

*DOE/NASA*  
*Review Committee Report*

*for the*

Technical, Cost, Schedule, and  
Management Review

of the

**Gamma-Ray Large Area Space Telescope**

**LARGE AREA  
TELESCOPE (LAT)  
PROJECT**

February 2001



## EXECUTIVE SUMMARY

On February 13-15, 2001, a Department of Energy (DOE) review committee conducted a preliminary review of the Large Area Telescope (LAT) project, the principal scientific instrument on the National Aeronautics and Space Administration (NASA) Gamma-Ray Large Area Space Telescope (GLAST) mission. The review was conducted at the Stanford Linear Accelerator Center (SLAC), the host laboratory for the project. By the request of the DOE/NASA Joint Oversight Group (Joint Oversight Group), the review committee was chaired by Daniel R. Lehman, Director of the Construction Management Support Division, Office of Science.

The charge to the Committee was to: 1) review the technical progress, including the status of R&D relative to the scientific requirements for the instrument; 2) examine the proposed budget, cost (and contingency), and schedule profile, including the commitment of funds and personnel, to determine its adequacy to complete the project on schedule and on budget, and 3) evaluate the management structure, including the relationships to the GLAST mission organization and relationships with foreign collaborating institutes, as to their adequacy to deliver the LAT within specifications and budget and on time for the projected launch date. The following is a description of the LAT systems and the Committee's findings for each system, relative to the charge.

The objectives of the LAT include the study of the mechanisms of particle acceleration in active galactic nuclei, pulsars, and supernova remnants, and the resolution of unidentified sources and diffuse emissions in the gamma-ray sky. The LAT will also study the high energy behavior of gamma-ray bursts and transients, as well as probe dark matter and the early universe. The GLAST LAT will be comprised of four key components: the tracker, calorimeter, data acquisition, and anticoincidence detector.

The design for the GLAST tracker consists of a four-by-four array of tower modules, each with interleaved planes of silicon-strip detectors and lead converter sheets. Silicon-strip detectors are able to more precisely track the electron or positron produced from the initial gamma-ray than other types of detectors. The Committee found that the concept of the LAT tracker is well matched to the science goals and utilizes mature technologies. A feasible design was presented that can be implemented within the available time. A strong consortium of groups has been established to build the tracker including Italy, Japan, SLAC, and the University of California at Santa Cruz.

The Calorimeter for GLAST uses Thallium doped Cesium Iodide crystals primarily because of the abundance of light output. Cesium-iodide bars, arranged in a segmented manner,

give both longitudinal and transverse information about the energy deposition pattern. Currently, planning is for only one vendor to be selected to provide the 1,600 crystals required for the calorimeter. This planning is based primarily on cost considerations. The calorimeter managers are both from the Naval Research Laboratory. Other participants include SLAC, as well as collaborators from France and Sweden. A number of organizational problems have developed within the French collaboration. As a result, GLAST funding has been put on hold by the French funding agency. The French collaboration has been reorganized and is currently in the process of reapplying for the necessary funding.

The Data Acquisition System records the gamma-ray signals and relays them to the ground. Significant components of the Science Analysis Software have been under development for some time. In particular, the simulation and reconstruction of particle interactions in the instrument have been successfully prototyped. This provides a good understanding of the effort needed in this critical part of the software project. There is a very good plan but there are several issues that must be clearly resolved before the Data Acquisition System can be ready for baselining. Key issues include: 1) definition of project scope and responsibility especially with respect to calibration and science software; and 2) pinning down all off-project sources of effort and funding with Memoranda of Agreement and including the effort in the project.

The Anticoincidence Detector vetoes out the charged particle background from cosmic ray primary and Earth albedo secondary electrons and nuclei. It consists of segmented plastic scintillator tiles, read out by wave-shifting fibers and photo-multiplier tubes. This technology matches the performance requirements. Design of the anticoincidence detector is not yet optimized. Choice of fiber layout in the tiles may affect the design of the mechanical support. Design of electronics is relatively more advanced than the tiles.

For integration and testing, the balloon flight program is well along, and uses completed pieces of tracker, calorimeter, and anticoincidence detector hardware from previous subtests. The readout software is new, and the balloon flight provides an opportunity for operational software checkout and data analysis software development. The flight is scheduled for June 2001.

The GLAST LAT Project Office (IPO) presented a LAT cost estimate of \$80.7 million actual year dollars, with an overall contingency of \$23 million, which represents 28.5 percent of the baseline cost. The total project cost of \$103.7 million is based upon the November 1999 proposal. For the Baseline Review planned for later in 2001, a new bottoms-up cost and schedule estimate will be prepared. The IPO is presently implementing a Project Management Control System (PMCS) that reports cost and schedule performance using an earned value system. The LAT PMCS is modeled after the SLAC B-Factory project cost and schedule system, and complies with DOE and NASA management requirements.

The IPO is in the process of finalizing a Memoranda of Agreement with collaborating institutions and funding agencies, and bringing on more staff to fill positions in the project. The incomplete status of a number of Memoranda of Agreement and Memoranda of Understanding has negatively impacted the schedule. This is an issue for the IPO and the funding agencies to resolve. The IPO staff is composed of experienced individuals, with a good mix of expertise and knowledge of large projects. Some uncertainty exists in tracking the PMCS in the IPO due to a planned transition from outside consultants to a more permanent team.

As a result of the review, several action items were assigned. By April 1, 2001, the Implementing Agreement between DOE and NASA should be approved. Also by April 1, DOE, NASA, and the IPO should issue a draft management plan for comment. By April 15, 2001, IPO is to inform DOE/NASA as to when they expect to be ready for a baseline review. Based on information available at this review, it appears that late summer or early fall would be the timeframe for the baseline review. A deadline of October 2001 was established.

**Intentionally Blank**

# CONTENTS

Executive Summary .....	i
1. Introduction.....	1
1.1 Introduction.....	1
1.2 Charge to the DOE/NASA Review Committee.....	2
1.3 Membership of Committee .....	2
1.4 The Assessment Process .....	2
2. Technical Systems Evaluations .....	5
2.1 Tracker (WBS 4.1.4).....	5
2.2 Anticoincidence Detector (WBS 4.1.6).....	7
2.3 Calorimeter (WBS 4.1.5).....	9
2.4 Reconstruction and Analysis (Ground Software).....	13
2.5 Trigger and Data Acquisition .....	17
2.6 Integration and Test .....	19
3. Cost Estimate .....	23
4. Schedule and Funding.....	27
5. Project Management .....	29

## Appendices

- A. Charge Memorandum
- B. Review Participants
- C. Review Agenda
- D. Schedule Chart
- E. Action Items



# 1. INTRODUCTION

## 1.1 Background

The Large Area Telescope (LAT) will be the principal scientific instrument on the National Aeronautics and Space Administration (NASA) Gamma-Ray Large Area Space Telescope (GLAST) mission that is scheduled to be launched in 2005. The LAT is a joint project organized by Department of Energy (DOE) and NASA supported scientists and institutions, involving teams from France, Italy, Japan, and Sweden. The LAT proposal was submitted to and accepted by NASA in response to the NASA Announcement of Opportunity (AO) 99-OSS-03. The DOE-supported Stanford Linear Accelerator Center (SLAC) is the host laboratory for the project and Professor Peter Michelson of Stanford University is the Instrument Principal Investigator under a NASA contract.

The science objectives of the LAT are largely motivated by discoveries made by the EGRET experiment aboard the Compton Gamma Ray Satellite and, for energies above 300 GeV, by ground-based atmospheric Cerenkov telescopes. These objectives include:

- studying the mechanisms of particle acceleration in active galactic nuclei, pulsars, and supernova remnants;
- resolving unidentified sources and diffuse emission in the gamma-ray sky;
- determining the high-energy behavior of gamma-ray bursts and transients;
- probing dark matter and the early universe.

The LAT is a gamma-ray telescope based on conversion of the gamma rays to electron-positron pairs in a stack of tungsten sheets interspersed with silicon pixel arrays to record the tracks of the particles. The silicon-tungsten stacks are followed by a segmented cesium iodide calorimeter to record the energies of the particles. The detector draws on the strengths of the high-energy physics community, typically supported by DOE, for the silicon and calorimeter technology and related physics analysis. Space qualification and telemetry are new dimensions for high energy physics, but well understood in astro-particle physics, typically supported by NASA, as well as the foreign collaborators.

NASA and DOE have formed a Joint Oversight Group at the Headquarters level to coordinate agency oversight of the project. Coordination and management of the project, including resource management and cost and schedule accountability and reporting, are supplied by the host laboratory under the leadership of the Instrument Principal Investigator. DOE/NASA relationships for the GLAST mission and the LAT project are formalized in a draft Implementing Arrangement and a draft Memorandum of Understanding, respectively.

## **1.2 Charge to the DOE/NASA Review Committee**

In a December 19, 2000, memorandum (Appendix A) the DOE/NASA Joint Oversight Group requested Mr. Daniel Lehman, Director, DOE Construction Management Support Division, to conduct a pre-baseline review of the GLAST LAT project on February 13-15, 2001. The charge to the Review Committee was to:

- Review the technical progress, including the status of R&D, relative to the scientific requirements for the instrument.
- Examine the proposed budget, cost, and schedule profile, including the commitment of funds and personnel and the level of contingency, to determine its adequacy to complete the project on schedule and on budget.
- Evaluate the management structures, including the relationships to the GLAST mission organization, and relationships with foreign collaborating institutes, as to their adequacy to deliver the LAT within specifications and budget, and on time for the projected launch date.

## **1.3 Membership of the Committee**

The Committee was chaired by Mr. Daniel R. Lehman, Director of the DOE Division of Construction Management Support in the Office of Science. It was organized into eight subcommittees with members drawn from universities, DOE National laboratories, and NASA Space Flight Centers. Committee membership and subcommittee structure are shown in Appendix B.

## **1.4 The Assessment Process**

The review was the first DOE/NASA review of the LAT project of a combined series that fulfills the otherwise-separate requirements of the DOE and NASA management oversight processes.

The review took place on February 13-15, 2001, at SLAC. The first day was largely devoted in plenary session to overview presentations by LAT project management and leaders of the detector subprojects. These presentations were based largely on the Flight Proposal, *GLAST Large Area Telescope Flight Investigation*, submitted in response to AO 99-OSS-03.

On the second day the members of each subcommittee met in the morning with their project counterparts to discuss the technical status and details of the scope, cost, schedule, and management of each subsystem. The presentations by the subsystems were well prepared and the discussions were very useful. The afternoon was devoted to subcommittee discussions and drafting of subcommittee review reports. The closeout with GLAST LAT management took place on the morning of the third day.

The primary method for assessing technical requirements, cost estimates, schedules, and adequacy of management structures was comparison with past experience. Relative to high energy physics detectors with which the DOE reviewers were familiar, the LAT is a small and simple detector. The additional complications due to space qualification were familiar to the NASA reviewers. The cost and schedule basis was, necessarily, the budget as presented in the Flight Proposal, pending a new, “bottoms-up” estimate.

**Intentionally Blank**

## **2. TECHNICAL SYSTEMS EVALUATIONS**

### **2.1 Tracker (WBS 4.1.4)**

#### **2.1.1 Findings**

A feasible design for the tracker was presented and can be implemented within the available time.

The silicon sensors have been designed. A suitable vendor has been identified and a first fabrication run of prototype devices is underway.

The front-end integrated circuit is relatively simple and can be implemented with mature processes. The design of the readout integrated circuit is nearly complete and will be submitted for fabrication within the next months.

A strong consortium of groups in Italy has taken responsibility for assembling and testing the ladders, trays, and towers. Plans for verification and testing are still rudimentary.

A detailed and comprehensive schedule has been developed with the right elements, but in its current form it is very tight. A bottoms-up cost estimate by the subproject yields a total cost of \$8.7 million of which \$4.5 million is labor. The overall estimate appears reasonable. The total contingency is \$1.7 million and is assigned entirely to materials and services. No contingency has been included for labor.

A Memorandum of Agreement (MOA) with Japan and University of California, Santa Cruz has been signed. A draft MOA with the Italian groups exists.

#### **2.1.2 Comments**

The concept of the LAT Tracker is well matched to the science goals. It utilizes a mature technology and builds on substantial experience and development effort in high energy physics. The tracker design is well advanced. The Committee was presented a feasible design that can be implemented within the available time. The required performance is well within the capabilities of standard technologies.

Specifications for the silicon sensors have been developed by a group with many years of experience in this field. The Committee is confident in the design and the selected vendor. A first fabrication run of prototype devices is underway and devices will be available for testing soon.

The front end integrated circuit is relatively simple and can be implemented with mature processes. The design of the readout integrated circuit is nearly complete and will be submitted for fabrication within the next months.

A web-based tracking program for monitoring status and location of all components is under development.

A practical scheme for assembling towers into the grid has been considered in some detail. Greater modularity of the sensor biasing scheme would help to avoid loss of a full tower in the event of a noisy detector or power supply failure. Other opportunities for increased fault tolerance may exist and further analyses of subsystem-specific failure modes should be pursued.

Plans for verification and testing are still rudimentary. Much more thought needs to go into the detailed testing procedures for integrated circuits, ladders, trays, and towers at the earliest possible time, as this determines design schedules for test systems. This applies to electronic, mechanical, and thermal testing, but the Committee sensed that additional effort is required in electronics. For example, near the end of assembly phase many tests are proceeding simultaneously and it must be ensured that sufficient test facilities are available when they are needed.

Engineering resources for electronics appear to be inadequate, especially for documentation.

A detailed and comprehensive schedule has been developed with the right elements. However, its current form is very tight, with delivery of the final tower scheduled for January 7, 2004, which is seven days beyond the milestone appearing in the project schedule. Sensor delivery drives the tower assembly schedule, so increasing the production rate and introducing more parallelism in the assembly sequence should alleviate this problem. Potential production bottlenecks must be identified and followed by mitigation plans. As it stands, the schedule is difficult to use for monitoring technical progress. Additional “working level” milestones should be defined.



A preliminary cost estimate was shown. Although insufficient time was available for a thorough evaluation, the overall estimate appears reasonable based on the main cost drivers. It was difficult to determine major cost drivers and allocation of material and labor costs. Overviews of costs and contingencies broken down into labor and materials and services at appropriate levels would assist project tracking. Additional effort for project, cost, and schedule tracking may be necessary.

The MOAs include clear lists of responsibilities and deliverables.

### **2.1.3 Recommendations**

1. Identify, at least four month's, explicit schedule contingency for delivery of the towers for final assembly.
2. Add labor contingency to the cost estimate.
3. Develop and review procedures for handling all high-value and mission-critical items.
4. Develop detailed test procedures beginning now.
5. Ensure adequate documentation, particularly for electronics.
6. Complete Memorandum of Agreement with the Italian groups.

## **2.2 Anticoincidence Detector (WBS 4.1.6)**

### **2.2.1 Findings**

#### ***Design Requirements***

The goal of the Anticoincidence Detector (ACD) is to reject charge particles with an efficiency of 0.9997 (inefficiency of  $3 \times 10^{-4}$ ). This requires both high light yield tiles and high hermeticity of the detector (minimal cracks).

Segmentation of ACD should be able to maintain efficiency for gamma events (reduce self-veto due to backslash).

Electronic noise has to be low enough not to cause more than one percent false vetos.

***Major milestones for ACD subsystem***

ACD & Thermal Blanket Preliminary Design Review	June 2001
ACD & Thermal Blanket Critical Design Review	June 2002
ACD Flight Subsystem Assembly Complete	October 2003
Flight ACD Ready for Integration at SLAC	January 2004

***Cost***

At the present time, cost estimate is based on the November 1999 GLAST proposal. The total cost of the ACD is approximately \$9.5 million (to be funded by NASA). A contingency analysis has not been performed. Shown below is the breakdown for the lower level of the \$9.5 million labor costs:

		<u>(on + off project)</u>
Management	\$1.5M	10+8 FTEs
Quality assurance	\$0.5M	1+1 FTEs
Detector construction	\$1.4M	2+4 FTEs
Electronics	\$3.8M	9+8 FTEs
Mechanical Components	\$0.8M	6+1 FTEs
Other (software, I&T, mission)	\$1.7M	

**2.2.2 Comments**

Technology chosen for the ACD (scintillating tiles with WLS fiber readout) matches the performance requirements (fast response, hermeticity, efficiency in cosmic ray rejection, low self veto for gammas) well.

Design of ACD is not optimized yet. Technical drawings for mounting of tiles do not exist yet. Choice of fiber layout in the tiles may affect the design of mechanical support. Design of electronics is relatively more advanced.

Short-term schedule for ACD is very aggressive. In particular, the Preliminary Design

Review is scheduled for June 2001. Long-term schedule (ACD delivery to SLAC by January 2004) is comfortable, assuming the design will be finalized soon.

The cost of the project is uncertain and contingency unknown. In particular labor estimates for mechanics and quality assurance seem to be relatively low compared to the management and electronics costs. A bottoms-up cost estimate is in progress.

### **2.2.3 Recommendations**

1. Perform optimization of the optics design:
  - a. Consider using clear fibers to transmit light between tiles and photomultiplier tubes to increase light yield.
  - b. Consider a simpler layout of WLS fiber (present design has up to 30 fibers/tile, a total 145 tiles) to reduce complexity of fiber routing.
2. Perform tests (bench measurements/Monte Carlo/Balloon) to prove that scintillating fiber ribbons reduce inefficiency of the ACD in the crack region (2-3 millimeters) to the level that satisfies the physics requirements of the GLAST mission.
3. Provide complete technical drawings for mounting of tiles and readout photomultiplier tubes on the support structure.
4. Perform a full bottoms-up cost estimate, including realistic fabrication, assembly, and installation scenario, with contingency covering possible increases of cost (if design not finalized).

## **2.3 Calorimeter (WBS 4.1.5)**

The LAT calorimeter along with the silicon tracker is used to reconstruct the energy of incident photons. The calorimeter is also critical to the identification and rejection of background. The LAT will study gamma rays in the energy range from 10 MeV to 300 GeV. Thallium (Tl) doped Cesium Iodide (CsI) crystals have been selected as an appropriate technology, primarily because of the abundance of light output. The crystals will be read out by two PIN diodes at each end. The calorimeter will consist of 16 identical modules. Each module will be comprised of eight layers of twelve crystals deployed in a hodoscopic arrangement. The calorimeter will be 8.5

radiation lengths deep, so the energy resolution is dominated by leakage rather than by cracks and material between crystals. The longitudinal and transverse segmentation of the calorimeter allows for a determination of the shower shape and a leakage correction. The longitudinal position in individual crystals can be determined using light asymmetry measurements from the two ends of the crystal.

### **2.3.1 Findings**

Two PIN diodes are attached to each end of each crystal. This is complicated by the extremes of temperature and vibration to which the calorimeter will be subjected. The preferred solution is to glue the diodes to the crystal face. The optical quality of the PIN diode glue joints have been shown to degrade during temperature cycling.

It appears that only one vendor will be selected to provide the 1,600 crystals required for the calorimeter. This decision is based primarily on cost considerations.

The calorimeter has an assigned mass contingency of 2 percent. To stay within this limit it will be necessary to closely monitor the dimensions of the crystals. It is generally the case that a significant fraction of the delivered crystals will have dimensions close to the upper end of the allotted tolerance. This is due to the production process where the crystals are cut to the high side of the mechanical tolerance to allow additional material to be removed during the final polish.

The estimated cost of the U.S. contribution to the calorimeter is \$11,382.4 K. Significant foreign contributions are also expected. The contingency for the U.S. contribution appears to be approximately ten percent. The majority of the costs are for labor rather than materials.

The cost estimate for the calorimeter system has not been updated since the proposal. Since that time, responsibility for the design of two Application Specific Integrated Circuits (ASICs) has been shifted from France to the U.S. (SLAC). It is not clear who is doing the final procurement and qualification of the production ASICs. This has not been included in the cost estimate.

The schedule for the calorimeter has been driven by milestones imposed from the top down and does not appear to be resource loaded. The schedule is very aggressive in all areas with no contingency. The schedule does not appear to be consistent with the funding profile. It

is unclear whether the financial resources are currently available to make sufficient technical progress to meet the Preliminary Design Report schedule. The schedule for the Preliminary Design Report is very tight.

The analog front end ASIC design was delayed for two years because of issues internal to the French collaborators. Responsibility for the design has been transferred to SLAC.

The Calorimeter Subsystem Manager is N. Johnson and the Calorimeter Project Manager is P. Carosso, both from the Naval Research Laboratory. The other participating U.S. institution is SLAC. Collaborators from France and Sweden also play important roles in the calorimeter project.

A number of serious problems have developed between the various French institutions involved in the calorimeter project. The details were not explored, but the fallout from these problems has had a significant negative impact. In particular, GLAST funding has been put on hold by the French funding agency. The French institutions are currently in the process of reapplying for the necessary funding to successfully execute their significant project responsibilities. The front-end analog ASIC was also a casualty of this situation and sat dormant for two years before being picked up by SLAC.

### **2.3.2 Comments**

The technical knowledge of the calorimeter team is outstanding. They clearly understand the interplay between the physics goals of the experiment and the performance requirements of the calorimeter. Many innovative solutions to technical problems have been developed. The mechanical structure and electronics interfaces have been particularly well planned. There is existing expertise to solve the remaining technical problems.

It is not unusual for crystal orders of this size to be split between multiple vendors to mitigate schedule delays and technical problems. The likely vendor has a track record that suggests they can handle an order of this size but some risk is always present with a single crystal vendor.

The crystal qualification tests have been well planned. The Swedish partners are well organized to do the job.

Ten percent contingency is clearly too small. The project is largely labor driven. Given the tight schedule there should be contingency available to add additional labor in areas where it might advance the schedule.

A resource loaded schedule is clearly needed. If the imposed milestones must be met in order to be ready for a particular launch date, then it is essential to understand critical paths and areas where additional resources could advance the schedule.

The French institutions are committed to providing approximately \$17 million to the calorimeter project. They are responsible for procurement and testing of PIN diodes, attaching the PIN diodes to the crystals and assembling crystal modules. Continued failure of the French partners to solidify their organization and commitment places the calorimeter system at considerable risk. The recent addition of some key personnel to the French organization does give the committee reason to be optimistic.

### **2.3.2 Recommendations**

1. Sign and implement Memorandum of Agreements with all international partners as soon as possible.
2. Organize the French effort and commitment to agreed upon roles, responsibilities, and schedule as soon as possible.
3. Develop an integrated bottoms-up resource loaded schedule with adequate contingency that takes into account the anticipated funding profile. Re-evaluate the schedule for the Preliminary Design Report.
4. Update the cost estimate and assign an adequate contingency.
5. Resolve the PIN diode glue problems. This should be given a high priority by both the Naval Research Laboratory and the French institutions.
6. Define responsibility for procurement, qualification, and testing of production ASICs and include in the schedule. The source of funds and manpower for this activity should be identified and included in the cost estimate.

## **2.4 Reconstruction and Analysis (Ground Software)**

## 2.4.1 Findings

Significant components of the Science Analysis Software have been under development for some time. In particular, the simulation and reconstruction of particle interactions in the instrument have been successfully prototyped. This provides a good understanding of the effort needed in this critical part of the software project.

Because of the rather small data rate, simplicity of the detector, and low occupancy, the software and computing problem to be solved here is modest compared to that in large high energy physics experiments. Nevertheless, the Scientific Analysis Software problem is significant and critical to the success of the project.

The WBS that was presented was similar to the one in the material the Committee received initially but the manpower estimate, and therefore the budget, was reworked and was quite different. The budget will increase significantly.

The schedule for the Preliminary Design Report for the software was not consistent with the schedule for other Preliminary Design Reports and, in fact, seemed to occur after the baseline review.

The major components of the project are:

- a. The Simulation and Reconstruction Software
- b. Analysis Infrastructure and Framework
- c. The Data Production Facility
- d. Scientific and Calibration Software

The first three components are well defined and much progress has already been made on items “a” and “b.” The third component is well understood but less urgent.

The last component is not as well defined. It is also not clear how much of the work will be done by this team, how much will be funded by this project’s budget but sourced to other groups within the collaboration or to foreign groups, and how much will be supplied through the Science Support Center (a separate project). Similarly, it was not clear what part of the calibration software and algorithms was to be provided by this project and what part of that was “off budget.”

Resource estimates do not include “off budget” contributions even where they are important to the success of the project.

The project has chosen to adopt several high energy physics codes, including Gaudi, Root, and GEANT4, to reduce the total amount of effort. This is good. However, the Committee feels that there are inadequate resources for support of these acquired high energy physics products. These are evolving and in GEANT4’s case need to even be debugged at some level. This effort should not be forgotten or underestimated. Two FTE’s, steady state, is reasonable.

Specific findings with respect to individual WBS items are:

- a. Simulation and reconstruction will be largely complete in next year or so. The estimates are credible: two programmers will need to be involved in this effort continuously until startup to make refinements, support development activities, and to act as back up for one another.
- b. Infrastructure and framework. This is always a sink of effort. It includes such essential but unglamorous activities such as code release, release management, tools like bug trackers, and database (ORACLE, MySQL) support. This activity must be supported during the construction phase and will require one or two FTE/programmer(s) at the minimum.
- c. Data Production Facility (software). This system must be a strong, check-pointed system, with a solid database and good documentation so it can be handed off to a lower level programmer or operator. Production for simulation and calibration during the construction must also be supported. This includes support for the balloon flight. The Committee found the estimate of three FTE programmers to be quite credible.
- d. Calibration. The Committee believes this is ill defined and the resource estimates are too low in the current plan. The estimate for FTE’s includes three scientists doing algorithms and one programmer to support them until 2003. After 2003, this reduces to one scientist doing algorithm development and 30 percent of an FTE programmer for support. These estimates assume that the detector subsystems will contribute in this area.

- e. Science Software. EGRET software provides a model and a good basis for making estimates but is too limited to adopt directly. There is a detailed “wish list” of software to be written. It requires nine nine FTEs, steady state, including the calibration activity mentioned above. Funding of programmers at Goddard through this project has been discussed. There is also the possibility of physicists doing this off budget. It is expected that some of the work will be done by the Science Support Center. Whatever division is made, an agreement has to be made to assure that GLAST gets the software it needs on schedule. The SSC and mission physicist goals and schedules may not completely align with GLAST.

#### **2.4.2 Comments**

There is a very good plan but there are several issues that must be clearly resolved before it can be ready for baselining. Key issues include:

- Definition of project scope and responsibility especially with respect to calibration and science software.
- Pinning down all off-project sources of effort and funding with MOAs and including the effort in the project.

The group carrying this work forward is very small but is currently holding its own. To continue to do this, it will need to maintain its current base and begin to grow quickly. The need to support software efforts for the design and construction effort makes this even more urgent. Funding should be secured for the current members of the team, some of whose support is uncertain at this time.

Some parts of the software covered are very important to the mission and these are well-defined. These should be assigned a reasonable contingency in the cost estimate (adding extra effort, etc.) for:

- Simulation and Reconstruction
- Analysis Infrastructure and Framework
- Data Analysis Facility

These activities currently constitute about 40 percent of the effort. Fifty percent contingency would allow them to add a significant but manageable number of programmers to deal with schedule slippage in these key areas.

Other parts of the software are less critical and are also typically more open-ended. These have “scope contingency” and should be defined as well as possible but then be viewed as “level of effort” and assigned only a very small dollar contingency.

On this basis, the Committee estimates a 20 percent overall contingency for this project if, after review, it continues to be defined with the full scope that was presented. However, this is simply an estimate based on the current understanding of the project. Management should work out the proper contingency once the project is completely defined.

The issue of how much effort will be available “off budget” from scientists supported through base programs should be understood. In high energy physics, significant effort is provided in this mode. This is less true in astrophysics due to the shorter average length of post-doctoral appointments and to traditions within the field.

“Off budget” effort that is important for completion of the project should be included in the cost and schedule because it will be impossible to judge whether the project can succeed without understanding this. Mechanisms for assuring that this effort is delivered also must be established.

An integrated total effort of order 75-100 FTE years from all sources will be required to do this project. This makes it about a \$10 million effort (much larger than the budget which we were shown which was claimed to include NASA funding only). In addition, there should be an appropriate contingency, which is discussed above. The actual budget could be lower but this depends on a clearer understanding of scope of the science and calibration software that is to be provided by this group and by an understanding of how much effort is provided “off budget” by scientists or foreign collaborators.

The Committee believes that this project is currently on track but must resolve these issues that have been raised and move to acquire the necessary staff quickly. Current staff is doing a good job and efforts should be made to secure their funding.

As a minor comment, the WBS that was presented at this review included completed projects and projects that will be completed before the baseline review. This makes the WBS appear more complicated than it really is. These should be eliminated before the actual review.

### **2.4.3 Recommendations**

1. Develop a resource loaded Cost and Schedule, in time for the baseline review, for all aspects of the Science Analysis Software including effort that is “off project.” This is a required resolution for all issues related to project scope.
2. Develop clear, formal agreements with all off-project software providers.
3. Plan for a sufficient level of infrastructure staffing to track changes and development in all the software tools planned for use.
4. Define parts of software that are mission critical and determine a reasonable contingency for those parts.
5. Plan for calibration software development in conjunction with the detector subsystems.

## **2.5 Trigger and Data Acquisition**

### **2.5.1 Findings**

In preparation for a Preliminary Design Review (expected in August 2001), requirement documents are being prepared for LAT Electronic Systems, individual subsystems, and some of the components of the subsystems, notably ASICs.

The technology and design choices that have been made are prudent and do not involve any speculative technologies.

Power, space, and channel count requirements on the electronics necessitates the design of several different analog and digital ASICs. Design of the digital ASICs appears to be well thought out, although the designs are not yet final, consistent with the maturity of the project. These ASICs should be straightforward to design by the group of designers assembled for this project.

- Three mixed analog and digital ASICs are needed for front end electronics of the silicon tracker, calorimeter, and the ACD. The responsibility for the calorimeter ASIC has recently been moved to SLAC, and a new team is now designing it.
- The design of the tracker and calorimeter ASIC are very far along, with a competent design group identified for each. Each of them has had successful partial prototypes. The design of these ASICs appears to be very well integrated into the overall system design of the LAT.
- The design of the ACD ASIC is in the preliminary conceptual stage, consistent with the progress on the ACD itself. This design should progress in the next year to the prototype stage.

Flight software is being designed under the aegis of the designers of the electronics. A small group has been assembled to design and begin to implement software to be flown on the instrument, based mainly at SLAC.

The management of this system appears to use the management tools set up by the project to track budgets and schedule. A very complete schedule that tracks progress against needs of the detectors has been developed.

### **2.5.2 Comments**

A very impressive and competent group of electronic designers has been assembled to work on this project. The overall system design is carefully thought out and documented.

The group at SLAC developing electronics for LAT has limited experience with instrumentation for spaceflight. It may be useful to make regular consultation with experts in this area available to the electronics management. Satisfaction of requirements by NASA for documentation, integration, and verification may require hiring or consulting with experienced spaceflight professionals.

It is important to manage and track the parts of the electronics being produced at remote institutions as carefully and thoroughly as the work at SLAC.

A commendable effort at analysis of failure modes and reliability has been made, and

should continue.

The management of the electronic subsystems has clearly been excellent, but there are many tasks that will compete for attention in the next year (preparation of the requirements documents, the design review, the balloon test, and many ASIC submissions), so any request for additional resources must be dealt with quickly to keep the project on schedule.

It is important to fill the open position for a software engineer stationed at SLAC to develop flight software as soon as possible.

### **2.5.3 Recommendations**

1. Carefully consider the need for additional manpower to work on flight software based on the estimated needs of this project.
2. Project management should quickly heed and act upon any requests by the management of the electronic subsystem for additional assistance.

## **2.6 Integration and Test**

This subcommittee reviewed the Mechanical System Design, Integration and Test, and Balloon Flight portions of the project. The Committee did not review reliability and quality assurance plans during this review.

### **2.6.1 Findings**

The balloon flight program is well along, and uses completed pieces of tracker, calorimeter, and ACD hardware from previous subtests. The readout software is new, and the balloon flight provides an opportunity for operational software checkout and data analysis software development. The flight is scheduled for June 2001. The effort is nearly two-thirds complete (by cost), out of an estimate of about \$1 million.

Mechanical system design and integration and test were reviewed together. There is a common WBS manager for both.

The Mechanical System Design (MSD) task includes: 1) mechanical design integration, management, spacecraft interface development, reliability, quality assurance, and mechanical

and thermal systems development; 2) system-level hardware design, including thermal control, radiators, and the grid; and 3) LAT integration and test support, subsystem integration and test, verification, LAT, and mission integration and test.

Integration and test task includes: 1) management, coordination and development of LAT integration, and test activities; 2) reliability and quality assurance, subsystem verification results; 3) integration and test preparation, preparation and development of LAT facilities, and calibration equipment; 4) calibration unit and flight LAT preparation for integration and test; and 5) mission integration and test support.

### **2.6.2 Comments**

Technical resources currently on board for the Balloon Flight effort are adequate, though there is competition for resources with those needed for the preliminary design review preparation. Rapid analysis of the balloon data is essential for maximum value to the project. The program provides an initial focus for the software efforts.

The Mechanical System Design and Integration and Test efforts have been centralized in the project office, such that these functions flow down to the subprojects from the project office. There are lower level shadow groups in each subproject, and these two groups will coordinate the overall verification and test plans. Due to this relationship, portions of the verification tests will be conducted by the same personnel who designed and built the device. The independence of the testing efforts is consistent with high energy physics projects, but is less than is typically applied in NASA efforts.

The project has developed a “plan-for-a-plan” for calibration and verification activities. Details of this plan have not been completed, and a working group has been proposed to assemble the components of such a plan in the coming months. Communication with the subgroups needs to be established on the same timescale, and capabilities of the subgroups with respect to verification activities desired confirmed.

This WBS item assumes additional integration and test support at the final assembly and checkout phase comes from the subprojects. Without a detailed verification and test plan it will be difficult for this and the other WBS managers to properly estimate the resources required for each of the integration and test tasks across the project.

There was considerable discussion of the plan for a final beam test of a few towers, rather than the whole device. The project personnel discussed the trade-offs involved, and demonstrated it to be adequate to the needs of the project. Such a review of each major system test across the project should be completed, focusing on the technical need and expectations, and allowing a reasonable time for the analysis of results.

The thermal and mechanical design of the grid has been through several iterations and appears adequate at this time in the project.

There is an understanding of the flow of performance and interface documents between subprojects, the LAT project, and the GLAST project. Drafts of several high level documents exist. Interface documents do not exist as yet. A schedule for the production of these documents does not exist.

Document and information control and dissemination systems are being established.

There is little apparent schedule float, although there may be hidden schedule contingency. The philosophy for statistical vs. complete testing for the components with large numbers has not been formulated, and directly impacts the test schedules.

It is unclear from the WBS, which boxes in integration and test are to be staffed and which are purely functional. The flow of money from several sources and lack of detailed scope definition make it difficult to evaluate the resources devoted to a single WBS item. The budgets as presented were \$5 million (for WBS 4.1.8) and \$4.7 million (for WBS 4.1.9).

The subsystem manager presented his personnel estimate, included in the baseline, including the ramping up of staff in FY 2001 and FY 2002 across these WBS items. The project is actively interviewing, and has offers on the table to fill two of the currently open positions.

At the current staffing levels, the workload over the next six months will be heavy and if problems arise, personnel will be stretched thin. The Committee supports the hiring of additional personnel to join the capable staff already on hand.

### **2.6.3 Recommendations**

1. Hire an integration and test expert, now scheduled for late FY 2001, as soon as possible.
2. Complete the performance specifications, at least to Rev 0, by the time of the Preliminary Design Baseline Review.
3. Complete the Interface Control Documents, at least to Rev 0, by the time of the Preliminary Design Baseline Review.
4. Create the verification and test plan, working with the other subprojects, to confirm the requirements, timing, and resources required to implement this plan.
5. Include testing of the LAT by independent personnel in the verification and test plan.

## **3. COST ESTIMATE**

### **3.1 Findings**

GLAST management presented a LAT baseline cost estimate of \$80.7 million (real year dollars), with an overall contingency of \$23 million (real year dollars), which represents 28.5 percent of the baseline cost. The total project cost of \$103.7 million (real year dollars) is based upon the November 1999 proposal.

LAT receives funding from two sources, in addition to receiving hardware from foreign collaborators. While LAT does have some flexibility to shift spending from one source to another, there are some limitations in spending funds on certain tasks originating from only one funding source.

In FY 2000, the project has paid \$4,251 K in actual costs. For FY 2001, GLAST plans to spend \$11,888 K. This totals to \$16,139 K, or about 20 percent of the planned project cost. Very little contingency cost was available for FY 2000 and FY 2001.

GLAST management is presently implementing a Project Management Control System (PMCS) that reports cost and schedule performance using an earned value system. Cost is generally reported down to the fifth level. The GLAST PMCS is modeled after the B-Factory cost and schedule system, and complies with DOE and NASA management requirements.

GLAST management is presently preparing a complete bottoms-up, resource loaded integrated cost and schedule for the LAT effort. This development effort is expected to be completed by April 30, 2001. After scrubbing by GLAST management, this integrated cost and schedule plan will constitute the baseline for the LAT.

The PMCS team has chosen Primavera P-3 as the schedule database tool, with COBRA selected for handling the actual costs for the GLAST project and providing products for external output for NASA and DOE reporting.

### 3.2 Comments

The PMCS team is a very competent team and the Committee thanks them for their thorough presentation and frank discussion of the present status and the challenges that they see ahead. It was noted that the PMCS team developing the baseline is primarily made up of a consulting team (at least six people from Applied Integration Management) that will leave the project in April or May 2001.

Resource loading in PMCS is assessed in dollars, regardless of whether an Materials and Services item or labor effort. This will not allow the PMCS system to roll-up manpower needs in terms of FTEs, particularly for DOE scientific support which is supported from base programs. Contingency, while assessed by the Level 2 subsystems during the baseline development using a risk and weighted matrix, will be maintained at Level 1.

**Table 3-1. LAT DOE & NASA Interim Cost Estimate (Escalated K\$)  
Based upon November 1999 Proposal**

WBS#	Subsystem	Cost Estimate (Real-Year K\$)		
		DOE	NASA	Total
4.1.1	Instrument Management	\$4,633.9	\$1,444.4	\$6,078.3
4.1.2	System Engineering	\$3,989.6		\$3,989.6
4.1.3	(reserved)			
4.1.4	Tracker	\$10,965.2		\$10,965.2
4.1.5	Calorimeter		\$11,382.4	\$11,382.4
4.1.6	Anti-Coincidence Detector		\$9,536.1	\$9,536.1
4.1.7	Electronics & Data Acquisition	\$2,366.6	\$17,000.4	\$19,367.0
4.1.8	Mechanical Systems	\$2,177.1	\$2,825.8	\$5,002.9
4.1.9	Instrument Integration & Test	\$2,168.0	\$2,491.2	\$4,659.2
4.1.A	Performance & Safety Assurance	\$2,626.0		\$2,626.0
4.1.B	Instrument Operations Center		\$2,102.0	\$2,102.0
4.1.C	Education & Public Outreach		\$1,503.0	\$1,503.0
4.1.D	Science Analysis Software		\$2,718.4	\$2,718.4
4.1.E	Suborbital Flight (Balloon) Test		\$784.9	\$784.9
<b>Agency Totals</b>		<b>\$28,926.4</b>	<b>\$51,788.6</b>	
<b>LAT Total Estimated Cost (TEC)</b>				<b>\$80,715.0</b>
<b>LAT Total Project Cost (TPC)</b>				<b>\$103,700.0</b>
<b>Contingency</b>				<b>\$22,985.0</b>
<b>Contingency (%)</b>				<b>28.5%</b>

### **3.3 Recommendations**

1. The core members of the Project Management Control System team should be in place as quickly as possible to allow adequate time to transfer technology and information from the consultants to the permanent team, and to provide a smooth transition into the implementation phase of the project.
2. Complete a bottoms-up, resource loaded cost and schedule estimate for the GLAST project to support the baseline review. Estimate qualifications should be provided describing the estimate, such as quotes or engineering estimates for Materials and Services costs, or fully loaded institutional labor rates for manpower costs.
3. Perform a bottoms-up contingency analysis based upon the appropriate parameters (risk and weight factors, etc.) at the lowest WBS for the LAT project to support the baseline review. The resulting contingencies should be explicitly identified and easily viewed.
4. Manpower should be tracked explicitly as FTE's in the Project Management Control System.

**Intentionally Blank**

## 4. SCHEDULE and FUNDING

### 4.1 Findings

The integrated cost and schedule baseline consists of about 4,000 schedule activities, and contains a set of milestones consistent with a launch date of September 2005. This includes a three-month period of explicit slack identified in the project.

During the implementation phase of LAT, the master P-3 project file will reside in the Project Office. Monthly updates in earned value (work performed) will be provided by the subsystem manager (or designee) to the PMCS staff on a monthly basis.

### 4.2 Comments

When an integrated cost and schedule baseline is established, the critical path(s) of each subsystem should be identified.

All activities related to off-line testing prior to spacecraft integration (such as vibration and/or acoustic testing) should be taken into consideration to ensure the three-month period of slack is against availability to integrate to the spacecraft.

The LAT has a tight schedule up to the launch date. GLAST management should use the overall strategy of advancing its work and procurements whenever possible to increase the schedule slack.

**Table 4-1. LAT DOE & NASA Funding Estimate (Escalated K\$)**

	<b>FY00</b>	<b>FY01</b>	<b>FY02</b>	<b>FY03</b>	<b>FY04</b>	<b>FY05</b>	<b>Total</b>
<b>DOE</b>	\$3,000.0	\$5,700.0	\$8,200.0	\$9,000.0	\$5,900.0	\$3,200.0	\$35,000.0
<b>NASA</b>	\$3,594.0	\$3,891.0	\$15,500.0	\$20,300.0	\$18,900.0	\$6,500.0	\$68,685.0
<b>Total</b>	\$6,594.0	\$9,591.0	\$23,700.0	\$29,300.0	\$24,800.0	\$9,700.0	\$103,685.0

### **4.3 Recommendations**

1. Continue to formalize and complete the integrated schedule, focusing on establishing the critical paths for each subsystem.
2. Include all activities in the integrated schedule, including non-costed and foreign activities.
3. Ensure that sufficient slack exists for the individual subsystem schedules.
4. Introduce a milestone hierarchy into Project Management Control System.
5. Develop and implement the GLAST Project Management Plan to capture the contingency thresholds and configuration management to control schedule changes.

## **5. PROJECT MANAGEMENT**

### **5.1 Findings**

The GLAST LAT Project Office (IPO) comprises the Principle Investigator (IPI), Project Manager, Technical Manager, Instrument Scientist, system engineers and subsystem managers. LAT management is in the process of developing documents and tools for managing the LAT project, including the Project Management Plan and the PMCS. They are in the midst of finalizing MOA with collaborating institutions and funding agencies, and are also bringing on more staff to fill positions in the project. The IPO is managing the development of a baseline for the GLAST LAT project.

### **5.2 Comments**

The IPO staff is of high quality; it is composed of experienced individuals, with a good mix of expertise and knowledge of large projects. They are putting in place a reasonable set of tools and documents for managing the project.

There is a lot of work to do in getting ready to baseline this project; the IPO seems well aware of this. Among these tasks are:

1. Development of an integrated, resource loaded schedule that takes into account the funding profile and schedule constraints. An important aspect of the IPO's effort between now and the Baseline Review is to develop a realistic schedule for the project, one that provides reasonable schedule and cost contingency. This schedule has to provide adequate time for Integration and Test.
2. Growth of the IPO staff to provide adequate system engineering resources, with the appropriate mix of skills and the right level of effort.
3. Completion of a Project Management Plan that meets the needs of both DOE and NASA, while maintaining as much project management flexibility as possible.

4. Training the managers at all levels to use the management tools the IPO is putting at their disposal.
5. Developing a plan for Risk Management. Members of the IPO convinced the committee that they take this hard-to-quantify issue seriously.

The Committee notes that the incomplete status of a number of MOAs and Memorandum of Understanding has had and will continue to have a negative impact on the schedule. This is an issue for the IPO and the funding agencies to work on.

The Committee also noted the need for improved communication between project management and subsystem management, especially subsystems managed outside SLAC. More frequent communication at the collaboration level would also be useful.

### **5.3 Recommendations**

1. NASA and DOE should complete the agreement that establishes the Joint Oversight Group as soon as possible.
2. Complete and approve a Project Management Plan as soon as possible.
3. NASA and DOE should agree on guidelines for reporting on and reviewing the project that do not burden Project Management with duplicate requirements.
4. Develop an integrated, resource loaded schedule and cost estimate.
5. Develop better means of communicating within the collaboration and with subsystems.

**Department of Energy/National Aeronautics and Space Administration  
Pre-Baseline Review of the  
GLAST Large Area Telescope (LAT) Project**

**DRAFT AGENDA**

**Tuesday, February 13—Orange Room, Central Laboratory Building**

8:00 a.m. DOE/NASA Executive Session  
9:00 a.m. Welcome ..... J. Dorfan  
9:15 a.m. Project Overview ..... P. Michelson  
9:40 a.m. Project Management ..... W. Althouse  
*10:15 a.m. Break*  
10:30 a.m. Instrument Design ..... S. Ritz  
11:05 a.m. Tracker ..... R. Johnson  
11:35 a.m. Calorimeter ..... N. Johnson  
*12:05 p.m. Working Lunch*  
1:00 p.m. Anticoincidence Detector ..... J. Ormes  
1:30 p.m. Electronics, Data Acquisition, Flight Software ..... G. Haller  
2:00 p.m. Mechanical Systems ..... M. Nordby  
2:30 p.m. Integration and Test, Calibration ..... Nordby/Kamae  
3:05 p.m. Science Analysis Software ..... R. Dubois  
3:30 p.m. DOE/NASA Subcommittee Executive Session (various rooms)  
5:00 p.m. DOE/NASA Executive Session  
6:30 p.m. Adjourn

**Wednesday, February 14**

8:00 a.m. Subcommittee Session, Presentations/Discussions  
*12:00 p.m. Working Lunch*  
1:00 p.m. Management Q&A Session  
2:00 p.m. DOE/NASA Subcommittee Session  
3:00 p.m. DOE/NASA Executive Session

**Thursday, February 15**

8:30 a.m. NASA DOE Executive Session Closeout Dry Run  
11:00 a.m. Closeout with DOE/NASA and GLAST Management  
12:00 p.m. Adjourn

## **Breakout Sessions, Tuesday Afternoon:**

### Management

Addressing: Systems Engineering  
Project Management Control System  
Reviews & Reporting  
International Agreements  
Performance & Safety Assurance  
Education & Public Outreach

### Instrument Trigger & Data Acquisition Strategy

Addressing: Background Rejection  
Triggering  
Calibration Plan  
Dataflow, Volume  
Simulations

### Instrument Integration & Test

Addressing: Integration Planning  
Test Flow  
Integration Facility Tour  
Balloon Flight Engineering Model Integration

## **Breakout Sessions, Wednesday Morning:**

### Instrument Technology and Implementation Details

Addressing: Tracker  
Calorimeter  
Anticoincidence Detector  
Electronics, Flight Software  
Schedules & Cost Estimates for the Above

### Ground Software and Dataflow

Addressing: Instrument Operations Center  
Science Analysis Software  
Mission Operations  
Data Analysis

### Management (Question & Answer Session)

**National Aeronautics and Space Administration  
and  
U.S. Department of Energy**

JOINT OVERSIGHT GROUP

December 19, 2000

**TO:** Mr. Daniel Lehman, Director, Construction Management Support Division, SC-81

**RE:** Request to Conduct a pre-Baseline Review of the GLAST LAT Project

The DOE/NASA Joint Oversight Group (JOG) for the GLAST Large Area Telescope Project (LAT) requests that you conduct a pre-baseline review of the LAT Project at the Stanford Linear Accelerator Center (SLAC) on February 13-15, 2000.

The LAT is the principal scientific instrument to be flown on the NASA Gamma Ray Large Area Space Telescope (GLAST) mission, scheduled for launch in 2005. The LAT is being designed and built by an international collaboration organized by Dr. Peter Michelson of Stanford University and the Director for Research of the Stanford Linear Accelerator Center (SLAC). Dr. Michelson is the spokesperson for the LAT Collaboration as well as the Principal Investigator for the NASA Contract with Stanford University for participation in the LAT Project. SLAC is Host Laboratory for the LAT Project, providing technical and management support. SLAC participation is funded through its M&O contract with DOE. Under an agreement between NASA and DOE, Dr. Michelson, with a simultaneous faculty appointment at SLAC, is the Instrument Principal Investigator for the Project with overall accountability for the technical, cost, and schedule management.

The LAT Collaboration, with support from NASA and DOE and the responsible foreign funding agencies, submitted a successful proposal to NASA in November 1999 in response to NASA AO-99-055-03 for the GLAST Mission. This proposal, as accepted by NASA, constitutes the basis of the LAT Project Management Plan (PMP). The full PMP will incorporate the joint reporting relationship to the U.S. funding agencies, the role of SLAC as Host Laboratory, including international financial arrangements and accountability.

The charge to the Review Committee for the February 13-15, 2000 review is:

- to review the technical progress, including the status of R&D, relative to the scientific requirements for the instrument.
- to examine the proposed budget, cost, and schedule profile, including the commitment of funds and personnel, to determine its adequacy to complete the project on schedule and on budget. Is the contingency adequate for the project at this stage of its development?
- to evaluate the management structures, including the relationships to the GLAST Mission organization and relationships with foreign collaborating institutes, as to their adequacy to deliver the LAT within specifications and budget and on time for the projected launch date.

We appreciate your assistance in this matter. As you know, these reviews are an important element of the NASA/DOE joint oversight of the GLAST LAT Project and help to ensure that the U.S. astroparticle physics program remains robust and meets its commitments on cost and schedule.

You are asked to submit a formal report of the review within 60 days of the closeout.

[Original signed by]

---

Alan Bunner  
NASA Co-Chair  
Office of Space Science  
NASA Headquarters  
Washington, D.C. 20546

[Original signed by]

---

John R. O'Fallon  
DOE Co-Chair  
Division of High Energy Physics, SC-22  
U.S. Department of Energy  
Germantown, MD 20874

Cc: M. Dresselhaus, SC-1  
J. Decker, SC-2  
S. Horowitz, NASA Hq  
M. Johnson, SC-3  
S. Lambros, GSFC  
J. Ritchie, SC-223  
P. Rosen, SC-20  
T. Toohig, SC-223  
J. Turi, SC-80  
E. Weiler, NASA Hq.

Concurrence:

TToohig	JRitchie	JO'Fallon	SHorowitz	DKniffen	ABunner
12/ /00	12/ /00	12/ /00	12/ /00	12/ /00	12/ /00

**Department of Energy/National Aeronautics and Space Administration  
Pre-Baseline Review of the  
GLAST Large Area Telescope (LAT) Project**

**REPORT OUTLINE/WRITING ASSIGNMENTS**

Executive Summary .....	TBD
1. Introduction.....	Toohig
2. Technical Systems Evaluations	
2.1 Tracker (WBS 4.1.4).....	Haber*, Subcommittee 1
2.1.1 Findings	
2.1.2 Comments	
2.1.3 Recommendations	
2.2 Anticoincidence Shield (WBS 4.1.6).....	De Barbaro*, Subcommittee 2
2.3 Calorimeter (WBS 4.1.5).....	Ray*, Subcommittee 3
2.4 Reconstruction and Analysis (ground software).....	Butler*, Subcommittee 4
2.5 Trigger and Data Acquisition.....	Haggerty*, Subcommittee 5
2.6 Integration and Test .....	Kerby*, Subcommittee 6
3. Cost Estimate .....	Reichanadter*, Subcommittee 7
4. Schedule and Funding.....	Reichanadter*, Subcommittee 7
5. Project Management .....	Aronson*, Subcommittee 8

Appendices

- A. Charge Memorandum
- B. Review Committee Membership
- C. Review Agenda
- D. Cost Tables
- E. Schedule Charts
- F. Funding Tables
- G. Action Items

\*denotes lead for writing assignment.

**Department of Energy/National Aeronautics and Space Administration  
Pre-Baseline Review of the  
GLAST Large Area Telescope (LAT) Project  
February 13-15, 2001**

**Daniel R. Lehman, DOE  
Chairman**

SC1	SC2	SC3	SC4	SC5
<b>Tracker, WBS 4.1.4</b>	<b>Anticoincidence Shield, WBS 4.1.6</b>	<b>Calorimeter, WBS 4.1.5</b>	<b>Reconstruct. and Analysis (ground software)</b>	<b>Trigger Data Acquisition</b>
* Carl Haber, LBNL Joe Incandela, Fermilab	* Pawel De Barbaro, Rochester	* Ron Ray, Fermilab John Mitchell, GSFC	* Joel Butler, Fermilab James Branson, UCSD	* John Haggerty, BNL Jon Thaler, U. of Illinois Fred Blanchette, GSFC

SC6	SC7	SC8
<b>Integration and Test</b>	<b>Cost and Schedule</b>	<b>Project Management</b>
* Jim Kerby, Fermilab Fiona Harrison, CalTech John Lindsay, GSFC	* Mark Reichanadter, Fermilab Tony Lavoie, MSFC	* Sam Aronson, BNL Martin Davis, GSFC Steve Tkaczyk, DOE/SC [Jim Kerby, Fermilab] [Mark Reichanadter, Fermilab]

<b>Observers</b>	
Jack Ritchie, DOE/SC	Dennis Dillman, NASA, GSFC
Timothy Toohig, DOE/SC	Lou Fantano, NASA GSFC
Ev Valle, DOE/OAK	Jeff Hein, NASA GSFC
Alan Bunner, NASA HQ.	Scott Lambros, NASA GSFC
Steve Horowitz, NASA HQ.	Bob Maichle, NASA GSFC
Donald Kniffen, NASA HQ.	Mark Seidleck, NASA GSFC
	Bill Anderson, QSS

**LEGEND**

SC Subcommittee  
\* Chairperson  
[ ] Part-time Subcom. Member  
**Count: 19 (excluding observers)**

**Department of Energy/National Aeronautics and Space Administration  
Pre-Baseline Review of the  
GLAST Large Area Telescope (LAT) Project**

**GLAST/LAT POINTS-OF-CONTACT**

	<u>Name</u>	<u>Telephone</u>	<u>E-Mail</u>
<b>SC 1</b>	<b>Tracker</b>		
	Robert Johnson	831-459-2125	<a href="mailto:johnson@scipp.ucsc.edu">johnson@scipp.ucsc.edu</a>
<b>SC 2</b>	<b>Anticoincidence Shield</b>		
	Jonathan Ormes	301-286-5705	<a href="mailto:jfo@lheapop.gsfc.nasa.gov">jfo@lheapop.gsfc.nasa.gov</a>
<b>SC 3</b>	<b>Calorimeter</b>		
	Neil Johnson	202-767-6817	<a href="mailto:johnson@gamma.nrl.navy.mil">johnson@gamma.nrl.navy.mil</a>
<b>SC 4</b>	<b>Reconstruction and Analysis</b>		
	Richard Dubois	650-926-3824	<a href="mailto:richard@slac.stanford.edu">richard@slac.stanford.edu</a>
<b>SC 5</b>	<b>Trigger and Data Acquisition</b>		
	Gunther Haller	650-926-4257	<a href="mailto:gxh@slac.stanford.edu">gxh@slac.stanford.edu</a>
<b>SC 6</b>	<b>Integration and Test</b>		
	Martin Nordby	650-926-3415	<a href="mailto:nordby@slac.stanford.edu">nordby@slac.stanford.edu</a>
<b>SC 7</b>	<b>Cost and Schedule</b>		
	Tanya Boysen	650-926-5461	<a href="mailto:tkb@slac.stanford.edu">tkb@slac.stanford.edu</a>
<b>SC 8</b>	<b>Project Management</b>		
	Bill Althouse	650-926-3249	<a href="mailto:wea@slac.stanford.edu">wea@slac.stanford.edu</a>

**Department of Energy/National Aeronautics and Space Administration  
Pre-Baseline Review of the  
GLAST Large Area Telescope (LAT) Project**

**REVIEW PARTICIPANTS ADDRESS/TELEPHONE LISTING**

**Dr. Samuel Aronson**

Brookhaven National Laboratory  
MS: 510C  
P.O. Box 5000  
Upton, New York 11973-5000  
516-344-2051  
[aronsons@bnl.gov](mailto:aronsons@bnl.gov)

**Professor Pawel De Barbaro**

University of Rochester  
Physics Department  
River Campus B&L Bldg.  
Rochester, New York 14627-0171  
630-840-2263  
[barbaro@fnal.gov](mailto:barbaro@fnal.gov)

**Dr. Fred Blanchette**

NASA/Goddard Space Flight Center  
MS: 429  
Greenbelt, Maryland 20771  
301-286-3655  
[frederick.m.blanchette.1@gssc.nasa.gov](mailto:frederick.m.blanchette.1@gssc.nasa.gov)

**Dr. Carl H. Haber**

Lawrence Berkeley National Laboratory  
MS: 50B-5239  
1 Cyclotron Road  
Berkeley, California 94720  
510-486-7050  
[chhaber@lbl.gov](mailto:chhaber@lbl.gov)

**Professor James Branson**

University of California, San Diego  
Department of Physics, 0319  
9500 Gilman Drive  
La Jolla, California 92093  
858-534-2978  
[jbranson@ucsd.edu](mailto:jbranson@ucsd.edu)

**Dr. John Haggerty**

Brookhaven National Laboratory  
MS: 510A  
P.O. Box 5000  
Upton, New York 11973-5000  
631-344-2286  
[Haggerty@bnlku2.phy.bnl.gov](mailto:Haggerty@bnlku2.phy.bnl.gov)

**Dr. Joel Butler**

Fermi National Accelerator Laboratory  
MS: 122  
P.O. Box 500  
Batavia, Illinois 60510  
630-840-3148  
[butler@fnal.gov](mailto:butler@fnal.gov)

**Professor Fiona Harrison**

California Institute of Tehnology  
Physics and Astronomy, 220-47  
Pasadena, California 91125  
626-395-6601  
[fiona@srl.caltech.edu](mailto:fiona@srl.caltech.edu)

**Dr. Martin Davis**

NASA/Goddard Space Flight Center  
MS: 415  
Greenbelt, Maryland 20771  
301-286-8998  
[martin.a.davis.1@gssc.nasa.gov](mailto:martin.a.davis.1@gssc.nasa.gov)

**Dr. Joseph Incandela**

Fermi National Accelerator Laboratory  
MS: 310  
P.O. Box 500  
Batavia, Illinois 60510  
630-840-8554  
[incandel@fnal.gov](mailto:incandel@fnal.gov)

**Mr. James Kerby**

Fermi National Accelerator Laboratory  
MS: 316  
P.O. Box 500  
Batavia, Illinois 60510  
630-840-3595  
[kerby@fnal.gov](mailto:kerby@fnal.gov)

**Mr. Daniel Lehman**

U.S. Department of Energy  
MS: SC-81  
19901 Germantown Road  
Germantown, Maryland 20874  
301-903-4840  
[daniel.lehman@science.doe.gov](mailto:daniel.lehman@science.doe.gov)

**Dr. John Lindsay**

NASA/Goddard Space Flight Center  
MS: 568  
Greenbelt, Maryland 20771  
301-286-7779  
[john.m.lindsay.1@gsfc.nasa.gov](mailto:john.m.lindsay.1@gsfc.nasa.gov)

**Dr. Anthony Lavoie**

NASA/Marshall Space Flight Center  
MS: 35812  
Huntsville, Alabama 35812  
256-544-2332  
[tony.lavoie@msfc.nasa.gov](mailto:tony.lavoie@msfc.nasa.gov)

**Dr. John Mitchell**

NASA/Goddard Space Flight Center  
MS: 661  
Greenbelt, Maryland 20771  
301-286-3199  
[john.w.mitchell.1@gsfc.nasa.gov](mailto:john.w.mitchell.1@gsfc.nasa.gov)

**Dr. Ronald Ray**

Fermi National Accelerator Laboratory  
MS: 231  
P.O. Box 500  
Batavia, Illinois 60510  
630-840-8090  
[rray@fnal.gov](mailto:rray@fnal.gov)

**Mr. Mark Reichenadter**

Fermi National Accelerator Laboratory  
MS: 205  
P.O. Box 500  
Batavia, Illinois 60510  
630-840-8205  
[reich@fnal.gov](mailto:reich@fnal.gov)

**Dr. Jon Thaler**

University of Illinois, Urbana-Champaign  
441 Loomis Laboratory of Physics  
1110 West Green Street  
Urbana, Illinois 60801  
217-333-8174  
[jjt@uiuc.edu](mailto:jjt@uiuc.edu)

**Mr. Stephen Tkaczyk**

U.S. Department of Energy  
MS: SC-81  
19901 Germantown Road  
Germantown, Maryland 20874  
301-903-3288  
[steve.tkaczyk@science.doe.gov](mailto:steve.tkaczyk@science.doe.gov)

**Dr. Jack Ritchie**

U.S. Department of Energy  
MS: SC-223  
19901 Germantown Road  
Germantown, Maryland 20874  
301-903-5475  
[jack.ritchie@science.doe.gov](mailto:jack.ritchie@science.doe.gov)

**Dr. Timothy Toohig**

U.S. Department of Energy  
MS: SC-223  
19901 Germantown Road  
Germantown, Maryland 20874  
301-903-4115  
[timothy.toohig@science.doe.gov](mailto:timothy.toohig@science.doe.gov)

**Mr. Ev Valle**

U.S. Department of Energy  
Stanford Support Office  
P.O. Box 4349  
Stanford, California 94025  
510-637-1703  
[ev.valle@oak.doe.gov](mailto:ev.valle@oak.doe.gov)

**Dr. Alan Bunner**

NASA Headquarters  
MS: 5G80  
Washington, DC 20546  
202-358-2150  
[abunner@mail.hq.nasa.gov](mailto:abunner@mail.hq.nasa.gov)

**Mr. Stephen J. Horowitz**

NASA Headquarters  
MS: 5T80  
Washington, DC 20546  
202-358-0895  
[shorowit@mail.hq.nasa.gov](mailto:shorowit@mail.hq.nasa.gov)

**Mr. Donald Kniffen**

NASA Headquarters  
MS: 4J55  
Washington, DC 20546  
202-358-0351  
[dkniffen@mail.hq.nasa.gov](mailto:dkniffen@mail.hq.nasa.gov)

**Mr. Dennis Dillman**

NASA/Goddard Space Flight Center  
MS: 301  
Greenbelt, Maryland 20771  
301-286-7237  
[ddillman@pop300.gsfc.nasa.gov](mailto:ddillman@pop300.gsfc.nasa.gov)

**Mr. Lou Fantano**

NASA/Goddard Space Flight Center  
MS: 545.0  
Greenbelt, Maryland 20771  
301-286-9965  
[louis.g.fantano.1@gsfc.nasa.gov](mailto:louis.g.fantano.1@gsfc.nasa.gov)

**Mr. Jeff Hein**

NASA/Goddard Space Flight Center  
MS: 740.3  
Greenbelt, Maryland 20771  
301-286-0487  
[jhein@pop700.gsfc.nasa.gov](mailto:jhein@pop700.gsfc.nasa.gov)

**Mr. Scott Lambros**

NASA/Goddard Space Flight Center  
MS: 740.2  
Greenbelt, Maryland 20771  
301-286-0118  
[scott.lambros@pop400.gsfc.nasa.gov](mailto:scott.lambros@pop400.gsfc.nasa.gov)

**Mr. Robert Maichle**

NASA/Goddard Space Flight Center  
MS: 730.0  
Greenbelt, Maryland 20771  
301-286-5222  
[robert.j.maichle.1@gsfc.nasa.gov](mailto:robert.j.maichle.1@gsfc.nasa.gov)

**Mr. Mark Seidleck**

NASA/Goddard Space Flight Center  
MS: 471.0  
Greenbelt, Maryland 20771  
301-286-7415  
[mseidleck@pop400.gsfc.nasa.gov](mailto:mseidleck@pop400.gsfc.nasa.gov)

**Mr. William Anderson**

QSS  
7404 Executive Place, Suite 400  
Seabrook, Maryland 20706  
301-867-0039  
[banderso@qssmeds.com](mailto:banderso@qssmeds.com)