Report from the Peer Review of the LAT Electronic/DAQ/Power/Flight Software Subsystem

Summary:
The GLAST LAT Electronic/DAQ/Power/Flight Software subsystem was peer reviewed on March 19/20 2003 at SLAC.
The review committee is listed in Appendix A, and the charge is shown in Appendix B.
In addition to the committee members and the subsystem representatives, a large number of interested people from the GLAST project office, the LAT and SLAC were in attendance, and contributed to the lively discussions.
Material submitted is available through the following website:
http://www-glast.slac.stanford.edu/Elec_DAQ/review03.htm

Findings:
A report by Co-chair Al Vernacchio reflecting the detailed comments by the committee is attached as Appendix C.
The list of RFAs submitted by committee members is attached as Appendix D.

In answer to the charge, at the concluding informal close-out session, the committee members gave the following assessment :

- Is the subsystem design maturity, qualification and verification planning near CDR level?
  Yes, "near".
- Has the subsystem identified open design issues and established appropriate resolution plans to ensure closure?
  Yes, as detailed in Appendix C.
- Is the subsystem near readiness for manufacturing?
  Yes, with the concerns listed in Appendix C.
- Has the subsystem identified open manufacturing issues and established appropriate resolution plans?
  Yes, with the main concern being the schedule and parts approval.
- Are there other issues the committee feels should be addressed?
  A few issues involving the LAT-S/C and LAT-Observatory interfaces are noted in the RFAs.

Comments:
The committee commented on the quality of work ("impressive", "cutting edge stuff"). Several members mentioned the huge science impact of the GLAST mission, and pledged their commitment to help making it a success. For example, given that there will be at least two more peer reviews of this subsystem, the committee expressed desire to be kept involved. It would welcome "home work assignments" prior to the reviews. Members of the committee volunteered to support the LAT CDR with a report from this review.

For the committee: Hartmut F.-W. Sadrozinski 3/24/03

APPENDIX A: Review Committee

Elec/DAQ/PWR/FLTSW – March 19-20, 2003 SLAC

Chairman:	Hartmut Sadrozinski	
Co-Chairman:	Al Vernacchio	
Members:	John Fox	Rick Schnurr
	Fred Huegel	Steve Scott
	Bob Jacobsen	Steve Smith
	Terry Schalk	Ron Zellar

APPENDIX B: Charge to the Review Committee
STANFORD LINEAR ACCELERATOR CENTER

February 21, 2003

To: GLAST LAT Peer Review Committee Members

Reference: LAT Subsystems Peer Review Charge

In order to assure that the GLAST-LAT design and development is progressing satisfactorily toward a LAT Instrument Critical Design Review, the GLAST-LAT Project Management is holding a series of Subsystem Peer Reviews. We request your participation in these Peer Reviews from March 17th through the 28th. The Calorimeter review will be held at NRL, all others will be at SLAC.

The Subsystems to be reviewed are as follows:

Calorimeter Subsystem	March 17th – 18th
Electronics/DAQ/Power/Flight Software Subsystem	March 19th – 20th
Tracker Subsystem	March 24th – 25th
Mechanical Subsystem	March 26th-27th
Integration & Test	March 28th

The Committee Chairs and Membership are listed in the attached table. The Chairmen will be responsible for coordinating Request for Actions (RFAs) that are proposed during the review and producing a summary consensus report. The chair should submit the report to me within 10 business days of the conclusion of the respective Subsystem Peer Design Review.

Websites with review materials will be provided prior to the reviews.

Each Committee is requested to evaluate and address the following questions:

- Is the subsystem design maturity, qualification and verification planning near CDR level?
- Has the subsystem identified open design issues and established appropriate resolution plans to ensure closure?
- Is the subsystem near readiness for manufacturing?
- Has the subsystem identified open manufacturing issues and established appropriate resolution plans?
- Are there other issues the committee feels should be addressed?

Sincerely,

W.E. Althouse
Project Manager, GLAST LAT

APPENDIX C: Comments by Al Vernacchio, Co-Chair

Overall, this was a good review with substantial detail provided on the electronics and FSW requirements, design, and development and test approach. The team did an excellent job presenting the material.

The main concern I have is schedule. The electronics implementation depends largely on procurements that are not finalized yet. This makes the effort dependent on the ability of vendors to deliver on time with quality products. It will be crucial that the LAT team work closely with vendors to ensure quality products are produced. The software schedule was not thoroughly reviewed during the meetings. I have that schedule and intend to review it in detail against the requirements and build plans.

The electronics design is sufficiently mature with many improvements and optimizations that were prudent. The mechanical analyses related to the boards and boxes must be reviewed further next week during the mechanical peer review with GSFC experts. It was noted during the review that an unconventional method for mechanical analyses was used. This approach needs to be reviewed by GSFC Mechanical engineers.

Several suggestions were made and documented in RFAs. I will not repeat them here. Some of the more critical system level issues that I noted are:

1. Definition of spacecraft responses to instrument problems. Clear definition is required for what is monitored and what the spacecraft responses will be.

2. EMI testing is planned only on the qualification unit. This is not consistent with GSFC practice which is to test all boxes to some level. The Project needs to resolve this outstanding issue.

3. Event filtering is probably the most crucial aspect of the system. FSW indicated they are close to the 98% rejection goal. However, they did not present a plan and schedule for getting to that level. This should be included in the overall FSW plan/schedule. Also, the criteria for event acceptance and the required success rate needs to be defined and planned and scheduled.

4. A clear and correct grounding scheme needs to be developed and presented at CDR.

5. Perhaps the largest threat to the design is the FMEA and the resultant impacts to the design. The FMEA needs to be complete soon so as to be able to effect the design appropriately.

6. Much of the manufacturing will be performed by vendors. However, SLAC intends to perform rework in-house which is more complex. SLAC needs to ensure that adequate training and exposure to initial manufacturing is achieved by those responsible for rework.

7. Is 96% reliability of a system this complex achievable?

8. SLAC engineering should ask themselves the following question once more (and perhaps frequently during instrument development). Is there anything the instrument needs to do to protect itself without depending on the spacecraft?

9. Reliance on the SIIS for I&T introduces risk. The LAT team needs to identify specifically what the SIIS will be used for and develop plans for I&T independent of the SIIS so as not to allow the SIIS to impact instrument I&T.

The review was very effective. The LAT team is encouraged to continue to involve the review team experts in their design and development. They should consider the review team as a resource for consulting and engineering support. The LAT team should attempt to coordinate subsequent peer reviews so that full review team support can be achieved.

APPENDIX D: List of Request for Action RFA

GLAST LAT DAQ/FSW Subsystem Peer Review March 19/20 2003

RFA Subject - Actionee Matrix

RFA #	Topic	DAQ	FSW	Elex	LAT, S/C, GBM etc
1	GBM Signal (Schalk)	x			x
2	Boot Process (Scott)		x		
3	Explanation of terms (Scott)		x		
4	Allocation and Derivation of FSW Reqmts. (Scott)		x		
5	Representation of FSW (Scott)		x		
6	Change Control of FSW design docs (Jacobson)		x		
7	Timing source (Andrews)	x		x	x
8	SIIS Redundancy (Andrews)	x		x	x
9	Population of CPU boards (Huegel)			x	
10	Benchmarking FSW data reduction (Smith)		x		x
11	Independent test team (Zellar)		x		
12	(Zellar) retracted				
13	GRB Alert Notification(Zellar)		x		x
14	(Zellar) retracted				
15	Event Builder/Router Switch (Schnurr)	x	x	x	
16	Error handling in Rad750 (Schnurr)	x	x	x	
17	Rad750 info exchange (Sadrozinski)	x		x	x
18	List of package functionality (Schalk)		x		
19	TFFS in LAT FSW (Schnurr)		x		
20	Hardware Protection of ACD PMT (Sadrozinski)			x	x
21	Mods to Reqs. Doc and test plan (Zellar)		x		
22	Accelerate scheduled FSW docs delivery (Zellar)		x		
23	SPICE Analysis of EMI (Schnurr)	x		x	x
24	Grounding Scheme (Huegel)			x	
25	Monitoring S/C Keep-alive (Leibee)		x		x
26	TEMS Mechanical (Fransen)			x	

List of RFAs in chronological order (collected by H. Sadrozinski)

March 19

1. **Use of GBM signal** **(Terry Schalk, UCSC)**

REQUEST: GRB alert line from SC is an interrupt signal. Can the interrupt rate be controlled (or shut-off) if as a result of a failure the rate becomes too high?

2. **Complete time line of events in boot-up** **(Steve S. Scott, GSFC)**

PRESENTATION: Risk p. 25
REQUEST: Provide a complete, sequential timeline of all the events in the boot-up sequence from initial application of power to completion of the boot-up sequence. Provide this timeline for both Primary Boot Process and the Secondary Boot Process.
REASON/COMMENT: Primary Boot Code is treated as critical code. Secondary Boot Code is essential to run the application code.

3. **Explanation of terms** **(Steve S. Scott, GSFC)**

PRESENTATION: Flight Software I,III and Overview
REQUEST: Provide an explanation of the terms and concepts of "Framework", "Event Fabric", "Task", and "Package" and how they fit into the flight software architecture.
REASON/COMMENT: It is not clear that these terms have been used in an industry-wide sense and how they provide an integrated architecture and what "pieces" might be missing.

4. **Allocation and derivation of Requirements** **(Steve S. Scott, GSFC)**

PRESENTATION: Flight Software I and Overview
REQUEST: Show the allocation and derivation of requirements from the Mission System Specific to the Flight Software Requirements showing the Level III (and Level IV) Software Requirements and where the designs addressing them are instantiated (i.e., in what package, task, build, etc. they are contained)
REASON/COMMENT: This was done for the electronics hardware but was <u>not done</u> for the FSW, contributing to some confusion about the allocation and derivation of FSW requirements. Only follow the FSW portion of the allocation/derivation since hardware was done.

5. **Representation of FSW and level of development (Steve S. Scott, GSFC)**

PRESENTATION: Flight Software I,III and Overview
REQUEST: Show how "Overview" p. 4, "Overview" p. 7, "Flight Software I" pp. 3,4, "Flight Software I" p. 26, and "Flight Software III" p. 25 are equivalent representations of the same system (and traceable to one another). Show us the level of development required for each element for each build EM1, EM2, Flight, etc.
REASON/COMMENT: Need to demonstrate requirements, architectural design and implementation consistency/ equivalence.

6. Change control of detailed design documents (Bob Jacobson, LBL)
PRESENTATION: Flight Software
REQUEST: Specify when detailed design documents (at the level of task inputs and outputs) will be under change control.

7. Timing source (Erik Andrews, GSFC via AV)
PRESENTATION: Electronics
REQUEST: LAT Electronics and FSW testing, as well as Instrument testing, assumes a timing source that meets the fidelity specified in the SC-LAT IRD (+- 1usec per 100 sec accuracy). Current SIIS design does not meet that accuracy, and LAT does not intend to implement an accurate source in its own GSE. Please identify (both subsystem and instrument level) specific testing limitations. If possible, identify tests in test plan/ procedure documents.
REASON/COMMENT: There is a risk associated with testing against a timing source that is outside specification. For GPO to assess and mitigate the risk, more detail of the test limitations must be known.

8. **SIIS Redundancy (Erik Andrews, GSFC via AV)**
PRESENTATION: Electronics
REQUEST: LAT Electronics and FSW testing, as well as Instrument testing, assumes a Two-sided (Primary and Redundant) Spacecraft – Instrument Interface Simulator (SIIS). Current SIIS design is single-string. Please identify specific testing limitations (both s/s level and instrument level) given a single-string SIIS. If possible, point to specific tests in subsystem and instrument test plan/procedures.
REASON/COMMENT: There is some amount of risk associated with not testing the LAT with two-sided GSE (unknown or unidentified feedback/noise on redundant lines). For GPO to assess and mitigate the risk, more detail of the test limitations must be known.

9. Populate parts in EPUs (Fred Huegel, GSFC)
PRESENTATION: EPU
REQUEST: Decide on whether or not to populate the parts for functions not needed in the EPUs.
REASON/COMMENT: Manufacturing and test plans will be impacted by this decision. In addition, some minor design changes will be required to properly terminate unused outputs and to properly tie unused inputs high or low.

March 20

10. Benchmarking FSW data reduction (Steve Smith, SLAC)
PRESENTATION: Flight Software
REQUEST: Agree on a metric, or set of benchmarks, by which to evaluate efficiency of data reduction (event rejection) algorithm.
REASON/COMMENT: Clearly the software team ius aware of the issue; they need something like a set of Monte Carlo events, with noise, etc. to evaluate algorithm efficiency. Need to measure ho big a baby we can throw out with the bath water.

11. Create an Independent Test team (Ron Zellar, GSFC)
PRESENTATION: Flight Software
REQUEST: Create an independent test team. (Recommend a level of effort equivalent to development effort.) Test team should have minimal contribution to the Requirements and design of the software.
Give the test team responsibility for the Test plan, test scenarios and test procedures. Track their progress using detailed schedule and staffing plan: FSW builds should be carried out as dependencies on testing schedule.
REASON/COMMENT: The appropriate level and nature of the software test program are not being achieved.

12. Modify/Create docs ---Retracted, captured in #21,22 (Ron Zellar, GSFC)
REQUEST:
REASON/COMMENT:

13. Requirement of GRB alert notification (Ron Zellar, GSFC)
PRESENTATION: Flight Software
REQUEST: Modify the Requirements document to reflect actual requirements of the GRB alert notification, namely the software is only required to service the discreet input. It does not need to switch filter parameters, or take additional actions initiated by this event.
REASON/COMMENT: The GLAST project stated that the LAT should not make accommodation for receiving this event. Since the LAT hardware is designed to accept it, and the electronics are being tested for connectivity, the software driver for the GRB interrupt should be similarly designed and tested. Software requirements should explicitly state that the interrupt is being serviced and nothing more.

14. **Observations on FSW risks ---Retracted by Questioner (Ron Zellar, GSFC)**
REQUEST:
REASON/COMMENT:

15. Information on event builder "router/switch" (Rick Schnurr, GSFC)
PRESENTATION: Electronics
REQUEST: Please provide additional information on event builder "router/switch" characteristics.
REASON/COMMENT: Design not presented in sufficient detail to determine if network will meet timing requirements of LAT instrument. Data rate margins were presented but latency, buffering were not addressed. Interference and coordination of tasks using the network was not addressed.

16. Review of BSP, error handling (Rick Schnurr, GSFC)
PRESENTATION: Electronics
REQUEST: Program should verify that the SU ROM/VxWorks BSP meetsw the program requirements. At a minimum the wait state settings/exception handling and bridge chip

error handlers should be reviewed by the program. Rad750 error handler provided by the vendor should be reviewed as well.
REASON/COMMENT: User can induce errors into the Rad750/Bridge which might not leave a signature after reset.

17. Rad750 experience (Hartmut Sadrozinski, UCSC)
PRESENTATION: Electronics
REQUEST: Make sure to interface with GSFC groups about experience with Rad750.
REASON/COMMENT: Rad750 is new and has not been flown. GSFC has several groups planning to fly it. Rick Schnurr has volunteered to provide the contacts.

18. List of functionality for each package EM0. EM1 (Terry Schalk, UCSC)
PRESENTATION: Flight Software
REQUEST: A bulleted list of functionality that is needed in each package for EM1/EM2/…
REASON/COMMENT:

19. Integration of TFFS into LAT FSW (Rick Schnurr, GSFC)
PRESENTATION: Flight Software
REQUEST: Please provide the document that describes how TFFS is integrated into the LAT FSW. Include info on drivers/telemetry.
REASON/COMMENT: Level of effort needed to implement TFFS is not clear from the information presented. Not clear that TFFS meets mission requirements. It is typical to havea RAM buffer that is used for volatile updates. A commit process can then be used to save the changes to the EEPROM.
How does the TFFS implement this? If the writes are controlled by the TFFS are they counted by driver to verify performance?

20. Hardware protection of PMT (GRB or SPE) (Hartmut Sadrozinski, UCSC)
PRESENTATION: Flight Software
REQUEST: Check that the ACD PMT HV hardware protection (current limit) does not interfere with GRB or Solar Flare science.
REASON/COMMENT: If the current due to particles from GRB or Solar Flares are larger than those expected in the SAA, the protection circuit would shot the HV off and prevent the instrument from acquiring science data.

21. Modification of Reqs. Doc and Test plan (Ron Zellar, GSFC)
PRESENTATION: Flight Software
REQUEST: Modify the following documents
1. Requirements Document- include more detail and describe more fully requirements on software that will allow independent development of test procedures.
2. Test Plan a) include a requirement to test Procedure Matrix. This matrix would show mapping from requirements to procedures and procedures to requirements.
b) include functional descriptions of simulators and specialized hardware required to complete a successful test program. Reference simulator design/requirements docs as required.

c) include acceptance testing in software test plan. Acceptance tests will exercise the FSW as a fully delivered system at the end of Test program and will include full regression testing of all software build tests, "stress" tests, and significant operational scenarios.
d)include evidence and conclusions of how the planned software test program is achievable.
REASON/COMMENT: Needed to conduct adequate test program.

22. Accelerate scheduled delivery of docs (Ron Zellar, GSFC)
PRESENTATION: Flight Software
REQUEST: Accelerate scheduled delivery of

1. Design/Architecture document- present a draft of a highlevel design document capable of showing self-consistency across software and between software modules, and that important software functions are thought out. Present draft at CDR.
2. Algorithm document- present a draft algorithm document at CDR that identifies types and high level functions of science algorithms needed by FSW.

REASON/COMMENT: Design/Architecture is needed to demonstrate capability to create necessary software for LAT. Algorithm is needed to mitigate the risk of schedule delays and for software testing.

23. EMI-SPICE analysis for LAT internal Power Bus (Rick Schnurr, GSFC)
PRESENTATION: Electronics
REQUEST: In order to understand EMI, perform SPICE analysis of the LAT internal power distribution bus. Include models for S/C DC/DC converters, all filters, and LAT DC/DC converters. Use model to establish EMI self-compatibility, i.e. will the internal EMI sources cause problems. Look at inrush issues as well.
REASON/COMMENT: Internal EMI may cause excessive instrument noise.

24. Clearer Grounding scheme (Fred Huegel, GSFC)
PRESENTATION: Electronics
REQUEST: For the CDR, revise the grounding scheme chart to make it more clear and accurate.
REASON/COMMENT: The chart as presented is not accurate and is confusing.

25. Monitor S/C Keep Alive (Jack Leibee, GSFC via AV)
PRESENTATION: Flight Software
REQUEST: Consider adding capability for FSW to monitor S/C keep-alive, and take appropriate action when they are no longer received.
REASON/COMMENT: Lack of S/C keep-alive indicates S/C problem -> unknown S/C state. LAT needs to safe itself.

26. TEMS Mechanical (C. Fransen, Swales/GSFC via AV)
PRESENTATION: Electronics Mechanical
REQUEST: 1. Assess the TEMS box designs using dynamic analysis based upon the current PF spectrum. A damping value of 5% is recommended and the net CG

response and interface forces should be output for direct calculation of fastener margins. It is also recommended that model's interface assume a pinned boundary (i.e., 3 translational dofs are fixed).
2. Note that the Page 5 Lateral Load factor as currently shown is incorrect, and should be changed to 7.4 G's to agree with the LAT Environmental Specification. It should also be noted that the Lateral and Axial load factors must be applied simultaneously in all combinations.
REASON/COMMENT:
1. While the use of SDOF detailed on pages 33-35 appears conservative, use of more conservative boundary conditions and actual random the results may change. A proper random analysis is particularly important considering that random vibration represents the dominant load case for the TEMS.
2. Correct for update to LAT Environmental Specification