACTEL FPGA's, one for CPI interface, one for LAT interface.	SLAC	Nelson	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.4.6	Data CPUs	Data-CPU generates control commands to the towers (via the LAT Communication card).It receives complete events from the LCB card and filters the events in Level 3 software filter. BAE RAD750 processor board. One each in 2 SIU and 3 EPU crates.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
4.1.7.4.8	GASU Global Trigger (GLT) Electronics	GASU Global Trigger Electronics Module. Interfaces to LCB, 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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication/ Commissioning
4.1.7.5	Spacecraft Interface Unit	Spacecraft Interface Unit. Includes instrument-control processor with interface to spacecraft. Commanding via MIL1553. Control processor communicates with DATA-CPU cards. All interconnected via crate 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.	SLAC	Haller	Fabrication
4.1.7.5.1	Design Requisites	Includes engineering time to create SIU requirement and conceptua design documents, including discussions to arrive at an appropriate design.	SLAC	Haller	Fabrication
4.1.7.5.2	Storage Interface Board	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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.5.3	GASU Event Builder Electronics	GASU Event Builder Electronics receives event data fragments from the 16 TEM's and the global trigger. It assembles a coherent LAT event and forwards the event to one of the event processors. Contains about 18 FIFO's and 1 or 2 FPGA's for control.	SLAC	Nelson	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.5.4	SIU Backplane	The SIU backplane provides the interconnection between LCB, RAD750, and power supply boards. Is cCPI backplane with user connections. 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	Haller	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.	SLAC	Haller	Fabrication
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	Fabrication
4.1.7.6.1	Design Requisites	Includes engineering time to create SIU requirement and conceptua design documents, including discussions to arrive at an appropriate design.	SLAC	Nelson	Fabrication
4.1.7.6.2	Power Distribution Unit (PDU)	The Power Distribution Unit 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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.6.4	(Reserved)				
4.1.7.6.5	TEM Power Supply	The TEM Power Supply 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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.6.6	GASU Power Supply	The GASU Power Supply 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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.6.7	Crate Power Supply	The Crate Power Supply 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. One board each for each EPU and SIU crate.	SLAC	Nelson	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
4.1.7.7	Enclosures	Includes the design and fabrication of the boxes holding the electronics boards.	SLAC	Freytag	Fabrication
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	Fabrication
4.1.7.7.1.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	SLAC	Freytag	Fabrication
4.1.7.7.1.1.1	Conceptual Design	Enclosure concept	SLAC	Freytag	Fabrication
4.1.7.7.1.1.2	Preliminary Design	Mechanical drawings of enclosure	SLAC	Freytag	Fabrication
4.1.7.7.1.1.3	Fab, Assembly & Test	Fabricate parts and assemble enclusure	SLAC	Freytag	Fabrication
4.1.7.7.1.2	Qualification Unit	Mechanical Encosure for qual model electronics	SLAC	Freytag	Fabrication
4.1.7.7.1.2.1	Design	Mechanical drawings of enclosure	SLAC	Freytag	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.7.7.1.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	SLAC	Freytag	Fabrication
4.1.7.7.1.3	Flight Unit	Mechanical Encosure for flight electronics	SLAC	Freytag	Fabrication
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	Fabrication
4.1.7.7.2.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	SLAC	Freytag	Fabrication
4.1.7.7.2.1.1	Conceptual Design	Enclosure concept	SLAC	Freytag	Fabrication
4.1.7.7.2.1.2	Preliminary Design	Mechanical drawings of enclosure	SLAC	Freytag	Fabrication
4.1.7.7.2.1.3	Fab, Assembly & Test	fabricate parts and assemble enclusure	SLAC	Freytag	Fabrication
4.1.7.7.2.2	Qualification Unit	Mechanical Encosure for qual model electronics	SLAC	Freytag	Fabrication
4.1.7.7.2.2.1	Design	Mechanical drawings of enclosure	SLAC	Freytag	Fabrication
4.1.7.7.2.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	SLAC	Freytag	Fabrication
4.1.7.7.2.3	Flight Unit	Mechanical Encosure for flight electronics	SLAC	Freytag	Fabrication
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.	SLAC	Haller	Fabrication
4.1.7.7.3.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	SLAC	Haller	Fabrication
4.1.7.7.3.1.1	Conceptual Design	Enclosure concept	SLAC	Haller	Fabrication
4.1.7.7.3.1.2	Preliminary Design	Mechanical drawings of enclosure	SLAC	Haller	Fabrication
4.1.7.7.3.1.3	Fab, Assembly & Test	Fabricate parts and assemble enclusure	SLAC	Haller	Fabrication
4.1.7.7.3.2	Qualification Unit	Mechanical Encosure for qual model electronics	SLAC	Haller	Fabrication
4.1.7.7.3.2.1	Design	Mechanical drawings of enclosure	SLAC	Haller	Fabrication
4.1.7.7.3.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	SLAC	Haller	Fabrication
4.1.7.7.3.3	Flight Unit	Mechanical Encosure for flight electronics	SLAC	Haller	Fabrication
4.1.7.7.4	SIU Enclosure	Includes the design and fabrication of the boxes holding the spacecraft interface electronics boards.	SLAC	Haller	Fabrication
4.1.7.7.4.1	Engineering Model 1	Mechanical Encosure for engineering 1 model electronics	SLAC	Haller	Fabrication
4.1.7.7.4.1.1	Conceptual Design	Enclosure concept	SLAC	Haller	Fabrication
4.1.7.7.4.1.2	Preliminary Design	Mechanical drawings of enclosure	SLAC	Haller	Fabrication
4.1.7.7.4.1.3	Fab, Assembly & Test	Fabricate parts and assemble enclusure	SLAC	Haller	Fabrication
4.1.7.7.4.2	Qualification Unit	Mechanical Encosure for qual model electronics	SLAC	Haller	Fabrication
4.1.7.7.4.2.1	Design	Mechanical drawings of enclosure	SLAC	Haller	Fabrication
4.1.7.7.4.2.2	Fab & Assembly	Fabricate parts and assemble enclusure	SLAC	Haller	Fabrication
4.1.7.7.4.3	Flight Unit	Mechanical Encosure for flight electronics	SLAC	Haller	Fabrication
4.1.7.8	Cable Harness	Includes the design and fabrication of the cable harness in the LAT.	SLAC	Freytag	Fabrication
4.1.7.8.1	Engineering Model	Includes the design and fabrication of the cable harness for the engineering 2 model electronics.	SLAC	Freytag	Fabrication
4.1.7.8.2	Qualification Unit	Includes the design, fabrication, inspection of the cable harness for the Qual Unit electronics.	SLAC	Freytag	Fabrication
4.1.7.8.3	Flight Unit	Includes the design, fabrication, inspection of the cable harness for the Flight Unit electronics.	SLAC	Freytag	Fabrication
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	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication/ Commissioning
4.1.7.9.1.1	Infra-Structure Development	development of framework	SLAC	Russell	Fabrication/ Commissioning
4.1.7.9.1.2	Test Bench Support	software support of hardware testbenches	SLAC	Russell	Fabrication/ Commissioning
4.1.7.9.2	Determine CPU Resources	Characterize memory, IO, CPU cycle needs.	SLAC	Russell	Fabrication
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	Fabrication
4.1.7.9.3.1	Architecture	Design overall architecture of software	SLAC	Russell	Fabrication
4.1.7.9.3.2	Low Level Diagnostics	Write low level diagnostics code	SLAC	Russell	Fabrication
4.1.7.9.3.3	Tower Command & Configuration	Write code to configure and command a tower	SLAC	Russell	Fabrication
4.1.7.9.3.4	Dataflow	move the data from the tower	SLAC	Russell	Fabrication
4.1.7.9.3.5	Housekeeping	Readout housekeeping data	SLAC	Russell	Fabrication
4.1.7.9.3.6	EM1 Simulator	Write the driver for the Front-end simulator	SLAC	Russell	Fabrication
4.1.7.9.3.7	Low Rate Science	Readout the rate counters	SLAC	Russell	Fabrication
4.1.7.9.3.8	EM1 Code Design/Development	Design architecture and code for the single tower, single CPU test stand. No hardware available yet in this phase.	SLAC	Russell	Fabrication
4.1.7.9.3.9	EM1 Code Develop/Test	Develop/test the software on engineering modules of the hardware. Hardware is VME CPU, VME transition board, TEM, TEM power supply, CAL and TKR sub-system front-end electronics.	SLAC	Russell	Fabrication
4.1.7.9.3.A	EM1 Unit Test	Unit test the packages developed for EM1. Unit test is with LTX test executive.	SLAC	Russell	Fabrication
4.1.7.9.3.B	EM1 Formal Testing	Formal Test of EM1 packages running on single-CPU/signel tower test stand. Uses Python scripts which are Compatible with I&T. Running on LATTE test executive.	SLAC	Russell	Fabrication
4.1.7.9.3.C	EM1 Documentation	Documents describing the packages and builts for EM1.	SLAC	Russell	Fabrication
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	Fabrication
4.1.7.9.4.1	EM1/EM2 Transistion		SLAC	Russell	Fabrication
4.1.7.9.4.2	Low Level Diagnostics	Write low level diagnostics code	SLAC	Russell	Fabrication
4.1.7.9.4.3	Facilities	Facilities	SLAC	Russell	Fabrication
4.1.7.9.4.4	Fast Monitoring	Write code to fast monitor the data	SLAC	Russell	Fabrication
4.1.7.9.4.5	Space Craft Ops	Communication and I/O	SLAC	Russell	Fabrication
4.1.7.9.4.6	GSE	Ground Suypport Equipment exploitation	SLAC	Russell	Fabrication
4.1.7.9.4.7	Uplink/Downlink	SSR management, input and output data formatting	SLAC	Russell	Fabrication
4.1.7.9.4.8	Calibration	Code to calibrate systems	SLAC	Russell	Fabrication
4.1.7.9.4.9	EM2 Simulator	Write the driver for the Front-end simulator	SLAC	Russell	Fabrication
4.1.7.9.4.A	Science	Science software	SLAC	Russell	Fabrication
4.1.7.9.4.B	Mulit-CPU Toolbox Effort	All effort to talk between CPUs	SLAC	Russell	Fabrication
4.1.7.9.4.B.1	Multi-CPU Toolbox	Code to talk between CPUs	SLAC	Russell	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.7.9.4.B.2	Multi-CPU Low Level Diagnostics	Low-level diagnostics code	SLAC	Russell	Fabrication
4.1.7.9.4.B.3	Multi-CPU Calibration	Calibration Code	SLAC	Russell	Fabrication
4.1.7.9.4.C	EM2 Code Design/Develop	Design architecture and code for the multi tower, single CPU test stand. No hardware available yet in this phase. Software needs to use GASU trigger, event-builder, Command-Response Unit, and ACD electronics module components.	SLAC	Russell	Fabrication
4.1.7.9.4.D	EM2 Code Develop/Test	Develop/test the software on engineering modules of the hardware. Hardware is VME CPU with PCI LCB board, VME transition board, GASU module, TEM, TEM power supply, CAL and TKR sub-system front-end electronics. Variation of this test-stand is for the Instrument Spacecraft Interface Simulator to Be delivered to Spectrum Astro.	SLAC	Russell	Fabrication
4.1.7.9.4.E	EM2 Unit Testing	Unit test the packages developed for EM2. Unit test is with LTX test executive.	SLAC	Russell	Fabrication
4.1.7.9.4.F	EM2 Formal Test	Formal Test of EM2 packages running on single-CPU/multi-tower test stand. Uses Python scripts which are Compatible with I&T. Running on LATTE test executive. Uses GASU module. Variation of this development stand is used in ISIS.	SLAC	Russell	Fabrication
4.1.7.9.4.G	EM2 Documentation	Documents describing the packages and builts for EM2 and ISIS.	SLAC	Russell	Fabrication
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	Fabrication
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	Fabrication
4.1.7.9.5.2.1	Facilities	Facilities	SLAC	Russell	Fabrication
4.1.7.9.5.2.2	(reserved)				Fabrication
4.1.7.9.5.2.3	Fast Monitoring	Write code to fast monitor the data	SLAC	Russell	Fabrication
4.1.7.9.5.2.4	Space Craft Ops	Communication and I/O	SLAC	Russell	Fabrication
4.1.7.9.5.2.5	GSE	Ground Suypport Equipment exploitation	SLAC	Russell	Fabrication
4.1.7.9.5.2.6	(reserved)				Fabrication
4.1.7.9.5.2.7	Science	Science software	SLAC	Russell	Fabrication
4.1.7.9.6	Flight Unit	Final software for the flight-unit electronics.	SLAC	Russell	Fabrication/ Commissioning
4.1.7.9.6.1	FU Code Design/Develop	Design architecture and code for the multi tower, multi test stand. No hardware available yet in this phase. Software needs to use GASU trigger, event-builder, Command-Response Unit, and ACD electronics module components with Siu and EPU crates.	SLAC	Russell	Fabrication
4.1.7.9.6.2	FU Code Develop/Test	Develop/test the software on engineering modules of the hardware. Hardware is PCI SIU crate with backplane, LCB card, SIB card and GASU module, TEM, TEM power supply, CAL and TKR sub-system front-end electronics.	SLAC	Russell	Fabrication/ Commissioning
4.1.7.9.6.3	FU Unit Testing	Unit test the packages developed for FU. Unit test is with LTX test executive.	SLAC	Russell	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.7.9.6.4	FU Formal Test	Formal Test of FU packages running on single-CPU/multi-tower test stand. Uses Python scripts which are Compatible with I&T. Running on LATTE test executive. Uses multiple CPU's.	SLAC	Russell	Fabrication
4.1.7.9.6.5	FU Documentation	Documents describing the packages and builts for FU.	SLAC	Russell	Fabrication
4.1.7.9.6.6	FSW Support During I&T	Support from FSW team during I&T of LAT.	SLAC	Russell	Fabrication/ Commissioning
4.1.7.9.7	Science/Spacecraft	Design/develop/test event filtering science, thermal control, GRB detection, and GBM data action code.	SLAC	Russell	Fabrication
4.1.7.9.7.1	Design/Develop/Test	Initial design and test of science packages for filtering.	SLAC	Russell	Fabrication
4.1.7.9.7.2	Unit Testing	Unit testing of science packages in LTX test executive.	SLAC	Russell	Fabrication
4.1.7.9.7.3	Formal Testing	Testing of software with python scripts using LATTE.	SLAC	Russell	Fabrication
4.1.7.9.7.4	Documentation	Preparing documentation for science software.	SLAC	Russell	Fabrication
4.1.7.9.8	Flight CPU Booting	Primary and secondary boot code for RAD750 CPU's.	SLAC	Russell	Fabrication
4.1.7.9.8.1	Design/Develop/Test	Design/develop/test boot code for RAD750 processor.	SLAC	Russell	Fabrication
4.1.7.9.8.2	Unit Testing	Unit test boot code packages with LTX test executive.	SLAC	Russell	Fabrication
4.1.7.9.8.3	Formal Testing	Formal testing of boot code using LATTE/Python.	SLAC	Russell	Fabrication
4.1.7.9.8.4	Documentation	Documention of software for boot of Siu and EPU processors. Primary and secondary boot.	SLAC	Russell	Fabrication
4.1.7.9.9	Front End Simulator	Code to program front-end simulator board for test-bed.	SLAC	Russell	Fabrication
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.	SLAC	Haller	Fabrication
4.1.7.A.1	EGSE Requirements Definition	All labor required to define the requirements of the EGSE system.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
4.1.7.A.2.1	EGSE S/W Development	Development of software	SLAC	Haller	Fabrication
4.1.7.A.2.2	EGSE H/W Development	Devlopment of hardware	SLAC	Haller	Fabrication
4.1.7.A.2.3	EM2 Support	GSE support for engineering 2 models	SLAC	Haller	Fabrication
4.1.7.A.2.4	Qual Unit Support	GSE support for qual models	SLAC	Haller	Fabrication
4.1.7.A.2.5	Flight Unit Support	GSE support for flight models	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
4.1.7.A.3.1	SIS Development	design space craft interface simulator	SLAC	Haller	Fabrication
4.1.7.A.3.2	Qual Unit Support	support effort to interface to LAT via SIS	SLAC	Haller	Fabrication
4.1.7.A.3.3	Flight Unit Support	support effort to interface to LAT via SIS	SLAC	Haller	Fabrication
4.1.7.A.4	Instrument Power System	All labor and material required to build the power supply system supplying power to the LAT.	SLAC	Haller	Fabrication
4.1.7.A.4.1	IPS Development	Power systme development for LAT	SLAC	Haller	Fabrication
4.1.7.A.4.2	Qual Unit Support	Power supplies for qual units	SLAC	Haller	Fabrication
4.1.7.A.4.3	Flight Unit Support	Power supplies for LAT	SLAC	Haller	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
4.1.7.C.1.1	Engineering Model 2	Integrate engineering 2 model electronics in box	SLAC	Freytag	Fabrication
4.1.7.C.1.2	Qualification Unit	Integrate qualification model electronics in box	SLAC	Freytag	Fabrication
4.1.7.C.1.3	Flight Unit	Integrate flight model electronics in box	SLAC	Freytag	Fabrication
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	Fabrication
4.1.7.C.2.1	Engineering Model 2	Integrate engineering 2 model electronics in box	SLAC	Freytag	Fabrication
4.1.7.C.2.2	Qualification Unit	Integrate qualification model electronics in box	SLAC	Freytag	Fabrication
4.1.7.C.2.3	Flight Unit	Integrate flight model electronics in box	SLAC	Freytag	Fabrication
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.	SLAC	Haller	Fabrication
4.1.7.C.3.1	Engineering Model 2	Integrate engineering 2 model electronics in box	SLAC	Haller	Fabrication
4.1.7.C.3.2	Qualification Unit	Integrate qualification model electronics in box	SLAC	Haller	Fabrication
4.1.7.C.3.3	Flight Unit	Integrate flight model electronics in box	SLAC	Haller	Fabrication
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.	SLAC	Haller	Fabrication
4.1.7.C.4.1	Engineering Model 2	Integrate engineering 2 model electronics in box	SLAC	Haller	Fabrication
4.1.7.C.4.2	Qualification Unit	Integrate qualification model electronics in box	SLAC	Haller	Fabrication
4.1.7.C.4.3	Flight Unit	Integrate flight model electronics in box	SLAC	Haller	Fabrication
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	Fabrication
4.1.7.C.5.1	Engineering Model 2	integration of engineering 2 models	SLAC	Haller	Fabrication
4.1.7.C.5.2	Qualification Unit	integration of qualification models	SLAC	Haller	Fabrication
4.1.7.C.5.3	Flight Unit	integration of flight models	SLAC	Haller	Fabrication
4.1.7.C.6	PDU Box I&T	Installation of PDU DAQ board in the PDU enclosure.	SLAC	Haller	Fabrication
4.1.7.C.6.1	Engineering Model 2	Installation of PDU DAQ board version engineering model 2 in the PDU enclosure.	SLAC	Haller	Fabrication
4.1.7.C.6.2	Qualification Unit	Installation of PDU DAQ board qualification unit in the PDU enclosure.	SLAC	Haller	Fabrication
4.1.6.C.6.3	Flight Unit	Installation of PDU DAQ board flight unit in the PDU enclosure.	SLAC	Haller	Fabrication
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.	SLAC	Haller	Commissioning
4.1.7.D.1	Observatory Testing	Labor to test the LAT when integrated with the spacecraft	SLAC	Haller	Commissioning
4.1.7.D.2	Ground Systems Compatibility Tests	Labor to test the LAT in regards to its compatibility with the ground systems.	SLAC	Haller	Commissioning
4.1.7.D.3	Training Simulations	Simulations of the LAT.	SLAC	Haller	Commissioning
4.1.7.D.4	Launch & Early Operations Support	Support for testing pre-launch and post-launch operation of the LAT.	SLAC	Haller	Commissioning
4.1.7.D.5	MSI&T Travel	All travel for MSI&T phase	SLAC	Haller	Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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**	**Campell**	Fabrication/ Commissioning
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	Campell	Fabrication/ Commissioning
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. Provide engineering support for response to GSFC, studies, updates, and off-baseline work requests. Provide engineering support of deltaPDR planning and Radiator re-design effort.	SLAC	Campell	Fabrication/ Commissioning
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. Includes travel for deltaPDR in Wash DC, 2 CDR's and additional trips to GSFC for interchange meetings. Also includes additional travel for second engineer.	SLAC	Campell	Fabrication/ Commissioning
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	Campell	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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. Re-estimate LM effort after Mech-PDR, PDR, and deltaPDR. Manage re-packaging and dPDR effort, coordinating with SLAC and GSFC. Develop Phase II proposal at end of Phase I. Develop Phase III proposal at end of Phase II.	SLAC	Campell	Fabrication/ Commissioning
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 during Phase I include: delta PDR at GSFC (2 people), CDR at GSFC (2 people), 1 meeting with the spacecraft contractor on east coast (2 people), 1 interchange meeting at GSFC (2 people). Specific events for which travel is required during Phase 2 include: 1 LAT review at GSFC, 2 meetings with the spacecraft (SC) contractor on east coast, 3 meetings at HPPC in Mississipi, Observatory integration and test, PSR at GSFC.	SLAC	Campell	Fabrication/ Commissioning
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	Campell	Fabrication/ Commissioning
4.1.8.2.1	Reliability	Covered by 4.1.A Performance and Safety Assurance	SLAC	Marsh	Fabrication
4.1.8.2.2	Quality Assurance	Covered by 4.1.A Performance and Safety Assurance	SLAC	Marsh	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Campell	Fabrication/ Commissioning
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	Campell	Fabrication
4.1.8.3.1	LAT Mechanical Design Integration	Design and develop subsystem interfaces, and interfaces with spacecraft. Update LAT design after PDR to reflect re-packaged Radiators and new interfaces to SC. Finalize ICD drawings with new packaging, and modify SC interface drawings. This is 50% FTE position from dPDR through delivery. Perform thermal mechanical analysis and simulation for the instrument. Work with subsystem mechanical engineers in developing subsystem mechanical designs, and in providing FEA models of subystem. Update thermal, structural, and thermal-mechanical analysis models for dPDR using updated models from subsystems. Develop reduced structural and thermal models and correlate with detailed and with translations sent to GSFC. Provide 25% FTE support of on-going GSFC questions through FY02. Update thermal, structural, and thermal-mechanical anlaysis models after spacecraft contractor is onboard for SC PDR through FY02.	SLAC	Campell	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Campell	Fabrication/ Commissioning
4.1.8.4.1	(LM) LAT Thermal Modeling	Develop Radiator TSS/SINDA model. Perform TSS/SINDA thermal analysis of the instrument, using Radiator model, and SLAC-supplied SINDA input file of LAT instrument. This includes running orbital transient thermal analyses 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, delta PDR, Spacecraft PDR, MEch-CDR, and I-CDE. Update model every quarter, if needed, to include new developments in the IAT design. Continuous updates are a 50% FTE effort through LAT CDR. Prepare and deliver a reduced LAT Thermal Math Model, in TSS/SINDA format to GSFC at delta PDR and CDR. Use SLAC supplied LAT instrument SINDA file. Maintain updated overall LAT thermal model and provide appropriate details of the analysis to allow coordination of the model with SLAC thermal models and with SC contractor's thermal models. This includes running orbital transient analysis of radiative heating of LAT with selected spacecraft and with final operational configurations.	SLAC	Campell	Fabrication/ Commissioning
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.This is initial conceptual work up to I-PDR. Redesign Radiators for dPDR. This includes complete update of thermal and structural analaysis and design detailed drawings.	SLAC	Campell	Fabrication
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	Campell	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.8.5.2	Control System Fabrication	Procure components for control system, and assemble and test. This includes heaters, thermostats, thermistors, fly-away instrumentation (if any), TCS electronic components and the Heater Control Box. Support integration and test of controls on Qual and Flight Grids and Radiators.	SLAC	Haller	Fabrication
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	Fabrication
4.1.8.6	(LM) Radiators and X-LAT Plate	Fabricate Heat Pipe engineering model (EM). Finalize Radiator designs after I-PDR and fabricate, assemble, and test flight Radiators. Finalize X-LAT Plate designs, fabricate, assemble, and test flight unit.	SLAC	Campell	Fabrication/ Commissioning
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	Campell	Fabrication
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	Campell	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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. Quantity: 2 radiators and 12+2 spare VCHP's. 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 sine sweep, acoustic and thermal vacuum acceptance test and thermal functional testing of VCHP's, heaters, and thermistors.	SLAC	Campell	Fabrication/ Commissioning'
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	Campell	Fabrication/ Commissioning
4.1.8.6.5	Heat Pipe Fabrication (LM)	Develop, design and perform analyses of Grid Heat Pipes after delta PDR. Make detailed drawings and fabrication plans for Heat Pipes. Prep for Mech and I-CDR. Support planning for assembling heat pipes I 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, 12 +2 spare of Downspout CCHP's, 2+1 spare U-shaped CCHP, 4+1 ground cooling pipes (fly-away). 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	Campell	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.8.6.6	TCS Protoflight Testing (LM)	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. This includes 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 of thermal testing. Correlate and update analytic Write test report.	SLAC	Campell	Fabrication/ Commissioning
4.1.8.6.7	LAT Thermal-Balance Test Support (LM)	Review LAT thermal balance test plan for I-CDR. Provide thermal analysis input to I & T for writing drafts of test procedures. Perform thermal analyses of LAT while in the test configuration and environment. This includes running a full radiation model of the test configuration, to predict test responses and place thermocouples. Test GSE information provided by I&T. Engineering support of thermal testing. Correlate and update analytical model. Write test report.	SLAC	Campell	Fabrication/ Commissioning
4.1.8.6.8	X-LAT Plate (LM)	Develop shop drawings and procedures for X-LAT Plate fabrication. Oversee X-LAT Plate fabrication and assembly. Finalize X-LAT Plate test procedures and oversee testing. Maintain CAD and FEA model of X-LAT Plate Update as-built drawings after fabrication and testing. Fabricate X-LAT Plate procure materials, fabricate assembly fixtures, and assemble X-LAT Plate Fabricate transport and storage GSE for X-LAT Plate. Fabricate X-LAT Plate test fixtures. Procure test equipment. Test X-LAT Plate Includes cost of use of test facilities and support team. Testing includes acceptance thermal testing of X-LAT Plate.	SLAC	Campell	Fabrication
4.1.8.7	Engineering Modeling	Develop, fab, and test Grid engineering models and prototypes after I-PDR. Finalize flight Grid interface designs.	SLAC	Campell	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.8.7.1	EM Development and Testing (SLAC)	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 four-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, X-LAT Plate fab fixture prototypes, fabrication prototypes and qual test samples. Support EM, proto, and qual testing. All work at SLAC.	SLAC	Campell	Fabrication
4.1.8.7.2	Flight Hardware Design Finalization (SLAC)	Update Grid, X-LAT Thermal Plate CAD models after Idelta-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	Campell	Fabrication
4.1.8.8	Fabrication, Assembly and Test (SLAC)	Fabricate grid, EMI shield, and grid box assembly. Supervise fabrication. 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 assembly fixtures and procedures for structural and thermal testing	SLAC	Campell	Fabrication
4.1.8.8.1	Grid (SLAC)	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.	SLAC	TBD	Fabrication
4.1.8.8.2	(Reserved)				
4.1.8.8.3	Mech Systems Assembly and Test (SLAC)	Close out Mechanical test actions from CDR	SLAC	Campell	Fabrication
4.1.8.8.4	(Reserved)		SLAC	Campell	Fabrication
4.1.8.8.5	(Reserved)				
4.1.8.8.6	Grid, EMI Skirt and Grid Details	Update post CDR designs. Procure raw materials for Grids. Fabricate 2 Grids, EMI skirt sets and Grid detail parts, including heat treatment of Aluminum billets, design and fabrication of manufacturing shop aids, tooling and shipping containers. Inspect hardware. Perform Finite Element Model verification test on one Grid.	SLAC	Campell	Fabrication
4.1.8.8.7	Grid Box Assembly	Write Grid Box assembly plans and procedures. Detail Grid Box fixtures/ground support equipment. Write test reports. Procure/fabricate Grid Box hardware and assembly fixtures. Perform assembly operations for Grid Box Base Assembly and Grid Box Assembly for Grids #1 and #2.	SLAC	Campell	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.8.8.8	Grid Box Test	Write Grid Box Static Load and Thermal Cycle test plans and procedures. Detail MGSE and test fixture designs for both tests. Write both test reports. Procure/fabricate Static Load and Thermal Cycle Test MGSE and test fixtures. This includes test facilities for these tests. Perform Static Load and Thermal Cycle Tests. Disassemble Grid Box Assembly and prep for delivery to I&T. Survey Grid.	SLAC	Campell	Fabrication
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.	SLAC	Campell	Fabrication/ Commissioning
4.1.8.9.1	LAT Integration Support (SLAC)	Support LAT instrument integration. This includes engineering support to resolve mechanical interface or structural problems. Provide mechanical technicians to integrate X-LAT Thermal Plate onto LAT. Finalize as-built drawings.	SLAC	Campell	Fabrication
4.1.8.9.2	LAT Structural Test Support (SLAC)	Support instrument testing, including structural engineering support to monitor instrument environmental and structural testing, at testing contractor.	SLAC	Campell	Fabrication
4.1.8.9.3	LAT Thermal-Vacuum Test Support (SLAC)	Support instrument thermal testing, including engineering support to monitor instrument environmental and structural testing, at testing contractor.	SLAC	Campell	Fabrication/ Commissioning
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	Campell	Commissioning
4.1.8.A.1	SC/LV I&T Support (SLAC)	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	Campell	Commissioning
4.1.8.A.2	Post-Launch Engineering Support (SLAC)	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	Campell	Commissioning
4.1.8.A.3	Mission Thermal Test Support (LM)	Support SC thermal testing, including thermal engineering support to monitor SC environmental testing at testing contractor and during LV integration.	SLAC	Campell	Commissioning
4.1.8.A.4	Post-Launch Thermal Engineering (LM)	Provide thermal engineering support for launch and on-orbit check-out, including thermal analysis of actual temperature data.	SLAC	Campell	Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9	**Integration and Test**	**Integrate and Test the LAT (excluding electical integration). This includes developing and executing I&T plans and procedures, developing, prototyping, fabricating, assembling, and testing I&T MGSE and elements of EGSE. Also includes environmental test planning and execution. This subsystem will integrate and test the EM units, Calibration Unit (CU) and flight LAT. This subsystem will verify the GLAST instrument Monte Carlo (MC) by comparing data collected in beam tests from EM units, CU, and LAT to MC predictions (NB: all beam tests are not accelerator beam tests). I&T will use the beam test data and MC to perform science verification, analysis, and calibration (SVAC) on all of these units. I&T will perform a set of tests in orbit, during the initial part of instrument commissioning (Phase 0), that are based on tests developed during ground I&T. Full performance test and baseline test which will be used to assure LAT performance prior to and post all configuration tests. These tests will be sufficient to demonstrate that the LAT instrument is working properly before transfer to the ISOC. To accomplish much of this work, I&T will develop and focus Collaboration support for beam test, SVAC, environmental test, and Phase 0 on orbit activities.**	**SLAC**	**E. Bloom**	Fabrication/ Commissioning
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 environmental requirements and performance metrics. Support quarterly team meetings and project reviews. Travel to meetings and site visit for test support. Develop and focus Collaboration support for beam test, SVAC, environmental test, spacecraft and launch vehicle integration and Phase 0 on orbit activities.	SLAC	E. Bloom	Fabrication/ Commissioning
4.1.9.1.1	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 environmental requirements and performance metrics. Support quarterly team meetings and project reviews, and travel thereto. Develop and focus Collaboration support for beam test, SVAC, environmental test, and Phase 0 on orbit activities. Control subsystem requirements metrics. Develop maintain and control LAT performance metrics. Prep and attend review, IDT meetings, etc.	SLAC	E. Bloom	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.1.2	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. All I&T department travel funds are held at this level.	SLAC	E. Bloom	Fabrication
4.1.9.1.3	I&T Support	Workstation, and Laptop Computers and software for supporting engineering effort for I&T.	SLAC	E. Bloom	Fabrication
4.1.9.2	Quality Assurance	Support Quality Assurance activities for the subsystem. 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	D. Marsh	Fabrication
4.1.9.2.1	Reliability	Perform reliability analysis of subsystem	SLAC	D. Marsh	Fabrication
4.1.9.2.2	QA	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	D. Marsh	Fabrication
4.1.9.3	Instrument Science Operations Center (ISOC) Coordinator	Ensure the orderly transition to the ISOC for LAT on-orbit operations. Leverage the development of the online software systems to minimize ISOC cost. Capture and retain LAT engineering knowledge in the operations team. Validate and verify all flight operations procedures, command and telemetry database entries, calibration procedures, and ISOC hardware and software prior to instrument delivery. Maximize the use of I&T opportunities for training instrument operators and science observers.	SLAC	D. Lung (acting)	Fabrication
4.1.9.3.1	Management and Engineering	Management and Engineering on a departmental basis. Travel to meetings and site visit for test support. Help I&T management develop and focus Collaboration support for Phase 0 on orbit activities.	SLAC	D. Lung (acting)	Fabrication
4.1.9.3.2	Prep	Coordinate online software, SVAC activities with ISOC planning	SLAC	D. Lung (acting)	Fabrication
4.1.9.3.3	EM-1	Coordinate online software, SVAC activities with ISOC planning.	SLAC	D. Lung (acting)	Fabrication
4.1.9.3.4	Calibration Unit	Coordinate online software and SVAC activities with ISOC planning.	SLAC	D. Lung (acting)	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.3.5	Flight Unit	Coordinate online software and SVAC activities with ISOC planning and activities. Validate and verify all flight operations procedures, command and telemetry database entries, calibration procedures, and ISOC hardware and software prior to instrument delivery. Maximize the use of I&T opportunities for training instrument operators and science observers.	SLAC	D. Lung (acting)	Fabrication
4.1.9.4	Mechanical Ground Support Equipment	Supports the other I&T departments, the observatory I&T, and launch, in their MGSE needs. This support begins with the EM-1 and continues through launch. This includes development, fabrication or procurement, assembly and qualification testing of all needed MGSE. It also includes support during use of the equipment. Work in this department should be coordinated with Mechanical Systems.	SLAC	E. Gawehn	Fabrication/ Commissioning
4.1.9.4.1	Management and Engineering	Provide program scheduling, cost accounting, and performance tracking and reporting for department. Support development of department specifications, verification plans, and interfaces with neighboring departments. Control department environmental requirements and performance metrics. Control departments requirement metrics. Travel to meetings and site visit for test support.	SLAC	E. Gawehn	Fabrication/ Commissioning
4.1.9.4.2	Prep	Develop and Prototype EM-1, CU and LAT MGSE equipment. Develop mechanical interface documentation to ACD, CALORIMETER, ELECTRONICS, MECHANICAL, TRACKER subsystems. Develop and prototype Van de Graff accelerator support and containment design. Develop and prototype LAT shipping container design. Develop interface documentation to spacecraft.	SLAC	E. Gawehn	Fabrication
4.1.9.4.2.1	Concept Development	Develop concepts for EM-1, CU, LAT Shipping Container MGSE	SLAC	E. Gawehn	Fabrication
4.1.9.4.2.2	Calibration Test Development	Conceptual design of Mechanical Calibration test equipment.	SLAC	E. Gawehn	Fabrication
4.1.9.4.2.3	Mechanical Interface Documentation	Obtain interface documentation to other Subsystems (ACD,Cal, Tkr,elec, Mech, S/C). This should be coordinated with Mechanical Systems Engineering	SLAC	E. Gawehn	Fabrication
4.1.9.4.3	EM-1	Fabricate or procure, assemble and test MGSE for use during EM-1 integration and test. Fabricate, assemble, and test Bld 33 Van de Graff accelerator support and containment. Support the MGSE needs in other I&T departments. Support EM-1 integration and test activities	SLAC	E. Gawehn	Fabrication
4.1.9.4.3.1	Engineering EM-1 Unit MGSE	Develop and detail MGSE for EM-1.	SLAC	E. Gawehn	Fabrication
4.1.9.4.3.2	Engineering Van De Graff MGSE	Detail containment and support stand for Van de Graff.	SLAC	E. Gawehn	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.4.4	Calibration Unit	Fabricate or procure, assemble, and test MGSE for use during CU integration and test and beam test. Support the MGSE needs in other I&T departments. Support CU integration and test activities.	SLAC	E. Gawehn	Fabrication
4.1.9.4.4.1	Engineering	Develop, detail plans and equipment to support the Calibration Unit MGSE.	SLAC	E. Gawehn	Fabrication
4.1.9.4.4.2	Equipment and Preparation	Procure and Assemble MGSE for Calibration Unit.	SLAC	E. Gawehn	Fabrication
4.1.9.4.4.3	(Reserved)				
4.1.9.4.4.4	Calibration Unit Beam Test MGSE	Provide MGSE support during the Beam Test.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5	Flight Unit	Fabricate or procure, assemble, and test MGSE for use during LAT integration and test. Fabricate LAT shipping container. Fabricate or procure, assemble and test MGSE for use during LAT environmental test at the vendor's facility. Support the MGSE needs in other I&T departments. Support LAT integration and test activities.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.1	LAT Integration	Provide engineering, preperation, fabrication of Flight Unit MGSE	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.1.1	Engineering	Develop, detail MGSE for flight unit, including procedures, support stand, cart, lift rigging, staging table, misc. equp, calibration detector, mounting stand, base isolated pallet, rigging forklift harness, transprt box, misc. transport containers.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.2	Integration Preparation	Fab/Assemble LAT Int. Equip, Fab/Assemble LAT Transport, Storage Equip, Prepare Integration Clean Room	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.2.1	Fab/Assemble LAT Int. Equip	Procure/ assemble, support tand, cart, lift rigging, staging table, misc. equipment and fixtures	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.2.2	(Reserved)				
4.1.9.4.5.2.3	Fab/Assemble LAT Transport, Storage Equip	Procure/assemble. LAT mounting stand, base isolated pallet, rigging forklift harness, dry transport box, misc. transport containers.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.2.4	Prepare Integration Clean Room	Support installation of stands in clean room, support of load testing, survey alignment support, test installed stands.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.3	LAT Airplane test support	Support LAT Airplane test plans and detail/design required fixturing/MGSE. Procure, assemble, test airplane fixturing/MGSE, including obtaining required certifications.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.3.1	Engineering	Support LAT Airplane test plans and detail/design required fixturing/MGSE.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.3.2	LAT Airplane test preparation	Procure, assemble, test airplane fixturing/MGSE, including obtaining required certifications.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.4	LAT Mechanical Testing	Support LAT mechanical testing plans and design/detail Vib mounts. Procure, assemble, test vibration test mount/equipment.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.4.1	Engineering	Support LAT mechanical testing plans and design/detail Vib mounts.	SLAC	E. Gawehn	Fabrication
4.1.9.4.5.4.2	Mechanical Vibration Testing Preparation	Procure, assemble, test vibration test mount/equipment.	SLAC	E. Gawehn	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.4.5.5	(Reserved)				
4.1.9.4.5.6	(Reserved)				
4.1.9.5	Online Software	Develop, test, and support software used to collect data from the EM units, CU and LAT test stands, saves them to persistent storage, and to monitor and control the test stand and data acquisition system. We define a "test stand" to be a collection of hardware and embedded software that communicates with the online software system via Ethernet over a Local Area Network. The Online Software department is responsible for the online software, workstations on which the online software operates, and network connections. The online software includes a test executive that communicates with the embedded system to control the test stand, collects data from the hardware under test, a scripting language, Graphical User Interface (GUI) tools, a database, analysis tools, and a mechanism to archive data. The Online Software Department will also provide a code management and release control system. The Online Software department is responsible for the design and implementation of a standard test suite (scripts) used to qualify the instrument sensors and accompanying electronics. The supplied tools will allow people external to the online department to develop independent test procedures (scripts) for specific situations as they find appropriate. The ELECTRONICS Subsystem is responsible for substantial elements of the test stand. Thus, there will be close coordination between the Online Software department and ELECTRONICS Subsystem. We expect that the online software system will evolve into the Instrument Science Operations Center (ISOC) software system that controls, monitors and collects data from the orbiting instrument.	SLAC	R. Claus	Fabrication
4.1.9.5.1	Management and Engineering	Provide program scheduling, cost accounting, and performance tracking and reporting for department. Support development of department specifications, verification plans, and interfaces with neighboring departments. Control department environmental requirements and performance metrics. Control departments requirements metrics. Travel to meetings and site visit for test support. Responsible for coordination of EGSE activities with ELECTRONICS and ISOC subsystems.	SLAC	R. Claus	Fabrication
4.1.9.5.1.1	Configuration management	Provide and establish a software configuration management system	SLAC	R. Claus	Fabrication
4.1.9.5.1.1.1	Version control	Track software revisions	SLAC	R. Claus	Fabrication
4.1.9.5.1.1.2	Release control	Track software releases	SLAC	R. Claus	Fabrication
4.1.9.5.1.1.3	Release building and distribution	Arrange for a system that builds and distributes software releases	SLAC	R. Claus	Fabrication
4.1.9.5.1.1.4	Problem reporting/tracking database	Arrange for a system that users use to report problems and tracks their resolution	SLAC	R. Claus	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.5.1.2	COTS software	Selection, procurement and familiarization of COTS software required for EGSE/Online	SLAC	R. Claus	Fabrication
4.1.9.5.1.2.1	Software evaluation and selection	Formulation of selection criteria of COTS software	SLAC	R. Claus	Fabrication
4.1.9.5.1.2.2	Software procurement & licenses	Procurement of COTS software	SLAC	R. Claus	Fabrication
4.1.9.5.1.2.3	Bootstrap effort	Effort required to learn use of COTS software	SLAC	R. Claus	Fabrication
4.1.9.5.1.2.4	Support contracts	COTS software maintenance and support contracts	SLAC	R. Claus	Fabrication
4.1.9.5.1.2.5	Consulting costs	Consulting contracts to enhance, or provide additional deliverables to us, of COTS software	SLAC	R. Claus	Fabrication
4.1.9.5.1.2.6	Training	COTS software training of end-users	SLAC	R. Claus	Fabrication
4.1.9.5.1.2.7	Updates	COTS software version updates	SLAC	R. Claus	Fabrication
4.1.9.5.1.3	WBS	Time spent on preparing the WBS	SLAC	R. Claus	Fabrication
4.1.9.5.1.4	PDR	Time spent on PDR	SLAC	R. Claus	Fabrication
4.1.9.5.1.5	CDR	Time spent on CDR	SLAC	R. Claus	Fabrication
4.1.9.5.1.6	Management Activities	Day to Day Management Activities	SLAC	R. Claus	Fabrication
4.1.9.5.2	Prep	Establish online software system architecture. Establish specific software tools for EM-1 and CU (EM-2) applications. Establish vendor communications and begin training for selected products. Staff up programming labor per budget and schedule.	SLAC	R. Claus	Fabrication
4.1.9.5.2.1	Definition of Requirements	Effort spent on understanding the problem to be solved and establishing a list of requirements	SLAC	R. Claus	Fabrication
4.1.9.5.2.2	Documents	Activities surrounding the production of various documents	SLAC	R. Claus	Fabrication
4.1.9.5.2.3	Test Stands	Activities surrounding the establishment of test stands	SLAC	R. Claus	Fabrication
4.1.9.5.3	EM-1	Develop and fabricate or procure, assemble, and test the EM1 online software and workstations used to develop test and qualify sensor hardware and electronics for EM-1. Distribute these units to ELECTRONICS, ACD, CAL, TRACKER, and I&T Subsystems. Support the software and workstations at the various venues used by the Subsystems. The latter may be done by remote networking techniques.	SLAC	R. Claus	Fabrication
4.1.9.5.3.1	Eng Model 1 Test stand S/W devel and support	Development and support of EM1 test stand software	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.1	SCL/hardware interface definition and implementation	Work with Electronics and Flight Software groups to establish the software interface to the hardware in SCL	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.1.1	TEM	Work with Electronics and Flight Software groups to establish the software interface to the TEM in SCL	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.1.2	AEM	Work with Electronics and Flight Software groups to establish the software interface to the AEM in SCL	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.1.3	GEM	Work with Electronics and Flight Software groups to establish the software interface to the GEM in SCL	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.2	Command/Monitor GUI tool	Use of the command/monitor GUI tool to produce GUIs for test stand use	SLAC	R. Claus	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.5.3.1.3	Relational Databases, tools and integration	Work to create local (MS ACCESS) and central (Oracle) database schemas. Create synchronization tool. Integration with SCL	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.4	Visualization tool and integration	Work to augment and integrate a visualization tool with SCL	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.5	Persistent data storage method and format	Work to establish a method and format for storing persistent event data	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.6	Test report generation and archiving	Work to automatically generate and archive test reports	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.7	SCL databases and scripts	Create SCL databases and scripts as starting points and training tools for end users	SLAC	R. Claus	Fabrication
4.1.9.5.3.1.8	Release	Testing, production, distribution, and support of EM-1 software releases	SLAC	R. Claus	Fabrication
4.1.9.5.3.2	Eng Model 2 Test stand S/W devel and support	Extension of the EM1 online software to EGSE EM2 and support thereof	SLAC	R. Claus	Fabrication
4.1.9.5.3.2.1	EM-2 software development	Development work to extend the EGSE EM1 code base to the EGSE EM2 level	SLAC	R. Claus	Fabrication
4.1.9.5.3.2.2	Instrument Power Supply	Design, implement, test and release IPS software	SLAC	R. Claus	Fabrication
4.1.9.5.3.2.3	Spacecraft Interface Simulator	Design, implement, test and release SIS software	SLAC	R. Claus	Fabrication
4.1.9.5.3.2.4	Release	Support of EM-2 software releases	SLAC	R. Claus	Fabrication
4.1.9.5.4	Calibration Unit	Develop and fabricate or procure, assemble, and test the CU online software and workstations used to develop test and qualify sensor hardware and electronics for the CU. Help create test scripts in coordination with the IFCT, Particle Test, and SVAC, departments. The CU test stands are used for accelerator beam tests and other beam tests with the CU. The CU test stands are also used for developing flight software. Support the software and workstations at the various venues used by I&T.	SLAC	R. Claus	Fabrication
4.1.9.5.5	Flight Unit	Develop and fabricate or procure, assemble, and test the LAT online software and workstations used to develop test and qualify sensor hardware and electronics for the LAT. Help create test scripts in coordination with the IFCT, and SVAC departments. The LAT test stands are used when the instrument is undergoing, shakedown, environmental, airplane, and pre-launch tests. Support the software and workstations at the various venues used by I&T.	SLAC	R. Claus	Fabrication
4.1.9.6	Integration, Facilities, Configuration and Test (IFCT)	Develop I&T plans for the EM units, CU, and LAT. Develop procedures, and equipment. Layout, spec, and procure equipment and facilities needed for LAT integration at SLAC. Train and certify technician support for LAT flight hardware handling. Provide on-going operational support of integration facilities and staff. Supervise I&T work in Bld 33.	SLAC	L. Wai	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.6.1	Management and Engineering	Develop and implement I&T plans for EM units, CU, and LAT. Supervise I&T activities in Bld 33 and manage Bld 33. Implement training and certification of technician support for LAT flight hardware handling. Supervise technician support at all LAT flight hardware test venues. Provide program scheduling, cost accounting, and performance tracking and reporting for department. Support development of department specifications, verification plans, and interfaces with neighboring departments. Control department environmental requirements and performance metrics. Control departments requirements metrics. Travel time to meetings and site visit for test support	SLAC	L. Wai	Fabrication/ Commissioning
4.1.9.6.2	Prep	Prepare I&T EM units, CU, and LAT plans for department. Prepare Bld 33 for I&T activities. Staff up technician labor for I&T activities per budget and schedule. Establish training procedures and work procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.2.1	Technician Training	Establish training procedures and work procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.2.1.1	Contamination Control	Train I& T Technicians for clean room procedures	SLAC	L. Wai	Fabrication
4.1.9.6.2.1.2	Flight Hardware Training	Train I&T technicians for flight hardware assembly, electrostatic discharge, and handling.	SLAC	L. Wai	Fabrication
4.1.9.6.2.1.3	Crane/Critical Lift	Train I&T technicians for safe operation of 5-ton crane in clean room high bay. Train technicians for safe operation of 15-ton crane in building 33.	SLAC	L. Wai	Fabrication
4.1.9.6.2.2	Clean Room Lab Operations	Specify, purchase, and set-up clean room systems.	SLAC	L. Wai	Fabrication
4.1.9.6.2.2.1	Real-Time Monitoring	Specify, purchase, and set-up electronic data acquisition systems for temperature, humidity, and particle count.	SLAC	L. Wai	Fabrication
4.1.9.6.2.2.2	Cleanroom Materials and Services	Specify and procure cleanroom de-contamination equipment, clean room storage cabinets, services, and decommission upon completion.	SLAC	L. Wai	Fabrication
4.1.9.6.2.2.3	Receiving Inspection	Prepare receiving inspection plan and test receiving inspection procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.2.2.4	Controlled Storage	Coordinate controlled storage plan with flight hardware subsystem engineers. Prepare and test controlled storage procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.2.3	Computers and Office Materials	Plan and specify materials and services needed for continuous operation of the integration area.	SLAC	L. Wai	Fabrication
4.1.9.6.2.3.1	Computers	Specify and purchase computer workstations.	SLAC	L. Wai	Fabrication
4.1.9.6.2.3.2	Office Materials and Supplies	Specify and purchase meeting area equipment.	SLAC	L. Wai	Fabrication
4.1.9.6.2.4	Flight Hardware Integration Tools	Specify and purchase flight hardware integration tools.	SLAC	L. Wai	Fabrication
4.1.9.6.2.4.1	Integrated Tower Metrology	Specify and purchase metrology system for LAT integration	SLAC	L. Wai	Fabrication
4.1.9.6.2.4.2	Electrical Test Tools	Specify and purchase electrical test tools to be used during mechanical intergration.	SLAC	L. Wai	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.6.2.4.3	Mechanical Assembly Tools	Specify and purchase assembly tools.	SLAC	L. Wai	Fabrication
4.1.9.6.2.4.4	Mechanical Test Tools	Specify and build mechanical mating test equipment.	SLAC	L. Wai	Fabrication
4.1.9.6.3	EM-1	Develop procedures and plans for the EM-1 unit. Perform EM-1 mechanical integration. Coordinate test equipment and fixtures with MGSE, online software, and particle test departments. Coordinate testing of assembled EM-1 with beam test, online and SVAC departments.	SLAC	L. Wai	Fabrication
4.1.9.6.3.1	EM-1 Integration	Develop, test and practice procedures for integration of EM-1 unit; execute integration procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.3.1.1	Single Tower Model	Design and build model for single tower integration.	SLAC	L. Wai	Fabrication
4.1.9.6.3.1.2	Integration Procedure	Develop, test and practice single tower integration procedure.	SLAC	L. Wai	Fabrication
4.1.9.6.3.1.3	Preparation	Prepare for EM-1 integration.	SLAC	L. Wai	Fabrication
4.1.9.6.3.1.4	EM-1 Grid	Integrate EM-1 grid onto MGSE.	SLAC	L. Wai	Fabrication
4.1.9.6.3.1.5	EM-1 Tower	In coordination with electronics subsystem Integrate EM-1 tracker tower, calorimeter module, and front-end electronics. Perform cable mating, cable tie down, and electrical tests.	SLAC	L. Wai	Fabrication
4.1.9.6.3.2	Van De Graf Test	Develop, test and practice procedures for exposure of EM-1 unit to Van De Graf radiation; execute test.	SLAC	L. Wai	Fabrication
4.1.9.6.3.2.1	Test Procedure	Develop, test and practice procedure for single tower Van De Graf exposure.	SLAC	L. Wai	Fabrication
4.1.9.6.3.2.2	Preparation	Prepare for EM-1 Van De Graf exposure.	SLAC	L. Wai	Fabrication
4.1.9.6.3.2.3	Test Execution	Expose EM-1 to Van De Graf radiation.	SLAC	L. Wai	Fabrication
4.1.9.6.3.3	(Reserved)				
4.1.9.6.4	Calibration Unit	Develop procedures and plans for the Calibration Unit. Perform Calibration Unit mechanical integration and tests. Coordinate test equipment and fixtures with MGSE, online software, and particle test. Coordinate transport, installation and testing of assembled Calibration Unit with MGSE, online software, particle test and SVAC departments.	SLAC	L. Wai	Fabrication
4.1.9.6.4.1	Calibration Unit Integration	Develop, test and exercise procedures for Calibration Unit integration; integrate Calibration Unit.	SLAC	L. Wai	Fabrication
4.1.9.6.4.1.1	Calibration Unit Model	Design and build four tower Calibration Unit model for integration procedure development, test, and exercise.	SLAC	L. Wai	Fabrication
4.1.9.6.4.1.2	Integration Procedure	Develop, test and exercise integration procedure for Calibration Unit; determine cable tie-down points.	SLAC	L. Wai	Fabrication
4.1.9.6.4.1.3	Preparation	Prepare for calibration unit integration.	SLAC	L. Wai	Fabrication
4.1.9.6.4.1.4	Calibration Unit Grid	Mate Calibration Unit Grid to MGSE.	SLAC	L. Wai	Fabrication
4.1.9.6.4.1.5	Towers A&B	Integrate Towers A&B.	SLAC	L. Wai	Fabrication
4.1.9.6.4.1.6	Towers 1&2	Integrate Towers 1&2	SLAC	L. Wai	Fabrication
4.1.9.6.4.1.7	Cross-Unit Electronics	Mechanicaly Integrate relevant cross-unit electronics; perform cross-unit cable tie-down.	SLAC	L. Wai	Fabrication
4.1.9.6.4.2	Van De Graf Test	Develop, test, and practice procedure for Calibration Unit exposure to Van De Graf radiation; execute 4 tower exposure test.	SLAC	L. Wai	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.6.4.2.1	Test Procedure	Coordinate development of procedures for 4-tower Van De Graf test with Particle Test manager. Test and practice procedures for test using Calibration Unit Model.	SLAC	L. Wai	Fabrication
4.1.9.6.4.2.2	Preparation	Prepare for Calibration Unit 4-tower exposure test.	SLAC	L. Wai	Fabrication
4.1.9.6.4.2.3	Test Execution	Perform Calibration Unit 4-tower exposure test.	SLAC	L. Wai	Fabrication
4.1.9.6.4.3	SLAC Particle Beam Test	Develop, test and practice procedures for exposure of Calibration unit to End Station A particle beams; execute test beam procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.4.3.1	Test Procedure	Coordinate development of Test Beam procedures with Particle Test Manager. Test and practice procedures using Calibration Unit Model. Test and practice procedures for transport of Calibration Unit to End Station A.	SLAC	L. Wai	Fabrication
4.1.9.6.4.3.2	Preparation	Prepare for Calibration Unit Particle Beam Test.	SLAC	L. Wai	Fabrication
4.1.9.6.4.3.3	Transport CU to End Station A	Transport Calibration Unit to End Station A.	SLAC	L. Wai	Fabrication
4.1.9.6.4.3.4	Test Execution	Execute Test Beam Procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.4.3.5	Transport CU to Bldg.33	Transport Calibration Unit to Building 33 Clean Room Area.	SLAC	L. Wai	Fabrication
4.1.9.6.4.3.6	De-integrate CU	Remove flight parts from the Calibration Unit	SLAC	L. Wai	Fabrication
4.1.9.6.5	Flight Unit	Develop procedures and plans for the LAT. Perform LAT mechanical integration and tests. Coordinate test equipment, fixtures and test scripts with MGSE, online software, particle test, and SVAC departments. Coordinate transport, testing of assembled LAT with environmental test, MGSE, online software, and particle test and SVAC departments.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1	LAT Integration	Develop, test and practice procedures for integration of LAT. Prepare and execute procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.1	LAT Integration Model	Design and build LAT Integration Model.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.2	Integration Procedure	Develop, test and practice procedures for integration of LAT. Determine cable tie-down points. Determine thermal readout points and practice thermocouple wiring, tie-down, and final cut-off. Determine accelerometer cable routing, tiedown, and removal.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.3	Preparation	Prepare for integration of LAT.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.4	LAT Grid	Mate LAT Grid to MGSE.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.5	Towers 3&4	Integrate Towers 3&4.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.6	Towers 5&6	Integrate Towers 5&6.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.7	Towers 7&8	Integrate Towers 7&8.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.8	Towers 9&10	Integrate Towers 9&10	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.9	Towers 11&12	Integrate Towers 11&12	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.A	Towers 13&14	Integrate Towers 13&14	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.B	Towers 15&16	Integrate Towers 15&16	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.C	(Reserved)				
4.1.9.6.5.1.D	LAT Survey	Survey Full LAT	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.E	LAT-wide Electronics	Mechanically Integrate LAT-wide electronics. Perform cable tie-down and flight hardware cable connection mates coordinated with electronics subsystems.	SLAC	L. Wai	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.6.5.1.F	ACD	Integrate ACD.	SLAC	L. Wai	Fabrication
4.1.9.6.5.1.G	Cross-LAT Thermal Plate	Integrate Cross-LAT Thermal Plate	SLAC	L. Wai	Fabrication
4.1.9.6.5.2	Comprehensive Test	Develop, test and practice procedures for comprehensive test of LAT. Execute procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.5.2.1	Test Procedure Development	Develop, test and practice procedures for LAT comprehensive test. Develop, test, and practice procedures for GSE cooling of LAT during full LAT multi-day data taking ground tests.	SLAC	L. Wai	Fabrication
4.1.9.6.5.2.2	Preparation	Prepare for LAT comprehensive test.	SLAC	L. Wai	Fabrication
4.1.9.6.5.2.3	Execute Test	Execute LAT comprehensive test.	SLAC	L. Wai	Fabrication
4.1.9.6.5.3	SLAC Thermal Cycle test	In coordination with enviromental test department. Develop procedures for SLAC thermal cycle test of LAT (subsequently cancelled).	SLAC	L. Wai	Fabrication
4.1.9.6.5.3.1	Test Procedure Development	Develop procedures for SLAC thermal cycle test (subsequently cancelled).	SLAC	L. Wai	Fabrication
4.1.9.6.5.3.2	Preparation	Prepare for SLAC thermal cycle test of LAT.	SLAC	L. Wai	Fabrication
4.1.9.6.5.3.3	Execute Test	Execute SLAC thermal cycle test of LAT.	SLAC	L. Wai	Fabrication
4.1.9.6.5.4	Airborne Cosmic Test	Develop, test and practice procedures for end-to-end airborne cosmic test of LAT. Execute procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.5.4.1	Test Procedure Development	Develop, test and practice procedures for LAT airborne cosmic test. Develop, test and practice procedures for transport of LAT to and from airplane. Document all procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.5.4.2	Preparation	Prepare for LAT airborne cosmic test.	SLAC	L. Wai	Fabrication
4.1.9.6.5.4.3	LAT Transport to airplane	Execute procedures for transport of LAT to airplane.	SLAC	L. Wai	Fabrication
4.1.9.6.5.4.4	Test Execution	Execute procedures for LAT airborne cosmic test.	SLAC	L. Wai	Fabrication
4.1.9.6.5.4.5	LAT Transport from airplane	Execute procedures for transport of LAT from airplane.	SLAC	L. Wai	Fabrication
4.1.9.6.5.5	Environmental Test	In coordination with enviromental test department, coordinate, develop, test and practice procedures for LAT environmental tests. Execute procedures.	SLAC	L. Wai	Fabrication
4.1.9.6.5.5.1	Test Procedure Development	Coordinate test procedures with Environmental Test Manager. Develop, test and practice procedures for LAT environmental tests. Develop, test and practice procedures for transport of LAT to and from Environmental Test Facility.	SLAC	L. Wai	Fabrication
4.1.9.6.5.5.2	Preparation	Prepare for LAT environmental test.	SLAC	L. Wai	Fabrication
4.1.9.6.5.5.3	Test Execution	Execute procedures for LAT environmental tests.	SLAC	L. Wai	Fabrication
4.1.9.6.5.5.4	LAT Transport	Execute procedures for transport of LAT from environmental test facility	SLAC	L. Wai	Fabrication
4.1.9.6.5.6	Final Comprehensive Test	Develop, test and practice procedures for LAT final comprehensive test. Execute procedures.	SLAC	L. Wai	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.7	Particle Test	Develop, plan, and lead in the implementation of particle tests for the EM units, CU, and LAT. Particle tests will include ground cosmic rays and Van de Graff photons for the EM units; ground cosmic rays, Van de Graff photons, and accelerator beam tests for the CU; ground cosmic rays, Van de Graff photons, and end-to-end test in an airplane using cosmic rays at altitude for the LAT. These tasks will require close coordination with all other departments in I&T. To accomplish much of this work, the particle test manager will help I&T management develop and focus Collaboration support.	SLAC	G. Godfrey	Fabrication
4.1.9.7.1	Management and Engineering	Lead development, planning, and implementation of all GLAST particle beam tests. Provide program scheduling, cost accounting, and performance tracking and reporting for department. Support development of department specifications, verification plans, and interfaces with neighboring departments. Control department environmental requirements and performance metrics. Control departments requirements metrics. Responsible for SLAC interface to the SLAC Experimental Facilities Department. Work with subsystem management to develop and focus Collaboration support for beam test. Travel time to meetings and site visit for test support	SLAC	G. Godfrey	Fabrication
4.1.9.7.1.1	Document	Document the beamline and gross instrument geometries. Document the beam event info data content. Transmit documentation to SVAC for inclusion in the MC simulation	SLAC	G. Godfrey	Fabrication
4.1.9.7.1.2	Procedures	Write Procedures for all Particle Tests	SLAC	G. Godfrey	Fabrication
4.1.9.7.2	Prep	Prepare EM units, CU, and LAT particle test plans for department. Working with MGSE and online software, install Van de Graff accelerator, prepare cosmic ray setup in Bld 33, and test. Working in close coordination with IFCT, staff up technician labor for particle tests per budget and schedule. Establish training and work procedures. Begin planning for particle tests in airplane and at environmental test vendor. This should be done in close coordination with the environmental test manager. Help develop and focus Collaboration support for these activities.	SLAC	G. Godfrey	Fabrication
4.1.9.7.2.1	Van de Graff	Move, install, refurbish and test Van de Graff	SLAC	G. Godfrey	Fabrication
4.1.9.7.3	EM Units	Lead in the implementation of ground cosmic ray and Van de Graff photon beam tests on EM units. This activity should be closely coordinated with IFCT, online software, and SVAC departments. Help develop and focus Collaboration support for these activities.	SLAC	G. Godfrey	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.7.4	Calibration Unit	Prepare EM units, CU, and LAT particle test plans for department. Working with MGSE and online software, install Van de Graff accelerator, prepare cosmic ray setup in Bld 33, and test. Working in close coordination with IFCT, staff up technician labor for particle tests per budget and schedule. Establish training and work procedures. Begin planning for particle tests in airplane and at environmental test vendor. This should be done in close coordination with the environmental test manager. Help develop and focus Collaboration support for these activities.	SLAC	G. Godfrey	Fabrication
4.1.9.7.4.1	Make Modifications to SLAC A-Line	Make modifications to SLAC-A Line	SLAC	G. Godfrey	Fabrication
4.1.9.7.4.2	Setup Beam Line in ESA	Setup the Beam Line in SLAC ESA	SLAC	G. Godfrey	Fabrication
4.1.9.7.5	Flight Unit	Develop the MGSE concepts for the LAT shipping container in close coordination with the MGSE department. Lead in the detailed planning, scheduling, and implementation of ground cosmic ray, Van de Graff photon, and airborne cosmic ray tests on LAT. This activity should be closely coordinated with IFCT, online software, environmental test, and SVAC departments. Help develop and focus Collaboration support for these activities.	SLAC	G. Godfrey	Fabrication
4.1.9.8	Environmental Test	Environmental Test is responsible for the preparation and execution of LAT environmental tests and for supporting mission level environmental testing. Responsible for coordinating and performing EMI/EMC, modal survey and random vibration/acoustic testing, thermal balance and thermal cycling, and other environmental tests as directed by the LAT verification test plan. Responsible for coordinating with other I&T departments to complete the environmental tests. Responsible interface with the environmental test facility	SLAC	M. Lovellette	Fabrication
4.1.9.8.1	Management and Engineering	Provide program scheduling, cost accounting, and performance tracking and reporting for department. Support development of department specifications, verification plans, and interfaces with neighboring departments. Control department environmental requirements and performance metrics. Control departments requirements metrics. Responsible interface with the environmental test facility. Help I&T management develop and focus Collaboration support for environmental test activities. Travel time to meetings and site visit for test support	SLAC	M. Lovellette	Fabrication
4.1.9.8.1.1	(Reserved)				
4.1.9.8.1.2	Meeting Support	Provide support for design and test readiness reviews for environmental test activities	SLAC	M. Lovellette	Fabrication
4.1.9.8.1.3	Test requirements definition	Define requirements, goals and success criteria for environmental tests	SLAC	M. Lovellette	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.8.2	Prep	Responsible for detailed preparation, environmental test flow, detailed schedule of activities, coordination with other I&T departments, coordination with environmental test facility.	SLAC	M. Lovellette	Fabrication
4.1.9.8.2.1	Test plan preparation	Prepare test plans for environmental test activities. Incorporate these test plans into the system test plan and verify that all test requirements will be satisfied after the completion of environmental test.	SLAC	M. Lovellette	Fabrication
4.1.9.8.2.2	Test Fixture Preparation	Prepare fixtures for LAT environmental testing with MGSE department	SLAC	M. Lovellette	Fabrication
4.1.9.8.2.3	Test Procedure Preparation	Prepare test procedure for LAT environmental testing	SLAC	M. Lovellette	Fabrication
4.1.9.8.3	EM Units	Support EM units integration and test as required or requested by other departments.	SLAC	M. Lovellette	Fabrication
4.1.9.8.4	Calibration Unit	Support CU integration and test as required or requested by other departments. Little or no work is currently planned for environmental testing of the CU.	SLAC	M. Lovellette	Fabrication
4.1.9.8.5	Flight Unit	Coordinate and perform the LAT environmental tests. Coordinate with the other I&T departments and subsystems to complete LAT performance and science verification tests required during the environmental test phase. Coordinate all activities with the environmental test facility and environmental test facility personnel.	SLAC	M. Lovellette	Fabrication
4.1.9.8.5.1	(Reserved)				
4.1.9.8.5.2	EMI test	Perform EMI test on flight unit	SLAC	M. Lovellette	Fabrication
4.1.9.8.5.3	Vibro/acoustic testing	Perform vibroacoustic testing on flight unit	SLAC	M. Lovellette	Fabrication
4.1.9.8.5.3.1	Modal Survey	Perfom a Modal Survey on the flight unit	SLAC	M. Lovellette	Fabrication
4.1.9.8.5.3.2	Sine Sweep	Perform a Sine Sweep on the flight unit	SLAC	M. Lovellette	Fabrication
4.1.9.8.5.3.3	Acoustic	Perform an Acoustic on the flight unit	SLAC	M. Lovellette	Fabrication
4.1.9.8.5.4	TVAC testing	Perform thermal vacuum testing on flight unit	SLAC	M. Lovellette	Fabrication
4.1.9.8.5.5	Environmental Test report generation	Prepare environmental test report	SLAC	M. Lovellette	Fabrication
4.1.9.9	Science Verification, Analysis & Calibration (SVAC)	Coordinate and help perform the data analysis for particle beam and cosmic ray tests. These tests are designed to ultimately calibrate the LAT, and to validate the Monte Carlo simulations that will be used to verify the LAT science performance requirements. The SVAC department plan builds gradually on the knowledge acquired from low-level calibration tests on hardware units by the subsystems, in the process of I&T, and from particle tests using EM units, mainly the CU, and finally applied to the LAT.	SLAC	E. do Couto e Silva	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.9.1	Management and Engineering	Lead development, planning, and implementation of all GLAST SVAC activities. Provide program scheduling, cost accounting, and performance tracking and reporting for department. Support development of department specifications, verification plans, and interfaces with neighboring departments. Control department requirements and performance metrics. Responsible main interface with Science Analysis Software Subsystem. Help I&T management develop and focus Collaboration support for SVAC activities. Travel time to meetings and site visit for test support	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2	Prep	Develop and design the SVAC plan. Coordinate with the ISOC, online software, and particle test departments to develop tests and the software to implement the SVAC plan. Working in close coordination with the online software department, staff up programmer labor for SVAC activities per budget and schedule. Help develop and focus Collaboration support for these activities. Working with I&T management, write IRD(s) with SAS subsystem that establishes reconstruction software and Monte Carlo deliverables and schedule from SAS, and establishes calibration products and other deliverables and schedule from the SVAC department.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.1	Documentation	Produce documentation to support SVAC activities.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.1.1	General	General documentation to support SVAC activities	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.1.2	Interface Control Documents	ICDs to support SVAC activities	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.1.3	SVAC Plan for EM	Data analysis plan for the Engineering Model	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.1.4	SVAC Plan for CU	Data analysis plan for the Calibration Unit	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.1.5	SVAC Plan for LAT	Data analysis plan for the LAT	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.1.6	Databases	Description of databases	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.2	Monte Carlo Simulation	Monte Carlo simulation activities prior to beam tests, to check parameter space , geometry and general infrastructure	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.2.1	Geometry	Geometry implementation and documentation	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.2.2	GISMO	Preparation to validate beam test parameter space	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.2.3	GEANT4	Preparation to validate beam test parameter space and alignment algorithms	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.2.3	Database	Development of infrastructure for the SVAC database	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.3	EM-1	Prototype high and low level calibration algorithms and the calibration database. Perform data analysis on ground cosmic ray and Van de Graff photon data. Help develop and focus Collaboration support for these activities.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.3.1	Monte Carlo Simulation	Produce and validate Monte Carlo simulation for comparison with real data	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.3.1.1	Geometry	Geometry implementation and documentation	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.3.1.2	Histograms	Develop of quality check hsitograms for MC validation	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.3.2	Infrastructure	Ensure that electronic catalog of runs and calibration algorithms are available.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.3.3	EGSE	Produce calibration scripts related to EGSE.	SLAC	E. do Couto e Silva	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.9.3.4	Database	Develop SVAC prototype database.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.3.5	Data Analysis	Perform low-level, high-level calibrations and demonstrate that van de Graf can be used for future tests. Produce a final report with results.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.4	SVAC General Support	Provide general support for the SVAC department including; support Tracker mini-tower tests, integration preparation, mini-tower cosmic ray analysis, Van de Graaff data analysis, SVAC ISOC coordination support, Survey Support, LAT Data Analysis.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.5	Flight Unit	Obtain data from each individual LAT FU for high level and low-level calibrations. Calibrate the ACD tiles after the ACD is integrated to the LAT. Analyze this data along with extensive data obtained from ground cosmic rays and the Van de Graff photon beam. Use the results of the data analysis to check parallel Monte Carlo simulations on the full LAT. Also, use this data to perform full inter-tower alignment on the ground. Use Data from metrology measurements of the LAT to check ground cosmic ray alignment procedure. Perform calibrations and alignment during environmental tests (e.g. to verify temperature dependence). Help develop and focus Collaboration support for these activities.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.5.1	Monte Carlo Simulation	Provide support of Monte Carlo simulation for LAT lead by SAS.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.5.2	Infrastructure	Ensure that electronic catalog of runs and calibration algorithms are available.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.5.3	EGSE	Produce calibration scripts related to EGSE.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.5.4	Database	Implement final SVAC database.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.9.5.5	Data Analysis	Perform low-level, high-level calibrations, science verification and publish a paper with results.	SLAC	E. do Couto e Silva	Fabrication
4.1.9.A	I&T Mission Support	Support planning and execution of Observatory and LV integration and test. Provide technician and engineering support of Observatory I&T through launch and on-orbit check out.	SLAC	E. Bloom	Fabrication/ Commissioning
4.1.9.A.1	I&T Mission Support - Management	Oversee I&T organization during Mission I&T Phase	SLAC	E. Bloom	Fabrication/ Commissioning
4.1.9.A.2	I&T Mission Support - QA	Provide QA support during Mission Phase	SLAC	D. Marsh	
4.1.9.A.3	I&T Mission Support - ISOC	Coordinate online software, particle test, and SVAC activities with ISOC activities. Maximize the use of I&T opportunities for training instrument operators and science observers. Validate and verify all flight operations procedures, command and telemetry database entries, calibration procedures, and ISOC hardware and software prior to instrument commissioning. Ensure the orderly transition to the ISOC for LAT on-orbit operations.	SLAC	D. Lung (acting)	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.9.A.4	I&T Mission Support - MGSE	Fabricate or procure, assemble, and test MGSE as needed for use during LAT integration to spacecraft and subsequent tests. Support observatory integration at spacecraft vendor's facility. Support launch vehicle integration to observatory and subsequent launch at the launch site.	SLAC	TBD - Mechanical Engineer	
4.1.9.A.5	I&T Mission Support - Online	Support the software and workstations at the various venues used by I&T. These will include observatory integration and test, launch, and orbit Phase 0 commissioning.	SLAC	R. Claus	Commissioning
4.1.9.A.6	I&T Mission Support - IFCT	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	L. Wai	Fabrication/ Commissioning
4.1.9.A.7	I&T Mission Support - Particle	Lead in the planning and execution of ground cosmic ray tests at the observatory integration vendor and launch pad. Provide on-site support of Observatory cosmic ray tests through launch and on-orbit check out.	SLAC	G. Godfrey	Commissioning
4.1.9.A.8	I&T Mission Support - Environmental	Work with spacecraft and launch vehicle providers to plan environmental testing during the observatory level phase. Provide oversight of the observatory level environmental tests. Support launch and Phase 0 commissioning of LAT on orbit.	SLAC	M. Lovellette	Fabrication/ Commissioning
4.1.9.A.9	I&T Mission Support - SVAC	Perform low-level calibrations during and after spacecraft integration. Check alignment of LAT using ground cosmic rays after observatory integration, but before launch. Perform the first on-orbit calibration during the Phase 0 commissioning of the LAT. Also during Phase 0, test Special calibration modes for low and high level calibrations and schemes for selecting Galactic Cosmic Rays from high Z elements. This work is to be completed prior to transfer of a working LAT to the Instrument Science Operation Center (ISOC).	SLAC	E. do Couto e Silva	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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**	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.A.1.1	Management	Personnel to perform Performance & Safety Assurance Management function.			Fabrication/ Commissioning
4.1.A.1.2	Travel	Travel to support performance & safety assurance responsibilities at vendors, subcontractors and collaborating team members facilities.			Fabrication/ Commissioning
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.			Fabrication/ Commissioning
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	Fabrication/ Commissioning
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.			

WBS	Task	Description	Responsibility	Manager	Phase
4.1.A.2.4	Contamination Control	Contamination control measuring equipment to assure project contamination requirements are met.			
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	Fabrication
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	Fabrication
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	Fabrication
4.1.A.5.1	Equipment, Services and Supplies	Materials, services and incidentals to support system safety function.			

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.B	**Instrument Science 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.**	**SLAC**	**Lung**	Fabrication/ Commissioning
4.1.B.1	Project Management	Manage the instrument operations effort including personnel and facilities management, planning, budgeting, and reporting	SLAC	Lung	Fabrication/ Commissioning
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 Science Operations Center (ISOC) development. Maintain cognizance of relevant rules and regulations of the University and the contracting agencies, and implement.			Fabrication/ Commissioning
4.1.B.1.2	Meetings & Reviews	Participate in a series of internal reviews to assess the status of each element of the ISOC design. Support weekly conferences, 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.			Fabrication/ Commissioning
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 ISOC, SSC, MOC, and other NASA centers and team members as required.			Fabrication/ Commissioning
4.1.B.1.4	Travel	Support travel to meetings, reviews, vendors, and development sites.			Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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 ISOC development effort including computer systems and software. Provide ISOC computer hardware maintenance and software licenses and make regular data backups.			Fabrication/ Commissioning
4.1.B.2	Performance Assurance	Develop ,implement and monitor the ISOC quality assurance and verification plans.	SLAC	Bator	Fabrication/ Commissioning
4.1.B.2.1	ISOC Performance Assurance	Develop the ISOC 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.			Fabrication/ Commissioning
4.1.B.2.2	ISOC Verification	Validate and verify ISOC procedures, drawings, inspections and tests. Assist in the development of the system verification program. Develop a verification plan for the ISOC. Participate in the verification efforts and evaluate the results of various tests. Support configuration control and verification of the command and telemetry database.			Fabrication/ Commissioning
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.	SLAC	Bator	Fabrication/ Commissioning
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 SSC, MOC, and the Flight Instrument.			Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.			Fabrication
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.			Fabrication/ Commissioning
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.	SLAC	Bator	Fabrication/ Commissioning
4.1.B.4.1	System Conceptual Design	Develop ISOC 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.			Fabrication
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 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 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.			Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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.			Fabrication/ Commissioning
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.			Fabrication/ Commissioning
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.			Fabrication/ Commissioning
4.1.B.4.5.1	Development Model	Hardware, software, system amnagement and operation to support development of the LOF system.			Fabrication
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.			Fabrication/ Commissioning
4.1.B.4.6	(Reserved)				
4.1.B.5	LOF Test	Perform LOF validation and verification testing.	SLAC	Bator	Fabrication/ Commissioning
4.1.B.5.1	Test Planning	Develop plans to support LOF integration and test.			Fabrication
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.			Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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.			Fabrication
4.1.B.5.4	LOF Interface Tests	Perform interface and verification tests with SAS, MOS and SSC. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.			Fabrication/ Commissioning
4.1.B.5.4.1	ISOC/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.			Fabrication/ Commissioning
4.1.B.5.4.2	ISOC/MOC Interface Tests	Perform interface and verification tests with the MOC. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.			Fabrication/ Commissioning
4.1.B.5.4.3	ISOC/SSC Interface Tests	Perform interface and verification tests with the SSC. Verify, benchmark, and test LOF performance under dry-run conditions, using LAT data.			Fabrication/ Commissioning
4.1.B.5.4.4	(Reserved)				
4.1.B.5.5	LOF I&T Travel	Provide travel to support LOF I&T activities.			Fabrication/ Commissioning
4.1.B.6	LAT Performance Verification	Perform planning and support implementation of LAT performance verification programs.	SLAC	TBD	Fabrication/ Commissioning
4.1.B.6.1	Performance Verification Test Planning	Support development of test plans for LAT performance verification. Develop test procedures and command procedures.			Fabrication/ Commissioning
4.1.B.6.2	Analysis Software	Develop analysis software to support performance verification and calibration programs.			Fabrication
4.1.B.6.3	Display Software	Develop displays to support performance verification and calibration programs.			Fabrication
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.			Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
4.1.B.6.5	LAT Testbed	Support LAT simulator development from the flight software testbed. Use the simulator to validate the observing programs, flight software updates, and instrument command sequences.			Fabrication/ Commissioning
4.1.B.7	LAT Integration & Test	Support LAT integration and test.	SLAC	TBD	Fabrication
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.			Fabrication
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.			Fabrication
4.1.B.7.3	LAT I&T Travel	Provide travel to support LAT I&T activities.			Fabrication
4.1.B.8	Mission Systems Integration & Test	Support mission systems integration and test.	SLAC	TBD	Commissioning
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			

WBS	Task	Description	Responsibility	Manager	Phase
4.1.C	**Education and Public Outreach**	**Education and Public Outreach Program for entire GLAST mission**	**SSU**	**Cominsky**	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.C.2	Reliability & Quality Assurance (Assessment)	Formal evaluation of all EPO activities and dissemination by WestEd	SSU	Cominsky	Fabrication/ Commissioning
4.1.C.3	Web Materials	2 Space Mystery Modules developed with Videodiscovery; the GLAST EPO website, design, maintenance and upkeep, and EIT compliance.	SSU	Cominsky	Fabrication/ Commissioning
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, UCSC teacher workshops and training. Also the GLAST Ambassador Program: 10 educators who will be helping to develop and disseminate GLAST EPO materials	GSFC, MSFC, SSU and SLAC	Cominsky	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.C.6	SLAC VVC Exhibit	Upgrade to SLAC VVC web site to include gamma-ray detector information	SLAC	Cominsky	Fabrication
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	Fabrication/ Commissioning
4.1.C.8	Telescope Network	Network of existing small and/or robotic telescopes: observations with these telescopes to be coordinated by SSU personnel in order to track optical behavior of GRBs and AGN	GSFC	Cominsky	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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**	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.D.1.1	Sources	Particle flux generators, which are the input to GlastSim.	UW	Burnett	Fabrication/ Commissioning
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	Fabrication
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	Fabrication/ Commissioning
4.1.D.1.3.1	Existing Simulation Upgrade	Modify AO-era code to new infrastructure plus small upgrades	UW	Burnett	Fabrication
4.1.D.1.3.2	New Geometry & Hits Scheme	Modify Gismo to make use of new geometry & "hits" schemes	UW	Burnett	Fabrication
4.1.D.1.3.3	Ongoing Support	Gismo Maintenance	UW	Burnett	Fabrication/ Commissioning
4.1.D.1.4	GEANT 4	similar to Gismo, but a separate package supported by a CERN-led consorium.	Italy	Longo	Fabrication/ Commissioning
4.1.D.1.4.1	External Package Requirements	Provide code build capabilities for CMT code management system	SLAC	Lindner	Fabrication
4.1.D.1.4.2	detModel Geometry converter	Use detModel interface to XML geometry description to derive GEANT4 geometry	Italy	Giannitrapani	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
4.1.D.1.4.4	GEANT4 Validation	Validate basic physics and compare to Gismo, TB99 and BFEM data.	Italy	deAngelis	Fabrication
4.1.D.1.4.5	Ongoing Support	Maintenance and consulting on the use of G4	Italy	Longo	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.D.1.5.1	Existing Digitization Upgrade	update digitization to use new structures	GSFC	Kelly	Fabrication
4.1.D.1.5.2	Upgrade for new hits scheme	Modify ACD digitization to accept new "hits" definition and structure	GSFC	Kelly	Fabrication
4.1.D.1.5.3	Ongoing Support	Maintenance and adiabatic upgrades	GSFC	Kelly	Fabrication/ Commissioning
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	Strickman	Fabrication/ Commissioning
4.1.D.1.6.1	Geometry	Create and maintain geometry descriptions for engineering models and the flight instrument	NRL	Chekhtman	Fabrication
4.1.D.1.6.2	Simulation	Simulation of the Calorimeter			Fabrication/ Commissioning
4.1.D.1.6.2.1	Initial Version of Simulation	Import existing simulation into new framework + small upgrades	NRL	Chekhtman	Fabrication
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	Fabrication/ Commissioning
4.1.D.1.6.3	Reconstruction	Calorimeter reconstruction algorithms - determine the deposited energy, estimating leakage. Determine shower directions.	NRL/France	Grove/Djannatti-Atai	Fabrication/ Commissioning
4.1.D.1.6.3.1	Initial Version of Reconstruction	Import existing reconstruction into new framework + small upgrades	NRL	Chekhtman	Fabrication
4.1.D.1.6.3.2	Reconstruction Improvements	Implement programme of improvements to algorithm	NRL/France	Strickman	
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	Strickman	Fabrication/ Commissioning
4.1.D.1.6.3.4	Failure modes/perforamce state	Prepare strategies for handling expected failure modes	NRL/France	Strickman	Fabrication
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	Fabrication/ Commissioning
4.1.D.1.7.1	Simulation Improvements	Import existing simulation into new framework + small upgrades	SLAC	Usher	Fabrication/ Commissioning
4.1.D.1.7.2	Digitization Improvements	Programme to improve charge sharing and TOT simulation	Italy	Giglietto	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.D.1.7.3	Initial Tracker Reconstruction	Import existing reconstruction into new framework + small upgrades	SLAC	Usher	Fabrication
4.1.D.1.7.4	Tracker Reconstruction Resdesign	Rework the pattern recognitiion and fitting	SLAC	Usher	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.D.1.A	Major Releases of Sim & Recon	Milestones for code releases	SLAC	Dubois	Fabrication
4.1.D.2	Analysis Tools	Tools and infrastructure to facilitate event analysis and give access to the data.	GSFC	Kelly	Fabrication/ Commissioning
4.1.D.2.1	Coding conventions	Standard coding rules	SLAC	Bogart	Fabrication
4.1.D.2.2	Static Constants Handling	These are for non-time dependent constants.	SLAC	Bogart	Fabrication
4.1.D.2.3	Gaudi developments	Infrastructure developments supporting the Gaudi framework	UW	Burnett	Fabrication/ Commissioning
4.1.D.2.4	Event Display	Interactive tool to view detector response correlated to the instrument geometry			Fabrication/ Commissioning
4.1.D.2.4.1	GlastSim GUI/graphics	event display contained in sim/recon packages	UW	Burnett	Fabrication
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	Fabrication/ Commissioning
4.1.D.2.5	Root-to-IDL	Interface for IDL users to access Root output classes directly	GSFC	Kelly	Fabrication/ Commissioning
4.1.D.2.6	Merit Improvements	Standard analysis package	UW	Burnett	Fabrication
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	Fabrication/ Commissioning
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	Fabrication/ Commissioning
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	Schlessinger	Fabrication/ Commissioning
4.1.D.2.A	Continuing tools development	Incremental development and support of analysis tools	GSFC	Kelly	Fabrication/ Commissioning
4.1.D.2.B	Ongoing User Support	Ongoing support of users and code packages	GSFC	Kelly	Fabrication/ Commissioning

WBS	Task	Description	Responsibility	Manager	Phase
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.	SLAC	Dubois	Fabrication/ Commissioning
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	Fabrication
4.1.D.3.2	Balloon Flight Support	These are the tasks that are specific to supporting the 2001 Balloon Flight.	SLAC	Dubois	Fabrication
4.1.D.3.3	4-Module Test Support	These are the tasks that are specific to supporting the 2003 module test	SLAC	Dubois	Fabrication/ Commissioning
4.1.D.3.4	I&T EM Test Support	These are the tasks that are specific to supporting the 2003 module test	SLAC	Dubois	Fabrication
4.1.D.3.5	Pre-launch Cosmic Ray FU Checkout	These are the tasks that are specific to supporting the 2003 module test	SLAC	Dubois	Fabrication
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	Fabrication/ Commissioning
4.1.D.4.1	Utilities	Basic Utilities used by multiple analysis tools	GSFC	Digel	Fabrication/ Commissioning
4.1.D.4.2	Analysis Software	Analysis tools	GSFC	Digel	Fabrication/ Commissioning
4.1.D.4.3	Analysis Databases	Databases supporting utilities and analysis tools	GSFC	Digel	Fabrication/ Commissioning
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	Flath	Fabrication/ Commissioning
4.1.D.5.1	Prototype Data Manager	First version of data server to handle performance studies and BFEM	SLAC	Schlessinger	Fabrication
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	Schlessinger	Fabrication/ Commissioning
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	Flath	Fabrication/ Commissioning
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	Fabrication/ Commissioning
4.1.D.6.1	Tools for Accessing Constants	Tools for Accessing Constants	SLAC	Bogart	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
4.1.D.6.2	ACD Calibration	ACD Calibration: tile gains and pedestals	GSFC	Kelly	Fabrication/ Commissioning
4.1.D.6.3	CAL Calibration	CAL Calibration: log gains and pedestals	NRL	Strickman	Fabrication/ Commissioning
4.1.D.6.4	TKR Calibration	TKR Calibration: hot, noisy strips; alignment	SLAC	Usher	Fabrication/ Commissioning
4.1.D.6.5	High Level Calibrations	Determining Instrument Response Functions	SLAC	do Couto e Silva	Fabrication/ Commissioning
4.1.D.7	Management		SLAC	Dubois	Fabrication/ Commissioning
4.1.D.7.1	Science Analysis Software Management	Management oversight and code architect	SLAC, UW	Dubois/Burnett	Fabrication/ Commissioning
4.1.D.7.2	Science Analysis Software Requirements	Level 3 & 4 requirements	SLAC	Dubois	Fabrication
4.1.D.7.2.1	Level 3 Requirements	Level 3 Requirements	SLAC	Dubois	Fabrication
4.1.D.7.2.2	Level 4 Requirements	Level 4 Requirements	SLAC	Dubois	Fabrication
4.1.D.7.3	PDR Support	PDR Support: prep for Instrument Performance studies	SLAC	Dubois	Fabrication
4.1.D.7.4	Mock Data Challenge I	Extensive simulation/reconstruction/analysis effort to exercise the entire data chain	SLAC	Dubois	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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**	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication

WBS	Task	Description	Responsibility	Manager	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Phase
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	Fabrication
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	Fabrication
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	Fabrication
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	Fabrication
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.			