Department of Energy/National Aeronautics and Space Administration
Review of the Large Area Telescope (LAT) Project

WHEN: March 31 – April 1, 2004
WHERE: Stanford Linear Accelerator Center

REVIEW COMMITTEE:

This review was co-chaired by Daniel R. Lehman of the Department of Energy (DOE) and Kevin Grady of the National Aeronautics and Space Administration (NASA) and included five technical consultants on the Review Committee, with specific areas of expertise applicable to the Large Area Telescope (LAT) project. In addition, there were three reviewers from DOE, seven reviewers from NASA headquarters, and the Gamma-ray Large Area Space Telescope (GLAST) Mission office. Below is the full committee:

Consultant	DOE	NASA
Fred Huegel	Dan Lehman (co-chair)	Kevin Grady (co-chair)
Jay Marx	Steve Tkaczyk	Dan Blackwood
Jim Ryan	Kathy Turner	Mark Goans
Helmuth Spieler	Ev Valle	Bernie Graf
Ron Zellar		Don Kniffen
		Jack Liebee
		Tom McCarthy
		Al Vernacchio

REVIEW PURPOSE:

The Office of High Energy Physics and NASA GLAST Mission Project Office conducted a status review of the LAT project on March 31–April 1, 2004 at the Stanford Linear Accelerator Center (SLAC). The LAT is the principal scientific instrument to be flown on the GLAST Mission, scheduled for launch in 2007. The purpose of this review was to examine the entire project in terms of its technical, cost, and schedule status. For NASA, the review also served as one of the GLAST Mission office's monthly reviews of project status, as well as an independent status review. The Committee was to determine if the project's status was consistent with the baseline objectives, whether the project was progressing adequately, and if the cost and schedule contingencies were adequate. This review followed a May 2003 joint DOE/NASA Conceptual Design Review and Critical Decision 3 (CD-3), Approve Start of Construction review. In July 2003, there was a review of the LAT's rebaseline proposal that was subsequently approved, along with the approval of CD-3.

FABRICATION PROJECT STATUS

Estimate at Completion (EAC)	$124.383M
Total Estimated Cost (TEC) – includes DOE, NASA, Japan	$136.830M
Remaining Contingency in TEC	$12.447M
Contingency as percent of cost-to-go	29.0%
Total DOE contribution	$42.0M
Percent Complete	65.0%
End of Fabrication date (CD-4)	March 15, 2006

TECHNICAL:
All subsystems have made significant progress since the May 2003 DOE/NASA review. The LAT baseline schedule and cost were restructured. The project now has 29 percent contingency and is 65 percent complete. Schedule float between completion of the LAT and start of observatory integration is nine weeks. Other Committee findings include:

- The calorimeter effort was successfully reorganized after the pullout of CNES (French space agency).
- The Anticoincidence Detector (ACD) subsystem has made good progress.
- All Application Specific Integrated Circuit (ASIC) designs are complete and in most instances flight parts have been fabricated and tested.
- Analysis software is progressing well—the first data challenge produced impressive results.
- Designs across LAT have matured and flight hardware is being procured or fabricated.
- System tests have begun, but there is a long way to go.
- The schedule is success oriented and leaves no margin for major setbacks. This applies to all systems.
- The Tracker is a very complex system and hence most vulnerable. Major components are very robust, but strong management will be essential for timely completion.
- Thermal test results from the Engineering Model Tracker meet specifications. A new design of the tower mounting interface has been developed and needs to be tested. A new mechanical design team was instrumental in this accomplishment.
- Tracker tower alignment procedures must be developed and verified.

This is a complex system built by a highly qualified and dedicated team. At this stage, there is no simple recipe that will ensure timely delivery of the system. The current design is sound, but "bumps in the road" towards completion are inevitable. Project management is monitoring progress carefully and it is essential to continually reassess risk when taking remedial action.

System tests of flight hardware are a high priority, but the urge to proceed to this major milestone should not compromise the subsequent fabrication program.

The key point is to find problems early in subsystem development. The project must resist the temptation to cut subsystem testing (performance and environmental) due to schedule pressures. This could lead to a much larger schedule hit down the road.

Tracker production is a case in point. Maintaining the overall production rate of the tracker towers is essential. Timely production of the initial batches of Multi-Chip Modules (MCM) is crucial to launching tower production. After assembly of the first tower, sufficient time must be allowed for testing and analyzing results to ensure that all weak points are recognized, so that mitigation techniques for further production can be developed. To maintain the schedule, additional engineering and analyst effort appears appropriate.

Because of the composite construction of the sidewalls and trays, sine burst testing to qualification levels of the flight tracker towers is recommended.

The presented integration and testing (I&T) plan did not go beyond the second tower. Plans for subsequent production must be developed allowing sufficient time for calibration. Successful execution of I&T requires the addition of a senior person with significant experience in integrating space flight hardware.

The flight software team has added test members to the software development process. This increased effort will reduce risk and enhance the quality of the flight software. However, the Committee is concerned that the Flight Unit build of the flight software is being delivered to I&T prior to the completion of flight software acceptance testing.

The Committee observed miscommunication between groups at SLAC and the ACD. This occurred from both sides. LAT management must ensure that all parties understand the scope and timing of deliverables.

Recommendations:

1. Maintain the schedule without compromising technical integrity.
2. Proceed towards system tests of flight hardware expeditiously, while allowing sufficient time to recognize and correct potential problems.
3. Assign effort to ensure that the required MCM production rate is attained and maintained.
4. Perform sine burst testing to qualification levels of the flight tracker towers.
5. Present a test plan for the grid strength qualification by September 2004.
6. Present a plan for software acceptance tests as part of a Flight Unit build design review by September 2004.
7. Identify possible setback and develop mitigation plans to protect the schedule.

COST:

At the September 2003 rebaselining, the TEC was $133.4 million. The project referenced the TEC for the LAT fabrication project (as of November 2003) of $133.8 million, with the change due to additional resources from NASA. From November 2003 to February 2004, the TEC increased by $2.98 million to $136.8 million, due to LAT management identifying areas requiring additional resources and manpower in order assure that the project meets its goals. The NASA GLAST Mission office added funds to the project for this additional staff. Other baseline changes totaling $1.9 million were also identified since November 2003 and were funded from existing project contingency. The total result is an increase in the EAC of $4.9 million, from $119.5 million to $124.4 million. The remaining project contingency is $12.4 million, which is 29 percent of the remaining costs. Approximately $0.8 million in change control actions have been identified in March 2004 and a list of potential additional contingency liens of $3.2 million was presented at the review. The table below summarizes project status through February 2004. The committee did not perform a detailed cost assessment.

	9/03 status	11/03 status	2/04 status	Change 11/03 to 2/04
Estimate at Completion (EAC)	$117.2M	$119.5M	$124.4M	$4.8M
Total Estimated Cost (TEC)	$133.4M	$133.8M	$136.8M	$3.0M
Total Project Cost (TPC)	$133.4M	$133.8M	$136.8M	$3.0M
Remaining Contingency in TEC	$16.2M	$14.3M	$12.4M	($1.9M)
Contingency as % of costs-to-go	25%	29%	29%	
Percent Complete			65%	

SCHEDULE:
There were no changes to the Level 1 Milestones since the project was rebaselined, with the Critical Decision 4 (CD-4), Start of Operation, date of March 15, 2006, remaining the same. The project's internal schedule has a July 14, 2005 date of completion for the requirements of CD-4 and includes five weeks of float. This internal schedule supports the December 1, 2005, NASA pre-shipment review date, and includes four additional weeks of float.

DOE Level 1 Milestones:

Mission Need (CD-0)	June 25, 2001
Preliminary Baseline Range (CD-1)	August 28, 2002
Performance Baseline (CD-2)	November 8, 2002
Start of Fabrication (CD-3)	September 3, 2003
End of Fabrication (CD-4)	March 15, 2006

The Committee's found that the project's internal schedule is challenging.

FUNDING:
The current funding profile, including the recent additional $2.98 million in funding from NASA is as follows:

	FY00	FY01	FY02	FY03	FY04	FY05	Total
DOE	$3,000	$5,689	$8,080	$8,910	$7,900	$8,421	$42,000
NASA	$3,863	$3,847	$13,137	$26,514	$28,660	$17,615	$93,636
Japan					$1,000	$194	$1,194
Total	$6,863	$9,536	$21,217	$35,424	$37,560	$26,230	$136,830

The anticipated changes to be made to the NASA funding profile in March are:

	FY04	FY05	Total
March CCB Actions	810		810
MPS Tax Transfer	-801	-249	-1050
Move Contingency	500	-500	0
	509	-749	-240

These changes would yield a projected March 2004 baseline funding profile as follows:

	FY00	FY01	FY02	FY03	FY04	FY05	Total
DOE	$3,000	$5,689	$8,080	$8,910	$7,900	$8,421	$42,000
NASA	$3,863	$3,847	$13,137	$26,514	$29,169	$16,866	$93,396
Japan					$1,000	$194	$1,194
Total	$6,863	$9,536	$21,217	$35,424	$38,069	$25,481	$136,590

This projected profile would not support the project as planned (see Management Section).

Recommendation:

1. Resolve the FY 2004 funding shortfall problem.

MANAGEMENT:
The schedule is extremely tight. There is very significant schedule risk that requires strong attention from the GLAST/LAT project management and from SLAC. The project is 65 percent complete; the funding contingency is 29 percent of cost to complete. Four weeks of schedule float has been lost since the re-baseline of the project. There is only three weeks of formal schedule float for meeting the "Start LAT Integration" milestone of August 24, 2004.

The schedule is very tight and success-oriented with a number of short-term threats to the schedule, including funding in FY 2004, and the rate of drawing release in the next few months. A number of subsystems are at or near the critical-path. In the medium-term, the very aggressive DAQ software schedule represents a schedule risk. Even if these are resolved, until a production-rate history is established there will be significant longer-term schedule uncertainty.

The staffing level is improving but additional people, including a few additional key space-experienced people, are badly needed. This issue contributes to the schedule risk.

The project scope and responsibilities are well defined, and communication within the management team seems good.

With support from SLAC, the project management and system engineering team appear to be capable of successfully completing this project.

Funding in the current fiscal year is an issue. A funding shortfall of approximately $5 million in FY 2004 must be resolved if the schedule is to be met.

Joint DOE/NASA oversight seems to be effective. The GLAST Mission Office has provided needed support. The project is receiving strong support from DOE, NASA, SLAC, and the scientific collaboration.

The major issue at the July 2003 DOE/NASA review—loss of CNES funding—has been resolved with work transferred to U.S. groups and funded provided in a rebaseline of the project. The Tracker and the I&T aspects of the project are very complex activities. Although there is good progress being made, significant management challenges remain.

International agreements are in reasonable shape with many signed and several with signature pending. Agreements between NASA and Japan; and NASA and Sweden are still in draft.

Education and public outreach activities are progressing well with many interesting GLAST-based brochures, games, etc., being developed and distributed. A Public Broadcast System (PBS) NOVA television show about black holes is under development.

Meeting the schedule is the key and most difficult challenge for LAT and for SLAC. SLAC must fully support this project by providing capable staff at the level needed to assure that the schedule can be maintained. Given the tightness of the schedule the needed additional staffing should be put in place as soon as possible. The project management fully realizes that the schedule is at risk, and have been working to implement short-term actions to mitigate this problem. However, there are significant risks to the schedule that are not yet fully under control.

Lack of timely drawing release is beginning to delay hardware building. In some areas of the project, especially the data acquisition (DAQ) system, drawing release could impact critical path. This problem is well recognized by management and mitigation is taking place, including the hiring of additional designers and having engineering staff focus on the needed work. Management's comments indicate a best effort to deal with the problem, but it is not at all clear that this will be adequate to avoid schedule slip.

It is expected that the additional $5 million needed in FY 2004 will be provided by NASA and/or from Stanford University. This must be accomplished in a timely manner if schedule slip is to be avoided.

The "just-in-time" availability of flight hardware documentation represents a significant challenge for the Quality Assurance Program.

The risk management activity is being used by management to focus on down-stream risks, especially to schedule, and on mitigation of the specific risks identified. Significant planning is taking place for verification and testing activities in order maintain the schedule downstream. Overall planning for mitigating down-stream schedule risk still needs additional work.

The management of the tracker must be strengthened to assure that the activities in several countries are well integrated and are successfully completed on schedule. I&T activities successfully require the addition of a senior person with significant experience leading the integration of a flight instrument.

The education and public outreach program is very impressive and should have a significant impact of educational activities in the schools.

Recommendations:

1. All parties should resolve the FY 2004 funding shortfall problem by May 30, 2004.

2. Project management should develop schedule recovery options to assure that the overall schedule is met. The trade-offs between accelerating the schedule and increasing high consequence technical risk must be considered. Complete by July 1, 2004.

3. Project management must strengthen the management of the Tracker and I&T by June 1, 2004.

4. The Laboratory Director must assure that all key staff vacancies are filled with appropriate experienced people by July 1, 2004.

ACTION ITEM:
There were no action items resulting from the review.